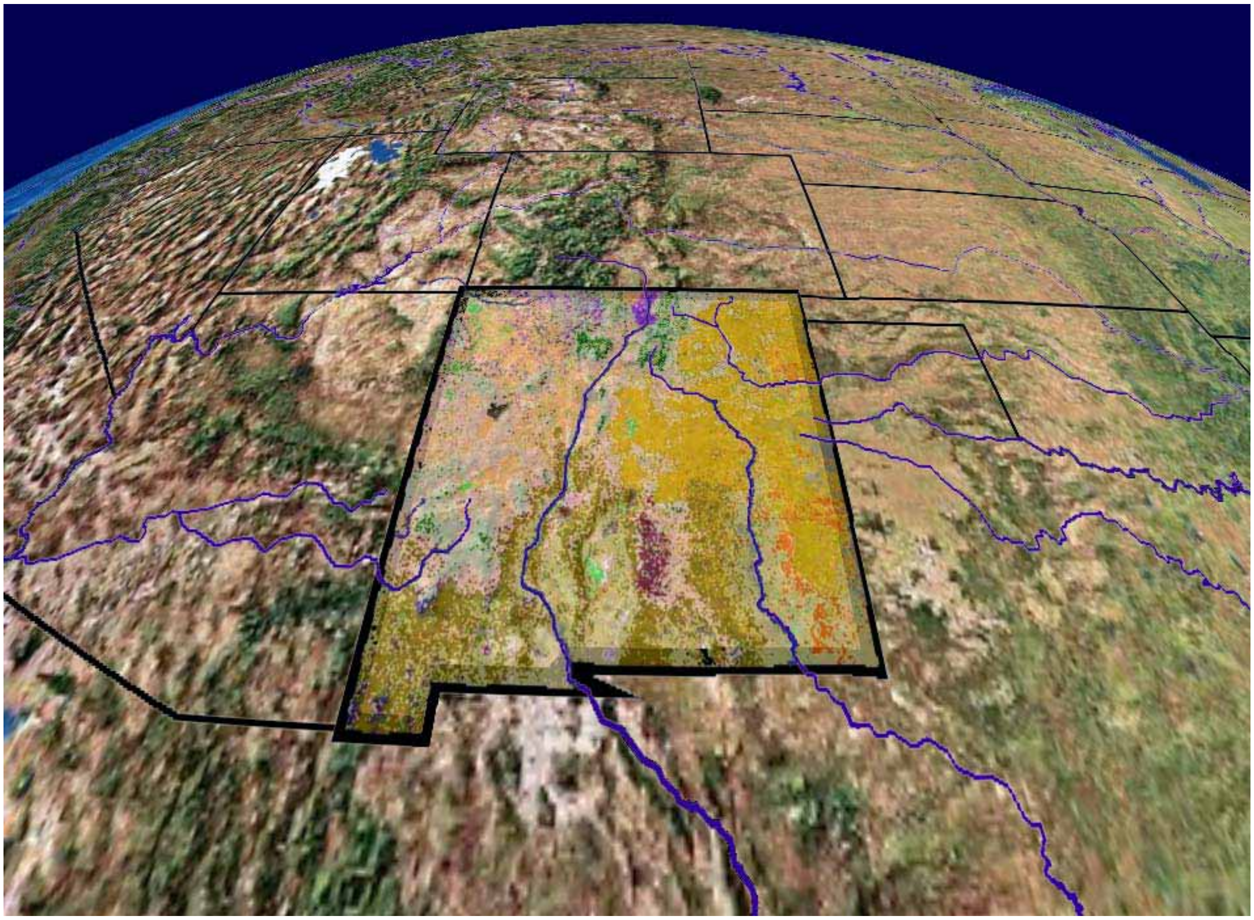
Comprehensive Wildlife Conservation Strategy For New Mexico



Prepared by:

New Mexico Department of Game and Fish

In cooperation with:

Over 170 public agencies, conservation organizations, commodity interests, municipalities, private partners, and tribal representatives.

February 14, 2006

Comprehensive Wildlife Conservation Strategy

For New Mexico

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State of New Mexico

Office of the Governor

Bill Richardson
Governor

September 26, 2005

National Acceptance Advisory Team
U.S. Fish and Wildlife Service
Arlington, VA

Dear Acceptance Team:

I am pleased to submit New Mexico's draft Comprehensive Wildlife Conservation Strategy for your review and acceptance.

This Strategy demonstrates our concern for wildlife and habitat resources here and across the nation. It is our job to keep our wildlife populations healthy and sustainable, and we take that responsibility seriously. The approaches to conservation expressed in the Strategy are substantial and sensible. An important consideration is that we have listened to many people and interests in the preparation of this Strategy. The New Mexico Department of Game and Fish, as facilitator of this Strategy, has contacted more that 400 public, private, and tribal interests; specific contributions from more than 125 of those interests are represented in the Strategy.

The Strategy fully addresses the eight essential elements established by Congress for the Strategy documents nationally. We have focused on strategic actions that are intended to keep common species common and work to prevent wildlife from becoming endangered. We have consulted rigorous science as available, and we have acknowledged where more information is needed. Importantly, we have constructed an ecological framework for identifying the species of greatest conservation need, the habitat treatments necessary to sustain them and other members of their ecological communities, and the periodic review process necessary to ensure citizen involvement and acceptance. This perspective is presented with responsible regard for the wide array of economic and social values that also are important to maintain on our landscape.

As shown by our policy progress in the past 30 months, I am a "conservation Governor." This Strategy, maintaining a strong place for New Mexico in the State Wildlife Grants program, is a significant part of that commitment. Thank you for your consideration of our contribution.

Sincerely,

Bill Richardson
Governor of New Mexico

Guy Riordan
Chairman, State Game Commission

PREFACE

This Comprehensive Wildlife Conservation Strategy for New Mexico is a product of the people and represents both a culmination and a springboard.

The Strategy is a culmination of 2 years of efforts on the part of resource professionals, conservation organizations, commodity interests, private individuals, tribal interests, municipal governments, and others to construct a better wildlife conservation overview for New Mexico. Those efforts have been directed by a national initiative for accomplishing such a perspective through Congressional interest in the State Wildlife Grants program. The need for comprehensive strategies has been recognized for many years and led to establishment of the October 2005 deadline for states to present strategies that address local and state-level conservation needs and which promote an ability to advise regional and national perspectives on wildlife conservation at landscape scales.

Importantly, this draft Strategy is the springboard to an important conservation future for wildlife in New Mexico and the Southwest. In addressing the eight essential elements prescribed by Congress for strategy construction, New Mexico has *consolidated* important insight about long-term needs of wildlife in the state, *articulated* an ecologically based approach to strategic actions that reverse declines and maintain beneficial population levels, and *formulated* the public engagement processes necessary to ensure involvement in, and acceptance and implementation of conservation strategies for years to come.

This Strategy is dedicated to expressing sensible approaches to conserving biological diversity in New Mexico in context with surrounding areas. We identify focus points on species and habitats warranting conservation actions. Further, we organize existing information and recognize where important information gaps remain. From that foundation, we identify cooperative and collaborative approaches to addressing the most important wildlife and habitat conservation needs in time and cost effective ways. The potential of this Strategy can only be realized through a broad array of natural resource agencies, other public programs, and private interests, all accepting this approach, being guided by it in operational planning, and pulling together to implement the actions.

New Mexico Department of Game and Fish has appreciated its role and responsibility in facilitating the compilation and construction of this Strategy. But, we acknowledge the greater contribution of many public, private, municipal, tribal, and other participants that kept us cognizant of all factors necessary to describe conservation actions that embrace the functional balance of wildlife and human interests. We are indebted to all who have participated to this point and all who will help this springboard to reaching fullest benefits for wildlife.

Bruce Thompson
Director, New Mexico Department of Game and Fish
September 2005

EXECUTIVE SUMMARY

In 2001, through the efforts of the 3000 member groups of the Teaming With Wildlife Coalition (http://www.teaming.com), the US Congress passed legislation now known as the State and Tribal Wildlife Grants Program (SWG) and created the nation's core initiative for conserving our country's biodiversity and thereby precluding the necessity of listing more species as threatened and endangered. Planning and actions to recover species that have become endangered are controversial and expensive. Annual spending on listed species in the United States has increased more than six fold over the past 10 years, to a level of over $600 million a year. The SWG program promotes proactive and collaborative conservation action *before* wildlife reaches that serious and controversial status. Since 2001, Congress has allocated more than $400 million to the states for this purpose, apportioned on the basis of their respective land areas and human populations. New Mexico's share of the national appropriation has averaged about $1 million per year. In order to maintain eligibility for this funding, each state must develop and submit a Comprehensive Wildlife Conservation Strategy (CWCS) no later than October 1, 2005.

The Comprehensive Wildlife Conservation Strategy for New Mexico focuses upon Species of Greatest Conservation Need (SGCN)), key wildlife habitats, and overcoming the challenges affecting the conservation of both. The overriding desired outcome is that New Mexico's key habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts. We believe this document will greatly facilitate meeting our statutory mandates to provide an adequate supply of game, fish, and furbearers and to carry out the provisions of the Wildlife Conservation Act pertaining to conserving indigenous threatened or endangered wildlife. Associated funding will allow the New Mexico Department of Game and Fish (NMDGF) and its partners to broaden their attention beyond single species to include the species and habitats necessary to conserve all of New Mexico's biodiversity. Some significant revelations emerging from development of the CWCS are:

- New Mexico has 452 vertebrate, mollusc, and arthropod SGCN. Significantly larger proportions of amphibians (58%) and crustaceans (91%) are recognized as SGCN than other taxonomic groups.

- The greatest diversities of terrestrial SGCN are predicted to occur in the Apache Highlands, Arizona-New Mexico Mountains, and Chihuahuan Desert Ecoregions.

- The greatest diversities of aquatic SGCN are predicted to occur in the Pecos, Rio Grande, and Gila Watersheds.

- The most significant factors affecting the persistence of SGCN statewide are those that cause habitat conversion, loss, and degradation.

- Conversion to other uses, extraction of minerals or water, removal of biological resources, and pollution present the highest probability of altering New Mexico's key habitats.

- Ephemeral natural catchments, perennial marsh/cienega/spring/seeps, and riparian habitats may be at a higher risk of alteration by multiple factors than other habitat types in New Mexico.

- The effects of oil and gas development on SGCN and their key habitats are of most concern in the Southern Shortgrass Prairie, Colorado Plateau, and Chihuahuan Desert Ecoregions. Mining poses potential adverse effects in the Arizona-New Mexico Mountains Ecoregion.

- The Chihuahuan Desert, Arizona-New Mexico Mountains, and Southern Shortgrass Prairie Ecoregions have been subjected to significant habitat alterations as the result of off-road vehicle and other recreational uses and military activities.

- Non-native aquatic species have considerable adverse effects upon native fish, molluscs, and crustaceans in New Mexico's aquatic habitats. However, many non-native species have been introduced to enhance sport fishing opportunity, and the challenge remains in balancing these interests with maintaining viable and resilient populations of native species.

- Findings to date suggest that key areas upon which to focus conservation efforts in New Mexico may include riparian and aquatic habitats throughout the state, areas in the "boot heel" region of southwestern New Mexico extending northward into the Madrean habitats, and areas of the shortgrass prairie and western mountain ranges where they converge with Chihuahuan Desert and Pecos River habitats. These areas contain key habitats, have a high diversity of SGCN, are subjected to a moderate to high magnitude of multiple habitat altering factors, and lack legal constraints or long-term management plans protecting them from habitat conversion.

- There is a strong need to fill the information gaps impeding assessment and conservation of New Mexico's biodiversity through the collaborative and coordinated implementation of research, survey, and monitoring projects.

- The highest priority conservation action for both terrestrial and aquatic key habitats statewide is to work with federal, state, and private organizations, research institutions and universities to design and implement research, survey, and monitoring projects to enhance our understanding of SGCN and their key habitats. Knowledge of SGCN abundance and distribution and the connectivity and condition of key habitats is of particular interest as are studies that monitor the status of SGCN and identify and quantify factors limiting their populations.

- We will need to create partnerships among local, state, federal, and tribal governments, non-government organizations, universities, and individuals to effectively forward our common wildlife conservation interests.

- We will need to implement conservation strategies that are effective on a landscape scale.

- Our perceptions and effectiveness can be greatly enhanced by involving private landowners and the agricultural industry in the CWCS implementation, review, and revision phases and otherwise providing them continual opportunities to inform and influence project development. New Mexico is 51% rangeland, 2.4% cropland, and 0.3% pasture. Even primarily urban Bernalillo County, which includes less than 1% of the state's total land area and 30% of its population, produces $40 million in agricultural products and has numerous agriculture-related industries.

Though NMDGF has led the development process to date, the CWCS is a strategic plan intended as a blueprint to guide collaborative and coordinated wildlife conservation initiatives involving NMDGF, local, state, federal, and tribal governments, non-governmental organizations (NGOs) and interested individuals. It identifies many more conservation actions and research, survey, and monitoring needs than can be addressed in the near term by any one entity. To facilitate effective implementation, this broad array of strategic intentions will need to be further narrowed through an executive staff process to comprise a wildlife action plan focused upon near-term conservation priorities. NMDGF will next employ an operational planning process by which to propose, select, schedule, design, staff, and budget the site or area-specific projects through which these strategic conservation priorities will be implemented. The operational planning process will include appropriate coordination with local, state, and federal government agencies and tribes and afford these entities, NGOs and interested publics opportunities to influence and participate in project design and implementation. NMDGF will encourage partnering and cost sharing with and among these interests. We will promote awareness of implementation progress through periodic announcements and events, including an annual CWCS for New Mexico Progress Report, and provide regularly scheduled and interim review and revision opportunities.

The scope, focus, and content of this document were influenced by the direct involvement of over 170 individuals external to NMDGF who provided valuable technical and socio-economic insights and constructive criticism from diverse and sometimes conflicting perspectives. We sincerely hope they will continue to engage with us in further CWCS development and implementation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ROADMAP TO THE ELEMENTS

This section is provided to assist the National Acceptance Advisory Team (NAAT) in evaluating the CWCS for New Mexico for compliance in adequately addressing the eight congressionally required elements. The chapters and page numbers indicated for each NAAT Guidance statement will assist in locating areas in the document where each element was addressed. However, information pertaining to each element may also occur throughout the document.

Element 1: Information on the distribution and abundance of species of wildlife, including low and declining populations as the state deems appropriate, that are indicative of the diversity and health of the state's wildlife.

NAAT Guidance	Chapter	Pages
The Strategy indicates sources of information (e.g., literature, data bases, agencies, individuals) on wildlife abundance and distribution consulted during the planning process.	**Chapter 2**…………………………	14, 15, 16, 21-22
	Chapter 4…………………………	58-62
	Supporting Documentation………	450-526
The Strategy includes information about both abundance and distribution for species in all major groups to the extent that data are available. There are plans for acquiring information about species for which adequate abundance and/or distribution information is unavailable.	**Chapter 2**…………………………	8-16
	Chapter 3…………………………	25, 52
	Chapter 4…………………………	53-62, 65, 82-83
	Chapter 5	
	Apache Highlands Ecoregion……	93-97, 100-101, 108-110
	AZ-NM Mountains Ecoregion……	113-116, 123-124, 132-134, 144-145
	Chihuahuan Desert Ecoregion……	149-152, 155-156, 161-162
	Colorado Plateau Ecoregion……...	165-167, 171
	So. Rocky Mountains Ecoregion…	174-177, 180, 191-194
	So. Shortgrass Prairie Ecoregion…	199-201, 205-206, 214-215
	Riparian Habitats…………………	220-223, 237-240
	Ephemeral and Tank Habitats…….	248-253, 258-259, 262-263, 266-267
	Canadian Watershed……………...	269-273, 274, 277, 281-282, 285
	Gila Watershed…………………...	287-291, 292-293, 296, 299-300, 303-304
	Mimbres Watershed………………	306-309, 310-311, 313, 316
	Pecos Watershed…………………	319-322, 324, 327-328, 331, 334-335, 339
	Rio Grande Watershed……………	341-344, 346-347, 349-350, 352-353, 356, 359-360
	San Juan Watershed………………	362-365, 366, 369, 373
	Tularosa Watershed………………	376-379, 381, 385
	Zuni Watershed…………………...	388-391, 392-393
	Additional SGCN………………...	396-400, 402-403, 405-416
	Chapter 6…………………………	419-425, 433-443
	Appendices	
	Appendix C………………………	537-548
	Appendix H………………………	574-585
	Appendix O………………………	624-625
	Appendix P………………………	626-627
	Appendix Q………………………	628-632

Element 1 Cont.

NAAT Guidance	Chapter	Pages
The Strategy identifies low and declining populations to the extent data are available.	**Chapter 2**…………………………	8-16
	Chapter 3…………………………	25, 52
	Chapter 4…………………………	53-62, 65, 82-83
	Chapter 5	
	Apache Highlands Ecoregion…….	93-97
	AZ-NM Mountains Ecoregion……	113-116
	Chihuahuan Desert Ecoregion……	149-152
	Colorado Plateau Ecoregion……...	165-167
	So. Rocky Mountains Ecoregion…	174-177
	So. Shortgrass Prairie Ecoregion…	199-201
	Riparian Habitats…………………	220-223
	Ephemeral and Tank Habitats…….	248-253
	Canadian Watershed……………...	269-273
	Gila Watershed…………………...	287-291
	Mimbres Watershed………………	306-309
	Pecos Watershed…………………	319-322
	Rio Grande Watershed……………	341-344
	San Juan Watershed………………	362-365
	Tularosa Watershed………………	376-379
	Zuni Watershed…………………...	388-391
	Additional SGCN………………...	396-397, 399, 402, 405, 407, 409, 411,412, 415
	Chapter 6…………………………	419-425, 433-443
	Appendices	
	Appendix C………………………	537-548
	Appendix H………………………	574-585
All major groups of wildlife have been considered or an explanation is provided as to why they were not.	**Chapter 2**…………………………	8-13
	Chapter 4…………………………	53-58
	Chapter 5	
	Apache Highlands Ecoregion…….	95
	AZ-NM Mountains Ecoregion……	113
	Chihuahuan Desert Ecoregion……	149
	Colorado Plateau Ecoregion……...	165
	So. Rocky Mountains Ecoregion…	174
	So. Shortgrass Prairie Ecoregion…	199
	Riparian Habitats…………………	220
	Ephemeral and Tank Habitats…….	248
	Canadian Watershed……………...	269
	Gila Watershed…………………...	289
	Mimbres Watershed………………	306
	Pecos Watershed…………………	319
	Rio Grande Watershed……………	343
	San Juan Watershed………………	364
	Tularosa Watershed………………	376
	Zuni Watershed…………………...	390
	Additional SGCN………………...	396
	Appendices	
	Appendix C………………………	537-548
	Appendix H………………………	574-585
The Strategy describes the process used to select the species in greatest need of conservation.	**Chapter 2**…………………………	8-13

Element 2: Descriptions of location and relative condition of key habitats and community types essential to conservation of species identified (SGCN) in Element 1.

NAAT Guidance	Chapter	Pages
The Strategy provides a reasonable explanation for the level of detail provided; if insufficient, the Strategy identifies the types of future actions that will be taken to obtain the information.	**Chapter 2**…………………………	11-12, 16
	Chapter 4…………………………	81-84
	Chapter 5…………………………	396, 415
	Chapter 6…………………………	425-428, 433-443
	Appendices	
	Appendix D………………………	549-568
	Appendix E………………………	569-571
	Appendix F………………………	572
	Appendix G………………………	573
	Appendix Q………………………	628-632
Key habitats and their relative conditions are described in enough detail such that the State can determine where (i.e., in which regions, watersheds, or landscapes within the State) and what conservation actions need to take place.	**Chapter 3**…………………………	31-51
	Chapter 5	
	Apache Highlands Ecoregion…….	94, 97-98, 102-104
	AZ-NM Mountains Ecoregion……	114, 117-118, 126-127, 138-139
	Chihuahuan Desert Ecoregion……	150, 152, 158-159
	Colorado Plateau Ecoregion……...	166-168
	So. Rocky Mountains Ecoregion…	174-175, 177, 182-183, 186
	So. Shortgrass Prairie Ecoregion…	200, 202, 208-209
	Riparian Habitats………………..	221, 223-226
	Ephemeral and Tank Habitats…….	249, 254-255, 261, 265
	Canadian Watershed……………...	270, 273, 276, 279, 283
	Gila Watershed…………………...	288, 291, 294-295, 298, 301-302
	Mimbres Watershed………………	307, 309, 312, 315
	Pecos Watershed…………………	320, 322-323, 326, 329, 333, 337
	Rio Grande Watershed…………..	342, 345, 348, 351, 355, 358
	San Juan Watershed……………..	363, 365, 368, 371
	Tularosa Watershed……………..	377, 379, 383
	Zuni Watershed…………………...	389, 391
	Additional SGCN………………...	396-397, 399, 402, 405, 407, 409, 411, 412, 415
	Appendices	
	Appendix D………………………	549-568
	Appendix E………………………	569-571
	Appendix F………………………	572
	Appendix G………………………	573
	Appendix Q………………………	628-632

Element 3: Descriptions of problems which may adversely affect species identified in Element 1 or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats.

NAAT Guidance	Chapter	Pages
The Strategy indicates sources of information (e.g., literature, databases, agencies, or individuals) used to determine the problems or threats.	**Chapter 2**…………………………	17-18
	Chapter 4…………………………	63-80
	Chapter 5	
	Apache Highlands Ecoregion…….	98-99, 104-108
	AZ-NM Mountains Ecoregion……	118-122, 127-130, 140-143
	Chihuahuan Desert Ecoregion……	153-154, 159-161
	Colorado Plateau Ecoregion……...	168-170
	So. Rocky Mountains Ecoregion…	178-179, 183, 187-190
	So. Shortgrass Prairie Ecoregion…	202-204, 210-213
	Riparian Habitats…………………	226-234
	Ephemeral and Tank Habitats…….	255-256, 261-262, 265
	Canadian Watershed……………...	273, 276-277, 280, 284
	Gila Watershed…………………...	291-292, 295,298, 302
	Mimbres Watershed………………	309, 312, 315
	Pecos Watershed…………………	323, 326, 330, 333-334, 337-338
	Rio Grande Watershed…………..	345, 348-349, 351-352, 355, 359
	San Juan Watershed………………	365, 368, 371-372
	Tularosa Watershed………………	379-380, 384
	Zuni Watershed…………………...	392
	Additional SGCN………………...	397, 399-400, 402-403, 405, 407, 409, 411, 413, 415
	Supporting Documentation………	450-526
	Appendices	
	Appendix I ………………………	586-614
	Appendix J………………………	615-616
	Appendix K………………………	617-618
	Appendix L………………………	619
The threats/problems are described in sufficient detail to develop focused conservation actions (for example, "increased highway mortalities" or "acid mine drainage" rather than generic descriptions such as "development" or "poor water quality"),	**Chapter 2**…………………………	17-18, 19-20
	Chapter 4…………………………	63-80
	Chapter 5…………………………	92
	Apache Highlands Ecoregion…….	98-99, 104-108
	AZ-NM Mountains Ecoregion……	118-122, 127-130, 140-143
	Chihuahuan Desert Ecoregion……	153-154, 159-161
	Colorado Plateau Ecoregion……...	168-170
	So. Rocky Mountains Ecoregion…	178-179, 183, 187-190
and,	So. Shortgrass Prairie Ecoregion…	202-204, 210-213
	Riparian Habitats…………………	226-234
The Strategy considers threats/problems, regardless of their origins (local, State, regional, national and international), where relevant to the State's species and habitats.	Ephemeral and Tank Habitats…….	255-256, 261-262, 265
	Canadian Watershed……………...	273, 276-277, 280, 284
	Gila Watershed…………………...	291-292, 295,298, 302
	Mimbres Watershed………………	309, 312, 315
	Pecos Watershed…………………	323, 326, 330, 333-334, 337-338
	Rio Grande Watershed…………..	345, 348-349, 351-352, 355, 359
	San Juan Watershed………………	365, 368, 371-372
	Tularosa Watershed………………	379-380, 384
	Zuni Watershed…………………...	392

Element 3 Cont. NAAT Guidance	Chapter	Pages
	Additional SGCN………………..	397, 399-400, 402-403, 405, 407, 409, 411, 413, 415
	Appendices	
	Appendix I ………………………	586-614
	Appendix J………………………	615-616
	Appendix K………………………	617-618
	Appendix L………………………	619
If available information is insufficient to describe threats/problems, research and survey efforts are identified to obtain needed information.	**Chapter 4**…………………………	82-84
	Chapter 5	
	Apache Highlands Ecoregion…….	100-101, 108-110
	AZ-NM Mountains Ecoregion……	123-124, 132-134, 144-145
	Chihuahuan Desert Ecoregion……	155-156, 161-162
	Colorado Plateau Ecoregion……...	171
	So. Rocky Mountains Ecoregion…	180, 184, 191-194
	So. Shortgrass Prairie Ecoregion…	205-206, 214-215
	Riparian Habitats…………………	237-240
	Ephemeral and Tank Habitats…….	258-259, 262-263, 266-267
	Canadian Watershed……………...	274, 277, 281-282, 285
	Gila Watershed…………………...	292-293, 296, 299-300, 303-304
	Mimbres Watershed………………	310-311, 313, 316
	Pecos Watershed…………………	324, 327-328, 331, 334-335, 339
	Rio Grande Watershed……………	346-347, 349-350, 352-353, 356, 359-360
	San Juan Watershed………………	366, 369, 373
	Tularosa Watershed………………	381, 385
	Zuni Watershed…………………...	392-393
	Additional SGCN………………..	398, 400-401, 403, 406, 407-408, 410, 411, 413-414, 416
	Appendices	
	Appendix M………………………	620-621
	Appendix N………………………	622-623
	Appendix O………………………	624-625
	Appendix P………………………	626-627
The priority research and survey needs, and resulting products, are described sufficiently to allow for the development of research and survey projects after the Strategy is approved.	**Chapter 2**…………………………	17-18, 19-20
	Chapter 6…………………………	433-443
	Chapter 7…………………………	444-449

Element 4: Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such activities.

NAAT Guidance	Chapter	Pages
The Strategy identifies how conservation actions address identified threats to species of greatest conservation need and their habitats.	**Chapter 2**…………………………	19-20
	Chapter 4…………………………	63
	Chapter 5…………………………	92
The Strategy describes conservation actions sufficiently to guide implementation of those actions through the development and execution of specific projects and programs,	**Chapter 2**…………………………	19-20
	Chapter 4…………………………	63, 84-88
	Chapter 5…………………………	92
	Apache Highlands Ecoregion…….	101-102, 111-112
	AZ-NM Mountains Ecoregion……	125-126, 135-138,146-148
	Chihuahuan Desert Ecoregion……	157-158, 201-202
	Colorado Plateau Ecoregion……...	172-173
and,	So. Rocky Mountains Ecoregion…	181-182, 185, 196-198
	So. Shortgrass Prairie Ecoregion…	207-208, 216-218
The Strategy describes conservation actions (where relevant to the State's species and habitats) that could be addressed by Federal agencies or regional, national or international partners and shared with other States.	Riparian Habitats…………………	242-247
	Ephemeral and Tank Habitats…….	260-261, 264,267-268
	Canadian Watershed……………...	275-276, 278-279, 282-283, 286
	Gila Watershed…………………...	293-294, 297, 300-301, 305
	Mimbres Watershed………………	311-312, 314, 317-318
	Pecos Watershed…………………	325-326, 328-329, 332-333, 336, 340
	Rio Grande Watershed…………..	347-348, 350-351, 354, 357-358, 361
	San Juan Watershed………………	367, 370-371, 374-375
	Tularosa Watershed………………	382-383, 386-387
	Zuni Watershed…………………...	394-395
	Additional SGCN………………...	398-399, 401, 404, 406-407, 408-409, 410, 412, 414-415, 416
	Chapter 6…………………………	433-443
	Chapter 7…………………………	447-449
The Strategy links conservation actions to objectives and indicators that will facilitate monitoring and performance measurement of those conservation actions (outlined in Element 5).	**Chapter 2**…………………………	19-20
	Chapter 6…………………………	433-443
	Chapter 7…………………………	444-449

Element 4 Cont. NAAT Guidance	Chapter	Pages
If available information is insufficient to describe needed conservation actions, the Strategy identifies research or survey needs for obtaining information to develop specific conservation actions.	**Chapter 4**…………………………	82-84
	Chapter 5	
	Apache Highlands Ecoregion…….	100-101, 108-110
	AZ-NM Mountains Ecoregion……	123-124, 132-134, 144-145
	Chihuahuan Desert Ecoregion……	155-156, 161-162
	Colorado Plateau Ecoregion……...	171
	So. Rocky Mountains Ecoregion…	180, 184, 191-194
	So. Shortgrass Prairie Ecoregion…	205-206, 214-215
	Riparian Habitats…………………	237-240
	Ephemeral and Tank Habitats…….	258-259, 262-263, 266-267
	Canadian Watershed……………...	274, 277, 281-282, 285
	Gila Watershed…………………...	292-293, 296, 299-300, 303-304
	Mimbres Watershed………………	310-311, 313, 316
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	San Juan Watershed………………	366, 369, 373
	Tularosa Watershed………………	381, 385
	Zuni Watershed…………………...	392-393
	Additional SGCN………………...	398, 400-401, 403, 406, 407-408, 410, 411, 413-414, 416
	Appendices	
	Appendix M………………………	620-621
	Appendix N………………………	622-623
	Appendix O………………………	624-625
	Appendix P………………………	626-627
The Strategy identifies the relative priority of conservation actions.	**Chapter 4**…………………………	84-88
	Chapter 5	
	Apache Highlands Ecoregion…….	101-102, 111-112
	AZ-NM Mountains Ecoregion……	125-126, 135-138,146-148
	Chihuahuan Desert Ecoregion……	157-158, 201-202
	Colorado Plateau Ecoregion……...	172-173
	So. Rocky Mountains Ecoregion…	181-182, 185, 196-198
	So. Shortgrass Prairie Ecoregion…	207-208, 216-218
	Riparian Habitats…………………	242-247
	Ephemeral and Tank Habitats…….	260-261, 264,267-268
	Canadian Watershed……………...	275-276, 278-279, 282-283, 286
	Gila Watershed…………………...	293-294, 297, 300-301, 305
	Mimbres Watershed………………	311-312, 314, 317-318
	Pecos Watershed…………………	325-326, 328-329, 332-333, 336, 340
	Rio Grande Watershed……………	347-348, 350-351, 354, 357-358, 361
	San Juan Watershed………………	367, 370-371, 374-375
	Tularosa Watershed………………	382-383, 386-387
	Zuni Watershed…………………...	394-395
	Additional SGCN………………...	398-399, 401, 404, 406-407, 408-409, 410, 412, 414-415, 416

Element 5: Proposed plans for monitoring species identified in Element 1 and their habitats for monitoring the effectiveness of the conservation actions proposed in Element 4, and for adapting these conservation actions to respond appropriately to new information or changing conditions.

NAAT Guidance	Chapter	Pages
The Strategy describes plans for monitoring species identified in Element #1, and their habitats.	**Chapter 6**………………………… **Chapter 7**…………………………	417-443 448-449
The Strategy describes how the outcomes of the conservation actions will be monitored.	**Chapter 6**………………………… **Chapter 7**…………………………	433-443 448-449
If monitoring is not identified for a species or species group, the Strategy explains why it is not appropriate, necessary or possible.	**Chapter 6**…………………………	417-443
Monitoring is to be accomplished at one of several levels including individual species, guilds, or natural communities.	**Chapter 6**………………………… **Chapter 7**…………………………	417-443 448-449
The monitoring utilizes or builds on existing monitoring and survey systems or explains how information will be obtained to determine the effectiveness of conservation actions.	**Chapter 4**………………………… **Chapter 5** Apache Highlands Ecoregion……. AZ-NM Mountains Ecoregion…… Chihuahuan Desert Ecoregion…… Colorado Plateau Ecoregion…….. So. Rocky Mountains Ecoregion… So. Shortgrass Prairie Ecoregion… Riparian Habitats………………… Ephemeral and Tank Habitats……. Canadian Watershed……………... Gila Watershed…………………... Mimbres Watershed……………… Pecos Watershed………………… Rio Grande Watershed…………… San Juan Watershed……………… Tularosa Watershed……………… Zuni Watershed…………………... Additional SGCN………………... **Chapter 6**…………………………	82-84 100-101, 108-110 123-124, 132-134, 144-145 155-156, 161-162 171 180, 184, 191-194 205-206, 214-215 237-240 258-259, 262-263, 266-267 274, 277, 281-282, 285 292-293, 296, 299-300, 303- 304 310-311, 313, 316 324, 327-328, 331, 334-335, 339 346-347, 349-350, 352-353, 356, 359-360 366, 369, 373 381, 385 392-393 398, 400-401, 403, 406, 407- 408, 410, 411, 413-414, 416 417-443
The monitoring considers the appropriate geographic scale to evaluate the status of species or species groups and the effectiveness of conservation actions.	**Chapter 6**………………………… **Chapter 7**…………………………	417-443 448-449
The Strategy is adaptive in that it allows for evaluating conservation actions and implementing new actions accordingly.	**Chapter 6**………………………… **Chapter 7**…………………………	433-443 448-449

Element 6: Descriptions of procedures to review the Strategy at intervals, not to exceed ten years.

NAAT Guidance	Chapter	Pages
The State describes the process that will be used to review the Strategy within the next ten years.	**Chapter 7**…………………………	444-449

Element 7: Plans for coordinating the development, implementation, review, and revision of the Strategy with Federal, state, and local agencies and Tribes that manage significant land and water habitats or administer programs that significantly affect the conservation of identified species and habitats.

NAAT Guidance	Chapter	Pages
The State describes the extent of its coordination with and efforts to involve Federal, State and local agencies, and Indian Tribes in the development of its Strategy.	**Chapter 2**………………………… **Appendices** Appendix R………………………	22-24 633-635
The State describes its continued coordination with these agencies and tribes in the implementation, review and revision of its Strategy.	**Chapter 7**………………………… **Appendices** Appendix R………………………	446-447 633-635

Element 8: Provisions to ensure public participation in the development, revision, and implementation of strategies, projects and programs. Congress has affirmed that broad public participation is an essential element of this process.

NAAT Guidance	Chapter	Pages
The State describes the extent of its efforts to involve the public in the development of its Strategy.	**Chapter 2**………………………… **Appendices** Appendix R………………………	22-24 633-635
The State describes its continued public involvement in the implementation and revision of its Strategy.	**Chapter 7**………………………… **Appendices** Appendix R………………………	446-447 633-635

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William D. Graves
CWCS Coordinator

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The listing herein of agencies, institutions, conservation organizations, sportsmen associations, agriculture interests, other interests, or individual participants should **not** be taken to imply that they agree with all portions of the CWCS or with the CWCS initiative in general.

Chapter 1
INTRODUCTION AND PURPOSE

Planning and actions to recover species that have become endangered are controversial and expensive. Annual spending on listed species in the United States has increased more than six fold over the past 10 years, to a level of over $600 million a year. Nationally, in 2004, there were 1,260 species listed as threatened and endangered, 31 species proposed for listing, and 256 more considered to be candidate species (http://www.teaming.com). Approximately 10% of New Mexico's fish and wildlife are listed as State Endangered or Threatened and many others have declined significantly (see Statewide Assessment and Strategies). In 2001, through the efforts of the 3000 member groups of the Teaming With Wildlife Coalition, the US Congress passed legislation now known as the State and Tribal Wildlife Grants Program and created the nation's core initiative for conserving our country's biodiversity and thereby precluding the necessity of listing more species as threatened and endangered. The Program promotes proactive and collaborative conservation action *before* wildlife reaches that serious and controversial status. Since 2001 Congress has allocated about $400 million to the states for this purpose, apportioned on the basis of their respective land areas and human populations. New Mexico's share has averaged about $1 million per year. In order to maintain eligibility for this funding, each state must develop and submit a Comprehensive Wildlife Conservation Strategy (CWCS) no later than October 1, 2005.

The CWCS is a blueprint for conservation, through which federal, tribal, state, and local governments and private entities can coordinate conservation efforts and reduce expenses associated with the processes of listing and recovering endangered species.

The New Mexico Department of Game and Fish (NMDGF) is mandated to protect and provide an adequate supply of game, fish, and furbearers and to carry out the provisions of the Wildlife Conservation Act pertaining to indigenous species of wildlife suspected or found to be threatened or endangered (Chapter 17 NMSA, 1978). We expect this CWCS to make our wildlife conservation efforts in this regard more strategic, holistic, and pro-active. The funding enabled by this document will allow the Department to broaden its attention beyond single species that are hunted, fished, trapped or endangered to include those that are of interest simply because they are necessary elements of the biodiversity that supports all New Mexico wildlife. We think this CWCS presents a sensible, collaborative approach that can function as a conservation blueprint through which interested federal, tribal, state, and local governments, and private entities might coordinate their conservation efforts and reduce the potential of incurring the conflicts and expenses associated with the processes of listing and recovering endangered species. The direct economic value of wildlife-associated recreation in New Mexico has been estimated at $1 billion annually, about $558 million of which is contributed by appreciative users. We think the CWCS will contribute significantly to the economy and quality of life in New Mexico by helping to sustain or improve opportunities for hunting, fishing, trapping, and appreciative, scientific, and educational uses of wildlife. We anticipate the CWCS will assist in averting the necessity of engaging in the costly and controversial recovery process for additional endangered species.

CONGRESSIONAL MANDATE AND GUIDANCE

Federal legislation requires that the CWCS focus upon the Species in Greatest Need of Conservation (SGCN), yet address the full array of wildlife and wildlife-related issues. The CWCS must provide and make use of:

1. Information on the distribution and abundance of species of wildlife, including low and declining populations as the State fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the State's wildlife; and

2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1).

3. Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats; and

4. Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions; and

5. Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions; and

6. Descriptions of procedures to review the Strategy at intervals not to exceed ten years; and

7. Plans for coordinating to the extent feasible, the development, implementation, review, and revision of the CWCS with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats.

8. Congress affirmed through the Wildlife Conservation and Restoration Program and State and Tribal Wildlife Grants Program that broad public participation is an essential element of developing and implementing these CWCS, the projects that are carried out while these CWCS are developed, and the Species in Greatest Need of Conservation that Congress has indicated such programs and projects are intended to emphasize.

The CWCS for New Mexico focuses upon Species in Greatest Need of Conservation yet addresses the full array of wildlife and wildlife-related issues.

The International Association of Fish and Wildlife Agencies (IAFWA) views development of the CWCS as an opportunity for state wildlife agencies to provide effective and visionary leadership in wildlife conservation and has suggested several guiding principles in this regard. The IAFWA encourages broad participation at multiple staff levels within each agency and public-private partnerships and shared responsibility in developing and implementing the CWCS. It recommends early and frequent communication, making the process and rationale for decisions obvious to those who read and use the CWCS, and that we make it highly readable through the inclusion of glossaries of technical terms. The IAFWA suggests we set measurable outcomes, achievable strategies, and address statewide issues across jurisdictions and interests, and coordinate with other states and countries. They suggest we use existing information and integrate elements from other plans and initiatives, identify information gaps, and not let lack of information inhibit decision making. IAFWA suggests we make the CWCS spatially explicit with a full complement of GIS and other maps, figures, and graphics and that we develop an updateable information system to monitor implementation and the status and trends of wildlife and habitat. Finally, the IAFWA suggests we make the CWCS a blueprint for action – a driving force in guiding diverse wildlife and habitat initiatives and land use decision-making by government, corporate, and private entities. NMDGF has attempted to adhere to these guiding principles in leading the development of the CWCS for New Mexico.

Broad agency and public participation, coordination, and partnerships with shared responsibility in developing and implementing the CWCS are fundamental for effective conservation programs.

ORGANIZATION AND FORMAT

New Mexico's CWCS is organized into seven chapters. Chapter 2 presents our approach to identifying species of greatest conservation need (SGCN), their abundance and distribution, key habitats, and the problems affecting both. We also summarize therein the opportunities for involvement we provided to local, state, and federal government agencies, tribes, non-government organizations (NGOs), and interested individuals as well as some of the issues they brought to our attention. In Chapter 3 we present information about New Mexico's floral and faunal biodiversity, climate, geology, population and economy, and land stewardship. Chapter 3 also presents information about New Mexico's ecoregions and key habitats as well as the status of its wildlife species. Chapter 4, Statewide Assessment and Strategies, identifies our SGCN and provides information about their abundance and distribution throughout New Mexico. In this chapter we summarize, on a statewide scale, problems affecting species or their habitats and identify the most important information gaps, research, survey, and monitoring needs, conservation actions, and the key areas for focusing conservation efforts.

Chapter 4 provides a synthesis of conservation priorities on a statewide scale, and suggests key areas for focusing conservation efforts.

Chapter 5, entitled Assessments and Strategies for SGCN and Key Habitats, is perhaps the heart of the CWCS. This chapter is organized by ecological frameworks; ecoregions for terrestrial habitats, watersheds for aquatic habitats, and statewide considerations for riparian and ephemeral aquatic habitats. Here we discuss the condition of key habitats, identify associated SGCN, and identify problems affecting both. But, there is much we don't know about New Mexico's SGCN, their key habitats, and the scope, scale, and effects of problems affecting them. Therefore in this chapter we've also identified information gaps and the research, survey, and monitoring work needed to fill them. Finally, we conclude each consideration of key habitats and associated SGCN by identifying desired future outcomes and prescribing prioritized conservation actions necessary to attain them. Also included in Chapter 5 is a discussion of SGCN that are not associated with key habitats, including arthropod SGCN other than crustaceans. Here we identify information gaps that limit our ability to associate these species with key habitats and summarize what we know about their distribution and abundance, habitat associations, limiting factors, and conservation actions. In Chapter 6 we summarize ongoing status and trends monitoring efforts for New Mexico's wildlife and habitats, note the importance of collaborative monitoring efforts, and present a synopsis of current monitoring needs.

Chapter 5 is the heart of the CWCS, and contains:

- Condition of key habitats,
- SGCN,
- Problems affecting species and habitats,
- Information gaps,
- Research, survey, and monitoring needs,
- Desired future conditions, and
- Prioritized conservation actions.

Chapter 7, entitled Implementation, Review, and Revision, describes how we will next develop a wildlife action plan comprised of near-term priorities and employ an operational planning process to guide and effect its implementation. In this chapter we discuss how the operational planning process will include appropriate coordination with local, state, and federal government agencies and tribes and afford these entities, NGOs, and interested publics opportunities to influence and participate in project design and implementation. We also describe our planned CWCS review and revision process, associated agency coordination and public involvement, and how we will integrate monitoring and adaptive management to measure progress toward stated biological outcomes, become aware of and adapt to new information or changing conditions, and to inform necessary revisions to conservation actions shown to be ineffective.

We hope our readers will find this document informative and useful in becoming aware of New Mexico's biodiversity, the problems affecting wildlife and its habitats, and in identifying appropriate conservation actions. Sources of information consulted in the development of the CWCS appear in the Supporting Documentation. A glossary of terms (Appendix A), complete lists of SGCN and their attributes, lists of habitats in New Mexico, and other supporting information are provided in the appendices. Defined below are the acronyms and abbreviations that are employed throughout the CWCS:

ACOE	Army Corps of Engineers
BISON-M	Biota Information System of New Mexico
BLM	United States Bureau of Land Management
BOR	United States Bureau of Reclamation
CASE	Center for Applied Spatial Ecology
CDOW	Colorado Division of Wildlife
CRP	Conservation Reserve Program
CWCS	Comprehensive Wildlife Conservation Strategy
EPA	United States Environmental Protection Agency
HUCs	Hydrological Unit Codes
ISC	Interstate Stream Commission (New Mexico)
NAS	National Academy of Science
NGO	Non-Governmental Organization
NM	New Mexico
NMCFWRU	New Mexico Cooperative Fish and Wildlife Research Unit
NMDGF	New Mexico Department of Game and Fish
NMSU	New Mexico State University
NRC	National Research Council
OSE	Office of the State Engineer (New Mexico)
SGCN	Species of Greatest Conservation Need
SWReGAP	Southwestern Regional Gap Analysis Project
TNC	The Nature Conservancy
UNM	University of New Mexico
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Abbreviations

ac = acre	**yd** = yard	**m^3** = cubic meter
mi = mile	**yd^3** = cubic yard	**in** = inch
ha = hectare	**m** = meter	**km** = kilometer

Chapter 2
APPROACH

This chapter addresses the methodology and rationale employed in identifying species indicative of the diversity and health of New Mexico's wildlife (**Element 1**) and in designating species of greatest conservation need (SGCN) subset. It addresses the approach employed in developing information about the distribution and abundance of SGCN (**Element 1**), designating and locating key habitats (**Element 2**), describing problems affecting species or their habitats (**Element 3**), and in developing conservation actions (**Element 4**). In addition, it presents a summary of the opportunities for broad agency and public involvement provided to date (**Elements 7 and 8**).

ORGANIZATIONAL STRUCTURE

In August 2003, the Director of the New Mexico Department of Game and Fish (NMDGF) designated the Comprehensive Wildlife Conservation Strategy (CWCS) core planning team comprised of the NMDGF's deputy and assistant directors, division chiefs, planner, and area operations chiefs. The core planning team assigned NMDGF taxa experts and technical teams to assist in CWCS development activities. The core planning team and the technical teams also sought expertise in this regard from outside the Department. In June 2004, NMDGF engaged the Center for Applied Spatial Ecology (CASE) with the New Mexico Cooperative Fish and Wildlife Research Unit (NMCFWRU) at New Mexico State University to assist in data acquisition, information management, and compilation (Table 2-1). With comments and contributions from many other agency, tribal and private cooperators that participated in CWCS partnering and public involvement events, this document represents considerable efforts and contributions of more than 210 individuals.

Table 2-1. Members of New Mexico Department of Game and Fish, New Mexico Cooperative Fish and Wildlife Research Unit, University of New Mexico, and New Mexico State Parks that served on the Core Planning Team or Technical Teams.

Person	Position	Task
Lief Ahlm	Assistant Chief, NE Area Operations	Core Planning Team, Contributing Author
Ken Boykin	Project Leader, SWReGAP, NMCFWRU	SWReGAP Coordinator, Contributing Author, Geographic Information Systems
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Stephanie Carman	Aquatic Species Recovery Coordinator, CSD	Contributing Author
Steve Cary	N.M. State Parks Nat. Res. Planner	Arthropod Technical Team
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Randy Floyd	Aquatic Habitat Specialist, Cons. Services Divisiom	Contributing Author
Marty Frentzel	Chief, Public Information & Outreach, NMDGF	Core Planning Team,
Eric Frey	Fisheries Specialist, NE Area Operations	Fish Technical Team, Contributing Author

Table 2-1 Cont.

Person	Position	Task
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Bill Graves	Planner, NMDGF	Core Planning Team, CWCS Coordinator, Contributing Author, Contributing Editor
Mark Gruber	Editor, Public Information and Outreach	Contributing Editor
Richard Hansen	Assist. Chief - Warm Water, FMD	Fish Technical Team, Contributing Author
Roy Hayes	Chief, SE Area Operations	Core Planning Team, Bird Technical Team
Bill Hays	NE Area Operations Chief	Core Planning Team - Past Member
Jerry Jacobi	Dragonfly Expert, NM Highlands Univ., Ret.	Arthropod Technical Team
Lisa Kirkpatrick	Chief, Conservation Services Division	Core Planning Team, Amphibian /Reptile Tech. Team, Molluscs / Crustacean Tech. Team, Contributing Editor
R. J. Kirkpatrick	Chief, Wildlife Management Division	Core Planning Team
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Julie McIntyre	Museum of Southwestern Biology, UNM	Arthropod Technical Team
Tim Mitchusson	Migratory Birds, Wildlife Management Division	Bird Technical Team
Charlie Painter	Reptiles, Amphibians, Cons. Services Division	Amphibian /Reptile Tech. Team,
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Dave Propst	Endangered Fish, Conservation Services Division	Fish Technical Team, Contributing Author
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Luke Shelby	Assistant Director	Core Planning Team
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Tod Stevenson	Deputy Director	Core Planning Team
Jim Stuart	Species Recovery Planner, Cons. Services Div.	Mammal Technical Team, Amphibian /Reptile Tech. Team
Robin Tierney	LOSS Supervisor, Wildlife Management Division	Contributing Author - Past Member
Janell Ward	Assistant Chief, Wildlife Habitat, CSD	Contributing Author
Mark Watson	Habitat Specialist, Conservation Services Division	Bird Technical Team, Mammal Technical Team, Contributing Author
Darrel Weybright	Big Game Grant, Wildlife Management Division	Mammal Technical Team
Sandy Williams	Endangered Non-Game Birds, CSD	Bird Technical Team
Kendal Young	Project Leader, CASE, NMCFWRU	CWCS Coordinator, Contributing Author, Contributing Editor Geographic Information Systems

IDENTIFICATION OF SPECIES OF GREATEST CONSERVATION NEED

Congressional guidelines require that each state's Comprehensive Wildlife Conservation Strategy identify and focus upon species the state finds to be of greatest conservation need (SGCN). For vertebrate, mollusc, and crustacean SGCN we began by identifying species indicative of the diversity and health of the state's wildlife, including low and declining populations as seem appropriate and species of high recreational, economic, or charismatic value. We subsequently designated indicative species found to be associated with key habitats as SGCN. Little is known about the arthropods of New Mexico other than crustaceans. However, through consultation with a variety of sources, we also identified a number of SGCN of the Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha classes. The following is an account of these processes.

> New Mexico's SGCN are species that are indicative of the diversity and health of the state's wildlife that are associated with key habitats, including low and declining populations, and species of high recreational, economic, or charismatic value.

Indicative Vertebrate, Mollusc, and Crustacean Species

The Biota Information System of New Mexico (BISON-M, http://fwie.fw.vt.edu/states/nm.htm, NMDGF 2005a) database contains accounts of species in New Mexico, Arizona, Colorado, Utah, Texas, Oklahoma, and the bordering states of Mexico. The New Mexico Department of Game and Fish and the Fish and Wildlife Information Exchange developed the BISON-M database, with contributions from the US Bureau of Land Management, US Fish and Wildlife Service, US Forest Service, US Bureau of Reclamation, US Army Corps of Engineers, New Mexico Land Office, and New Mexico Natural Heritage Program (University of New Mexico), and the Conservation Management Institute. By applying three filters to the BISON-M database (Fig. 2-1), the NMDGF identified vertebrate, mollusc, and crustacean species that are indicative of the diversity and health of New Mexico's wildlife.

Species in New Mexico

The Bison-M database has biological information on greater than 1,400 species. Our first filter was to exclude all species in the BISON-M database that do not occur in New Mexico, retaining 1,166 species for further consideration.

Criteria to Identify Indicative Species

New Mexico's 1,166 species were sorted taxonomically and technical teams examined them for characteristics that might prove useful as criteria for identifying indicative species. Teams employed scientific literature, existing plans, and expert opinion to inform their considerations and to identify potential indicative species. Their deliberations (Appendix B) resulted in a second filter of standardized criteria (Table 2-2) that was used to select environmentally responsive species as well as those that have high recreational, economic, or charismatic values. Species received one point for each criterion met and those with total scores greater than or equal to 1 were retained. Approximately 676 species were excluded through this process, resulting in a set of 490 mammals, birds, fish, reptiles, amphibians, molluscs, and crustaceans considered to be

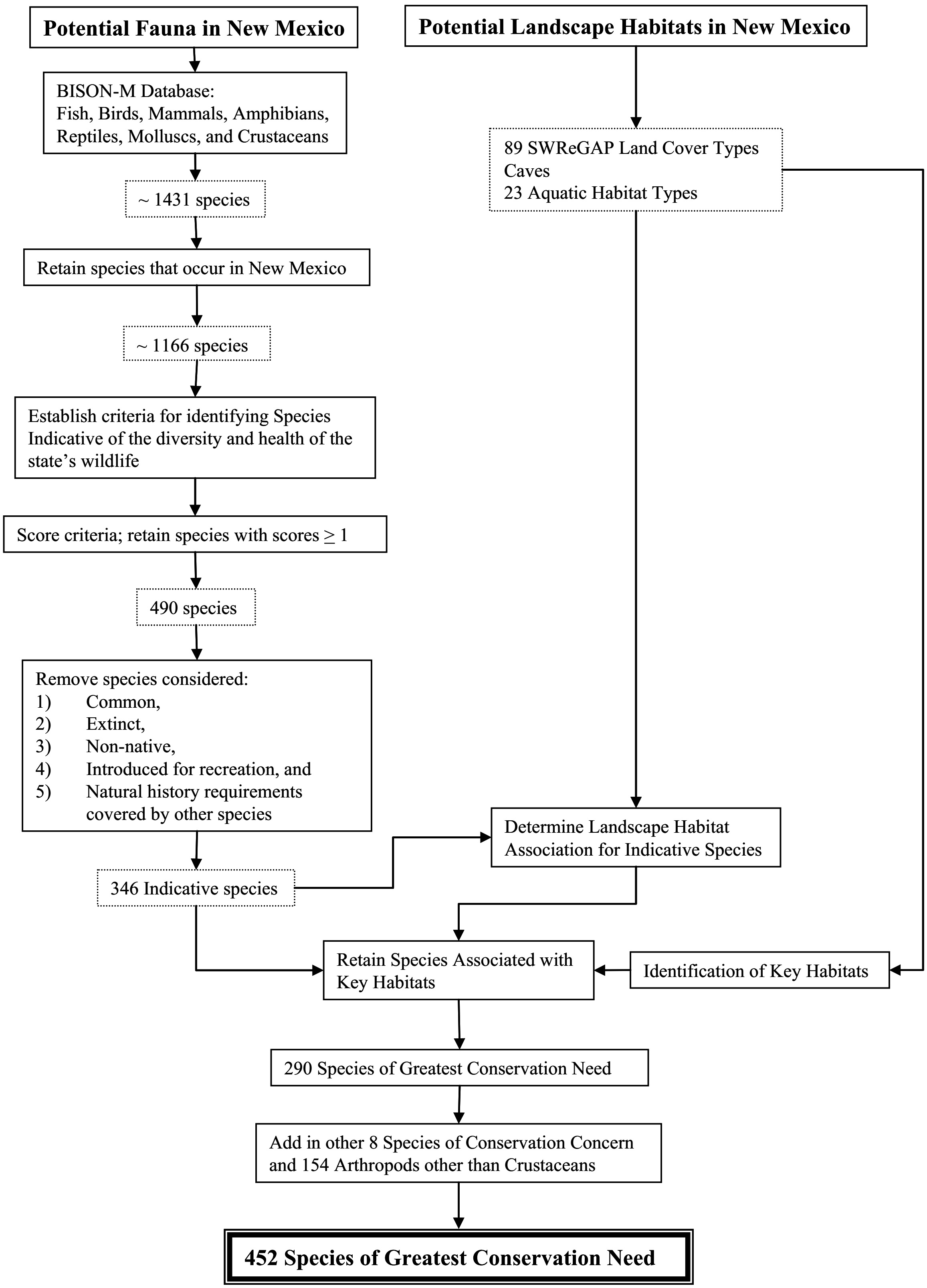


Figure 2-1. Approach employed to identify Species of Greatest Conservation Need in New Mexico.

indicative of New Mexico's diverse life zones, habitats, and natural heritage (Fig 2-1). Among these were state and federally listed species, candidate species of concern, game species with high recreational value and documented population declines, and other species of high conservation interest because of endemism or vulnerability.

> Species indicative of New Mexico's diverse life zones, habitats, and natural heritage included 346 fish, birds, mammals, amphibians, reptiles, molluscs, and crustaceans.

Remove Common Species

The list of species resulting from scoring criteria for species that occur in New Mexico was then re-evaluated by each taxonomic team and it was decided to remove species considered common, extinct, non-native, and those that were introduced for recreation or whose natural history requirements were covered by other species (Fig 2-1). A total of 144 species was removed using these criteria (Table 2-3). The remaining 346 species are considered indicative of the diversity and health of New Mexico's wildlife (Appendix C).

Table 2-2. Criteria (one point per criterion) used to identify species indicative of New Mexico's diverse life zones, habitats, and natural heritage.

Criteria	Definition
Declining	Species that exhibits significant long-term declines in habitat and/or numbers, and are subject to a high degree of threat, or may have unique habitat or behavioral requirements that expose them to great risk.
Vulnerable	Usually abundant, may or may not be declining, but some aspect of their life history makes them especially vulnerable (e.g. migratory concentrations, or rare/endemic habitat).
Endemic, Disjunctive, or Keystone	Populations that are restricted to an ecoregion (or small geographic area within an ecoregion, or depend entirely on a single area for survival. This category includes populations that are geographically isolated from other populations and species that contribute to ecosystem function in a unique and significant manner through their activities.
Wide-Ranging	Species that depend on vast areas, such as wolves, grizzly bears, pike minnow, and migratory mammals, birds, bats, and insects.
Recreational, Economic, or Charismatic	Species with recreational (hunted or fished), economic, or charismatic appeal.

Table 2-3. Number of species considered extinct, exotic, common, or that were introduced for recreation, or their natural history requirements covered by other species identified.

Removal Criteria	Species Removed
Species considered extinct	1
Non-native species	4
Species introduced or stocked for recreation. Populations are widespread and stable when natural reproduction occurs	25
Species is common with little to no threats	33
Species natural history requirements are covered by other species	81

Indicative Species Landscape Habitat Associations

The Southwest Regional Gap Analysis Project (SWReGAP) modeled 125 land cover types across New Mexico, Arizona, Colorado, Nevada, and Utah (SWReGAP; http://fws-nmcfwru.nmsu.edu/swregap/), 89 of which occur in New Mexico (Appendix D). NMDGF also recognized caves as an important habitat type in New Mexico and included this habitat type for species associations.

In addition to land cover mapping, SWReGAP predicted habitat associations for 833 vertebrate species that reside, breed, or use habitat for a substantial portion of the their life history in the five state region (SWReGAP; http://fws-nmcfwru.nmsu.edu/swregap/). Species habitat associations, identified by reviewing peer-reviewed and technical documents and consulting species experts, were cross-walked to SWReGAP land cover classes. NMDGF species experts reviewed and, where necessary, corrected resultant matrices of species habitat associations by the 89 New Mexico land cover types and caves. Habitat associations for indicative species (primary subspecies level) that were not included in the 833 vertebrate species modeled by SWReGAP were constructed in a similar manner by SWReGAP, NMDGF and CASE. Further, NMDGF identified 23 aquatic habitats in New Mexico (Appendix E). Aquatic species habitat associations were populated to these 23 aquatic habitat types. Additional information recorded for aquatic species included the 4-digit hydrologic unit and elevation range to estimate geographic distribution.

Identification of Key Habitats

In order to focus conservation actions on those habitats and communities most essential to conserving New Mexico's SGCN, we entered into a process of designating key habitats from among the 113 habitat types identified in New Mexico (89 land cover types mapped by SWReGAP, 23 aquatic habitats, and caves). We first aggregated several similar SWReGAP land cover types. Sixteen riparian land cover types were grouped into a Riparian class (Appendix F). Further, Rocky Mountain Montane Mesic and Dry-Mesic, Conifer Forest and Woodland were grouped into one habitat. The Chihuahuan Piedmont Semi-Desert Grassland and the Chihuahuan-Sonoran Desert Bottomland and Swale Grassland types were combined as Chihuahuan Semi-Desert Grassland. The Madrean Pine-Oak and Conifer-Oak Forest and Woodlands were also aggregated as one habitat type. For the aquatic habitats, several habitat types were also aggregated (Appendix G). Ephemeral ponds, small reservoirs and tanks were combined into one habitat type. Further, perennial spring/seeps and marsh/cienegas were combined. After aggregations were completed, there were still 83 possible habitat types in New Mexico. Those found by technical teams to have one or more of the following properties were designated as key habitats:

- Important to the biodiversity of New Mexico,
- Important to endemics or obligate species of New Mexico,
- Captures a broad range of indicative species,
- Adds unique species to state fauna,
- Hosts a variety of scarce or threatened wildlife,
- Threatened by land uses/management practices,

- Limited or has been significantly reduced in New Mexico,
- Habitat type is unique to New Mexico, Southwest, US, or worldwide,
- Key breeding or foraging habitat for species of concern,
- Hosts wide-ranging species that are not found in other habitats,
- Supports species with isolated or relict distributions in New Mexico,
- Habitat functions as a refuge or indicator of the quality of the system, and
- Functioning habitat; habitat has greater ecological value.

Ten key aquatic habitats and nine key terrestrial habitats were thus identified (Table 2-4). Key aquatic habitats ranged from Perennial Large Reservoirs to Ephemeral Marsh/Cienegas and key terrestrial habitats encompassed riparian, forest and woodland, shrubland, and grassland communities.

Species of Greatest Conservation Need

Vertebrates, Molluscs, and Crustaceans

Nineteen key landscape habitat types were identified:

- 9 terrestrial, and
- 10 aquatic.

Of the 346 vertebrate, mollusc, and crustacean species considered indicative of the diversity and health of New Mexico's wildlife (Appendix C), technical teams found 290 to be associated with key habitats and identified these as SGCN. There were an additional eight indicative species of conservation concern that were not associated with key habitats (Table 5-19). These species were included for a total of 298 vertebrate, mollusc, and crustacean SGCN (Appendix H). These eight species are addressed under Additional Species of Greatest Conservation Need, Chapter 5.

Table 2-4. Key aquatic and terrestrial habitats in New Mexico.

Aquatic Habitats	Terrestrial Habitats
Perennial Large Reservoir	Chihuahuan Semi-Desert Grassland
Perennial 1st and 2nd Order Stream	Intermountain Basins Big Sagebrush Shrubland
Perennial 3rd and 4th Order Stream	Madrean Encinal
Perennial 5th Order Stream	Madrean Pine-Oak/Conifer-Oak Forest and Woodland
Perennial Tank	Riparian
Perennial Marsh/Cienega/Spring/Seep	Western Great Plains Sandhill Sagebrush Shrubland
Ephemeral 1st and 2nd Order Stream	Western Great Plains Shortgrass Prairie
Ephemeral Natural Catchments	Rocky Mountain Alpine-Montane Wet Meadow
Ephemeral Man-Made Catchments	Rocky Mountain Montane Mixed Conifer Forest and Woodland
Ephemeral Marsh/Cienega	

Additional Arthropods

Arthropods of New Mexico other than crustaceans are relatively poorly known and the current list of additional arthropod SGCN is biased toward those taxonomic groups for which we have some information. An extensive inventory of New Mexico arthropods (terrestrial and aquatic insects and other terrestrial arthropods) is needed before all New Mexico taxa can be addressed with confidence. We are aware of approximately 50 undescribed arthropod species, most of which are narrow endemics that have been recently discovered in New Mexico as a result of local biological inventory studies and collecting by taxonomic researchers. We anticipate future discoveries of undescribed taxa, as well as new geographic distribution and ecological information for many more described and undescribed species.

The technical team consulted a number of sources to inform its identification of arthropod SGCN. Federal (US Fish and Wildlife Service) and state (NMDGF, New Mexico Natural Heritage Program) agencies, USGS Northern Prairie Wildlife Research Center Online, and NatureServe listings were searched for arthropod taxa of conservation concern. Federal and state protection status and ratings also were obtained from those listings. Former federal threatened and endangered candidate species listed prior to 1996 were searched for Candidate 2 Species that were dropped from Federal listings in 1996 for lack of biological/ecological information (February 28, 1996; 61 FR 7596). Taxa of limited geographic distributions, including local endemic species, and taxa restricted to habitats that are threatened or potentially threatened by human caused environmental disturbance, were obtained from experts for various arthropod taxonomic groups, scientific literature, and the New Mexico Natural Heritage Program database. Lists of arthropods harvested for commercial trade were obtained from regional online commercial insect vendors. We subsequently designated 154 additional arthropods of the classes Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha as SGCN (Appendix H) on the basis that they meet one or more of the following criteria:

- Present and/or historical species (Federal Candidate 2 Species) listed by Federal and State natural resource agencies as species of conservation concern (endangered, threatened, sensitive, or species of concern), or

- Species known to be represented by few geographically and environmentally restricted, isolated, and/or declining populations, including rare species that are known to be harvested for commercial trade purposes, and/or

- Species restricted to habitats that are threatened or potentially threatened in the foreseeable future by human caused environmental disturbance, and/or

- Species of significant natural heritage value to New Mexico.

New Mexico's Species of Greatest Conservation Need (SGCN) consist of 298 fish, birds, mammals, amphibians, reptiles, molluscs, and crustaceans, and 154 arthropods (other than crustaceans), for a total of 452 SGCN.

SGCN ABUNDANCE AND DISTRIBUTION

In New Mexico, there is little quantified data estimating wildlife populations. Indeed, some species were selected as SGCN because of unknown population status. Describing the current distribution of species presents similar challenges, as species have not been inventoried across the entire state. We therefore relied on information provided by other groups and organizations for estimating the abundance and distribution of New Mexico's SGCN.

SGCN Abundance

We used the NatureServe (http://www.natureserve.org) State (S) and National (N) conservation status codes as an estimator of abundance for SGCN. Global (G) conservation status codes were not used because the global status for a large percent of the SGCN was unknown. NatureServe provides information about the conservation status, taxonomy, distribution, life history, and habitat requirements of species. This database has been developed over the past 30 years, and includes information from NatureServe, its natural heritage member programs, and a large number of collaborators in government agencies, universities, natural history museums, botanical gardens, and other conservation organizations. The standardized methods for gathering, managing, and analyzing biological and ecological data employed by NatureServe allow conservation status codes to be compared among organisms and across political boundaries. Conservation status assessments are based on the best available information and consider a variety of factors such as abundance, distribution, population trends, and threats. Status assessments should reflect current conditions and understanding. NatureServe and its member programs strive to update these assessments with new information from field surveys, monitoring activities, consultation, and scientific publications at least once a year and status assessments are based on a combination of quantitative and qualitative information (http://www.natureserve.org). Species conservation status codes are designated based on:

- Total number and condition of occurrences (e.g., populations);
- Population size;
- Range extent and area of occupancy;
- Short and long-term trends in the above factors;
- Scope, severity, and immediacy of threats;
- Number of protected and managed occurrences;
- Intrinsic vulnerability; and
- Environmental specificity.

> NatureServe conservation status codes for New Mexico SGCN were adjusted by NMDGF based on their professional knowledge and experience.

NatureServe conservation status ranks are assigned a numeric scale from one to five, ranging from critically imperiled (1) to demonstrably secure (5) (Table 2-5). Species that are possibly extirpated are not given a numeric value. Species experts with the NMDGF reviewed the conservation status codes for all SGCN in New Mexico. Conservation status ranks were adjusted for the CWCS in New Mexico based on their professional knowledge and experience. Conservation status codes for SGCN are provided in Appendix H. State and

National conservation status ranks for SGCN were summarized into four groups (Table 2-6) to expedite abundance summaries provided in the Statewide Assessment and Strategies and the Assessments and Strategies for SGCN and Key Habitats chapters.

Table 2-5. Conservation status rank definitions provided by NatureServe (http://www.natureserve.org). Status codes can be applied to State and National scales.

Numeric Rank	Conservation Status Rank Definitions
H	**Possibly Extirpated** (Historical)—Species or community occurred historically in the nation or state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. The NH or SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences.
1	**Critically Imperiled**—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
2	**Imperiled**—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
3	**Vulnerable**—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
5	**Secure**—Common, widespread, and abundant in the nation or state/province.

Table 2-6. Conservation status ranks summarized into groups to facilitate New Mexico's SGCN abundance summaries for the CWCS.

<table>
<tr><td colspan="3"></td><td colspan="5">National Level</td></tr>
<tr><td></td><td colspan="2" rowspan="2">Conservation Status Ranks and Codes</td><td>Critically Imperiled</td><td>Imperiled</td><td>Vulnerable</td><td>Apparently Secure</td><td>Secure</td></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td rowspan="2">State Level</td><td>Possibly Extirpated
Critically Imperiled
Imperiled
Vulnerable</td><td>0
1
2
3</td><td colspan="3">Species that are both state and nationally vulnerable, imperiled, critically imperiled or possibly extirpated.</td><td colspan="2">Nationally secure species, but State vulnerable to imperiled</td></tr>
<tr><td>Apparently Secure
Secure</td><td>4
5</td><td colspan="3">Secure State species, but National vulnerable to imperiled</td><td colspan="2">No immediate threats to species</td></tr>
</table>

SGCN Distribution

Terrestrial Vertebrate Species

The Southwest Regional Gap Analysis Project (SWReGAP) modeled potential habitat for 833 vertebrate species in New Mexico, Arizona, Colorado, Nevada, and Utah (SWReGAP; http://fws-nmcfwru.nmsu.edu/swregap/). Species habitat models are based on the concept of wildlife habitat relationships, in which are described resources and conditions present in areas where a species persists, reproduces, or otherwise occurs. These modeled relationships predict, and depict spatially, areas of potentially suitable habitat. Modeling of each predicted species habitat was informed by consulting peer-reviewed and technical documents and species experts.

Species associations with land cover, elevation, slope, aspect, and hydrology were modeled in a Geographic Information System (GIS) environment. Model input variables were combined in a Boolean overlay to predict areas of suitable habitat within New Mexico. The 8-digit hydrologic units were used to constrain habitat associations based on a species geographic range. Species experts internal and external to NMDGF reviewed the draft predicted habitat models. Their corrections were incorporated into the final habitat models. Predicted habitat models for SGCN that were not included in the 833 vertebrate species modeled by SWReGAP (primary subspecies considerations) were constructed in a similar manner.

Aquatic Vertebrate Species

Spatial depictions of aquatic vertebrate species distributions were created by using information on aquatic habitat associations developed by NMDGF personnel. The National Hydrography Dataset (NHD) (http://nhd.usgs.gov) was used to spatially depict aquatic habitats. The NHD is a 1:100,000 scale digital spatial data set that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. The 4-digit hydrologic units and suitable elevations within those hydrologic units were used to estimate species geographic range. Habitat associations and estimated geographic range were incorporated into a GIS environment and a Boolean overlay technique was used to model the predicted SGCN habitat in a manner similar to that employed for terrestrial species.

Mollusc, Crustacean, and Other Arthropod Species

Accurate spatial depictions of suitable habitats for molluscs, crustaceans, and other arthropods in New Mexico are not available. Many of these species are endemics and only occur in one mountain range or in some cases on one mountain. Spatial scale issues make modeling fine scale habitats difficult. There are currently no useful data sources that depict ephemeral habitats or marsh, springs, seeps, or cienegas, or perennial ponds. Future research and survey efforts should address this information gap.

IDENTIFICATION OF FACTORS INFLUENCING SPECIES AND HABITATS

Assessment of factors that influence species and habitats is central to resource agencies' statutory mandates to manage, protect, and conserve wildlife. This process requires basic biological knowledge of species' life history, habitat requirements, and population demographics. Understanding the interaction and ecological role that a species, population, or assemblage may play in any given ecosystem relative to resource management (past, current, and future) is also required. Assessments of such factors are broadly-based and intuitively-derived perceptions of outcomes (Wood and Armitage 1997). These perceptions may be documented by direct experience or by drawing from past examples at various spatial scales (Niemi *et al.* 1990).

Our assessment of factors that influence species or habitats was primarily focused at the habitat scale, as these factors directly influence wildlife communities and SGCN populations. Our assessment was based on review of peer-reviewed and technical documents, professional knowledge, by consulting species experts, and advice obtained from public forums. The NMDGF's assessment was derived from a framework provided by Salafsky *et al.* (2003), whose approach was to identify factors that influence habitats and group them into general categories to facilitate broader analyses. We also identified individual factors that most influence the persistence of each SGCN (Appendix I). Factors that influence species were considered statewide, but were not cartographically depicted.

> Assessment of factors that influence species or habitats was primarily focused at the habitat scale, as these factors directly affect wildlife communities and SGCN populations.

In our assessment of factors that influence species and habitats, we primarily assess those practices that are harmful to wildlife at certain levels of use or extent. It should be understood that it is the manner in which a human activity or practice is conducted that determines if it has a negative or positive effect on wildlife populations. We recognize that many human activities across today's landscapes have the potential to be either beneficial or detrimental to wildlife. Many factors that influence New Mexico landscapes are based on legal and accepted practices.

To allow for statewide spatial analyses, factors that influence habitats were identified for the 89 land cover types mapped by SWReGAP, the 23 aquatic habitats identified by the NMDGF (Appendix D and E), and caves. We adapted eight categories of factors that influence habitats (Table 2-7) presented in Salafsky *et al.* (2003). Within these categories, 43 possible generic factors that may influence habitats were identified (Appendix J). Definitions for each factor are presented in Appendix K.

The spatial scope and severity of each factor per habitat type were scored based on guidelines provided by Salafsky *et al.* (2003) (Table 2-8). Numeric magnitude scores were calculated by adding spatial scope and severity. Thus, total magnitude scores for each generic factor ranged from 2-8. Magnitude scores of all generic factors were summed within categories to facilitate analyses of factors that affect habitats across the state. Further, we summed magnitude scores of each of the 43 generic factors within each key habitat in New Mexico to provide a basis in understanding the possible synergistic effects, and where we might need further clarification on the outcomes of these factors. We also mapped these cumulative magnitude scores for each landscape habitat type in ArcGIS 9.0 to provide a broad spatial reference of factors that may influence habitats in New Mexico, and enhance our understanding of geographic areas where synergistic effects of potential factors may influence some habitats more than others.

Calculation of Magnitude Scores for each Generic Factor

Spatial Scope + Severity = Magnitude

(1 to 4) + (1 to 4) = (2 to 8)

Calculation of Cumulative Magnitude Score per Habitat

Sum magnitudes scores for all 43 generic factors for each habitat type.

Highest Possible Cumulative Score per Habitat =
43 (General Factors) * 8 (highest possible magnitude score) = 344.

Table 2-7. Description of categories of factors that influence habitats used in the CWCS for New Mexico. Descriptions derived from Salafsky *et al.* (2003).

Category	Description of Category
Abiotic Resource Use	Human extraction of non-biological resources.
Consumptive Biological Use	Human harvesting or use of biological resources from an ecosystem that removes the resources from the system.
Habitat Conversion	Total loss or destruction of natural habitat.
Invasive Species	Human linked introduction and spread of species from one ecosystem to another. Includes alien or exotic species plant and wildlife species and escaped native species.
Modification of Natural Processes and Ecological Drivers	Human caused changes in natural systems and overarching ecosystem drivers, e.g., drought.
Non-Consumptive Biological Use	Human use of biological resources in an ecosystem in a way that does not remove the resources from the system.
Pollution	Human caused introduction and spread of unwanted matter and energy into ecosystems. Includes chemical, biochemical, thermal, radiation, and noise pollution.
Transportation Infrastructure	Development of long narrow corridors for transporting people, goods, and energy.

Table 2-8. Numeric scores (categorical measurement) given to each threat identified for each SWReGAP habitat type in New Mexico. Scores and definitions from Salafsky *et al*. (2003).

Variable	Continuous Measurement	Categorical Measurement	Comments
Spatial Scope	Area threatened expressed in hectares or as a % of the total possible project area	4 = Throughout (>50%) 3 = Widespread (15 – 50%) 2 = Scattered (5 – 15%) 1 = Localized (< 5%)	Calculated as % of possible area (i.e., water pollution is % of aquatic habitat at a site, not entire site)
Severity	Actual measure of reduced target viability/integrity (e.g., nesting success, stream temperature)	4 = Serious damage or loss 3 = Significant damage 2 = Moderate damage 1 = Little or no damage	Independent of area; the degree to which a threat has an impact on the viability/integrity of targets within the project area within 10 years.

IDENTIFICATION OF CONSERVATION ACTIONS

Strategies, or conservation actions in CWCS terminology, are the broad approaches or interventions that will be employed to overcome a problem or take advantage of an opportunity so as to bring about attainment of a desired outcome. One or more species-or-habitat-based conservation actions have been developed through professional knowledge or literature review and presented herein to address any one problem or opportunity. Conservation actions were constructed based on: 1) SGCN, 2) condition of key habitats, 3) problems affecting species or habitats, 4) information gaps that limit our ability to make informed conservation decisions, 5) research, survey, and monitoring needs that would enhance our ability to make conservation decisions, and 6) desired future outcomes for habitats or SGCN (Fig. 2-2). The Assessment and Strategies for SGCN and Key Habitats (Chapter 5) provides descriptions of each of these components for key habitats within each ecological framework.

After identifying the SGCN associated with the key habitat of interest within a particular ecological framework, we began the thought process for developing conservation actions when we described the relative condition, or current state, of key habitats in terms of their ability to support SGCN (Fig. 2-2). Current condition may be thought of as the extant result or effect of past land use decisions. Describing these conditions begins to suggest *restorative* conservation actions that might be appropriate, such as reconnecting fragmented/disjunctive habitats.

Next, we identified factors that may adversely affect SGCN or their habitats (Fig. 2-2). These are essentially the "threats" that may destroy, degrade, or otherwise impair the biodiversity or natural processes that sustain them. They are the underlying causes that create current or future condition. Problems identified facilitated our later development of *interventions*, conservation actions to preclude or mitigate their effect. Though past problems may in part be responsible for the current condition of the habitat, problem and condition are not equivalents.

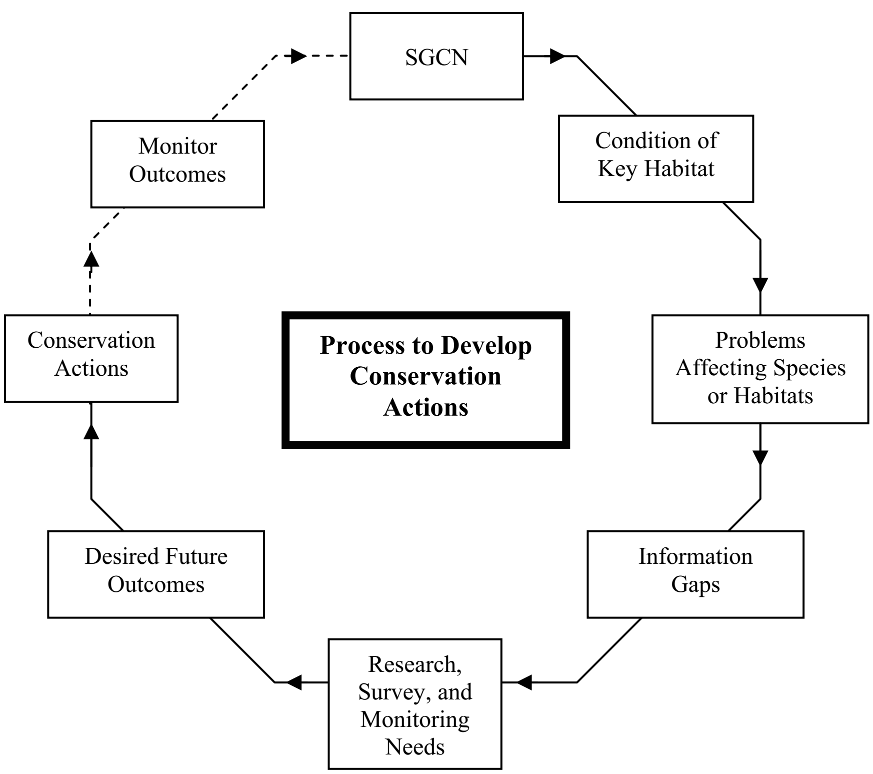


Figure 2-2. Process used to develop conservation actions for the CWCS for New Mexico.

We then identified information gaps that limit our ability to accurately assess the situation and/or develop effective conservation actions (Fig.

2-2). These are often matters of scale and scope or cause and effect such as "What is the extent and configuration of fragmentation in a particular habitat?" or "How are sand dune lizards and their habitat affected by a single well pad?" Information needs often became apparent when attempting to describe habitat condition and identifying problems. Information gaps provided the basis for identifying and rationalizing research, survey, and monitoring needs. Research, survey, and monitoring needs, when fulfilled, may help us to better understand our situation and develop effective conservation actions.

Desired future outcomes describe the ultimate conditions we would like to exist in the future. We also stated some intermediate outcomes, such as having some needed policy in place, that may serve as milestones to progress toward the ultimate outcome. Desired future outcomes are consistent with the overall CWCS outcome that the nation's (and of course New Mexico's) biodiversity is conserved to the extent that no more species need be listed as threatened or endangered.

Conservation Actions articulate the means by which we will overcome problems and attain the desired future outcomes. Our conservation actions are intentionally broad, directional, and nonspecific so as not to constrain our selection of means for implementing them. For example, a conservation action such as "Develop regulations which will protect the female component of the bear population" allows for many different regulatory approaches, e.g., closing the season, delaying opening until females are denned, prohibiting the taking of females, or closing the season when a quota for females is taken. Most people might agree that we should protect females, but some may object to the way in which we do it because of adverse impacts upon their interests. A broad strategy, while delineating the rationale that subsequent actions must satisfy, provides room for finding the specific actions all interests can live with. Whichever regulatory actions we eventually find acceptable, the strategy requires that they protect females. Tasks for implementing conservation actions will be specified, scheduled, staffed, and funded in operational plans.

Conservation actions propose what could be done without consideration of agency, department, financial or workforce capacities to implement them. These considerations are made during operational planning.

Because plans provide the means of coordinating work across organizational and jurisdictional boundaries our conservation actions set forth all necessary interventions; not just those to be performed by organizational units within NMDGF. Conservation actions may include explicit needs for law enforcement, information and education, land acquisition, access development, information technology, habitat management or other functions and are not limited to those over which the NMDGF has direct control or authority, because many agencies and other interests will ultimately plan and implement operational actions of the CWCS. Further, conservation actions do not give consideration to NMDGF's financial or workforce capacities to implement them. No commitment of money or manpower to any conservation action is therefore made or implied until such time as NMDGF and cooperators choose to implement it through operational planning and budgeting processes, in concert with pertinent collaborators and partners.

IDENTIFICATION OF KEY AREAS FOR CONSERVATION ACTION

The process we employed in developing the CWCS for New Mexico also provided the foundation to identify potential key areas for focusing biodiversity conservation efforts. Spatially explicit predicted habitat distribution models for aquatic and vertebrate SGCN were developed indicating areas in New Mexico that host a great diversity of terrestrial and aquatic SGCN. Synergistic effects of factors that influence habitats were modeled to indicate areas and key habitats that may be greatly altered by multiple factors. Stewardship data depicting landscapes with long-term protection from anthropogenic degradation were obtained from SWReGAP. These variables, when combined, can give some indication as to which landscapes may be key areas for focusing conservation efforts.

We created a spatial model indicating potential key areas for conservation efforts by giving the four model input variables described numeric values from 1-4 (Table 2-9). These models were combined in an additive Boolean overlay to predict potential key areas for conservation efforts within New Mexico. The resulting analysis produced a spatial model of values that ranged from 4-16. Landscapes with higher scores are areas that are within key habitats, have a high number of terrestrial and aquatic SGCN taxa, may be potentially altered by synergistic effects that influence habitats, and lack long-term legally-binding management plans protecting them from anthropogenic degradation. These landscapes were identified as key areas to consider when applying conservation efforts.

Table 2-9. Criteria used to code model inputs to numeric values from 1-4 to identify landscapes that may be key areas for focusing conservation efforts.

	Four Input Models			
Numeric Values of Input Models	Key habitats[1]	Terrestrial and aquatic SGCN diversity[2] (SGCN Taxa Modeled)	Synergistic effects of factors that may influence habitats[3] (Total Magnitude Score)	SWReGAP land status categories[4] (Status Code)
1	Not Present	44-59	0-40	1 (e.g., Wilderness Areas)
2		60-76	41-80	2 (e.g., National Park Lands)
3		77-93	81-120	4 (e.g., Private lands)
4	Present	94-109	120-165	3 (e.g., Multiple use lands)

[1] See Chapter 2, Identification of Key Habitats section for details. SGCN diversity was assigned to the 8-digit HUCs as described for the species distribution models.

[2] See Chapter 4, SGCN Abundance section for details.

[3] See Chapter 2, Factors Influencing Species and Habitats section for details.

[4] See Chapter 3, Land Stewards section, Table 3-3, for details. Ranks of land status categories were modified from SWReGAP original ranks because multiple use lands typically have long-term legally binding management plans and are areas that have high opportunity for collaboration between federal, state, and local land managers.

OPPORTUNITIES FOR AGENCY AND PUBLIC INVOLVEMENT

The CWCS agency and public involvement/partnering process began in May and June 2003 with separate meetings with representatives of The Nature Conservancy and Natural Heritage New Mexico to explore opportunities for partnering and sharing information. NMDGF made its first public presentation about the CWCS to the State Game Commission in October 2003. Several articles followed that were placed in 30 newspapers with a total circulation of 332,000 explaining the CWCS initiative and inviting people to let us know of their interest in participating. An early draft of the CWCS was placed on the NMDGF website and people were asked to let us know their opinions by completing an online survey or simply sending us an e-mail. In addition, separate presentations about the CWCS were made to the NM Wildlife Federation Conference and the Native American Fish and Wildlife Society. We conducted three forums for potential partners from local, state, federal, and tribal governments and non-governmental organizations representing recreation, conservation, agricultural, and energy development interests. A fourth forum was held exclusively for tribal interests. Forums were held in each of the four areas of the state primarily to orient and solicit input from county commissioners, local Natural Resources Conservation Service (NRCS) staff, and some additional agricultural interests. Two additional forums were held to assure sportsmen's groups opportunity for awareness and participation. Just over 400 individuals were invited to these 10 forums, including State Game Commissioners, and 112 individuals attended. Forum participants represented such diverse interests as:

NM Farm and Livestock Bureau
Eddy County Farm Bureau
Carlsbad Sportsmen's Club
NM Wild Turkey Federation
Natural Resource and Conservation Service
Dona Ana Co. Commission
NM Department of Agriculture
Southwest Environmental Center
Otero County Grazing Association
Bureau of Land Management
Fisheries and Wildlife, NMSU
Museum of Southwestern Biology, UNM
Playa Lakes Joint Venture
The Nature Conservancy
Cannon Air Force Base
US Forest Service
US Fish and Wildlife Service
Acoma Pueblo
Isleta Pueblo
Sandia Pueblo
Northern Pueblos Agency, BIA
Southern Pueblos Agency, BIA
Southwest Consolidated Sportsmen
Mesilla Valley Flyfishers
Grant Co. Farm and Livestock Bureau
NM State Parks
CS Ranch
Bell Ranch
South Valley Alliance
NM Cattle Growers
NM Wool Growers
NM Wildlife Federation
NM State Game Commission
Navajo Nation
BIA Natural Resources, Mescalero
Santa Ana Pueblo
Santo Domingo Tribe
Pueblo of Zuni
NM Natural Heritage Program
Turner Enterprises
Leopold Education Project
People for Native Ecosystems
Governor's Office
NM House of Representatives
Sandia Mtn. Bear Watch
NM Highlands Wild Lands Network Project
Audubon Society
Picacho Gun Club

Rocky Mountain Elk Foundation	Wild Turkey Association
Quail Unlimited	NM Trout
Society of American Foresters	NM Council of Outfitters and Guides
Mule Deer Foundation	Trout Unlimited

In addition, through other presentations, e-mails, and phone conversations the NMDGF has exchanged information with such groups as Amigos Bravos, Friends of the Wild Rivers, Animal Protection of NM, Defenders of Wildlife, The Sierra Club, the Wilderness Society, the NM River Otter Working Group, the Albuquerque Wildlife Federation, the New Mexico Farm and Livestock Bureau, the NM Federal Lands Council, and several unaffiliated individuals. In all, the scope, focus, and content of this document were influenced by the direct involvement of over 170 individuals external to NMDGF who provided valuable technical and socio-economic insights and constructive criticism from diverse and sometimes conflicting perspectives. Regional coordination has been fostered through participation in multi-state project grants and events associated with CWCS development.

The scope, focus, and content of this document were influenced by the direct involvement of over 170 individuals external to NMDGF who provided valuable technical and socio-economic insights and constructive criticism from diverse and sometimes conflicting perspectives.

The listing herein of agencies, institutions, conservation organizations, sportsmen associations, agriculture interests, other interests, or individual participants should **not** be taken to imply that they agree with all portions of the CWCS or with the CWCS initiative in general.

The Department also participated in the 2004 Wildlife Values in the West Survey (Teel and Dayer, 2005), which contains several questions pertaining to public attitudes on conserving New Mexico's biodiversity. Of 5002 surveys mailed to New Mexicans 859, were completed and returned. Results indicate that about 75% of New Mexicans view conserving our state's biodiversity as quite to extremely important. Another 23% view conserving our biodiversity as slightly to moderately important. Only 2% find such conservation unimportant. A majority (89%) of respondents feel it is important to manage and conserve wildlife that are not hunted or fished and 68% feel it is quite to extremely important to increase populations of endangered species. About 82% of New Mexicans feel it is quite to extremely important to protect and improve lands and waters used by wildlife and 76% feel it is quite to extremely important to maintain sufficient water in our lakes and rivers to support water-dependent wildlife. About 89% of New Mexicans agree that fish and wildlife are a benefit to all of society and that paying for their conservation should be the responsibility of all New Mexicans. A large proportion (78%) disagrees with the notion that people who only view or appreciate wildlife and do not hunt, fish, or trap should not have to pay for fish and wildlife conservation. About 84% of respondents agreed that hunting, fishing, and wildlife viewing activities have a strong positive effect on state and local economies.

75% of New Mexicans view conserving our state's biodiversity as quite to extremely important.

Our agency and public involvement efforts not only produced many useful technical suggestions and expressions of support but also revealed a number of potential issues. New Mexico Farm and Livestock Bureau representatives expressed concern about the potential of the CWCS to impact agricultural operations, add to the burdens already placed upon landowners, and cause private property rights to be usurped. They are especially concerned that agriculture not be incorrectly implicated in adversely affecting the condition of key habitats and the status of SGCN through unsubstantiated references to the effects of grazing. Some agricultural interests are also concerned that the identification of arthropod SGCN may interfere with their need to control insects. Believing the CWCS needs further review and revision, the Agricultural Resources and Programs Division of the New Mexico Department of Agriculture requested an extension of the time for CWCS consideration and increased interaction with a broader constituency group to assist in its completion.

Tribal representatives, though interested in the potential to partner in CWCS development and implementation, expressed concerns about the inequity they perceive in funding for tribal wildlife grants, the potential obstructive effect of sovereignty issues, and that revealing information about the presence of SGCN on tribal lands might precipitate federal land use constraints through critical habitat designations. Some private landowners share this last concern with respect to their properties.

New Mexico State Parks Division representatives expressed concern that our efforts to restore native species not conflict with the availability of exotic sport fish popular with the angling publics visiting park facilities. The Department will continue to engage all of the above entities to help resolve these and other issues of CWCS implementation.

80% of New Mexicans:

- Feel it is quite to extremely important to protect and improve lands and waters used by wildlife,
- Feel it is quite to extremely important to maintain sufficient water in our lakes and rivers to support water-dependent wildlife,
- Agreed that hunting, fishing, and wildlife viewing activities have a strong positive effect on state and local economies.

Chapter 3
NEW MEXICO'S BIODIVERSITY

STATE RESOURCES

Physical Description

New Mexico is the 5th largest state in the United States with a total surface area of approximately 121,666 square miles (315,114 km^2). Though primarily a xeric or dry state, New Mexico has approximately 234 square miles (606 km^2) of rivers, streams, lakes, and reservoirs. Elevations range from 2,842 ft (866 m) at Red Bluff Reservoir in the southeastern desert to 13,151 ft (4,008 m) at Wheeler Peak in the northern Sangre de Cristo range (Vigil-Giron 2003). New Mexico spans a variety of regions from the Great Plains, Rocky Mountains, Colorado Plateau, and Madrean Archipelago to the Great Basin, Chihuahuan, and Sonoran Deserts (Mehlman 1996).

Geologic History

New Mexico has a complex geologic history. A shallow sea covered the state during the Paleozoic era. Limestone deposits formed during this time can be seen in the karsts, salt deposits, and soils of the southeastern portion of the state. Near the end of the Paleozoic, the ancestral Rocky Mountains uplifted the central and northern part of the state and a great barrier reef developed to the south. As water evaporated, deposits of salt, potash, and gypsum were left and remain visible today. The repeated advance and retreat of another shallow sea during the Mesozoic era resulted in a tropical swampland rich with vegetation and fauna. Coal deposits found in New Mexico were formed during this era. The Cenozoic era was punctuated by volcanic activity and the formation of today's Rocky Mountains and Colorado Plateau. During the Pleistocene epoch, the land was again covered by lush vegetation and marshes. A cycle of glaciations covered northern New Mexico and etched much of the present day landscape.

Climate

The climate of New Mexico is as diverse as its landforms. Temperature varies significantly with changes in altitude and monitoring stations 4,700 ft apart in elevation can differ by as much as 16° F. New Mexico's highest temperature of record is 122° F (50° C), recorded in 1994. The coldest temperature of record is -50 °F (-46° C), recorded in 1951. Monthly average temperatures range from a high of 93°F (34° C) to a low of 22°F (-6° C). Rainfall varies with latitude and altitude. Most of the rainfall and snowfall occurs in the northern part of the state, where the Pacific weather systems lose much of their moisture in the high elevations of the southern Rocky Mountains. The eastern portion of the state receives precipitation from the Gulf of Mexico. Severe but brief thunderstorms during the summer monsoons of late July, August and early September are the source of most precipitation for the more arid portions of the state.

Flora and Fauna Biodiversity

The size, topography, and physical location of New Mexico combine to make it is one of the more biologically diverse states, with more than 4,500 different species of plants and animals.

Vegetation communities include alpine tundra, coniferous forests, woodlands, grasslands, desert shrublands, and riparian areas. Some of the most diverse flora can be found within the state's many riparian areas, which provide habitat for obligate wetland species as well as facultative upland species. Several life zones converge in southwestern New Mexico, making this area one of the more biologically diverse of the southwestern states (Fig. 3-1).

More than 1100 species of amphibians, reptiles, mammals, birds, invertebrates, and fish are found within the state's geopolitical boundaries (Table 3-1). The bird fauna is diverse, with more than 500 species. Mammal diversity is high compared to other southwestern states, with approximately 184 species known to occur here. New Mexico has approximately 26 species of amphibians and over 100 species of reptiles. Though the total number of species is unknown, invertebrate diversity is high among molluscs, crustaceans, and other arthropods. New Mexico Department of Game and Fish (NMDGF) has management authority for approximately 52% of these species (Table 3-1).

New Mexico's Population and Economy

New Mexico is a mostly rural state with few population centers. The Census Bureau estimates, New Mexico was home to approximately 1,874,614 people and had a population density of 15.4 people/square mile (5.9 people/km^2) in 2003. Albuquerque (Bernalillo County) is the state's largest city, with a population of 448,607 people as of 2000. Las Cruces and the capitol, Santa Fe, are the next largest cities. During the 1990s, the population of New Mexico increased 20%.

The Bureau of Economic Analysis (http://www.bea.gov) estimated New Mexico's per capita personal income at $24,995 in 2003. New Mexico's total state product for 2003 was approximately $57 billion. Construction, retail trade, real estate, health services, and non-educational state and local government industries make up the top 5 industries in New Mexico's economy (Ashcroft 2005). The construction industry output approximately 7.3 billon dollars, while real estate output approximately 6.0 billion dollars in 1998. In rural New Mexico (all but Bernalillo County), the agriculture industry replaces health services in the top 5 industries in terms of output (Ashcroft 2005). The total economic value derived from agriculture within New

Table 3-1. Approximate number of species in New Mexico and the percent of those species that fall under NMDGF management authority (Data: Bison-M, http://fwie.fw.vt.edu/states/nm.htm).

Taxa Group	Number in State	Number of Taxa Group with NMDGF Management Authority	Percent of Taxa Group with NMDGF Management Authority
Amphibians	26	8	31%
Birds	504	441	88%
Crustaceans	35	2	6%
Fish	130	58	45%
Mammals	184	54	29%
Molluscs	182	25	14%
Reptiles	105	17	16%
Total	*1166*	*605*	*52%*

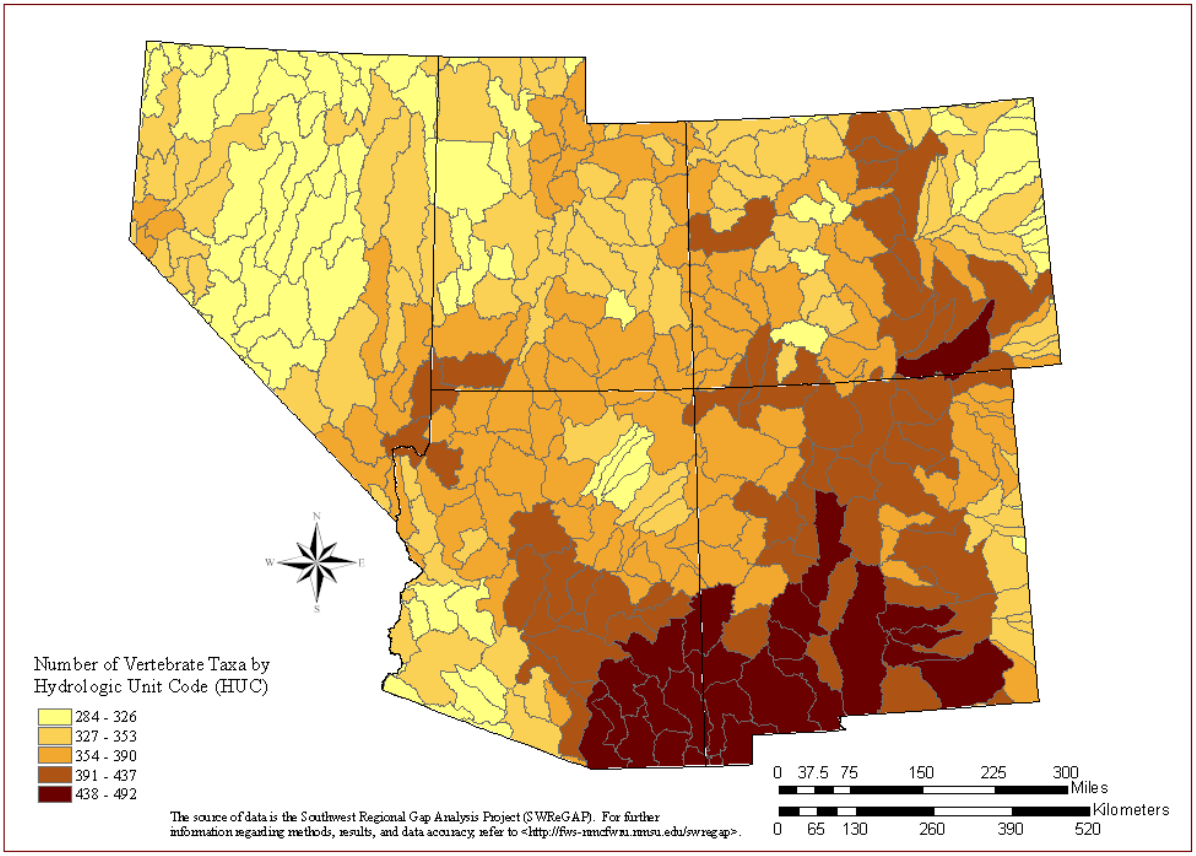


Figure 3-1. Species richness (number of vertebrate taxa) modeled by SWReGAP in Nevada, Arizona, Utah, Colorado, and New Mexico (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Mexico was 3.5 billion dollars in 1998. Bernalillo County alone (a non-rural county) produced 40 million dollars in agriculture products in 1998 (Ashcroft 2005). Approximately 5% of New Mexico employment in 1998 was related to agriculture (Ashcroft 2005). Approximately 25% of the state's non-agricultural based jobs are local, state, and federal government based (Vigil-Giron 2003). The educational and health services, retail trade, and professional and business services each employ approximately 12% of the state's non-agricultural based jobs (Vigil-Giron 2003).

New Mexico had approximately 52% rangeland, 7% forest, 2% cropland, 36% non-rural, and 3% other rural uses in 1997 (US Department of Agriculture 2000) (Fig 3-2). The livestock sector is one of the larger agricultural industries in the state, partly due to large federal land acreages and areas of open space (Ashcroft 2005). Agriculture products include hay, sorghum, pecans, onions, potatoes and chiles. Cattle and dairy products top the list of major animal products of New Mexico. The beef industry is one of New Mexico's larger agricultural products that have major economic implications for neighboring states (Ashcroft 2005). The agriculture industry also supports many related or value added industries in New Mexico. As such, agriculture is an important economic, cultural, and social industry to New Mexico (Ashcroft 2005).

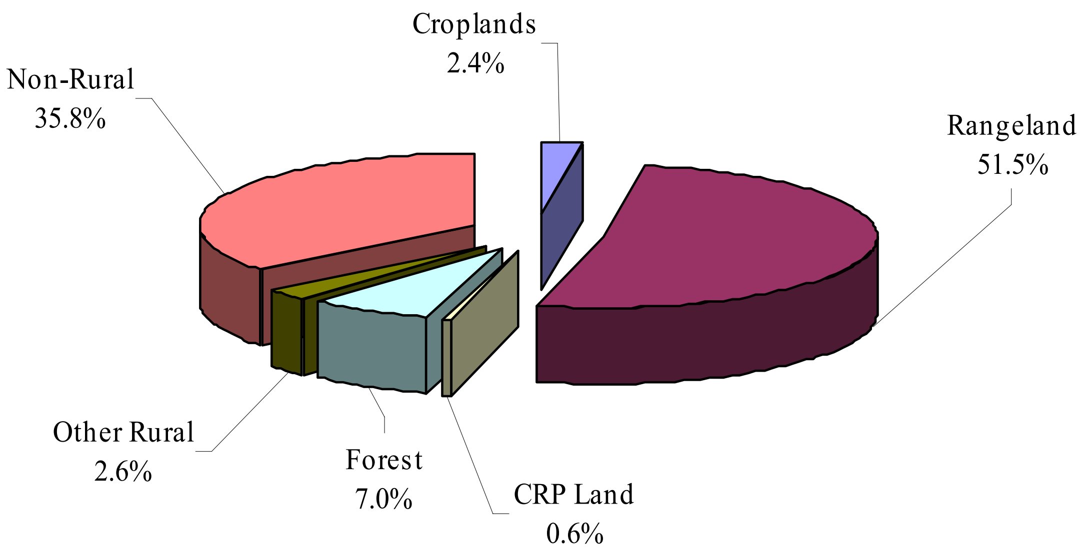


Figure 3-2. Approximate percentages of rangeland, cropland, Conservation Reserve Program land, forest, other rural uses, and non-rural lands in New Mexico. Estimates derived from US Department of Agriculture (2000).

New Mexico also has a long history of mineral extraction and produces uranium ore, manganese ore, potash, salt, perlite, copper ore, beryllium, and tin concentrates. Oil and gas extraction is a major resource-based industry in the state, especially in the southeast and northwest.

Land Stewards

In assessing the current status of New Mexico's biodiversity, it is important to consider land management stewardship and the extent to which areas are, or are not protected or conserved in some fashion. Approximately 34% of New Mexico is federally owned, 12% is state owned, 10% is within Native American (tribal) reservations, and 44% is privately owned (Table 3-2, Fig. 3-3) (Williams 1986, SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Land management jurisdiction varies across the state. Federally owned lands are primarily under the stewardship of the Bureau of Land Management, US Forest Service, Department of Defense, and National Park Service. The State Land Office, State Parks Division, and State Game Commission manage state owned-lands. There are 22 Indian tribes and reservations in New Mexico (Vigil-Giron 2003). The Navajo Nation owns much of the northwestern part of the state, especially along the Arizona border. The Zuni also own land in the northwestern part of the state along the Arizona border, and the Jicarilla and Mescalero Apache Tribes own land in the north and southeast, respectively. Most of the Pueblos are located along the northern half of the Rio Grande. Several non-governmental organizations (NGOs), such as The Nature Conservancy, Audubon Society, and the Rocky Mountain Elk Foundation, manage parcels within the state. Multiple state and federal policies and management priorities on private lands affect the conservation of New Mexico's biodiversity. About 6% of New Mexico has legal protection from conversion of natural land cover and mandated management plans in operation to maintain some semblance of a natural state (Table 3-3, Fig. 3-4) (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/). The majority of the state (57%) either lacks long-term (10+ years) legal mandates to prevent conversion of natural land cover to anthropogenic land cover types or is not classified. While many private lands fall under this category, these lands are subjected to varied land steward objectives that provide important habitat for many wildlife species.

Table 3-2. Land area (acre) and percent in 12 land steward categories in New Mexico estimated by New Mexico Gap Analysis Project (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Steward Category	Land Area (acre)	Percent of Land Area
Bureau of Land Management	13,544,240	17%
Bureau of Reclamation	71,940	< 1%
Forest Service	9,293,923	12%
National Park Service	384,978	< 1%
Fish and Wildlife Service	375,256	< 1%
Department of Defense	2,560,690	3%
Other Federal	110,827	< 1%
State Parks	95,272	< 1%
State Trust Lands	8,858,392	11%
State Wildlife Areas	161,379	< 1%
Tribal	8,008,717	10%
Private	34,167,843	44%

Table 3-3. Land area (acre) and percent of New Mexico in four land status categories estimated by New Mexico Gap Analysis Project (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

Status	Description	Amount (acre)	Percent
1	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events are allowed to proceed without interference or are mimicked through management.	664,900	1%
2	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.	4,256,100	5%
3	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intensity type. It also confers protection to federally listed endangered and threatened species throughout the area.	28,377,500	36%
4	No known mandate to prevent conversion of natural land cover to anthropogenic land cover and allows for intensive use throughout the tract, or existence of such restrictions is unknown.	44,334,700	60%

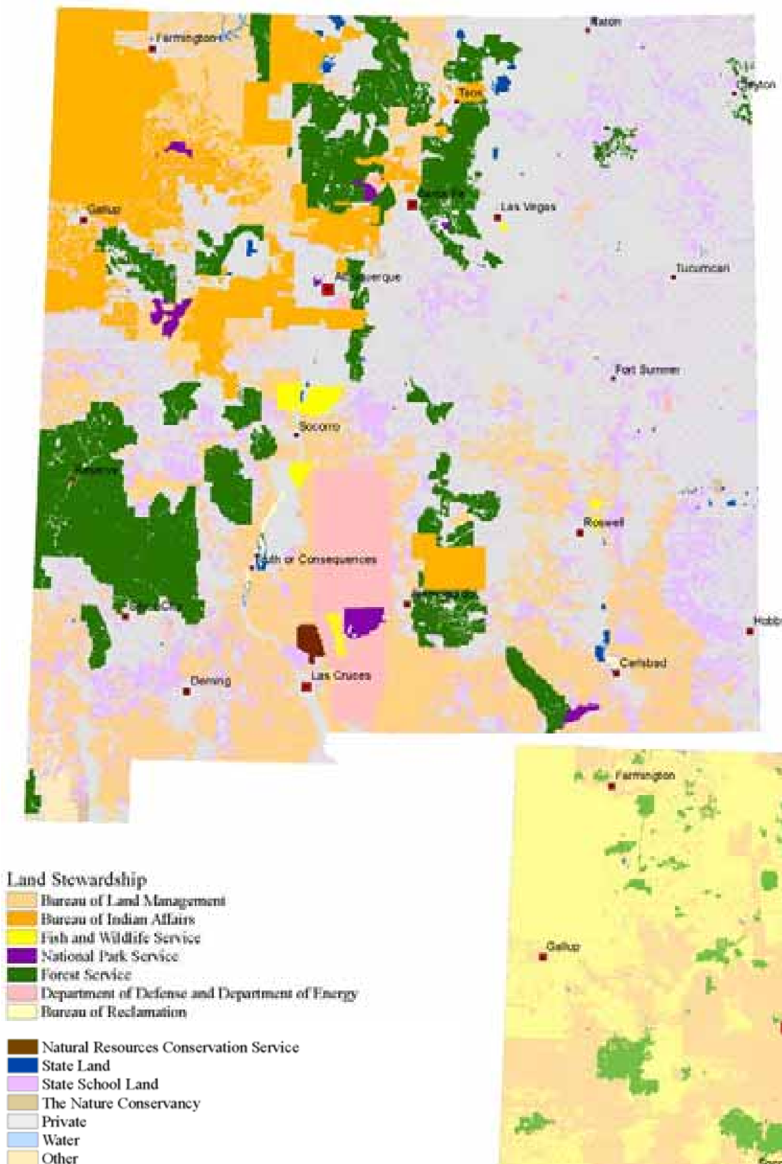


Figure 3-3. (*Left*) New Mexico's land stewardships categorization (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/).

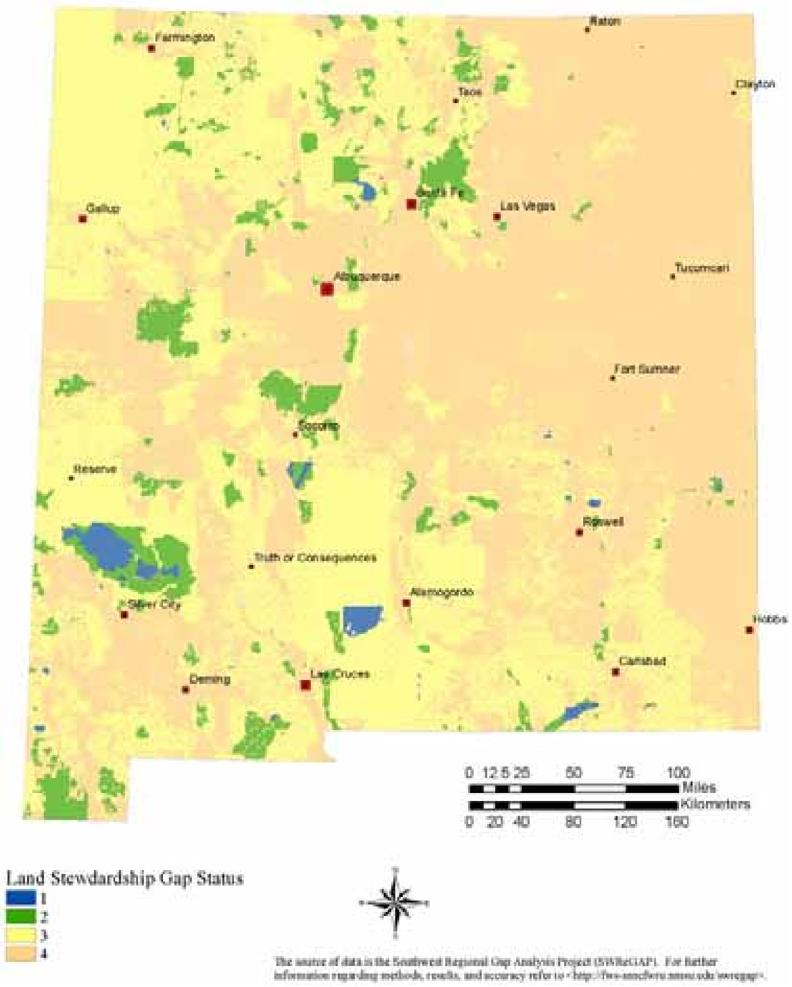


Figure 3-4. (*Right*) Land Steward Conservation Status in New Mexico as estimated by SWReGAP (http://fws-nmcfwru.nmsu.edu/swregap/). Descriptions of land stewardship gap status codes are presented in Table 3-3.

NEW MEXICO'S ECOLOGICAL FRAMEWORKS AND KEY HABITATS

Ecological Frameworks

A desired outcome of the Comprehensive Wildlife Conservation Strategy (CWCS) initiative is the eventual ability to aggregate information from each state plan so as to facilitate a regional and national perspective and cross-jurisdictional coordination. In New Mexico, the diversity of flora and fauna and the nature of problems influencing habitats or species required the use of multiple ecological frameworks. The seven Nature Conservancy (TNC) Ecoregions identified for New Mexico (Fig. 3-5) provide a convenient organizational framework for developing state, regional, and national perspectives with respect to terrestrial habitats. Originally based on Robert Bailey's US Forest Service ecoregions, these boundaries have been extensively modified by TNC's eocregional planning teams (Bailey 1988, 1995, 1998). The Central Shortgrass Prairie Ecoregion (Burget *et al*. 1998), however, encompasses only about 500,000 acres (202,340 ha) in the northeastern part of the state and we found it practical to assimilate it into the neighboring Southern Shortgrass Prairie Ecoregion for planning purposes. Thus, our terrestrial habitats are partitioned into six rather than seven TNC ecoregions.

> The diversity of flora and fauna and the nature of problems influencing habitats or species in New Mexico required the use of three ecological frameworks:
> - Ecoregions,
> - Watersheds, and
> - Statewide.

Using watershed drainages as the ecological framework best facilitates regional or national aggregation of New Mexico's aquatic habitat considerations. There are 83 hydrological units (8-digit Hydrological Unit Codes; HUCs) identified in New Mexico. These hydrological units were combined into eight major drainages in New Mexico to serve as our aquatic ecological framework (Fig. 3-6).

Considerations of habitat related problems, Species of Greatest Conservation Need (SGCN), and conservation actions for some habitats in New Mexico are best made on a statewide scale. Thus, key riparian, ephemeral aquatic, and perennial tank habitats are treated within a statewide ecological framework.

Ecoregions

Apache Highlands Ecoregion

The Apache Highlands Ecoregion extends from central to southeastern Arizona into southwestern New Mexico and northern Mexico. This ecoregion contains 30 million ac, 2.6 million ac (1 million ha) of which occur in New Mexico. Woodland and forested habitats types in this ecoregion occur within the greater Madrean Archipelago complex, which are so-named because of the many isolated mountain ranges spread across the ecoregion (Gehlbach 1993). These isolated mountain ranges are separated from one another by plains and valleys of desert and semi-desert grasslands and shrublands. These intervening habitats are thought to limit genetic interchange between the sky island mountain range habitats, creating isolated areas with high evolutionary implications for plant and animal populations (Warshall 1995).

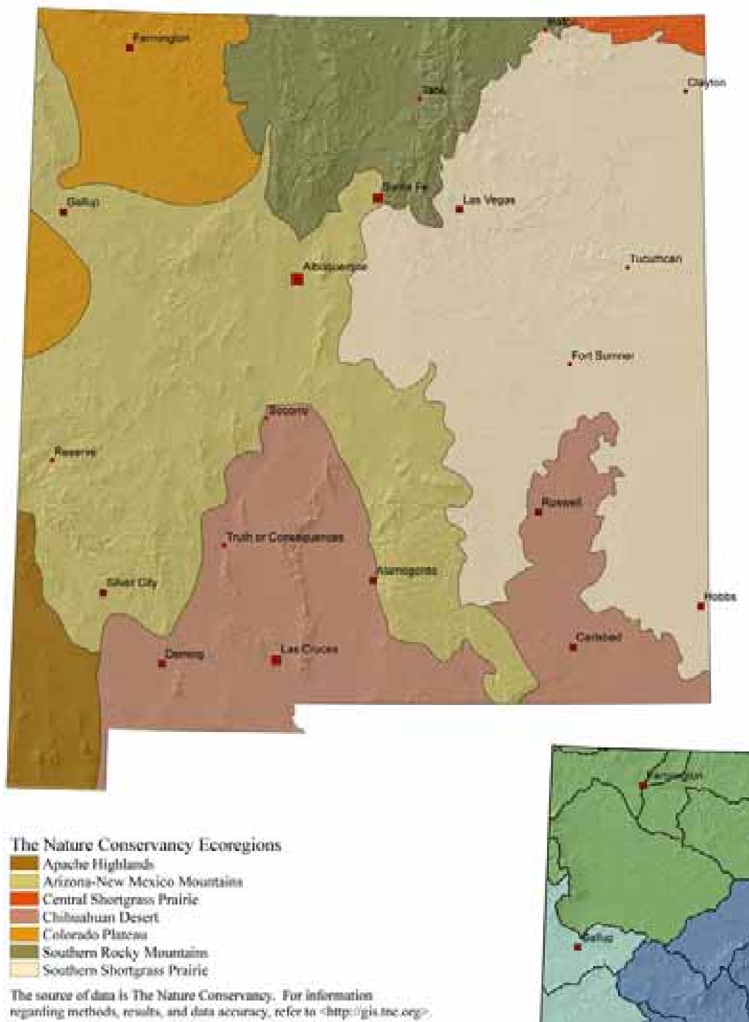


Figure 3-5. (*Left*) The Nature Conservancy (TNC) ecoregions used as the ecological framework for terrestrial habitats in New Mexico.

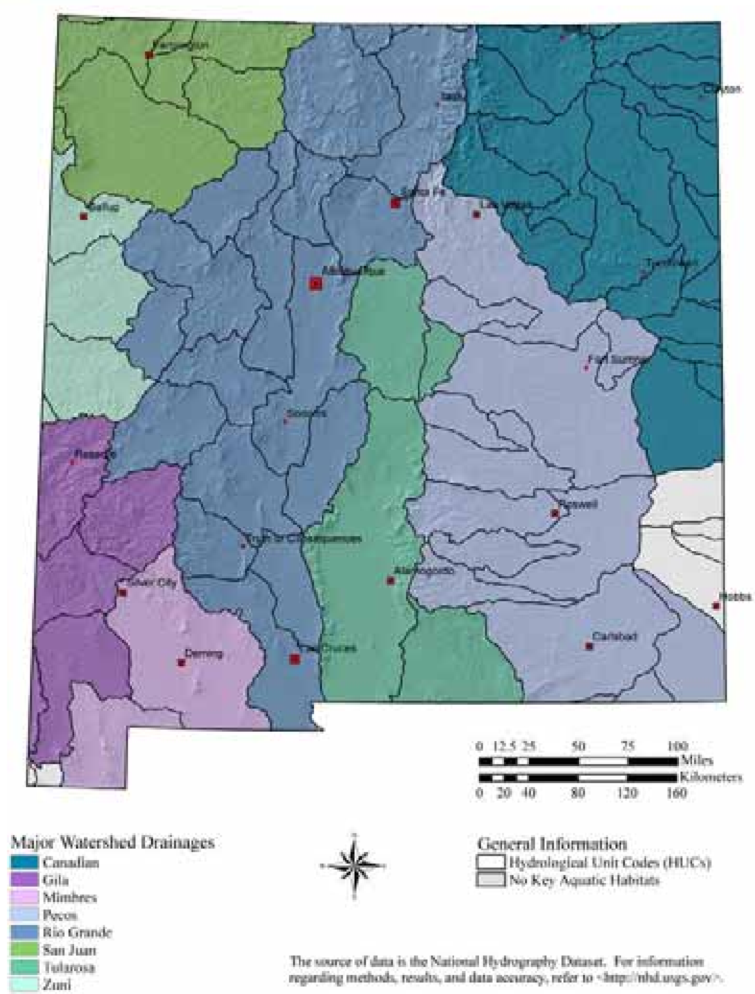


Figure 3-6. (*Right*) Watersheds used for the ecological framework for aquatic habitats in New Mexico.

Elevation in the Apache Highlands Ecoregion ranges from about 2,200 ft (670 m) to 10,717 ft (3,266 m) and averages about 4,340 ft (1,323 m). The diverse plant and animal communities of the Apache Highlands Ecoregion reflect the variation in elevations and the merging of the northern Rocky Mountains in the north and the Sierra Madre Occidental and neotropical regions of Mexico to the south. This high level of diversity and unusual community structure has appropriately been described as a stacking of biotic communities on mountain islands (Marshall 1957).

Arizona-New Mexico Mountains Ecoregion

The Arizona-New Mexico Mountains Ecoregion encompasses the highlands of eastern Arizona and central and western New Mexico, encompassing 29 million ac (12 million ha) of land (Bell *et al.* 1999). New Mexico hosts greater than 23 million ac (9.5 million ha) (78%) of this ecoregion. Mountains in this ecoregion are among the oldest in the southwest. Many are composed of Precambrian igneous rocks and once active volcanoes. This diverse physiographic region has elevations ranging from 4,500 ft (1,371 m) to 12,600 ft (3,840 m) and contains steep foothills, mountains, and plateaus rising above the surrounding desert grasslands and shrublands.

> The Arizona-New Mexico Mountains Ecoregion is host to more species of birds and mammals than any other ecoregion in the southwest.

The Arizona-New Mexico Mountains Ecoregion contains a number of mountain ranges and desert plains. The more prevalent habitats include Madrean pine-oak conifer-oak forest and woodland, Rocky Mountain forest and woodland, and Rocky Mountain montane mixed conifer, in the higher elevations and piñon-juniper/juniper savanna, steppe and grasslands, Chihuahuan semi-desert grassland, and Western Great Plains shortgrass prairie in the lower elevations. This ecoregion contains the headwaters for a number of important streams and rivers, including the Little Colorado, Gila, San Francisco, and Mimbres. Riparian habitats in this ecoregion host a variety of flora and fauna. This ecoregion is considered to host more species of birds and mammals than any other ecoregion in the southwest (Bell *et al.* 1999).

Chihuahuan Desert Ecoregion

The Chihuahuan Desert Ecoregion encompasses approximately 174 million ac (70 million ha) from San Luis Potosi, Mexico north to southwestern Texas and southern New Mexico (Bell *et al*. 2004). Approximately 75% of the Ecoregion is in Mexico, with only 2.5% of its total area under formal protection (Dinerstein *et al*. 2000). In New Mexico, the Chihuahuan Desert Ecoregion includes Luna, Dona Ana, Sierra, and Eddy counties, and portions of Socorro, Lincoln, Otero, Chaves, and Lea counties, totaling approximately 15.2 million ac (6.1 million ha). Metropolitan areas in the ecoregion include Las Cruces, Deming, Carlsbad, Artesia, and Roswell. Counties in the ecoregion experienced an average 24% increase in human population between 1990 and 2000 (US Census Bureau, 2001). Chihuahuan semi-desert grasslands and desert scrub vegetation dominate (Bell *et al*. 2004), although SWReGAP identified and mapped 53 landcover types in the New Mexico portion of the Ecoregion.

Colorado Plateau Ecoregion

The Colorado Plateau Ecoregion encompasses the Four Corners region of Arizona, Colorado, New Mexico, and Utah and is a geologically complex region of badlands, sheer-walled canyons, buttes, mesas, plains, dunes, and isolated mountain ranges (Truhy *et al*. 2002). Several major rivers flow through this ecoregion, including the Colorado, Little Colorado, San Juan, and Escalante rivers. These rivers have carved large canyons through the plateau. The ecoregion contains 48.5 million ac (19.6 million ha) of mostly public and tribal land, and elevation ranges from 1,200 ft (370 m) in the Grand Canyon to 12,700 ft (3,870 m) in the La Sal Mountains. The climate within the Colorado Plateau Ecoregion is often described as "desert" because the average yearly rainfall is less than 10 in (25 cm). Most of the precipitation occurs in the winter in the form of snow, allowing much of the water to infiltrate the soil (Truhy *et al*. 2002).

More than 300 plant species in the Colorado Plateau are not found anywhere else in the world.

Ecological importance of this ecoregion lies in its geologic features and diverse and unique fauna and flora. More than 300 plant species extant here are found nowhere else in the world (Truhy *et al*. 2002). Habitat conservation concerns include drying of wetlands, damming of rivers and tributaries, invasion of exotic species, suppression of natural fire patterns, and land uses such as livestock grazing, and mining. Species such as the grizzly bear, gray wolf, lynx, and river otter have been extirpated from this region for decades.

About 12%, approximately 6.2 million ac (2.5 million ha), of the Colorado Plateau Ecoregion occurs in two areas of the northwestern corner of New Mexico. The Chuska Mountains on the west, the San Mateo Mountains to the south, and the San Pedro Mountains to the east border the northernmost area. The San Juan River cuts through this part of the plateau in an east-west direction. The southern area extends southwest of Gallup to the western border and is bordered by the Zuni Mountains to the northwest. The Zuni River flows through this part of the plateau.

Southern Rocky Mountains Ecoregion

The Southern Rocky Mountains Ecoregion, two-thirds of which is publicly owned, encompasses nearly 40 million acres (16 million ha) across portions of southern Wyoming, central Colorado, and northern New Mexico. Two major mountain belts and the intermountain valleys between characterize this ecoregion. Elevation ranges from 3,700 ft (1,127 m) to over 14,000 ft (4,267 m), both extremes occurring in Colorado. High rugged glaciated mountains, plateaus, alpine cirques, glacial moraines, and broad valleys were formed through glacial activity (Neely *et al*. 2001). The climate is a temperate semiarid steppe influenced by the prevailing west winds and the general north-south orientation of the mountain belts. Approximately 7.2 million ac (2.9 million ha) (18%) of the ecoregion occurs in New Mexico. The Sangre de Cristo and the San Juan mountain ranges form the southern portions of the eastern and western mountains belts, respectively. The major intermountain valley between these ranges is the Rio Grande.

Southern Shortgrass Prairie Ecoregion

The Southern Shortgrass Prairie occupies more than 67 million ac (27 million ha) of northeastern New Mexico, northern Texas, and small portions of western Oklahoma. New Mexico contains 22.2 million acres (9 million ha) or approximately 33% of the ecoregion. The western part of this ecoregion is characterized by high plains plateaus broken by escarpments (The Nature Conservancy 2004). Soils in the ecoregion are diverse, ranging from Aridisols to Mollisols. Much of the topography is flat to rolling plains dissected by canyons and caprock escarpments. In addition to the relatively level plains, the ecoregion is topographically diverse and includes isolated volcanic formations (The Nature Conservancy 2004). Depressional basins, known as playas, punctuate the relatively flat portions of the ecoregion and represent significant wetland habitat for migratory waterfowl, shorebirds, and other species. Average annual rainfall in the southwestern part of the ecoregion is approximately 13 in (325 mm).

The Southern Shortgrass Prairie Ecoregion lies within the Southwest Plateau and Plains Dry Steppe and Shrub Province (Bailey 1995) and is bordered by the Central Shortgrass Prairie Ecoregion on the north, Edwards Plateau and Chihuahuan Desert Ecoregions on the south, Central Mixed-grass Prairie and Crosstimbers and Southern Tallgrass Prairie Ecoregions to the east, and the Southern Rocky Mountains and Arizona-New Mexico Mountains Ecoregions to the west.

The ecoregion was historically dominated by expanses of shortgrass prairie, with blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). The development and maintenance of this system was dependent on several ecological processes, most likely driven by climate. Bison grazing and fire were also important processes that maintained the grasslands of the shortgrass prairie (TNC 2005). Today Chihuahuan desert grasslands are dominant over shortgrass prairie in arid areas towards the southwestern part of this ecoregion and shortgrass prairie is replaced by mixed-grass prairie to the east where greater moisture is available.

The varied topography and geologic features in this ecoregion allow for a wide range of floral and faunal communities. Other important habitats in the New Mexico part of the Southern Shortgrass Prairie Ecoregion include juniper and piñon-juniper woodlands and sand shrublands. Changes in natural processes have led to shrub invasion of the prairie systems. Riparian woodlands are typically dominated by eastern cottonwood (*Populus deltoides*); however tamarisk (*Tamarix* sp.) and Russian olive (*Eleagnus angustifolia*) are significant non-native invaders (The Nature Conservancy 2004).

Watersheds

Eight major watersheds serve as our aquatic habitat ecological framework in New Mexico.

Canadian Watershed

The Canadian Watershed, in northeast New Mexico, encompasses about one-sixth the land area of the state or about 10.9 million ac (4.4 million ha) (New Mexico Water Quality Control Commission 2002). Canadian River tributaries flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado. As it traverses the Great Plains in a southerly and then easterly direction several perennial tributaries, including the Vermejo, Cimarron, Mora, and Conchas Rivers, join the South Canadian River before it exits New Mexico to Texas near Logan. The Upper Canadian, Middle Canadian, Upper Beaver, and the Dry Cimarron are the only perennial sub-basins.

Settlement and irrigation withdrawal along high mountain valleys in the Mora River dates back to the 1700's. Since the late 1800's, the area has been subject to extensive logging, grazing, and mining. Numerous impoundments and diversions have been built throughout the upper drainage for irrigation and municipal water. Livestock grazing continues to be the primary land use throughout the Canadian River drainage. Logging activities are now limited to small tracts in the upper tributaries. Most coal mines were abandoned by the 1950's. Two large dams, Conchas River (constructed 1938) and Ute Dam on the Canadian River (constructed 1962), impound reservoirs and modify natural flows as the river approaches the New Mexico-Texas border.

Gila Watershed
The Gila River watershed lies within southwestern New Mexico, and is comprised of two major streams, the Gila and San Francisco Rivers. In high elevation (ca. 10,000 ft; 3,000 m) headwaters, the small, canyon-bound streams are bordered by blue spruce (*Picea pungens* Engelm), Douglas fir (*Pseudotsuga menziesii*), and aspen (*Populus tremula*). As the streams descend and coalesce, ponderosa (*Pinus ponderosa*), juniper, and piñon (*pinus edulis*) become the dominant conifers and stands of willow (*Salix* spp.) are common in moderate gradient reaches. Headwater streams of the Gila join to form three forks (West, Middle, and East) in the Mogollon Mountains. From their juncture, the Gila River flows westerly and exits the Mogollon Mountains just east of Gila. Along its mountain course, the river is bordered by ponderosa, piñon, juniper, cottonwood, Arizona sycamore (*Platanus wrightii*), boxelder (*Acer negundo*), and Arizona walnut (*Juglans major*).

The primary land uses along the river in the Cliff-Gila Valley are livestock grazing and some irrigated cropland. Water is seasonally diverted from the river. At the western end of the valley, the river is narrowly confined as it flows through the Middle Box. Downstream of the Middle Box, the Gila River flows across desert grasslands and shrublands to exit New Mexico. Livestock grazing is the primary land use in the lower reaches of Gila River in New Mexico, but some irrigated cropland is present near Virden. Arizona sycamore, cottonwood, and mesquite (*Prosopis* spp.) comprise the primary woody riparian vegetation in the lower reaches. US Forest Service administers mountainous portions of the Gila Watershed. Substantial portions of this watershed are within the Gila and Aldo Leopold wildernesses. The Bureau of Land Management and Forest Service administer portions of the lower watershed, but most lands are privately owned. The Gila River is the last main stem in New Mexico without a major water development.

Mimbres Watershed
The Mimbres Watershed encompasses parts of Hidalgo, Luna and Grant Counties in New Mexico. However, almost all of the perennial waters from the Mimbres River are within Grant County. Its lower most and few permanently watered reaches are in northern Luna County. Formerly, small farms, orchards, and dispersed livestock grazing in uplands were the predominant land use in much of the Mimbres Valley. Now, much of the valley is a checkerboard of small residential ranchettes.

The Mimbres River occupies a small endorheic basin in southwest New Mexico. Headwaters are along west- and south-facing slopes of the Black Range flow southward and dissipate onto the desert north of Deming. Much of the permanently watered portion of the river is in the Mimbres Valley, where the system is more cienega in character than riverine. Uplands are largely under Forest Service jurisdiction and valley lands are largely privately owned. Although rural, the valley has been subdivided into numerous small tracts, many of which have dwellings with private wells and septic systems. On private lands, the river channel is frequently mechanically realigned and woody riparian vegetation removed. The Nature Conservancy and NMDGF manage small tracts along the river, which provide some protection for aquatic habitats.

Pecos Watershed
The Pecos River is the primary drainage in the Pecos Watershed. The river rises on the eastern slope of the Sangre de Cristo Mountain range in Mora County, New Mexico, and runs south through San Miguel, Guadalupe, De Baca, Chaves, and Eddy counties in New Mexico before it enters Texas.

The Pecos Watershed encompasses 12.3 million ac (4.0 million ha) in New Mexico. Principal New Mexico cities in the watershed include Las Vegas, Santa Rosa, Fort Sumner, Roswell, Artesia, and Carlsbad. Counties in the Pecos Watershed have experienced positive population growth from 1990-2000 (New Mexico Economic Development Data), with only De Baca County showing slight population declines. Land use in this watershed is mainly rangeland, with some irrigated cropland and pastureland along the Pecos River. Roughly 10% of the industry in the lower Pecos Valley is agriculture based (De Baca, Chavez, and Eddy Counties). Primary crops include small grains, alfalfa, and other hay crops. Oil and gas development occurs within the lower Pecos River valley.

Rio Grande Watershed
The Rio Grande Watershed originates in the San Juan Mountains of southern Colorado and flows south through central New Mexico for the entire length of the State. At El Paso, Texas, the drainage area is approximately 20.1 million ac (8.3 million ha), including the drainage area in Colorado (US Geological Survey 1996). There are a number of streams that drain into the Rio Grande. These include: 1) the Rio Chama, which joins the Rio Grande in north central New Mexico and is the most significant tributary, 2) the Jemez River which joins the Rio Grande near Bernalillo, and 3) the San Jose/Rio Puerco Drainage which also joins the Rio Grande near Bernalillo. Smaller watersheds drain mountains in southern New Mexico. These drainages lack the diversity of those to the north, and many of them are ephemeral. Flow in the Rio Grande, typically low in the winter, is most significantly affected by snowmelt and summer rain events. A spring peak generally occurs between early April and mid May from snow melt. Low flow returns in June followed by smaller peaks of shorter duration associated with monsoonal rain events. Fall generally has decreasing flow (Bullard and Wells 1992). This historic flow regime has been greatly affected by irrigation diversions and agricultural reservoirs in the lower part of the system. Irrigation flows have increased the relative magnitude and duration of summer peaks and reduced the peak associated with snowmelt.

Most lands within the Rio Grande Watershed are under federal and quasi-federal ownership. The headwaters typically occur in National Forests (Carson, Santa Fe, Cibola, and Gila). The main stem of the Rio Grande flows through large tracts of Bureau of Land Management holdings, as well as the Middle Rio Grande Conservancy District and Elephant Butte Irrigation District. Cultivated cropland or orchards occupy about 7% of the basin. This form of agriculture is particularly dense in the Española Valley, Middle Rio Grande Valley, and the Mesilla Valley. Other reaches are used extensively for livestock grazing.

San Juan Watershed
In New Mexico the San Juan River Watershed occurs almost entirely within San Juan County. The San Juan River originates in the San Juan Mountains of southwestern Colorado, enters New Mexico northeast of Farmington, and flows westward for about 93 mi (150 km) to exit the state near the Four Corners area. Navajo Dam impounds the upper 19 mi (30 km) of the river in New Mexico. From Navajo Dam downstream to Farmington the river is restricted to a single, moderately incised channel and habitats are mainly cobbled riffles, moderately deep runs, and large pools. Gradient diminishes as the river progresses downstream from Farmington to Shiprock, but flow remains mostly in a single channel. Downstream of Shiprock the channel is frequently divided among two, three, or four courses. Habitat diversity increases with channel complexity. In addition to habitats common in upstream reaches backwaters, embayments, shoals, and secondary channels (having their own mix of habitats) are present. Navajo Dam controls flows in the river and several low-head diversion dams seasonally diminish discharge. The San Juan River within New Mexico is permanently-watered, but permanently flowing tributaries are currently limited to the Navajo, Animas, and Mancos rivers. The San Juan River upstream of Four Corners drains about 6.9 million ac (2.8 million ha) including portions of the system in Colorado. The Bureau of Land Management administers much of the watershed upstream of Farmington and large portions of the watershed are within Navajo Nation and Jicarilla Apache jurisdiction.

Aquatic habitats of the San Juan Watershed are influenced by regulated flows, channelization, water diversion, runoff from municipalities, roads, and row-cropped agricultural lands, and petroleum-extraction activities. Currently, Navajo Reservoir operates to mimic a natural hydrograph as per conditions of a Biological Opinion issued to Bureau of Reclamation by the US Fish and Wildlife Service. Considerable data on water quality and habitats of the main stem of the San Juan River are available in various reports produced by the San Juan River Basin Recovery Implementation Program.

Tularosa Watershed
The Tularosa Basin encompasses approximately 3.2 million ac (1.2 million ha) in south central New Mexico in the northern Chihuahuan Desert. It is a closed basin, meaning that all of the water within the watershed remains in the watershed and that there is no inlet or outlet. Because much of the Tularosa Basin is federal government property (White Sands Missile Range, Holloman Air Force Base, White Sands National Monument), there has been limited development in the watershed.

The closed Tularosa Basin includes parts of Torrance, Socorro, Lincoln, Otero, and Dona Ana Counties and the municipalities of Alamogordo, Carrizozo, and Mountainair. Between 1990 and 2000, population growth in the basin varied from a 65% increase in Torrance Country to a 20% increase in Otero County.

Zuni Watershed
The Zuni River drains about 800,000 ac (300,000 ha) as it flows from its headwaters in west-central New Mexico to the Little Colorado River in Arizona. Continuous flow is absent from the headwaters downstream to the Arizona/New Mexico border and surface flow is generally only continuous during heavy spring run-off. Many stream reaches are dry except near perennial

springs. Headwaters of the Zuni River watershed include 1st and 2nd order streams such as Rio Nutria and Tampico Draw. Lower areas of the watershed include the main stem of the Zuni River, a 3rd and 4th order system, and associated impoundments such as Black Rock Reservoir. The Little Colorado River Watershed in New Mexico includes parts of San Juan, McKinley, Valencia, and Catron Counties and the municipalities of Gallup, Zuni, Quemado, and Ramah. Landownership is primarily private and Forest Service in the upper watershed and tribal in the lower areas.

Post-European settlement changes to the landscape and subsequent effects on the Zuni River watershed are well documented (see *Zuni River Watershed Plan*, NRCS 1998, for a summary). The watershed was severely degraded by extensive logging and overgrazing in the late 1800s and early to mid 1900s. Resultant removal of vegetation increased surface erosion, gullying, and headcutting and caused wide discharge fluctuations and loss of water from the system. The effects were so severe that the Pueblo of Zuni brought litigation against the United States government in the early 1970s. The settlement, entitled the Zuni River Watershed Act of 1990, seeks to restore tribal lands damaged because of upstream misuse of resources.

Subsequent to impacts of the early 20th century, the Zuni River was dammed for flood control, irrigation storage, and recreational fishing. In addition, water withdrawals for irrigation and human consumption led to decreased surface discharge in the system. Water quality in the Zuni River watershed is largely unknown; however, limited monitoring in the Zuni River above Black Rock Reservoir indicates that the water is fairly hard, with a mean total dissolved solids concentration of 537 mg/l and heavy metals well below allowable standards.

Habitat/Vegetation Classification Systems

Habitat and vegetation classification systems are hierarchical systems that describe units used for analyses at the state or local level. Habitat conservation is an important component of species-level conservation and can serve as a mechanism for conserving more common species that are not treated individually in the CWCS.

Within New Mexico, SWReGAP mapped 89 land cover classes. Rare land cover types and riparian areas were generally poorly mapped due to limitations of remote sensing techniques.

We employed land cover types modeled by the Southwest Regional Gap Analysis Project (SWReGAP)(NatureServe 2004b) as our terrestrial habitat classification system. The SWReGAP land cover was created by classifying remotely sensed Enhanced Thematic Mapper plus (ETM+) satellite imagery. SWReGAP mapped 125 land cover classes throughout the states of Arizona, Colorado, New Mexico, Nevada, and Utah. Within New Mexico there were 89 land cover classes mapped (Appendix D). Rare land cover types and land cover types occurring in linear strands (e.g., riparian vegetation) were generally poorly mapped due to limitations of remote sensing techniques.

The New Mexico Department of Game and Fish (NMDGF) identified 23 aquatic habitats that are important to the aquatic fauna of New Mexico. These habitat types ranged from ephemeral playas to large 5th order perennial streams (Appendix E). The diversity of aquatic habitats varies among and within watersheds.

Key Habitat Types

New Mexico Department of Game and Fish identified 19 key habitat types, 9 terrestrial and 10 aquatic, from the 89 land cover types modeled by SWReGAP and 23 aquatic habitat types (Approach Chapter; Table 2-4).

Nineteen key landscape habitat types were identified:
- 9 terrestrial, and
- 10 aquatic.

Descriptions of Key Terrestrial Habitat Types

Chihuahuan Semi-Desert Grasslands

Chihuahuan Semi-desert Grasslands is a broadly defined desert grassland, mixed shrub-succulent or xeromorphic tree savanna that is typical of the borderlands of Arizona, New Mexico and northern Mexico. This intermingled and naturally fragmented habitat type contains a highly varied flora with taxa from the lower and warmer elevations as well as taxa from the evergreen-oak woodland and chaparral of the higher and cooler elevations (McClaran 1995). It is found on gently sloping bajadas and on mesas, and steeper piedmont and foothill slopes in the Chihuahuan Desert. This habitat type also includes relatively small depressions on broad mesas and plains, and valley bottoms that receive runoff from adjacent areas. These depressions have deep, fine-textured soils that are neutral to slightly saline/alkaline. Vegetation on the bajadas, mesas, and piedmont slopes is typically characterized by diverse perennial grasses. Common grass species include black grama (*Bouteloua eriopoda*), hairy grama (*B. hirsuta*), Rothrock's grama (*B. rothrockii*), sideoats grama (*B. curtipendula*), blue grama, plains lovegrass (*Eragrostis intermedia*), bush muhly (*Muhlenbergia porteri*), curlyleaf muhly (*Muhlenbergia setifolia*), James' galleta (*Pleuraphis jamesii*), tobosagrass (*Pleuraphis mutica*), and alkali sacaton (*Sporobolus airoides*). Succulent species include agave, dasylirion, and yucca. Vegetation in the depressions is typically dominated by tobosa swales or other mesic graminoids such as western wheatgrass (Pascopyrum smithii), vine mesquite (*Panicum obtusum*), alkali sacaton, or big sacaton (*Sporobolus wrightii*). With tobosa swales, sand-adapted species such as soaptree yucca (*Yucca elata*) may grow at the swale's edge in the deep sandy alluvium that is deposited there from upland slopes. Alkali sacaton and big sacaton are more common in alkaline soils (Johnson 1974, Dinerstein *et al*. 2000, NatureServe 2004b).


Photo of soaptree yucca (*Yucca elata*) in Chihuahuan semi-desert grassland habitat. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Intermountain Basins Big Sagebrush Shrubland

The Intermountain Basins Big Sagebrush shrubland is a cold desert located in the northwestern to north central part of New Mexico (Dick-Peddie 1993), and typically occurs in broad basins between mountain ranges, plains and foothills at altitudes of 4,920-7,545 ft (1,500-2,300 m). Soils are typically deep, well-drained and non-saline. These shrublands are dominated by basin big sagebrush (*Artemisia tridentate tridentate*) and/or Wyoming big sagebrush (*A. t. wyomingensis*), while scattered Juniper, greasewood (*Sarcobatus vermiculatus*) and saltbrush (*Atriplex* spp.) may also be present. Rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), antelope bitterbrush (*Purshia tridentate*), or mountain snowberry (*Symphoricarpos oreophilus*) may codominate disturbed stands. Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species include Indian ricegrass (*Achnatherum hymenoides*), blue grama, streambank wheatgrass (*Elymus lanceolatus*), Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), basin wildrye (*Leymus cinereus*), James' galleta, western wheatgrass, Sandberg bluegrass (*Poa secunda*), or bluebunch wheatgrass (*Pseudoroegneria spicata*) (NatureServ 2004b).


Madrean Encinal habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by SWReGAP.

<u>Madrean Encinal</u>

Madrean Encinal occurs on foothills, canyons, bajadas and plateaus in southern New Mexico. These woodlands are dominated by Madrean evergreen oak species. Emory oak (*Quercus emoryi*) is the most common tree species in Madrean Encinals, and is found in associations with varying intermixtures of Mexican blue oak (*Q. oblongifolia*), gray oak (*Q. grisea*) silverleaf oak (*Q. hypoleucoides*), and Arizona white oak (*Q. arizonica*) (Ffolliott 1980, Brown 1982, McPherson 1992, McPherson 1997, McLaren and McPherson 1999). Arizona cypress (*Cupressus arizonica*), piñon, and juniper trees may be present, but do not codominate. Tree stand density and openess of the landscape are related to local site characteristics such as soils, fire disturbance and land use histories (Gottfried *et al.* 1995, Ffolliott 2002). Lower elevation stands are typically open woodlands or savannas where they transition into desert grasslands, chaparral, or desertscrub. Chaparral species include pointleaf manzanita (*Arctostaphylos pungens*), alderleaf mountain mohagany (*Cercocarpus montanus*), cliffrose and bitterbrush (*Purshia* spp.), Wright's silktassel (*Garrya wrightii*), Sonoran scrub oak (*Quercus turbinella*), beechleaf frangula (*Frangula betulifolia*), and sumac (*Rhus* spp.) (NatureServe 2004b).

The three-needled Mexican piñon (*Pinus cembroides*), alligator juniper (*Juniperus deppeana*), and red berry juniper (*J. erythrocarpa*) are often found in Madrean Encinal habitats of southern New Mexico and Arizona (Gottfried *et al.* 1995). Madrean Encinal also includes seral stands dominated by shrubby Madrean oaks typically with a strong graminoid layer that is dominated by warm-season grasses such as threeawn (*Aristida* spp.), blue grama, sideoats grama, Rothrock's grama, Arizona cottontop (*Digitaria californica*), plains lovegrass, curly-mesquite (*Hilaria belangeri*), green sprangletop (*Leptochloa dubia*), muhly (*Muhlenbergia* spp.), James' galleta, or Texas bluestem (*Schizachyrium cirratum*) (NatureServe 2004b). Common grass species include sideoats grama, blue grama, hairy grama, and purple grama (*Bouteloua radicosa*), plains lovegrass and Mexican lovegrass (*Eragrostis mexicana*), muhly's bullgrass (*Muhlenbergia emersleyi*), and longtongue (*M. longiligula*) (Brown 1982, McClaren *et al.* 1992, McPherson 1992, McPherson 1994, McPherson 1997, McLaren and McPherson 1999).

<u>Madrean Pine-Oak Conifer-Oak Forest and Woodland</u>
Madrean Pine-Oak Conifer-Oak Forest and Woodland occurs on mountains and plateaus in southern New Mexico and is composed of Madrean pines (Arizona (*Pinus arizonica*), Apache (*Pinus engelmannii*), Chihuahuan (*Pinus leiophylla*), or southwestern white (*Pinus strobiformis*) pines) and evergreen oaks (Arizona white, Emory, and gray oaks) intermingled with patchy shrublands on most mid-elevation slopes (4,920-7,545 ft; 1,500-2,300 m). Other tree species include Arizona cypress, alligator juniper, Mexican piñon, border piñon (*Pinus discolor*), and ponderosa pine (with Madrean pines or oaks). Soil moisture could at times be the principal limiting factor for vegetation in this dry region (Felger and Johnson 1995). Subcanopy and shrub layers may include typical encinal and chaparral species such as *Agave* spp., Arizona madrone (*Arbutus arizonica*), Pringle manzanita (*Arctostaphylos pringlei*), pointleaf manzanita, Wright's silktassel, beargrass (*Nolina* spp.), and Sonoran scrub oak. This habitat type can also be characterized by large- and small-patch forests and woodlands dominated by Douglas fir, Coahuila fir (*Abies coahuilensis*), or white fir (*Abies concolor*), and Madrean oaks such as silverleaf oak and netleaf oak (*Quercus rugosa*). Some stands have moderate cover of perennial graminoids such as bullgrass, longtongue muhly, screwleaf muhly (*Muhlenbergia virescens*), and Texas bluestem (NatureServe 2004b). Fires are frequent with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent ground fires on gentle slopes. The current distribution of Madrean pine-oak and oak-conifer forests and woodlands is the result of shifting climatic conditions over the past 24,000 years (Jackson 1970). During the late Quaternary, 8,000 to 35,000 years before present, temperatures in the southwestern US were 5-6 degrees cooler and precipitation was 20-25% greater than current conditions (Merrill and Pewe 1977).

Analysis of plant matter in ancient packrat middens has allowed documentation of the changing distributions of vegetation types over the past 22,000 years in the Apache Highlands ecoregion (Van Devender and Spaulding 1979). The study of ancient pollen grains from the region indicates an upward vertical movement of vegetation zones of at least 3,000-4,000 ft (915 to 1,220 m) during pluvial times (Hevly and Martin 1961). This displacement allowed Rocky Mountain forest flora to spread southward into the Madrean pine-oak and oak-conifer forests and woodlands of the Southwestern US. In general, these highest forest zones are more representative of Rocky Mountain flora, with the lower elevation Madrean Encinal more representative of the Madrean flora of Mexico. Climatic patterns at local and regional scales have influenced the establishment and survival of these vegetational systems over the last 24,000 years (Gottfried *et al.* 1995).

<u>Rocky Mountain Alpine-Montane Wet Meadow</u>
Rocky Mountain Alpine-Montane Wet Meadows are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from 3,280-1,800 ft (1000-3600 m). Soils of this system may be mineral or organic and display hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. The most important factor controlling the distribution and growth of alpine plants is soil moisture (Billings and Mooney 1968). These habitat types can occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toe slope seeps and are typically found on flat areas or gentle slopes, but may also

occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late melting snow patches or on snow beds. This habitat often occurs as a mixture of several plant associations, often dominated by graminoids, including slimstem reedgrass (*Calamagrostis stricta*), white marsh marigold (*Caltha leptosepala*), heartleaf bittercress (*Cardamine cordifolia*), sheep sedge (*Carex illota*), smallwing sedge (*Carex microptera*), black alpine sedge (*Carex nigricans*), mountain sedge (*Carex scopulorum*), Northwest Territory sedge (*Carex utriculata*), native sedge (*Carex vernacular*), tufted hairgrass (*Deschampsia caespitosa*), fewflower spikerush (*Eleocharis quinqueflora*), Drummond's rush (*Juncus drummondii*), icegrass (*Phippsia algida*), alpine yellowcress (*Rorippa alpine*), arrowleaf ragwort (*Senecio triangularis*), Parry's clover (*Trifolium parryi*), and American globeflower (*Trollius laxus*). Often alpine dwarf-shrublands, especially those dominated by willow (*Salix*), are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding (NatureServe 2004b).

Rocky Mountain Montane Mixed Conifer Forest and Woodland

Rocky Mountain Montane Mixed Conifer Forest and Woodland is a highly variable habitat of the montane zone of the Rocky Mountains. These are mixed-conifer forests occurring on all aspects at elevations ranging from 3,900-10,800 ft (1,200-3,300 m). Rainfall averages less than 30 in (75 cm) per year with summer "monsoons" during the growing season contributing substantial moisture. Douglas fir and white fir are most common canopy dominants, but Engelmann spruce (*Picea engelmannii*), or blue spruce may be present, with ponderosa pine being present to codominant. Douglas fir forests occupy drier sites, and white fir-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. Blue spruce is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. This system also includes mixed conifer/aspen stands. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including a few maple (*Acer* spp.) and blueberry (*Vaccinium*) species, gray alder (*Alnus incana*), kinnikinnick (*Arctostaphylos uva-ursi*), water birch (*Betula occidentalis*), redosier dogwood (*Cornus sericea*), Arizona fescue (*Festuca arizonica*), fivepetal cliffbush (*Jamesia Americana*), creeping barberry (*Mahonia repens*), Oregon boxleaf, (*Paxistima myrsinites*), Kuntze mallow ninebark (*Physocarpus malvaceus*), New Mexico locust (*Robinia neomexicana*), mountain snowberry, and Gambel oak (*Quercus gambelii*). Herbaceous species include fringed brome (*Bromus ciliatus*), Geyer's sedge (*Carex geyeri*), Ross' (*Carex rossii*), dryspike sedge (*Carex siccata*), screwleaf

Rocky Mountain Montane Mixed Conifer Forest and Woodland habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by SWReGAP.

muhly, bluebunch wheatgrass, sprucefir fleabane (*Erigeron eximius*), Virginia strawberry (*Fragaria virginiana*), smallflowered woodrush (*Luzula parviflora*), sweetcicely (*Osmorhiza berteroi*), bittercress ragwort (*Packera cardamine*), western meadow-rue (*Thalictrum occidentale*), and Fendler's meadow-rue (*Thalictrum fendleri*) (NatureServe 2004). Naturally occurring fires are characterized by a high degree of variable return intervals and lethality due to the range of moisture found in this habitat.

<u>Western Great Plains Sand Sagebrush</u>
Western Great Plains Sand Sagebrush is found mostly in southeastern areas New Mexico. The climate is semi-arid to arid. Soils are somewhat to excessively well-drained, deep and sandy and are often associated with dune systems and ancient floodplains. This habitat type is characterized by a sparse to moderately dense woody layer dominated by sand sagebrush (*Artemisia filifolia*). In some areas, this habitat may actually occur as a result of overgrazing in prairie habitats, leading to decreasing dominance of some of the grass species such as sand bluestem (*Andropogon hallii*), giant sandreed (*Calamovilfa gigantean*), and little bluestem (*Schizachyrium scoparium*). Associated species can vary with geography, amount and season of precipitation, disturbance and soil texture. These species include several graminoid species, such as sand bluestem, little bluestem, sand dropseed (*Sporobolus cryptandrus*), giant sandreed, needle and thread, and grama spp.; other shrub species, such as soapweed yucca (*Yucca glauca*), honey mesquite (*Prosopis glandulosa*), skunkbush sumac (*Rhus trilobata*), and Chickasaw plum (*Prunus angustifolia*); and, in the southern range, Havard oak (*Quercus havardii*). Havard oak is able to resprout following a fire and thus may persist for long periods of time once established. Fire and grazing are the most important dynamic processes for this type, although drought stress can impact this system significantly in some areas (NatureServe 2004).

<u>Western Great Plains Shortgrass Prairie</u>
Western Great Plains Shortgrass Prairie is found primarily in the eastern third of New Mexico and occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sandy to clayey. This habitat forms a matrix system with blue grama dominating. Associated graminoids may include purple threeawn (*Aristida purpurea*), sideoats grama, hairy grama, buffalograss, needle and thread, prairie Junegrass (*Koeleria macrantha*), western wheatgrass, James' galleta, alkali sacaton and sand dropseed. Although mid-height grass species may be present especially on more mesic land positions and soils, they are secondary in importance to the sod-forming short grasses. Sandy soils have higher cover of needle and thread, spike dropseed (*Sporobolus cryptandrus*), and soaptree yucca. Scattered shrub and dwarf-dwarf species such as sand sagebrush, prairie sagewort (*Artemisia frigida*), big sagebrush (*Artemisia tridentate*), fourwing saltbrush (*Atriplex canescens*), spreading buckwheat (*Eriogonum effusum*), broom snakeweed (*Gutierrezia sarothrae*), wolfberry (*Lycium palida*), may also be present. High variation in amount and timing of annual precipitation impacts the relative cover of cool and warm season herbaceous species. Large-scale processes such as climate, fire, and grazing influence this habitat. Fire is less important than other prairie habitats because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency. The short grasses that dominate this habitat type are extremely drought and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing (NatureServe 2004).


Riparian habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Riparian Habitats

Riparian habitats are assemblages of plant, animal, and aquatic communities whose presence can be either directly or indirectly attributed to stream-induced or related factors (Kauffman and Krueger 1984). These habitats tend to support a greater diversity of plants and animals than upland habitats. A significant percentage of all wildlife in the Southwest uses riparian habitat (Thomas *et al.* 1979, Johnson *et al.* 1977) and approximately 80% of all sensitive and specially classified vertebrate species in New Mexico depend upon riparian or aquatic habitat at some time during their life cycle (New Mexico Department of Game and Fish 2000).

Wetlands and riparian ecosystems comprise less than 1% of New Mexico (Dahl 1990, Henrickson and Johnston 1986, Allen and Marlow 1992). Riparian habitats occur where water is perennial, intermittent, or ephemeral. Their relatively small size, elevational continuum, complexity, and variation present a significant challenge to mapping their aerial extent. Thus, there are no reliable estimates for the acreage of riparian habitats in New Mexico.

Dick-Peddie (1993) classified riparian habitats in New Mexico into: 1) alpine riparian, 2) montane riparian, 3) floodplain-plains riparian, 4) arroyo riparian, and 5) closed basin riparian. Alpine riparian areas are similar to subalpine grasslands (Dick-Peddie 1993) communities and are discussed in the Alpine Wet Meadow section in the Southern Rocky Mountain Ecoregion. We grouped arroyo riparian and closed basin riparian types because of their similarity in New Mexico.


Riparian habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Sixteen SWReGAP land cover types illustrate riparian habitats in New Mexico (Table 3-4). Floodplain-Plains riparian communities occur primarily along the major rivers of New Mexico. Xeric riparian communities included basins, playas, alkali sinks, and arroyos. Many of New Mexico's riparian communities have been altered by invasive species. Their presence in riparian communities is sufficient enough to be mapped using remotely sensed data (SWReGAP: http://fws-nmcfwru.nmsu.edu/swregap/). While this community is likely more prevalent in the floodplain-plains riparian communities, invasive riparian communities are present throughout New Mexico riparian systems.

Table 3-4. SWReGAP land cover types (NatureServe 2004b) used to illustrate riparian communities in New Mexico.

Riparian Type	SWReGAP Land Cover Types
Montane Riparian	
	Rocky Mountain Bigtooth Maple Ravine Woodland
	Rocky Mountain Subalpine-Montane Riparian Shrubland
	Rocky Mountain Subalpine-Montane Riparian Woodland
	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
Floodplain-Plains Riparian	
	Western Great Plains Riparian Woodland and Shrubland
	North American Warm Desert Riparian Woodland and Shrubland
	North American Warm Desert Riparian Mesquite Bosque
	North American Arid West Emergent Marsh
Xeric Riparian	
	Inter-Mountain Basins Greasewood Flat
	Inter-Mountain Basins Greasewood Wash
	Inter-Mountain Basins Playa
	North American Warm Desert Wash
	North American Warm Desert Playa
	Western Great Plains Saline Depression
Invasive Riparian Communities	
	Invasive Southwest Riparian Woodland and Shrubland

Rocky Mountain Bigtooth Maple Ravine Woodland
This ecological system occurs in scattered localities in New Mexico. It is dominated by bigtooth maple (*Acer grandidentatum*) but can include mixed stands of Gambel oak or with scattered conifers. Some stands may include box elder (*Acer negundo*) or quaking aspen (*Populus tremuloides*) as minor components (NatureServe 2004b).

Rocky Mountain Subalpine-Montane Riparian Shrubland
The montane/subalpine riparian shrubland ecological system is a linear and small patch system confined to specific environments occurring on floodplains or terraces of the upper Rio Grande and its tributaries (Rondeau 2001). It primarily occurs in shallow broad valleys. This ecological system can be found within a broad elevation range, from approximately 8,000-11,000 ft (2,400-3,350 m). It often occurs as a mosaic of multiple communities that are shrub-dominated. The dominant shrubs reflect the large elevational gradient and include gray alder, dwaft birch (*Betula glandulosa*), water birch, redosier dogwood, and willow species (*Salix* spp.) (NatureServe 2004b). Generally, the upland vegetation surrounding these riparian systems is either conifer or aspen forests, while adjacent riparian systems range from herbaceous-dominated communities to tree-dominated communities. Beavers are primary users and drivers of this ecological system and the foremost species necessary to maintain its hydrology. Annual and episodic flooding is important, too, as any alteration of the flooding regime may produce changes to plant composition or community composition (Kittel *et al*. 1999). Aquatic species and water quality may be as important as vegetation as indicators of system health.

Rocky Mountain Subalpine-Montane Riparian Woodland
The montane/subalpine riparian forest and woodland ecological system is a linear system confined to specific environments occurring on floodplains or terraces of rivers and streams (Rondeau 2001). It is the primary riparian matrix of the upper Rio Grande watershed. The montane/subalpine riparian woodland ecological type forms small patches within this linear-matrix system. Upper montane/subalpine riparian forest and woodland occurs at higher elevations (8,000-11,000 ft; 2,400-3,350 m) and contains a mosaic of one or two communities dominated by either white and subalpine fir, Englemann and blue spruce, or aspen (Fullerton and Batts 2003, NatureServe 2004b).

Rocky Mountain Lower Montane Riparian Woodland and Shrubland
The lower montane riparian woodland ecological system is a linear system confined to specific environments occurring on floodplains or terraces (Rondeau 2001). It is scattered throughout the upper watershed within a broad elevation range, from approximately 3,000-9,000 ft (900-2,700 m). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The plant associations connected to this system reflect a variety of elevations, stream gradients, floodplain widths, and flooding events. The dominant trees may include boxelder, cottonwood, balsam poplar (*P. balsamifera*), Douglas fir, blue spruce, or Rocky Mountain juniper (*Juniperus scopulorum*). Dominant shrubs include Rocky Mountain maple (*Acer glabrum*), gray alder, birch, dogwood, and willow species. The upland vegetation surrounding this riparian system can range from forests to grasslands (NatureServe 2004b).

North American Warm Desert Lower Montane Riparian Woodland and Shrubland
This system consists of mid-low elevation (3,600-5,900 ft; 1,100-1,800 m) riparian corridors along perennial and seasonally intermittent streams throughout canyons and valleys of southern New Mexico. This system occurs along the upper Gila River and its tributaries, the upper San Francisco River and its tributaries, the upper Zuni River and its tributaries, and probably the upper reaches of streams draining the east slopes of the Sierra Blanca, Sacramento Mountains, and Guadalupe Mountains. Dominant species of this system include gray alder, river hawthorn (*Crataegus rivularis*), stetchberry (*Forestiera pubescens*), cottonwood (*Populus* spp.), wild plum (*Prunus virginina*), skunkbush sumac, and willow species (NatureServe 2004b). The surrounding upland systems range from grasslands, to shrublands and woodlands. Within the levees between Las Cruces and El Paso, this habitat is extremely fragmented and of low quality (Fullerton and Batts 2003). There is little or no regeneration due to the lack of floods, and to frequent mowing inside the levees. There are isolated pockets of remnant cottonwood–willow habitat, but saltcedar is dominant.

Western Great Plains Riparian Woodland and Shrubland
This ecological system is found in medium and small rivers and streams throughout eastern New Mexico. It can occur as far west as the Rio Grande. Dominant species can include cottonwood, willow, silver sagebrush (*Artemisia cana*), western wheatgrass, spike dropseed, and little bluestem (NatureServe 2004b).

North American Warm Desert Riparian Woodland and Shrubland
This ecological system consists of low elevation (< 3,900 ft; 1,200 m) riparian corridors along medium to large perennial streams throughout New Mexico. It occurs along the main stems and

tributaries of lower Gila River, lower San Francisco River, the lower Zuni River, and probably the lower reaches of streams draining the east slopes of the Sierra Blanca, Sacramento Mountains, and Guadalupe Mountains (NatureServe 2004b).

North American Warm Desert Riparian Mesquite Bosque
This ecological system consists of low-elevation (< 3,600 ft; 1,100 m) riparian corridors along intermittent streams in southern New Mexico. The dominant trees include honey mesquite with shrubs including seep willow (*Baccharis salicifolia*), arrow-weed (*Pluchea sericea*), and coyote willow (*Salix exigua*)(NatureServe 2004b).

North American Arid West Emergent Marsh
This ecological system occurs throughout the arid and semi-arid regions of New Mexico. These marshes can occur in depressions, around lakes, and along streams and rivers. Soils have anaerobic characteristics and plants that occur are adapted to saturated soil conditions. Common plants include species of sedges (*Scirpus* spp.) and/or cattail (*Typha* spp.), rush (*Juncus* spp.), pondweed (*Potamogeton* spp.), and reed (*Phalaris* spp.)(NatureServe 2004b).

Inter-Mountain Basins Greasewood Flat
This ecological system is a complex of many communities dominated or codominated by greasewood, fourwing saltbush (*Atriplex canescens*), shadescale saltbush (*Atriplex confertifolia*), or winterfat (*Krascheninnikovia lanata*). It occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas and can be open to moderately dense shrublands (NatureServe 2004b).

Inter-Mountain Basins Greasewood Wash
This ecological system is barren and sparsely vegetated restricted to intermittently flooded streambeds and banks. Shrubs include greasewood, rubber rabbitbrush, Apache plume (*Fallugia paradoxa*), and/*or* silver sagebrush. A continuous or intermittent linear canopy in and along drainages occurs but does not extend out into flats. Saltgrass (*Distichlis spicata*) meadows can occur where water remains for the longest periods (NatureServe 2004b).

Inter-Mountain Basins Playa
This ecological system is comprised of barren and sparsely vegetated playas found in the intermountain west. The system is characterized by species such as iodinebush (*Allenrolfea occidentalis*), greasewood, spiny hopsage (*Grayia spinosa*), lemmon's alkali grass (*Puccinellia lemmonii*), basin wildrye, inland saltgrass, and saltbrush (NatureServe 2004b).

North American Warm Desert Wash
This ecological system occurs in intermittent washes or arroyos that dissect bajadas, mesas, and plains of the warm deserts. This habitat type occurs as linear or braided strips within desert vegetation matrix. The vegetation can be quite variable ranging from sparse to moderately dense often on the banks, but can occur within the steam channel. Species that are dominant in this system include catclaw acacia (*Acacia greggii*), cut-leaf brickellia (*Brickellia laciniata*), desert broom (*Baccharis sarothroides*), desert willow (*Chilopsis linearis)*, Apache plume, burro brush (*Hymenoclea monogyra* and *H. salsola*), mesquite, littleleaf sumac (*Rhus microphylla*), and greasewood (NatureServe 2004b).

North American Warm Desert Playa
This ecological system is comprised of barren and sparsely vegetated playas found across the warm deserts. Larger playas have vegetation rings which are formed in response to salinity. Species characterizing this system include iodinebush, inland saltgrass, common spike rush (*Eleocharis palustris*), ricegrass (*Oryzopsis* spp.), dropseed, and saltgrass (NatureServe 2004b).

Western Great Plains Saline Depression
This ecological system is comprised of shallow lakes and depressions with strongly saline soils. Salt encrustations can occur on the surface in some these areas and vegetation must be salt-tolerant species such as inland saltgrass, alkali sacaton, and foxtail barley (*Hordeum jubatum*). During wet years, less tolerant species can occur as the increase in precipitation dilutes the salt concentration (NatureServe 2004b).

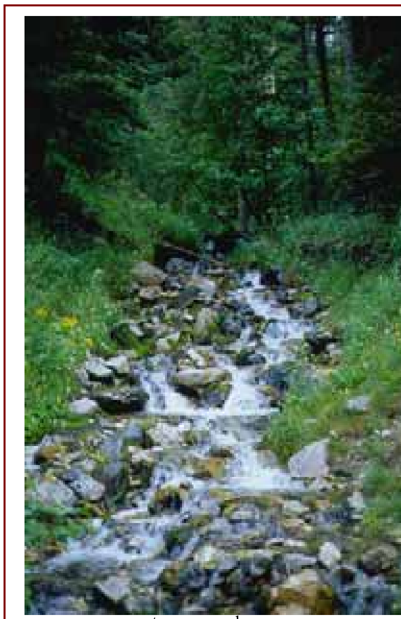
Invasive Southwest Riparian Woodland and Shrubland
This is a semi-natural system predominantly comprised of saltcedar and Russian olive (*Elaegnus angustifolus*) (NatureServe 2004b). This vegetation type can occur throughout the state but is often found within perennial drainages and around lakes.

Ten key aquatic habitats were identified in New Mexico.

Descriptions of Key Aquatic Habitat Types
Perennial Marsh/Cienega/Spring/Seep
Perennial marsh/cienegas occur statewide as geographically isolated wet depressions or seeps that are hydrologically supported by seasonal discharge of shallow groundwater aquifers and precipitation events. These wet areas collect and hold water that commonly supports moisture-loving plants (e.g., marsh emergents), soils, and wildlife.

Perennial Large Reservoir
Large reservoirs (>1,000 ha) occur on many of New Mexico drainages. Elephant Butte, Navajo, Heron, El Vado, Abiquiu, Ute, Sumner, Brantly, Red Bluff, Caballo, Conchas, Cochiti, and Eagle Nest are large reservoirs in New Mexico. These reservoirs are managed for irrigation and/or flood control. They support a diverse sport fishery of primarily non-native fish. Dams associated with these large reservoirs alter the natural flow regime and influence up- and down-stream habitats.

Perennial 1st and 2nd Order Stream
Headwater streams are 1st order streams. When two 1st order streams join, they form a 2nd order stream. Perennial 1st and 2nd order streams occur in all watersheds except the San Juan.


Perennial 1st and 2nd Order Stream habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Perennial 3rd and 4th Order Stream

When two 2nd order streams join, they form a 3rd order stream. Similarly, when two 3rd order streams join, they form a 4th order stream. Perennial 3rd and 4th order streams occur in all watersheds except the Tularosa.

Perennial 3rd and 4th Order Stream habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Perennial 5th Order Stream

When two 4th order streams join, they form a 5th order stream. In New Mexico, 5th order streams are the Rio Grande, Pecos, San Juan and Gila River.

Perennial Tank

Perennial tanks occur statewide and are hydrologically supported by natural springs, seepage from permanent streams, and precipitation events. These permanent tanks collect and hold water for sufficient periods to support wildlife and numerous emergent and submerged aquatic plants. Cattails and larger sedges often form thick mats on the stabilized banks that may extend some distance into the tank.

Ephemeral 1st and 2nd Order Stream

Based on US Geological Survey maps (1:2,000,000 Digital Line Graph), approximately 80 percent of the drainages in New Mexico are ephemeral. More than 3,900 miles of intermittent streams exist within geographically isolated, closed basins statewide (NMDGF 2003).

Ephemeral Man-Made Catchments

In New Mexico, man-made depressions occur statewide and serve as ephemeral catchments for seasonal run-off waters. These depressions are variously termed dirt tanks, stock tanks, drinkers, and catchments. Roadside pools, created as borrow pits or storm water run-off storage basins, also are included in this category.

Perennial tank habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo by provided by NMCFWRU.

Ephemeral Natural Catchments

Ephemeral natural catchments exist in all ecoregions of New Mexico (Cole 1996, Jones 1997) as geographically isolated wetlands that are commonly termed "playas" or "prairie potholes" (NMAC 2000). Ephemeral natural catchments vary in size from less than an acre to several hundred acres, and can occur at any elevation as a network of isolated wetlands within endorheic basins or flyways (Central or Intermountain West), or as isolated depressions found statewide.

Playas of the Southern High Plains of eastern New Mexico and adjacent states (Colorado, Oklahoma, Texas) are perhaps the most recognized and well-studied type of ephemeral wetland in the state (Smith 2003), where it is estimated that some 2,460 playa lakes occur on the "Llano Estacado" south of the Canadian River drainage (Guthery and Bryant 1982). However, playa lakes represent but one type of a great diversity of ephemeral wetland habitat types found throughout New Mexico. Additional descriptive names of ephemeral natural catchments may include: salt basins (salterns, flats or lakes), alkali flats, tinajas (rock pools), grassland and woodland vernal pools, karst sinkholes, swales, among others (Witham 1998, Erikson and Belk 1999, Lang and Rogers 2002, Tiner *et al.* 2002, Tiner 2003, Zedler 2003).

Ephemeral natural catchment habitat in New Mexico. This photo records a brief moment in time, and does not portray the range of conditions of this habitat type. Photo provided by NMCFWRU.

Ephemeral Marsh/Cienega/Seeps/Springs

Ephemeral marsh/cienegas occur statewide as geographically isolated wet depressions or seeps that are hydrologically supported by seasonal discharge of shallow groundwater aquifers and precipitation events. These seasonally wet areas collect and hold water for sufficient periods that commonly support moisture-loving plants (e.g., marsh emergents), soils, and wildlife.

WILDLIFE SPECIES AND STATUS

Game Species

New Mexico has 103 game species that require either a big game license, federal migratory bird permit, fishing license, furbearer license, small game license, or duck stamp to harvest. This list includes 30 species of mammals, 29 fish, 43 birds, and one amphibian (see Bison-M database for greater details; http://fwie.fw.vt.edu/states/nm.htm).

State Threatened and Endangered Species

The New Mexico Department of Game and Fish emphasizes the need for identifying and protecting endangered wildlife in New Mexico. More than 75 taxa have been extirpated from one or more counties, including six that are considered to be extinct and 19 which have been extirpated from the state (NMDGF 2004a).

A total of 118 species and subspecies are on the 2004 list of state-threatened and state-endangered New Mexico wildlife (NMDGF 2004a). The list includes two crustaceans, 25 molluscs, 23 fishes, six amphibians, 15 reptiles, 32 birds, and 15 mammals. An additional seven species of mammals have been listed as restricted to facilitate control of traffic in federally protected species within New Mexico. A species is state-endangered if it is in jeopardy of extinction or extirpation from the state; a species is state-threatened if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in New Mexico. Only species or subspecies of mammals, birds, reptiles, amphibians, fishes, molluscs, and crustaceans native to New Mexico may be listed as threatened or endangered under the Wildlife Conservation Act. During the Biennial Review, species may be upgraded from threatened to endangered or downgraded from endangered to threatened, based upon data, views, and information regarding the biological and ecological status of the species. Investigations for new listings or removals from the list (delisting) can be undertaken at any time, but require additional procedures from those for the Biennial Review. The 2004 Biennial Review contained recommendations regarding the listing status for each of the 125 species or subspecies listed as threatened, endangered, or restricted under the New Mexico Wildlife Conservation Act (NMDGF 2004a). Of these, 123 were recommended to retain their current listing status. Two species, the Jemez Mountains salamander (*Plethodon neomexicanus*) and sand dune lizard (*Sceloporus arenicolus*), were up-listed from state threatened to state endangered. Both species persist within very limited ranges and have been experiencing increasing threats to their habitats within recent years. Changes from threatened to endangered confer no regulatory authority to the NMDGF over the habitat of these species. However, state-endangered status emphasizes the importance of, and demonstrate the ability for, state-level management to support the long-term persistence of otherwise imperiled native wildlife.

Federal Threatened and Endangered Species

The U.S Fish and Wildlife Service lists 29 New Mexico animal species as threatened or endangered species (USFWS 2005). The list includes one crustacean, two molluscs, 12 fishes, one amphibian, one reptile, eight birds, and five mammals.

Chapter 4
STATEWIDE ASSESSMENT AND STRATEGIES

This chapter describes Species of Greatest Conservation Need in New Mexico and their distribution and abundance (**Element 1**). We further present a synthesis of conservation priorities. This synthesis describes problems affecting habitats and species across New Mexico (**Element 3**) and summarizes information gaps and related research, survey, and monitoring needs (**Element 3**) identified within ecological frameworks and key habitats (Chapter 5) as well as additional points that limit our ability to make informed conservation assessments and decisions. We also summarize the top five conservation actions necessary to overcome problems and achieve desired future outcomes listed in each ecological framework and key habitat (**Element 4**). This level of organization should not supersede those identified and prioritized in Chapter 5. Rather, this organizational framework takes a broader-scale approach to synthesizing prioritized conservation actions applicable to the statewide scale. We anticipate that those who will use this Strategy as a resource and planning guide will reference conservation actions under each ecological framework and key habitat as well as this synthesized approach. We end this chapter with an analysis that enhances our understanding of geographic areas where conservation efforts might be focused.

SPECIES OF GREATEST CONSERVATION NEED

Through the process described in the Approach chapter, 452 Species of Greatest Conservation Need (SGCN) have been identified in New Mexico (Table 4-1). Of these 298 species are fish, birds, mammals, amphibians, reptiles, molluscs, and crustaceans. The remaining 154 species are arthropod species in the classes of Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha. Although the percent of New Mexico's biodiversity represented as SGCN is unknown (the amount of arthropods other than crustaceans in New Mexico is unknown), approximately 26% of New Mexico's vertebrate, mollusc, and crustacean fauna are considered SGCN (Table 4-2). Most of the crustacean fauna (91%; 32 species) in the state are considered SGCN. Conversely, only 15% (74 species) of the birds in the state are considered SGCN. Although little is known about most arthropods in New Mexico, the arthropod working group considers those species designated as SGCN to be appropriate for conservation planning at this time. However, additional taxa may be identified in the future as new information becomes available. Arthropod SGCN (classes Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha) identified to date represent potentially declining species, and taxa that are considered indicative of the health and diversity of New Mexico's varied landscapes, habitats, and natural heritage. Additional information is needed to fully understand the status of these species in New Mexico.

In New Mexico, 452 Species of Greatest Conservation Need have been identified, representing fish, birds, mammals, amphibians, reptiles, molluscs, crustaceans, and other arthropods.

Approximately 26% of New Mexico's vertebrate, mollusc, and crustacean fauna are considered SGCN.

Table 4-1. Species of Greatest Conservation Need (SGCN) identified in New Mexico. Of the 452 species designated as SGCN, 298 species are fish, birds, mammals, amphibians, reptiles, molluscs, and crustaceans. The remaining 154 species are arthropod species in the classes of Arachnida, Chilopoda, Diplopoda, Entognatha, and Insecta. Scientific names to species can be found in Appendix C.

Common or Scientific Name[1]		
Fish		
Smallmouth Buffalo	Rainwater Killifish	Spikedace
Blue Catfish	Bigscale Logperch (Native pop.)	Central Stoneroller
Headwater Catfish	Loach Minnow	Blue Sucker
Chihuahua Chub	Rio Grande Silvery Minnow	Zuni Bluehead Sucker
Gila Chub	Suckermouth Minnow	Desert Sucker
Headwater Chub	Colorado Pikeminnow	Razorback Sucker
Rio Grande Chub	Pecos Pupfish	Rio Grande Sucker
Roundtail Chub	White Sands Pupfish	Sonora Sucker
Speckled Chub	Gray Redhorse	Mexican Tetra
Canadian Speckled Chub	Mottled Sculpin	Gila Topminnow
Southern Redbelly Dace	Pecos Bluntnose Shiner	Rio Grande Cutthroat Trout
Greenthroat Darter	Rio Grande Shiner	Gila Trout
Pecos Gambusia		
Birds		
Eared Grebe	Lucifer Hummingbird	Sage Sparrow
American Bittern	Violet-Crowned Hummingbird	Baird's Sparrow
White-Faced Ibis	Pinyon Jay	Botteri's Sparrow
Neotropic Cormorant	Yellow-Eyed Junco	Grasshopper Sparrow
Common Black-Hawk	Thick-Billed Kingbird	Bank Swallow
Painted Bunting	Hooded Oriole	Black Swift
Varied Bunting	Osprey	Interior Least Tern
Sandhill Crane	Boreal Owl	Bendire's Thrasher
Yellow-Billed Cuckoo	Burrowing Owl	Sage Thrasher
Long-Billed Curlew	Elf Owl	Juniper Titmouse
Mourning Dove	Whiskered Screech-Owl	Abert's Towhee
Northern Pintail	Mexican Spotted Owl	Elegant Trogon
Bald Eagle	Greater Pewee	Gould's Wild Turkey
Golden Eagle	Wilson's Phalarope	Northern Beardless-Tyrannulet
Aplomado Falcon	Band-Tailed Pigeon	Bell's Vireo
Peregrine Falcon	Sprague's Pipit	Gray Vireo
Olive-Sided Flycatcher	Mountain Plover	Grace's Warbler
Southwestern Willow Flycatcher	Snowy Plover	Black-Throated Gray Warbler
Northern Goshawk	Lesser Prairie-Chicken	Lucy's Warbler
Common Ground-Dove	White-Tailed Ptarmigan	Red-Faced Warbler
Blue Grouse	Montezuma Quail	Yellow Warbler
Northern Harrier	Scaled Quail	Gila Woodpecker
Ferruginous Hawk	Painted Redstart	Lewis's Woodpecker
Broad-Billed Hummingbird	Williamson's Sapsucker	Red-Headed Woodpecker
Costa's Hummingbird	Loggerhead Shrike	

Table 4-1 Cont.

Common or Scientific Name[1]		
Mammals		
Allen's Big-Eared Bat	White-Nosed Coati	White-Sided Jack Rabbit
Pocketed Free-Tailed Bat	Mule Deer	White-Tailed Jack Rabbit
Lesser Long-Nosed Bat	Coues' White-Tailed Deer	Yellow-Nosed Cotton Rat
Mexican Long-Nosed Bat	Swift Fox	Desert Bighorn Sheep
Mexican Long-Tongued Bat	Southern Pocket Gopher	Rocky Mountain Bighorn Sheep
Arizona Myotis Bat	Snowshoe Hare	Arizona Shrew
Western Red Bat	Jaguar	Least Shrew
Spotted Bat	American Marten	New Mexico Shrew
Western Yellow Bat	NM Meadow Jumping Mouse	Preble's Shrew
Black Bear	Northern Pygmy Mouse	Abert's Squirrel
American Beaver	River Otter	Arizona Gray Squirrel
Organ Mts. Colorado Chipmunk	Goat Peak Pika	Arizona Montane Vole
Oscura Mts. Colorado Chipmunk	Black-Tailed Prairie Dog	Prairie Vole
Penasco Least Chipmunk	Gunnison's Prairie Dog	Mexican Gray Wolf
Amphibians		
Eastern Barking Frog	Plains Leopard Frog	Tiger Salamander
Western Chorus Frog	Rio Grande Leopard Frog	Arizona Toad
Chiricahua Leopard Frog	Mountain Tree Frog	Western Boreal Toad
Lowland Leopard Frog	Jemez Mountain Salamander	Colorado River Toad
Northern Leopard Frog	Sacramento Mountain Salamander	Great Plains Narrowmouth Toad
Reptiles		
Western River Cooter	Reticulate Gila Monster	Milk Snake
Texas Banded Gecko	Western Diamondback Rattlesnake	Green Rat Snake
California Kingsnake	New Mexico Ridgenose Rattlesnake	Arid Land Ribbon Snake
Gray-Banded Kingsnake	Banded Rock Rattlesnake	Blotched Water Snake
Sonoran Mountain Kingsnake	Mottled Rock Rattlesnake	Ornate Box Turtle
Madrean Alligator Lizard	Mountain Skink	Sonoran Mud Turtle
Collared Lizard	Big Bend Slider	Western Painted Turtle
Bunch Grass Lizard	Yaqui Blackhead Snake	Midland Smooth Softshell Turtle
Regal Horned Lizard	Mexican Garter Snake	Gray-Checkered Whiptail
Sand Dune Lizard	Narrowhead Garter Snake	Giant Spotted Whiptail
Desert Massasauga	New Mexico Garter Snake	
Molluscs		
Alamosa Springsnail	Hacheta Mountainsnail	Western Glass Snail
Blunt Ambersnail	Mineral Creek Mountainsnail	Animas Mountains Holospira Snail
Lake Fingernailclam	Rocky Mountainsnail	Cockerell Holospira Snail
Long Fingernailclam	Socorro Mountainsnail	Cross Holospira Snail
Swamp Fingernailclam	Paper Pondshell Mussel	Metcalf Holospira Snail
Texas Hornshell	Lilljeborg's Peaclam	Texas Liptooth Snail
Wrinkled Marshsnail	Sangre de Cristo Peaclam	Distorted Metastoma Snail
Bearded Mountainsnail	Creeping Ancylid Snail	Chupadera Pyrg Snail
Black Range Mountainsnail	Pecos Assiminea Snail	Gila Pyrg Snail
Black Range Mountainsnail	Crestless Column Snail	New Mexico Hotspring Pyrg Snail
Fringed Mountainsnail	Amber Glass Snail	Pecos Pyrg Snail

Table 4-1 Cont.

Common or Scientific Name[1]		
Molluscs cont.		
Roswell Pyrg Snail	Northern Treeband Snail	Peloncillo Mountain Talussnail
Socorro Pyrg Snail	Koster's Tryonia Snail	San Luis Mountains Talussnail
Whitewashed Radabotus Snail	Vallonia Snail	Tularosa Springsnail
New Mexico Ramshorn Snail	Blade Vertigo Snail	Woodlandsnail
Marsh Slug Snail	Ovate Vertigo Snail	Animas Peak Woodlandsnail
Shortneck Snaggletooth Snail	Animas Talussnail	Big Hatchet Woodlandsnail
Sonoran Snaggletooth Snail	Big Hatchet Mountain Talussnail	Cook's Peak Woodlandsnail
Spruce Snail	Dona Ana Talussnail	Hacheta Grande Woodlandsnail
Star Gyro Snail	Florida Mountain Talussnail	Iron Creek Woodlandsnail
Obese Thorn Snail	Franklin Mountain Talussnail	Jemez Woodlandsnail
Three-Toothed Column Snail	Organ Mountain Talussnail	Sangre de Cristo Woodlandsnail
Crustaceans		
Akali Fairy Shrimp	*Eocyzicus concavus*	*Lynceus brevifrons*
BLNWR cryptic species Amphipod	*Eocyzicus digueti*	Mexican Beavertail Fairy Shrimp
Cryptic Species Amphipod	*Eulimnadia antlei*	Moore's Fairy Shrimp
Noel's Amphipod	*Eulimnadia cylindrova*	Packard's Fairy Shrimp
Beavertail Fairy Shrimp	*Eulimnadia diversa*	Tadpole Shrimp
Brine Shrimp	*Eulimnadia follismilis*	Sideswimmers / Scuds
Colorado Fairy Shrimp	*Eulimnadia texana*	*Streptocephalus n. sp. 1*
Conchas Crayfish	Great Plains Fairy Shrimp	*Streptocephalus n. sp. 2*
Procambarus simulans simulans	Socorro Isopod	Sublette's Fairy Shrimp
Northern (Canadian River) Crayfish	Knobblip Fairy Shrimp	Versatile Fairy Shrimp
Cyzicus sp. (mexicanus?)	*Lepidurus lemmoni*	
Other Arthropods		
Arachnids (Arachnida)		
Texella longistyla	*Aphrastochthonius pachysetus*	Peloncillo Scorpion
Texella welbourni	*Chitrella welbourni*	Jemez Spider
Cave Obligate Mite	*Neoallochernes incertus*	
Centipedes (Chilopoda)	*Millipedes (Diplopoda)*	
Cave Obligate Centipede	Cave Obligate Millipede	Chihuahuan Millipede
Springtails (Entognatha)		
Oncopodura prietoi	*Pseudosinella vita*	*Tomocerus grahami*
Insects (Insecta)		
Aphaenogaster punctaticeps	*Perdita sidae*	*Perdita tarda*
Leptothorax bestelmeyeri	*Osmia prunorum*	*Perdita viridinotata*
Leptothorax colleenae	Mason Bee	Centris Bee
Capulin Mountain Arctic	Melittid Bee	*Osmia phenax*
Andrena mimbresensis	*Pityophthorus franseriae*	Bonita Diving Beetle
Andrena neffi	*Pityophthorus torridus*	Southwestern Hercules Beetle
Perdita geminata	Anthony Blister Beetle	Glorious Jewel Beetle
Perdita grandiceps	*Andrena vogleri*	Leconte's Jewel Beetle
Perdita maculipes	*Perdita austini*	Wood's Jewel Beetle
Perdita mesillensis	*Perdita biparticeps*	Animas Minute Moss Beetle
Perdita senecionis	*Perdita claripennis*	Tiger Beetle

Table 4.1 Cont.

Common or Scientific Name[1]		
Other Arthropods Cont.		
Insects (Insecta) Cont.		
Glittering Tiger Beetle	*Megaphorus lascrucensis*	Tiger Moth
Guadalupe Mtns. Tiger Beetle	Soldier Fly	Mirid Plant Bug
Los Olmos Tiger Beetle	Capitan Mountains Fritillary	Dashed Ringtail
Maricopa Tiger Beetle	Freija Fritillary	Cassus Roadside-Skipper
Nevada Tiger Beetle	Nitocris Fritillary	Large Roadside-Skipper
Buchholz's Boisduval's Blue	Nokomis Fritillary	Slaty Roadside-Skipper
Mogollon Rim Greenish Blue	Raton Mesa Fritillary	Texas Roadside-Skipper
Hemileuca comwayae	Silver-Bordered Fritillary	Silkmoth
Hemileuca (nevadensis) artemis	*Aeoloplides rotundipennis*	Zephyr Eyed Silkmoth
Hemileuca hera magnifica	*Cibolacris samalayucae*	Apache Skipper
Mountain Checkered-Skipper	Band-Winged Grasshopper	Arizona Agave Borer Skipper
Chalcedon Checkerspot	Hebard's Blue-Winged Desert Grasshopper	Carlsbad Agave Borer Skipper
Sacramento Mountain Checkerspot	Lichen Grasshopper	Viola's Yucca Borer Skipper
Tawny Crescent	Nevada Point-Headed Grasshopper	Western Crossline Skipper
Mescalero Camel Cricket	Shotwell's Range Grasshopper	Deva Skipper
Organ Mountains Camel Cricket	Spur-Throat Grasshopper	Mary's Giant Skipper
Rodent Burrow Camel Cricket	Spur-Throat Grasshopper	Poling's Giant Skipper
Gypsum Sand-Treader Camel Cricket	Ilavia Hairstreak	Ursine Giant Skipper
WS Sand-Treader Camel Cricket	Poling's Hairstreak	Western Hobomok Skipper
Carlsbad Cave Cricket	Sandia Hairstreak	Moon-marked Skipper
Mescalero Sands Jerusalem Cricket	Oslar's Soapberry Hairstreak	Sunrise Skipper
Arroyo Darner	Xami Hairstreak	Yuma Skipper
Ellis Dotted-Blue	Mescalero Sands Katydid	Four-Spotted Skipperling
Spalding's Dotted-Blue	*Hexagenia bilineata*	Arizona Snaketail
Bleached Skimmer Dragonfly	*Homoeonuria alleni*	West's Primrose Sphinx
Scudder's Duskywing	*Lachlania dencyannae*	Vega Sphinx
Dusty-Wing	*Leucrocuta petersi*	*Capnia caryi*
Desert Elfin	Arizona Metalmark	*Isoperla jewetti*
Caenotus inornatus	*Carales arizonensis*	*Taenionema jacobii*
Caenotus minutus	Borer Moth	Arizona Viceroy
Chrysotus parvulus	Albarufan Dagger Moth	Tarantula Hawk Wasp
Neurigona perbrevis	Geometrid Moth	*Dasymutilla homole*
Thinophilus magnipalpus	Noctuid Moth	*Odontophotopsis augusta*
Mydas Fly	*Euhyparpax rosea*	*Odontophotopsis grata*
Efferia cuervana	*Oligocentria delicate*	Chiricahua White
Furcilla delicatula	Pyralid Moth	

[1] Scientific names are provided where common names for the species does not exist.

Table 4-2. Approximate number and percent of Species of Greatest Conservation Need (SGCN) taxa in New Mexico.

Taxa Group	Approximate Number of Taxa in each Taxa Group in New Mexico	Number (%) of SGCN Taxa in each Taxa Group
Amphibians	26	15 (58)
Birds	504	74 (15)
Crustaceans	35	32 (91)
Fish	130	37 (28)
Mammals	184	42 (23)
Molluscs	182	66 (36)
Reptiles	105	32 (31)
Subtotal	1166	298 (26)
Other Arthropods[1]	Unknown	154
Total	**--**	**452**

[1] Classes Arachnida, Chilopoda, Diplopoda, Entognatha, and Insecta

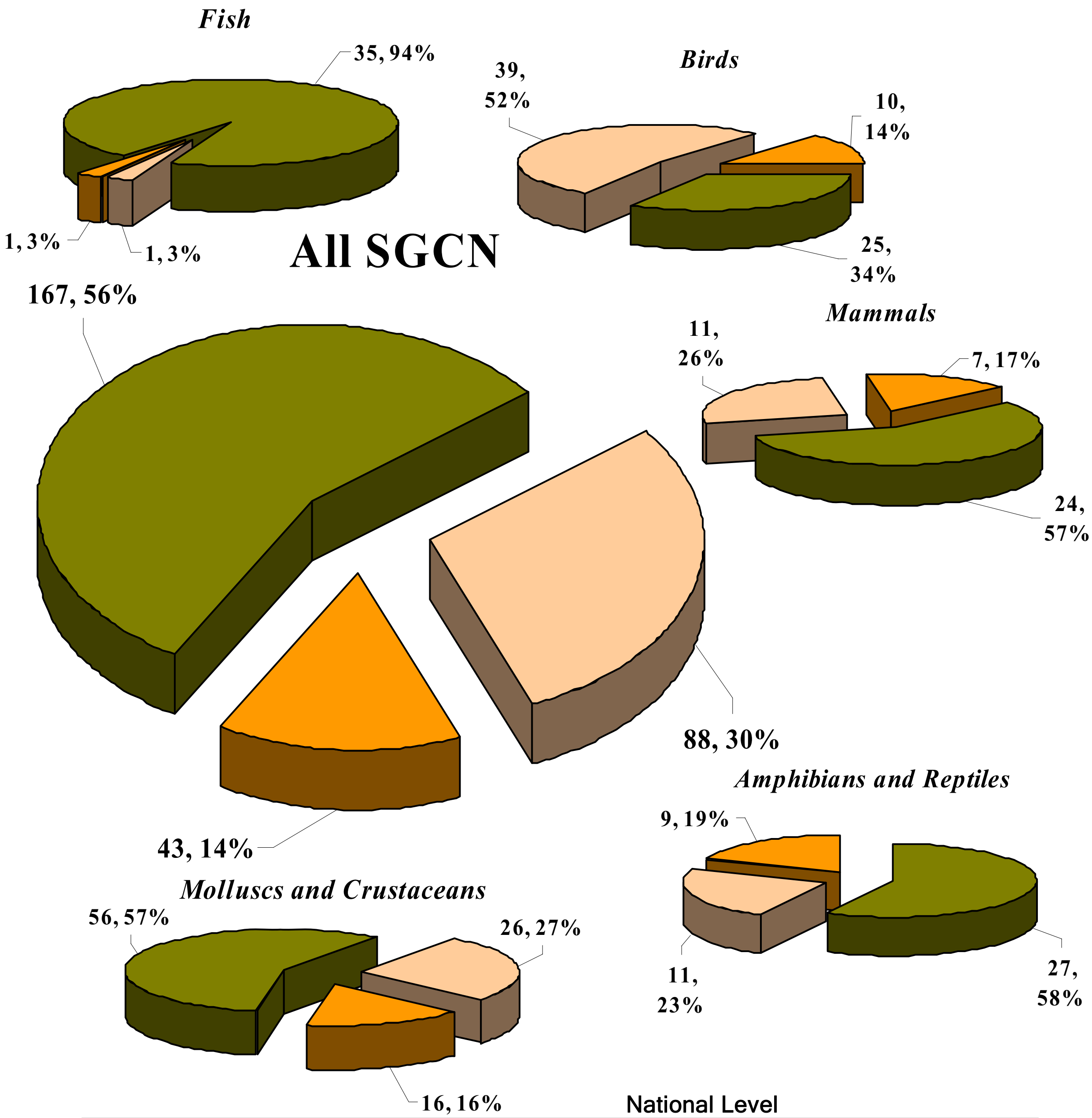
SGCN Abundance

Based on the adjusted NatureServe conservation status ranks, most (167, or 56%) of the 298 vertebrate, mollusc, and crustacean SGCN were considered both state and nationally vulnerable, imperiled, or critically imperiled (Fig. 4-1). Sixty-four (21%) of the SGCN were critically imperiled both nationally and in New Mexico. None of the vertebrate, molluscs, and crustacean SGCN were considered secure or apparently secure in New Mexico, but nationally vulnerable.

Most (56%) of the 298 vertebrate, mollusc, and crustacean SGCN are considered both state and nationally vulnerable, imperiled, or critically imperiled.

Eighty-eight (30%) of our SGCN are nationally secure or apparently secure, but are state vulnerable, imperiled, critically imperiled, or possibility extirpated. These species are fairly evenly distributed among birds, mammals, reptiles, molluscs, and crustaceans (Fig. 4-1). There are 43 species that are considered apparently secure or secure at both the state and national levels. Species in this group include blue catfish (*Ictalurus furcatus*), mourning dove (*Zenaida macroura*), hooded oriole (*Icterus cucullatus*), Abert's Squirrel (*Sciurus aberti*), black bear (*Ursus americanus amblyceps*), tiger salamander (*Ambystoma tigrinum*), collared lizard (*Crotaphytus collaris*), western glass snail (*Vitrina pellucida alaskana*), and the Whitewashed Radabotus Snail (*Radbotus dealbatus neomexicanus*).

A majority of the fish (94%), mammal (57%), amphibian and reptile (58%), and mollusc and crustacean (57%) SGCN are considered both state and nationally vulnerable, imperiled, or critically imperiled (Fig. 4-1). Conversely, only 34% of the birds are both state and nationally vulnerable, imperiled, or critically imperiled. Most (52%) of the bird SGCN are nationally secure, but state vulnerable, imperiled, or critically imperiled.



National Level

State Level	Conservaton Status Ranks and Codes		Critically Imperiled 1	Imperiled 2	Vulnerable 3	Apparently Secure 4	Secure 5
	Possibly Extirpated	0	1	2			2
	Critically Imperiled	1	64	17	12	6	13
	Imperiled	2		21	15	18	9
	Vulnerable	3	1	2	32	20	20
	Apparently Secure	4				12	14
	Secure	5				1	16

Figure 4-1. The amount and percent of vertebrate, mollusc, and crustacean Species of Greatest Conservation Need for each taxa group within conservation status groups. Codes to color and large numbers are given in table below pie graphs.

SGCN Distribution

Predictive habitat models for SGCN were created by the Southwest Regional Gap Analysis Project (SWReGAP) and identify areas that are likely suitable habitat for a species but which may or may not be occupied (see Approach chapter for greater details). Examples of predicted species distributions in New Mexico are provided in Figure 4-2 through 4-4. A linkl to the predictive habitat models (distribution models) for all terrestrial and aquatic vertebrate SGCN in New Mexico are located on NMDGF website (http://wildlife.state.nm.us/). Species distribution models for the five state region modeled by SWReGAP are located at the following website: http://fws-nmcfwru.nmsu.edu/swregap. Spatial depictions of suitable habitats for molluscs, crustaceans, and other arthropods in New Mexico are not currently available. Since many of these species are endemics and only occur in one mountain range or in some cases on one mountain, spatial scale issues make modeling fine scale habitats difficult. Further, there are currently no useful data sources that depict ephemeral habitats or marsh, springs, seeps, or cienegas, or perennial ponds.

Predictive habitat (distribution) models for terrestrial and aquatic vertebrate SGCN identify areas that are likely suitable habitat. Links are located on NMDGF website (http://wildlife.state.nm.us/).

Areas within New Mexico that host the greatest predicted number of terrestrial and aquatic SGCN occur where multiple ecoregions and habitat types converge. For example, the "boot heel" region of southwestern New Mexico has the highest predicted number of terrestrial and aquatic SGCN taxa, which reflects the variation in elevations and the merging of the northern Rocky Mountains, the Madrean Archipelago, neotropical regions of Mexico, the Chihuahuan Desert, and influences from the Sonoran Desert. Another species rich area in New Mexico is in the southeastern part of the state where habitats from the Pecos River, Guadalupe and Sacramento Mountains, the shortgrass prairie and the Chihuahuan Desert converge (Table 4-3, Fig 4-5). Further, the Rio Grande and Pecos drainages in New Mexico traverse many ecoregions and habitat types, and have high SGCN richness.

Table 4-3. Number of SGCN taxa by groups and ecoregion or watershed in New Mexico.

	Crustacean	Fish	Amphibian	Bird	Mammal	Mollusc	Reptile	Total
Ecoregion								
Arizona-New Mexico Mountains			4	35	16	15	10	80
Chihuahuan Desert			2	22	13	10	10	57
Colorado Plateau				8	5		2	15
Southern Rocky Mountains			2	26	14	7	1	50
Southern Short Grass Prairie			3	15	6		6	30
Apache Highlands			3	44	20	17	18	102
Watershed								
Canadian	3	5	4	15	2	6	1	36
Gila	1	11	6	17	8	3	3	49
Mimbres	1	3	7	15	7	1	3	37
Pecos	1	18	5	17	4	10	3	58
Rio Grande	2	11	6	18	6	7	3	53
San Juan	1	4	2	13	1		1	22
Tularosa	2	2	3	10	4	4		25
Zuni	1	2	2	8	1			14

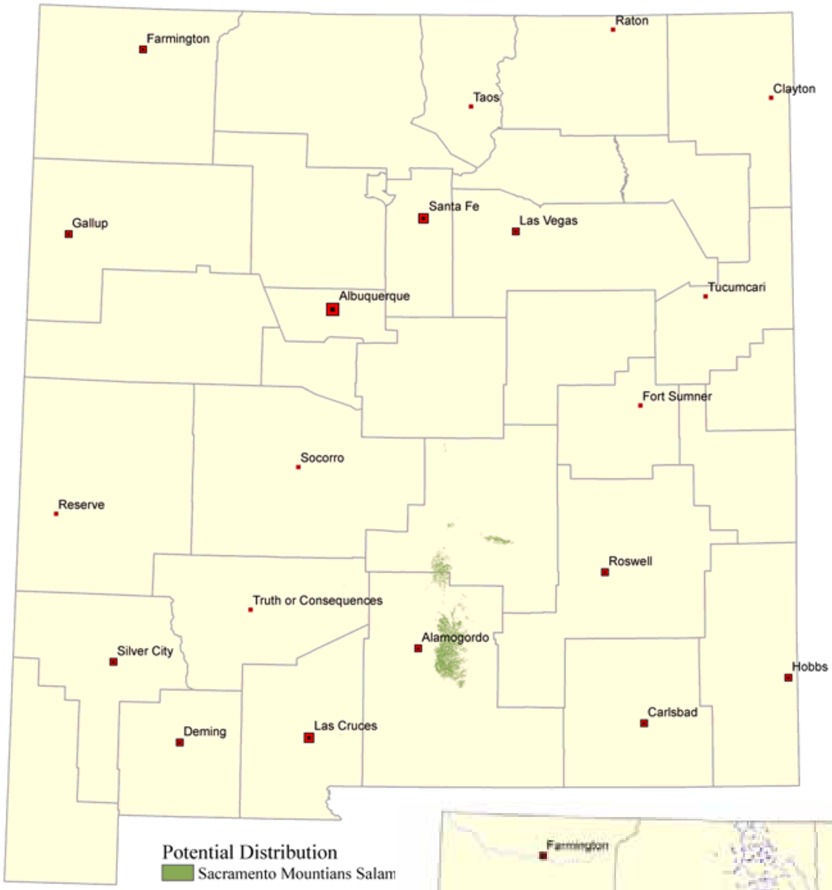
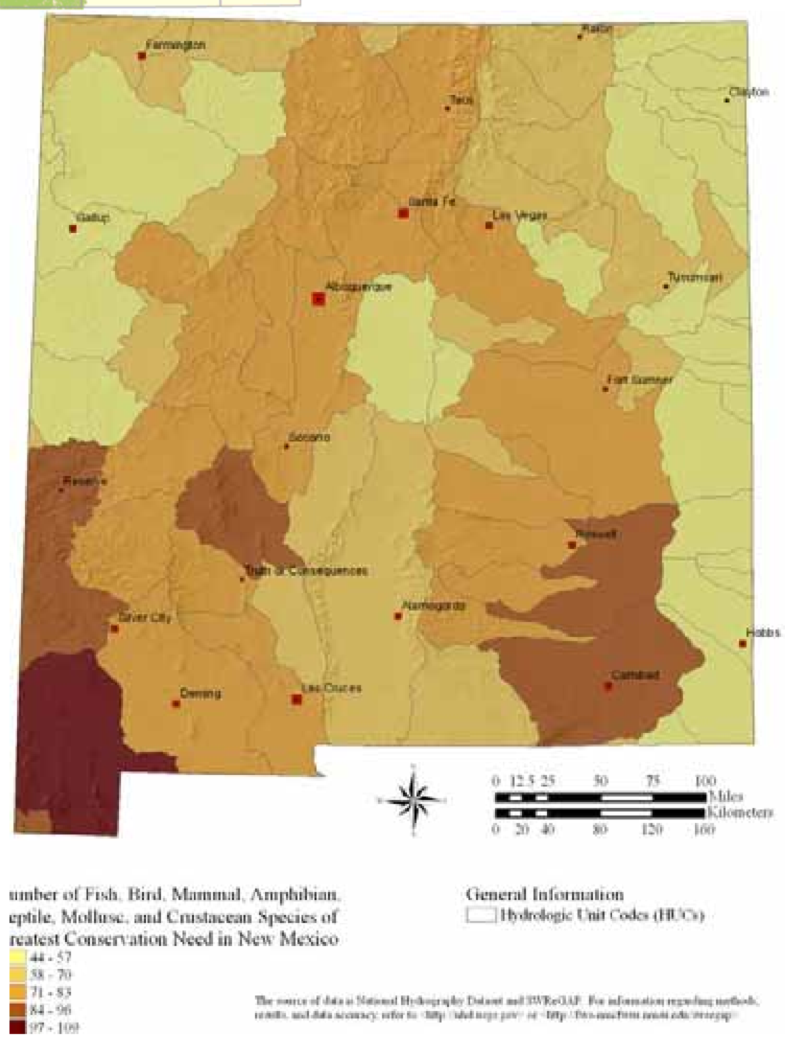


Figure 4-2. (*Left*) Predicted distribution of the Sacramento Mountains Salamander (*Aneides hardii*) in New Mexico.

Figure 4-3. (*Right*) Predicted distribution of the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) in New Mexico.

Figure 4-4. (*Left*) Predicted distribution of Arizona Myotis (*Myotis occultus*) in New Mexico.

Figure 4-5. (*Right*) Terrestrial and aquatic Species of Greatest Conservation Need richness (number of SGCN taxa) in New Mexico. Darker areas indicate greater number of SGCN taxa present.



SYNTHESIS OF CONSERVATION PRIORITIES

As indicated in the Approach chapter, conservation actions were constructed based on: 1) SGCN, 2) key habitats, 3) problems affecting species or habitats, 4) information gaps that limit our ability to make informed conservation decisions, 5) research, survey, and monitoring needs that if met would enhance our ability to make conservation decisions, and 6) desired future outcomes for habitats or SGCN. The Assessment and Strategies for SGCN and Key Habitats (Chapter 5) provides descriptions of each of these components for each key habitat within ecological frameworks.

> Conservation actions provided in this chapter were prioritized based on the number of key habitats in which they were identified, and their priority rank in each key habitat within ecological frameworks.

Below, we offer a summary of statewide conservation concerns. We present a discussion of factors that influence New Mexico habitats and wildlife. We also provide summarized information gaps and research, survey, and monitoring needs from the ecological frameworks and key habitats (Chapter 5) as well as additional points that limit our ability to make informed conservation decisions.

We also summarize the top five conservation actions listed in each key habitat within ecological frameworks (Chapter 5). Conservation actions provided in Chapter 4 were prioritized based on the number of key habitats in which they were identified, and their priority rank in each key habitat within ecological frameworks. As such, conservation actions that were in multiple habitats and received higher prioritization in Chapter 5 were given higher prioritization ranks below.

Priorities collectively identified in Chapter 4 should not supersede those identified in Chapter 5. Rather, Chapter 4 organizational framework takes a broader-scale approach to synthesizing prioritized conservation actions applicable to the statewide scale. We anticipate that those who will use this Strategy as a resource and planning guide will reference conservation actions under each ecological framework and key habitat as well as this synthesized approach.

Factors that Influence Species and Habitats

Over the past century, New Mexico's landscapes have changed dramatically. Natural flows of aquatic systems have been altered by human development and dams. Terrestrial ecosystems have been altered by development and other human activities. All of these changes have influenced New Mexico's wildlife.

> Many legal and accepted human activities and practices have the potential to be either beneficial or detrimental to wildlife. It is the manner in which activity is conducted that determines if it has a negative or positive effect on wildlife populations.

NMDGF recognizes that many human activities across today's landscapes have the potential to be either beneficial or detrimental to wildlife. Many factors that influence New Mexico landscapes are based on legal and accepted practices. It is not the intent of the CWCS to debate the benefits and detriments of historical activities on New Mexico's landscapes. Our intent is to evaluate landscapes as they exist today and develop strategies on how best to make meaningful improvements to benefit species of greatest conservation need. At times, we reference historic land management practices, as these practices have helped shape today's landscapes. In doing so, we do not intend to imply that historic land management practices still occur today.

Our assessment of factors that influence species or habitats is primarily focused at the habitat scale, as these factors directly affect wildlife communities and SGCN populations. A description of the process used for this assessment and evaluation of factors that influence habitats can be found in the Approach chapter. We also identify individual factors that most influence the persistence of each SGCN, based on literature review and professional knowledge. We provide this information in Appendix I. Given that most of the species-specific factors that influence the long-term persistence of SGCN are habitat conversion, loss, and degradation, fire (burning and suppression), and improper grazing practices, we do not discuss species-specific factors separately from habitat factors. We also provide a more spatially explicit discussion on the factors that adversely influence SGCN in ecoregions and habitat types in the Assessments and Strategies for SGCN and Key Habitats chapter.

Our assessment of factors that influence species or habitats is primarily focused at the habitat scale, as these factors directly affect wildlife communities and SGCN populations.

In our discussion of factors that influence species and habitats, we primarily discuss those practices that are harmful to wildlife at certain levels of use or extent. It should be understood that it is the manner in which a human activity or practice is conducted that determines if it has a negative or positive effect on wildlife populations. For example, livestock grazing can be a valuable tool to improve wildlife habitat. However, if livestock grazing is applied improperly, it can be detrimental to plant communities and wildlife.

Our list of potential factors that may influence habitats in New Mexico is based on some guidelines provided by Salafsky *et al.* (2003) for describing categories and factors and the proceeding discussion is primarily organized by these categories and individual factors.

Habitat Conversion

Declines in populations of plants and animals are usually caused by more than one event. However, habitat conversion through human-caused degradation and alteration is one of the most serious factors adversely affecting wildlife and plants worldwide. There are many causes of habitat conversion. Examples include urban, residential, commercial, or recreational development, agricultural and livestock production, drainage of wetlands, altered hydroperiods, and development of dams and channels that regulate water flows. Habitat conversion factors affect habitats on a statewide basis.

Development Activities

Human resource use has led to a condition in which large areas of formerly continuous landscapes have become increasingly fragmented and isolated (Finch 2004). Urban, residential, commercial, and recreational development, agriculture and other such activities have accelerated over the past century, subdividing the natural world into disjunctive remnants of native ecosystems embedded in a matrix of anthropogenic land uses (Saunders *et al.* 1991). Urban and commercial development contributes greatly to the loss of native vegetation, increased water use, ground water depletion, and increased erosion through soil compaction and runoff concentration. These activities may ultimately cause further habitat fragmentation and loss through landscape conversion, land clearing, road development, and increased vehicular traffic.

The negative ecological impacts of fragmentation on natural systems have led many ecologists to identify habitat fragmentation as one of the greatest threats to biodiversity (Harris 1984, Wilcox and Murphy 1985, Noss and Cooperrider 1994). Adverse effects of habitat fragmentation upon wildlife species and populations are numerous. Habitat fragmentation causes increased isolation of populations or species, which leads to decreased genetic diversity and increased potential for extirpation of localized populations or even extinction. Habitat fragmentation alters vegetative composition and cover and the type and quality of the food base. Further, habitat fragmentation changes microclimates by altering temperature and moisture regimes, changes nutrient and energy flows, and increases opportunities for predation and exploitation by humans.

> The negative ecological impacts of habitat fragmentation on natural systems are one of the greatest threats to biodiversity.

Aquatic Habitat Conversion Factors
Many aquatic habitats in New Mexico have been altered and fragmented by dams and water diversions. Dams modify natural flows and alter water quality. Reservoirs act as sediment traps and disrupt or alter the sediment budgets of downstream reaches. Decreases in sediment inputs alter the natural dynamics of mesohabitat creation and maintenance. Dams also fragment species ranges, preventing up and downstream movement of fishes and other aquatic species. Altered hydroperiods of seasonally astatic pools may reduce hydrologic connection to other wetlands, or other waters, reducing the quality of these habitats.

Abiotic Resource Use

Habitat disturbances from abiotic resource uses such as mining, oil and gas development, wind energy, ground water depletion, and hydropower occur throughout New Mexico, although they typically have localized impacts. Oil and gas development concerns are greatest in the shortgrass prairie, Colorado Plateau, and Chihuahuan Desert regions. There are concerns about mining in the Arizona-New Mexico Mountain Ecoregion.

Extractive Resource Uses
Extractive resource uses such as mining and oil and gas development occur throughout New Mexico and can influence ecosystem function, resilience and sustainability. On federal lands these activities are conducted under standards established by the Bureau of Land Management and are subject to further regulation by the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division. Extractive resource uses may result in habitat fragmentation and loss through associated land clearing, road building, and disturbance from traffic, hauling and maintenance activities. Associated point-source pollution causes heavy-metal and highly acidic water pollution (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995, Hilliard 1994), groundwater pollution (Miller *et al.* 1996), air pollution, noise, and habitat conversion (Dinerstein *et al.* 2000). Any of these activities and their adverse outcomes may ultimately lead to the reduction of wildlife populations (Sias and Snell 1998).

Wind Energy Development

Wind energy facilities are not yet widespread in New Mexico. However, as alternative sources of energy become more important to the state and nation and related technology improves there is potential for more wind-energy sites to be developed. Wind-generated electrical energy is environmentally friendly. It does not create air-polluting and climate-modifying emissions. Nevertheless, wind turbines, particularly in the large arrays, can adversely affect wildlife and wildlife habitats. Effects include habitat fragmentation due to access roads and pads and direct killing of bats and birds (particularly raptors) that strike moving blades. Lighted wind towers over 200 feet have the same potential as communication towers to attract and kill night-flying migratory birds and bats (NMDGF 2004b).

Ground Water Depletion

Groundwater levels in New Mexico have dropped considerably due to pumping for agricultural and urban needs. Several proposals and plans exist for desalination plants in New Mexico. The surface water loss resulting from the water withdrawal and dewatering necessary to support anthropocentric water needs, exacerbated by drought conditions, will continue to influence habitats in New Mexico. Lowered water tables affect all of New Mexico's habitats, but can have considerable affects on small cienegas, springs, seeps and marshes and their associated SGCN.

Pollution

Concerns about pollution sources influencing New Mexico's habitats are primarily focused on aquatic habitats. Pollution factors such as agricultural chemicals, livestock and dairy groundwater contamination, and solid waste can negatively affect the long-term persistence of SGCN in affected habitats. Runoff from livestock feedlots, dairy operations, and urban road surfaces introduces nutrients and numerous contaminants to aquatic habitats. Petrochemical pollutants reach aquatic habitats from various refinery operations. Mercury and petrochemicals have been identified in many of New Mexico's reservoirs. Typically, pollution sources are regulated by various federal and state agencies, such as the New Mexico Environment Department, Surface Water Quality Bureau, which monitors water quality in New Mexico's reservoirs. However, more information on the extent and sources of pollution in New Mexico will aid conservation decisions.

Consumptive Biological Uses

Consumptive biological uses such as improper grazing practices, logging, fuel wood collection, and deforestation have the potential to affect SGCN and their habitats throughout New Mexico. Where multiple consumptive biological uses occur (e.g. national forests), concerns persist regarding the ability to maintain habitats in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN. Whether or not national forests can host a variety of land uses without heightened resource conflicts is a serious question.

Improper grazing practices are those practices that reduce long-term plant and animal productivity, and include both domestic livestock and wildlife.

Grazing Practices

Domestic animal grazing is an extensive land use activity across the New Mexico land surface (See Chapter 3, New Mexico's Biodiversity). Thus, it has significant association with factors that widely influence condition of wildlife habitat. Discussion here and elsewhere in the CWCS acknowledges this pattern while also recognizing that livestock operations are a permissible and important part of the New Mexico culture and economy.

Improper grazing practices have influenced vegetation communities and fish and wildlife habitat throughout New Mexico. Improper grazing practices are those practices that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), and include both domestic livestock and wildlife. Major changes in vegetation composition in New Mexico and the southwest have been linked to improper livestock grazing that occurred in the late 1800s when livestock numbers peaked (Leopold 1924, Cottam and Stewart 1940, Cooper 1960, Buffington and Herbel 1965, Humphrey 1987, Grover and Musick 1990, Archer 1994, Fleischner 1994, Pieper 1994). Preferred forage plants such as cool-season grasses declined, while weedy and unpalatable plants and shrubs increased (Wooton 1908, Bohrer 1975, Bahre and Shelton 1993). Improper grazing practices and climatic fluctuations were recognized as major triggers of soil erosion, flooding, and arroyo cutting in the southwest (Cooperrider and Hendricks 1937, Cottam and Stewart 1940, Smith 1953, Hastings and Turner 1965, Cooke and Reeves 1976, Branson 1985, Humphrey 1987, Bahre 1991, Webb and Betancourt 1992, Felger and Wilson 1995). These acts reduced and/or eliminated fine herbaceous fuels which practically eliminated high-frequency, low-intensity wildfires across New Mexico and the southwest (Savage and Swetnam 1990, Swetnam 1990, Swetnam and Baisan 1996). All of these acts perpetuated further landscape degradation. By the 1930's, Congress recognized that western rangelands were being degraded, and approved the Taylor Grazing Act of 1934. This act regulated grazing on the public lands through the use of permits. The Taylor Grazing Act provided a way to regulate the occupancy and use of the public land, preserve the land from destruction or unnecessary injury, and provide for orderly use, improvement, and development. The Federal Land Policy and Management Act of 1976 and the Public Rangelands Improvement Act of 1978 further guide the management of livestock grazing on public lands and are designed to speed restoration of public rangelands while improving the delivery of services to public land users.

Outcomes of improper grazing practices on wildlife include increased competition for limited water, forage, and space, alteration of vegetative composition and structure, impacts on stream hydrology and water quality, and reduced soil permeability and potential to support plants due to soil compaction (Armour *et al*. 1994, Fleischner 1994, The Wildlife Society 1996, Belsky and Blumenthal 1997). More informed grazing practices have been implemented on many private and public land tracts in recent years, but recovery of vegetation may take many years and is not possible on some sites.

> Impact of livestock grazing on rangeland wildlife is largely dependent on the grazing management practices used.

It is important to remember that the impact of livestock grazing on rangeland wildlife is largely dependent on the grazing management practices used (Holechek *et al.* 2004). Broad generalizations on the impact of livestock grazing on rangeland wildlife are typically incorrect because different grazing practices are unique and wildlife species have different habitat requirements. Grazing management variables that affect wildlife habitat include stocking rates, stocking density, the age and physiological condition of cattle, grazing season, forage selection, and cattle distribution. In addition, factors such as range condition, soil type, temperature, and precipitation also greatly influence the relationships between grazing and habitat quality for rangeland wildlife (Holechek *et al.* 2004). Grazing plans, therefore, need to be site-specific and consider the habitat needs of the wildlife species of interest.

Over the last couple of decades, there has been considerable research on interactions between rangeland wildlife and livestock, including comprehensive reviews by Holechek *et al.* (1982), Kie *et al.* (1994), Krausman (1996), Sarr (2002), and Holechek *et al.* (2004). Unfortunately, many of these scientific studies have been observational, anecdotal, based on unreplicated experiments, compromised by lack of true controls, employed weak methodologies, and used inaccurate or overly broad quantification of grazing intensity such as heavy vs. light or no grazing (Holechek *et al.* 2004, Lucas *et al.* 2004).

Holechek *et al.* (1982), Kirby *et al*. (1992), Launchbaugh *et al.* (1996), and Holechek *et al.* (2001) indicate that judicious grazing practices can have positive affects on wildlife and be a beneficial management tool. These include: 1) increase in vegetation composition diversity and improve forage availability and quality for early to mid-successional wildlife species, 2) creating patchy habitat with high structural diversity for feeding, nesting, and hiding, 3) opening up areas of dense vegetation to improve foraging areas for a variety of wildlife, 4) removal of rank, coarse grass that will encourage re-growth and improve abundances of high quality forages for wild ungulates, 5) stimulating browse production by reducing grass biomass, and 6) improving nutritional quality of browse by stimulating plant re-growth. There are a few examples in the literature which suggest that many wildlife species are tolerant of moderate grazing and many appear to benefit from light to conservative grazing. Smith *et al.* (1996) found that lightly grazed climax rangelands and conservatively grazed late seral rangelands had similar songbird and total bird populations. Smith *et al.* (1996) concluded that wildlife diversity was higher on the conservatively grazed late seral than the lightly grazed climax rangeland. Similarly, Nelson *et al.* (1997) reported that wildlife observations were greater on moderately grazed mid seral Chihuahuan Desert rangelands compared to conservatively grazed late seral rangelands. In a study comparing wildlife observations for grassland (late seral), shrub-grass (mid seral), and shrubland (early seral) communities in the Chihuahuan Desert of New Mexico, Nelson *et al.* (1999) found observations for birds and mammals were higher in shrub-grass than in grassland or shrubland. Studies in southeastern Arizona by Bock *et al.* (1984) support the hypothesis that conservatively to moderately grazed areas in mid or late seral condition supported greater diversity of wildlife than ungrazed areas in climax condition. However, these studies did not investigate livestock grazing intensity on wildlife population dynamics, or habitat requirements.

There has also been research directed towards evaluating managed livestock grazing systems on targeted wildlife species, especially with upland gamebirds and large mammals. For example, Montezuma quail (*Cyrtonyx montezumae*) are sensitive to livestock grazing and require adequate residual bunchgrass cover following the growing season for nest and escape habitat. Research suggests that Montezuma quail require a minimum of 7.8 in (20 cm) height of bunchgrasses and at least 50% herbaceous cover (Bristow and Ockenfels 2003). Grazing practices that employ light to moderate grazing can benefit Montezuma quail by increasing availability of food plants

(Brown 1982, Bristow and Ockenfels 2000). Other studies on scaled quail (*Callipepla squamata*) indicated that they can be benefited by conservative to moderate grazing (on non-degraded rangelands) which improves their mobility by opening dense grass stands (Campbell *et al.* 1973, Saiwana *et al.* 1998). Livestock grazing can be used to enhance forage for elk (*Cervus elaphus*) and manage their distribution by increasing availability and nutritional value of preferred grasses in early growth stages (Holechek *et al.* 2004).

Scientific studies that clearly demonstrate a cause and effect relationship with grazing as the primary factor endangering a specific species are rare (Holechek *et al*. 2004). This is largely because studies that are specifically designed to detect these relationships are difficult to conduct in natural environments. Although there is certainly strong circumstantial evidence that heavy grazing can be a major factor resulting in the decline of several endangered rangeland wildlife species, carefully controlled studies are needed to better examine and understand the relationships between controlled grazing (i.e. light, conservative, and moderate grazing intensity) and endangered species (Sarr 2002, Holechek *et al*. 2004, Lucas *et al.* 2004).

Logging
Extraction of timber products is an important economic pursuit, but can have adverse effects on wildlife if not implemented wisely and responsibly. Over the last century, species composition and structure of New Mexico's forests have been altered by the combined effects of commercial logging, fire suppression, and improper grazing practices (US Forest Service 1993, Covington and Moore 1994). Logging practices in New Mexico and the Southwest have gone through differing management phases. In the late 1800s and early 1900s relatively indiscriminate cutting practices occurred (deBuys 1985), followed by selective logging in the mid-1900s, and even-aged timber stand management during the 1960s through 1980s (Bogan *et al.* 1998). Extensive road networks were developed within the forests to allow easy timber removal (Allen 1989).

Earlier logging practices tended to remove larger, older trees. More recently, logging techniques have moved toward more selective, uneven-aged silvicultural practices. Timber harvests from public forests have declined in recent years (Bogan *et al.* 1998). Some emphasis has been placed on federal endangered species habitat and ecosystem management. This has come about primarily through legal actions advanced under the Endangered Species Act, National Forest Management Act, and National Environmental Policy Act. Relatively recent Forest Service Region 3 directives require the maintenance of at least some old-growth forests for SGCN, such as the northern goshawk (*Accipiter gentilis*) and Mexican spotted owl (*Strix occidentalis lucida*). Fuel reduction is a focus of current forest management efforts, with millions of dollars directed at thinning understory trees and the reintroduction of prescribed fires to reduce the potential for widespread catastrophic wildfires (Bogan *et al.* 1998). Indications are that 50% of the allocated monies will be expended on protecting human structures and neighborhoods in the wildland urban interface areas.

Fuel Wood Collection
Fuel wood collection has reduced the abundance of large diameter snags and dead-and-down logs. Large diameter snags function as important nesting structures for cavity-nesting birds (Thomas *et al.* 1979, Hejl 1994) and as roost sites for bat species (Bogan *et al.* 1998). Dead-and-down logs provide important wildlife habitat and ecosystem functions. Legal and illegal roads

created for access to fuel wood can further fragment forests and woodlands and adversely affect important habitats, such as wetlands and meadows, by transporting non-native organisms and draining wetlands. Fuel wood collection may also introduce disturbances from noise, off-road vehicle use, or accidental fire ignition.

Non-Consumptive Biological Uses

Habitat disturbances related to off-road vehicle use, military activities, and recreational use are a concern over most of New Mexico. The Chihuahuan Desert Ecoregion, Arizona-New Mexico Mountains Ecoregion, and the Southern Shortgrass Prairie Ecoregion in particular have been subjected to significant habitat alterations as a result of non-consumptive biological use.

> Off-road vehicle travel can cause damage to soils and vegetation and impact wildlife by destroying and fragmenting habitat, causing direct mortality of wildlife, or altered their behavior.

Off-Road Vehicles
Recreational off-road vehicle use can be found across the entire state. There are several organized events held each year in Doña Ana, Socorro, Otero, Eddy, Chaves, and San Juan counties. The New Mexico Statewide Comprehensive Outdoor Recreation Plan (SCORP), 2004-2009 identified a moderately increasing trend in off-road vehicle use from 1996-2001 (Henkel and Fleming 2004). The specific effects of off-road vehicle use on New Mexico habitats are poorly understood. Off-road vehicle travel can cause damage to soils and vegetation (Holechek *et al.* 1998) and impact wildlife by destroying and fragmenting habitat, causing direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983). The Forest Service has published in the Federal Register two proposed rules pertaining to off-road vehicle use. The first designates routes and areas for motor vehicle use and the second petitions states for inventoried roadless areas. Both of these proposed rules would impact future ATV use on Forest Service lands in New Mexico. Other regulatory initiatives seek to improve ATV safety requirements and increase registration fees, with revenues targeted for the development of designated ATV trails and facilities.

Military and Borderland Security Activities
The Department of Defense (DoD) manages 4% of the land in New Mexico. White Sands Missile Range (WSMR) is the largest DoD installation, covering approximately 2.2 million ac (0.9 million ha). It operates primarily for the support of research, development, testing, and evaluation of weapon and space systems, subsystems, and components. Other DoD installations in New Mexico contain sites for live bombing, air defense missile firing, mechanized brigade training exercises, battalion-size or smaller training exercises, ballistic missile testing, aircraft takeoff, landings and training courses, maintenance of fighter wing capabilities, and general military training exercises. While restricted access to many military lands provide substantial benefit to wildlife, military land uses also may destroy or fragment existing habitats.

Border security measures are being implemented throughout the New Mexico/Mexico borderlands region to intercept illegal drug shipments, illegal immigrants, and other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Associated road building and traffic in the borderlands region causes additional habitat loss and fragmentation, reduces effective (usable) habitat for wildlife populations, increases road kill, poaching, illegal collecting of wildlife and general habitat destruction (Forman *et al.* 2003).

Recreation
Skiing, hiking, mountain biking, snowmobiling, off-road vehicle use, rock climbing, camping, sightseeing, bird watching, and picnicking are popular recreational pursuits in New Mexico (Conner *et al.* 1990). The overall impact of these activities is not fully understood, nor is there a full understanding of how much recreational use can be tolerated before there is an adverse effect on wildlife or wildlife habitat. However, recreational activities are increasing and their potential effects on habitats and species should be considered in conservation planning (Conner *et al.* 1990, McClaran *et al.* 1992).

Invasive and Non-Native Species

Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plant and animal species (including threatened and endangered species), disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, DeLoach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002).

Noxious weed infestation is now the second leading cause of native species being listed as threatened or endangered nationally. As of 1998, non-native species have been implicated in the decline of 42% of species federally listed under the Endangered Species Act (Center for Wildlife Law 1999). In addition to environmental problems, invasive plants also pose a serious economic problem. Rangelands infested with Russian knapweed, a serious problem in New Mexico, typically suffer reductions in livestock carrying capacity of 50% or more. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Invasive species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions.

Non-native aquatic species have considerable affects on native fish, molluscs, and crustaceans in New Mexico's aquatic habitats. The integrity of native fauna populations is negatively affected by non-native species through resource competition, predation, hybridization, habitat alteration, and through the introduction of diseases and toxins.

Diseases, Parasites, and Pathogens
Many of the avian and mammalian SGCN are affected by diseases such as West Nile virus, rabies, hantavirus, pasturella pneumonia, and bubonic plague (Table 4-4). The growing wildland urban interface exposes wildlife to potentially infected domestic and feral pets and may contribute to the spread of these diseases. Increased exposure to refuse, pesticides or other toxins, and parasites may also affect wildlife at this interface.

Table 4-4. Potential diseases, hazards, toxins, and parasites contacted by wildlife at the wildland-urban interfaces.

Potential Diseases, Hazards, Toxins, and Parasites	Avifauna	Mammals
Rabies		X
Bubonic plague		X
Canine distemper		X
Electrocution	X	X
Tuberculosis		X
Foot and mouth disease		X
Contagious ecthyma		X
Pesticide poisoning	X	X
Lead poisoning	X	X
Gastroenteritis (clostridials)		X
Bovine diarrheal virus		X
Lungworm and pneumonia complex		X
Tapeworm larvae/hydatid cysts		X
Ear mites		X
Brucellosis (currently in Wyoming and Montana)		X
Vesicular stomatitis		X
Canine heartworm		X
Parvovirus		X
Tularemia		X
Feline panleukopenia (feline leukemia)		X
Salmonella	X	X
Giardia		X
Chronic wasting disease		X
Johne's disease		X
Bluetongue and hemorrhagic disease		X
Mycoplasma diseases (sinusitis)	X	
Pasturella (avian cholera)	X	
West Nile disease	X	
Blackhead disease	X	
Avian pox	X	
Trichomoniasis	X	
Avian influenza	X	

The presence of whirling disease in rainbow trout (*Oncorhynchus mykiss*) was confirmed in New Mexico the spring of 1999. Since this confirmation, four of the six New Mexico state hatcheries, several private ponds and salmonid populations in the San Juan, Rio Grande, Canadian, and Pecos drainages in New Mexico have tested positive for the disease. As a result, routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated for 173 coldwater streams and reservoirs. These waters may have been contaminated through inadvertent stocking of infected rainbow trout or by natural or anthropogenic vectors. Although New Mexico has adopted a "no tolerance" policy that bans the stocking or importation of fish infected with whirling disease, the potential for accidental introduction still exists. The most devastating potential of the disease lies in the threat it poses to native salmonid populations that rely on natural reproduction.

Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) presently occupies a fraction of its presumed historic range throughout the Rio Grande watershed (Stumpff and Cooper 1996, Calamusso and Rinne 1999) and is considered at risk by the NMDGF (Paroz *et al*. 2002). Recent surveys indicate populations of Rio Grande cutthroat trout are reproducing in the Jemez and Pecos drainages (DuBey and Caldwell 2003). Portions of the Pecos drainage have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Very little is known regarding whether the disease exists in cutthroat trout populations. However, the species produces young fish from March through June when temperatures are conducive for optimum triactinomyxon production. Thus, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection. Core Conservation Areas contain isolated populations of Rio Grande cutthroat trout and are specifically managed for their genetic purity and potential use in restoration of the species.

Chronic wasting disease is also a concern in New Mexico. A total of 12 cases of chronic wasting disease have been confirmed in New Mexico as of September 2005. All were mule deer (*Odocoileus hemionus*) located in the Organ Mountains east of Las Cruces. Two mule deer subjected to tonsillar biopsies and released in December of 2004 in southern New Mexico as part of a research project were later found to be positive for chronic wasting disease. In 2001, a New Mexico game park imported 21 elk from a southern Colorado game ranch at which animals tested positive for chronic wasting disease. Investigation revealed that, subsequent to the initial importation, the New Mexico facility transferred animals to four other game parks in New Mexico. All five New Mexico game parks are precluded from transferring ungulates until the imported animals are shown to be disease free for not less than 60 months. No New Mexico game parks have as yet tested positive for chronic wasting disease.

Phytophagous (plant-eating) insect outbreaks cause tree mortality and reduced growth in New Mexico's forests and woodlands (Haack and Byler 1993). Bark beetles and inner bark borers are primary tree killers (Haack and Byler 1993). Phytophagous insects have traditionally been considered detrimental to forest health and commercial timber harvest (Schowalter 1994). However, most phytophagous insects that affect forest trees in New Mexico are native organisms (Wilson and Tkacz 1994) and, from an ecosystem perspective, perform functions that are instrumental in sustaining forest health and function through succession, decomposition, nutrient cycling and soil fertility (Haack and Byler 1993).

Altered forest conditions have likely increased the frequency, intensity, and extent of insect outbreaks and diseases (Haack and Byler 1993, Wilson and Tkacz 1994, New Mexico Energy, Minerals, and Natural Resources Department 2004). Changes in forest tree age, size, density, species composition, and vertical stratification across temporal and spatial scales influence patterns of forest insect herbivory at the ecosystem and landscape levels (Schowalter *et al.* 1986, New Mexico Energy, Minerals, and Natural Resources Department 2004). Environmental stresses such as drought, late spring frosts, wind throw, and air pollution can encourage insect outbreaks (Haack and Byler 1993). Although insect outbreaks in forest ecosystems occur naturally, they can cause shifts in vegetative species composition and structure (Haack and Byler 1993). Further, certain phytophagous insects are attracted to fire-damaged or fire-killed trees and their build-up in weakened host trees can threaten adjacent, unburned stands (US Forest Service 1999).

The magnitude of disturbance from an outbreak depends upon the particular insect or pathogen, and on the condition of the forest ecosystem affected (Wilson and Tkacz 1994). Closely spaced host trees are likely to trigger outbreaks of phytophagous insects and pathogens. In compositionally and structurally diverse forests, however, potential host trees can be harder for insects to locate among non-host trees, and vulnerable host trees may be relatively resistant to small numbers of insects that find their way through the surrounding non-host vegetation (Hunter and Aarssen 1988, Waring and Pitman 1983). Outbreaks are typically worse in single-species, monocultural tree stands especially during vulnerable periods such as drought (Mattson and Haack 1987, Schowalter and Turchin 1993, Waring and Pitman 1983). Populations of most foliar and sap-feeding insects peak during particular stages of host-tree development (Schowalter *et al.* 1986), which make monoculture stands of single-aged trees more susceptible to outbreaks.

Drought provides a more favorable environment for phytophagous insect growth, survival, and reproduction, and may reduce the effectiveness of the biochemical defense system that some plant species have evolved (Mattson and Haack 1987).

Modification of Natural Processes and Ecological Drivers

Changes in natural processes and ecological drivers (e.g., drought, fire management, ecological sustainability and integrity, or loss of keystone species) have influenced all habitats in New Mexico and the Southwest. However, some habitats are more resilient or resistant to these modifications. Aquatic systems, especially ephemeral habitats, may be considerably altered by drought conditions. Other ecosystems may have the ability to maintain or rebound to conditions of diversity, integrity, and sustainable ecological processes following such disturbances.

Climate Change and Drought

Climate change may occur in the Southwest from increased atmospheric concentrations of CO_2 and other “greenhouse” gases. Effects may include increased surface temperatures, changes in the amount, seasonality, and distribution of precipitation, more frequent climatic extremes, and a greater variability in climate patterns. Such changes may affect vegetation at the individual, population, or community level and precipitate changes in ecosystem function and structure (Weltzin and McPherson 1995). They will likely affect competitive interactions between plant and animal species currently coexisting under equilibrium conditions (Ehleringer *et al.* 1991).

Plants respond differently to changes in atmospheric gases, temperature and soil moisture, in part based on their C_3 or C_4 photosynthetic pathways (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson *et al*. 1993). For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses. Increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin *et al*. 1986).

Drought (an extended period of abnormally dry weather) is one of the principal factors limiting seedling establishment and productivity (Schulze *et al*. 1987, Osmond *et al*. 1987). Soil moisture gradients are directly altered by drought conditions. The distribution and vigor of some plant communities may be controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993). Drought and climate change can potentially have a substantial effect on New Mexico’s habitats.

Fire Management
For thousands of years, wildfires have been an integral process in New Mexico and southwestern forest and grassland ecosystems. Prior to 1900, naturally occurring wildfires were widespread in all western forests at all elevations (Swetnam 1990). From an ecological perspective, fire may be the most important disturbance process for many western forests (Hessburg and Agee 2003). Ecosystem processes and patterns are influenced and shaped by fire. These include soil productivity and nutrient cycling, seedling germination and establishment, plant growth patterns, vegetative plant community composition and structure, and plant mortality rates (Beschta *et al.* 2004).

Tree-ring and fire-scar data for the Southwest indicate that past fires were frequent and widespread (with an elevation range of variability) at least since AD 1700 (Swetnam and Baisan 1996). Within ponderosa pine and lower mixed-conifer forests and woodlands in New Mexico, naturally-occurring wildfires were frequently of low-intensity and helped maintain stands of older trees with an open, park-like structure (Moir and Dieterich 1988). Higher elevation, mixed conifer and spruce-fir forests (wetter forest types) exhibited less frequent fire return intervals and fires were generally stand-replacing fires of higher intensity, (Pyne 1984, Walstad *et al.* 1990, Agee 1993).

The extent to which fire occurred in southwestern grasslands varied geographically and is related to climatic variables such as seasonal and annual rainfall and physiographic variables such as elevation, slope and aspect (Archer 1994). Fire may have been rare in desert grasslands and limited in extent due to low biomass and a lack of continuity in fine fuels (Hastings and Turner 1965, York and Dick-Peddie 1969). In more mesic grassland and savanna systems where fire was a prevalent and recurring force, pre-historic frequency and intensity appear to have been regionally synchronized by climatic conditions (Swetnam and Betancourt 1990).

The elimination of high-frequency, low-intensity wildfires across New Mexico and the Southwest coincided with the reduction and/or elimination of fine herbaceous fuels caused by improper grazing practices (Savage and Swetnam 1990, Swetnam 1990, Swetnam and Baisan 1996). These grazing practices further reduced grass competition, thereby increasing tree and shrub establishment (Archer 1994, Gottfried *et al.* 1995), which further altered natural fire cycles. Since the early 1900s, systematic fire suppression efforts have further curtailed the natural fire regimes that historically kept ponderosa pine, mixed conifer and spruce-fir stand densities and fuel loads relatively low. Fire suppression allowed the development of ladder fuels and the accumulation of heavy fuel loads. Catastrophic, stand replacing crown fires are now the standard, rather than the exception as a result of these changes (Covington and Moore 1994).

> Fire suppression activities have had adverse effects on many New Mexico habitats by fragmenting, simplifying, or destroying habitats, and greatly modifying disturbance regimes.

Land management practices and fire suppression have had adverse effects on many New Mexico habitats through fragmenting, simplifying, or destroying habitats, and greatly modifying disturbance regimes (McIntosh *et al.* 1994, Hessburg and Agee 2003). These human-caused changes have created conditions that are outside of the evolutionary and ecological tolerance limits of native species (Beschta *et al.* 2004). Cumulatively, these practices have altered ecosystems to the point where local and regional extirpation of sensitive species is increasingly common (Rieman *et al.* 1997, Thurow *et al.* 1997). As a result, the integrity of many terrestrial and aquatic ecosystems has been severely degraded at the population, community, and species levels of biological organization (Nehlsen *et al.* 1991, Frissell 1993).

Ecological Sustainability and Integrity
When biotic and abiotic disturbances are modified or removed from New Mexico's ecosystems, plant and animal diversity and ecological sustainability are lost (Benedict *et al.* 1996). Ecological sustainability is essentially the maintenance (or restoration) of the composition, structure, and processes of the ecosystem over time and space (US Forest Service 2000). Likewise, ecosystem integrity incorporates the concept of functioning and resilience. It includes: 1) maintaining viable populations, 2) preserving ecosystem representation, 3) maintaining ecological processes, 4) protecting evolutionary potential, and 5) accommodating human use (Grumbine 1994). The loss of ecological sustainability and integrity will thus affect species that are closely tied to specific habitats or ecosystems.

Loss of Keystone Species
Keystone species, such as beavers (*Castor canadensis*), bison (*Bison bison*), and prairie dogs (*Cynomys* sp.), are species that have a large overall effect, disproportionate to their abundance, on the structure or function of habitat types or ecosystems. If a keystone species is extirpated from a system, other species that are closely associated with the keystone species will also disappear. In New Mexico, several keystone species have either been completely removed or have experienced significant population reductions in their historic range. With their removal or reduction in population levels, other species population levels variously decline or benefit.

Transportation Infrastructure

Roads, highways, railroad, and utility corridors have the potential to be detrimental to some wildlife. They fragment habitats and landscapes (Reed *et al.* 1996, Saunders *et al.* 1991) dividing large landscapes into smaller patches and converting interior habitat into edge habitat. Studies in other states have demonstrated negative correlations between increasing road densities and wildlife populations (Lee *et al.* 1997, Wisdom *et al.* 2000).

New Mexico has over 206,000 miles (33,152 km) of major and minor roads, including US Forest Service classified roads (Earth Data Analysis Center, RGIS Tiger Data: http://edac.unm.edu/). A 16 foot-wide road removes approximately two acres of habitat per mile of road. Accident report data compiled by the University of New Mexico documented 914 large game animal/vehicle collisions in 2002 in New Mexico. An annual average of 828 large game animal/vehicle collisions has occurred since 1998 (Forman *et al.* 2003). Since many incidents go unreported, this number represents only a fraction of the total large animal/vehicle collisions that actually occur annually. In addition to collisions with vehicles, roads facilitate legal and illegal killing and collection of many large and valuable animals. In the US Forest Service's Southwestern Region, 57% of threatened, endangered and proposed species under the federal Endangered Species Act, and 54% of US Forest Service's Sensitive Species are dependent on habitat within or affected by Inventoried Roadless Areas (IRAs) (US Forest Service 2000).

Roads and similar structures influence stream characteristics, such as channel and floodplain configuration, substrate embeddedness, riparian condition, amount of woody debris, stream flow, and temperature regime (Furniss *et al.* 1991). Timing of water runoff can change as roads and related drainage structures intercept, collect, and divert water. These factors can accelerate water delivery, resulting in an increase in the potential for greater magnitude of runoff peaks than in watersheds without roads (Wemple *et al.* 1996). Roads, highways, railroad, and utility corridors serve as a means of dispersal for many non-native and invasive plant species. Ground disturbance associated with the creation and maintenance of these facilities provides additional opportunities for establishment of non-native species (Parendes and Jones 2000).

Synergistic Effects of Factors Influencing Species and Habitats

It is difficult, and perhaps impossible, to separate individual causal factors that influence habitats or SGCN. Multiple factors are closely linked in cause and effect relationships across spatial and temporal scales. Adverse effects from multiple ecosystem stressors can have cumulative effects that are much more significant than the additive effects alone, with one or more stressors predisposing biotic organisms to additional stressors (Paine *et al.* 1998). For example, reduced fire frequency from a century of fire suppression is partly responsible for conditions that have allowed major outbreaks of several phytophagous insects (Peet 1988). Further, unusually dry periods and/or climate changes reduce available soil moisture causing water associated stress, reduced xylem pressure and pitch production in trees. These conditions allow insects to bore into and infect and kill trees. Affected stands with high tree mortality quickly accumulate dead standing and downed woody fuels. In turn, these conditions greatly increase the risk of catastrophic, stand-replacing wildfire and subsequent insect attack on trees injured or weakened by the fire (Gara *et al.* 1985).

Many of the factors discussed are closely linked in cause and effect relationships across spatial and temporal scales. It is difficult, and perhaps impossible, to separate individual causal factors that influence habitats or SGCN.

To further illustrate the interactive and synergistic effects of these factors, consider historic grazing practices that reduced fine fuels and affected natural fire cycles. This condition, in combination with a century of fire suppression and multiple years of drought has created un-natural stand and fuel conditions, making forest and woodland habitat types increasingly susceptible to stand-replacing catastrophic wildfires. Add to this mix, insects and diseases linked with decreased forest health. The overall impact converts late-successional mixed conifer forests to early-successional grasslands, shrublands and recovering forests. Roads contribute to habitat fragmentation and are linked as well to other major habitat altering factors such as timber removal, fire ignition and suppression, fuel wood collection, and recreation.

The effects of climate change on ecosystems and species are likely to be exacerbated in areas that have already been substantially affected by human activities such as habitat loss and fragmentation, air and water pollution, and the establishment of invasive species. Habitat fragmentation decreases the ability of plant and animal species to migrate in response to changing conditions or species requirements. Invasive species are most successful in ecosystems already disturbed by anthropogenic activities (Elton 1958). Climate change may act as a form of disturbance creating opportunities for invasive species to colonize and displace native species

(Malcolm and Pitelka 2000). When suitable habitat conditions disappear or shift faster than populations can adjust, the likelihood of species extirpation or extinction increases (Malcolm *et al.* 1998).

Magnitude scores of each of the 43 generic factors within each key habitat were summed to provide a better understanding of their possible synergistic effects.

Many of the factors discussed above coincide in the same geographic area. Given the synergistic effects of multiple factors, it is difficult to understand the overall impact these factors will have on New Mexico landscapes, habitats, or Species of Greatest Conservation Need. In addition, it is difficult to understand which habitats may have higher risk of being altered by multiple factors. However, we conducted a simple analysis by summing magnitude scores of each of the 43 generic factors within each key habitat (See Approach chapter for details). This approach, while is not perfect, gives us a basis for understanding the possible synergistic effects, and where we might need further clarification on the outcomes of these factors.

Ephemeral natural catchments, perennial marsh/cienega/ spring/seeps, and riparian habitats may be at a higher risk of alteration by multiple factors than other habitat types in New Mexico.

The highest possible cumulative magnitude score for any habitat is 344 (see Approach Chapter). However, the top score of any key habitat was 165 (ephemeral natural catchments). Perennial marsh/cienega/spring/seeps and riparian habitats also yielded high cumulative magnitude scores (158 and 156, respectively) (Fig 4-6). Magnitude scores for each key habitat within category of factors that influence habitats are provided in Appendix L. Using cumulative magnitude scores as an indicator of the potential synergistic effects of all factors, these 3 key habitats may be at a higher risk of alteration by multiple factors than other habitat types in New Mexico. Likewise, aquatic habitats may be more likely to be altered than terrestrial habitats, with the exception of riparian habitats.

This information may be displayed spatially, allowing us to enhance our understanding of geographic areas where synergistic effects of potential factors may influence some habitats greater than other habitats (Fig. 4-7). Given this spatial representation, aquatic and riparian habitats statewide, areas in the shortgrass prairie in eastern New Mexico, and Madrean systems in the Gila National Forest may have several factors, that when placed together, influence the integrity of these habitats. These are key areas to investigate and enhance our understanding of factors that influence habitats.

Key areas to enhance our understanding of factors that influence habitats include:

- Aquatic and riparian habitats located throughout the state,
- Areas within the shortgrass prairie, and
- Madrean habitats.

These areas may have several factors, that when placed together, greatly influence the integrity of these habitats.

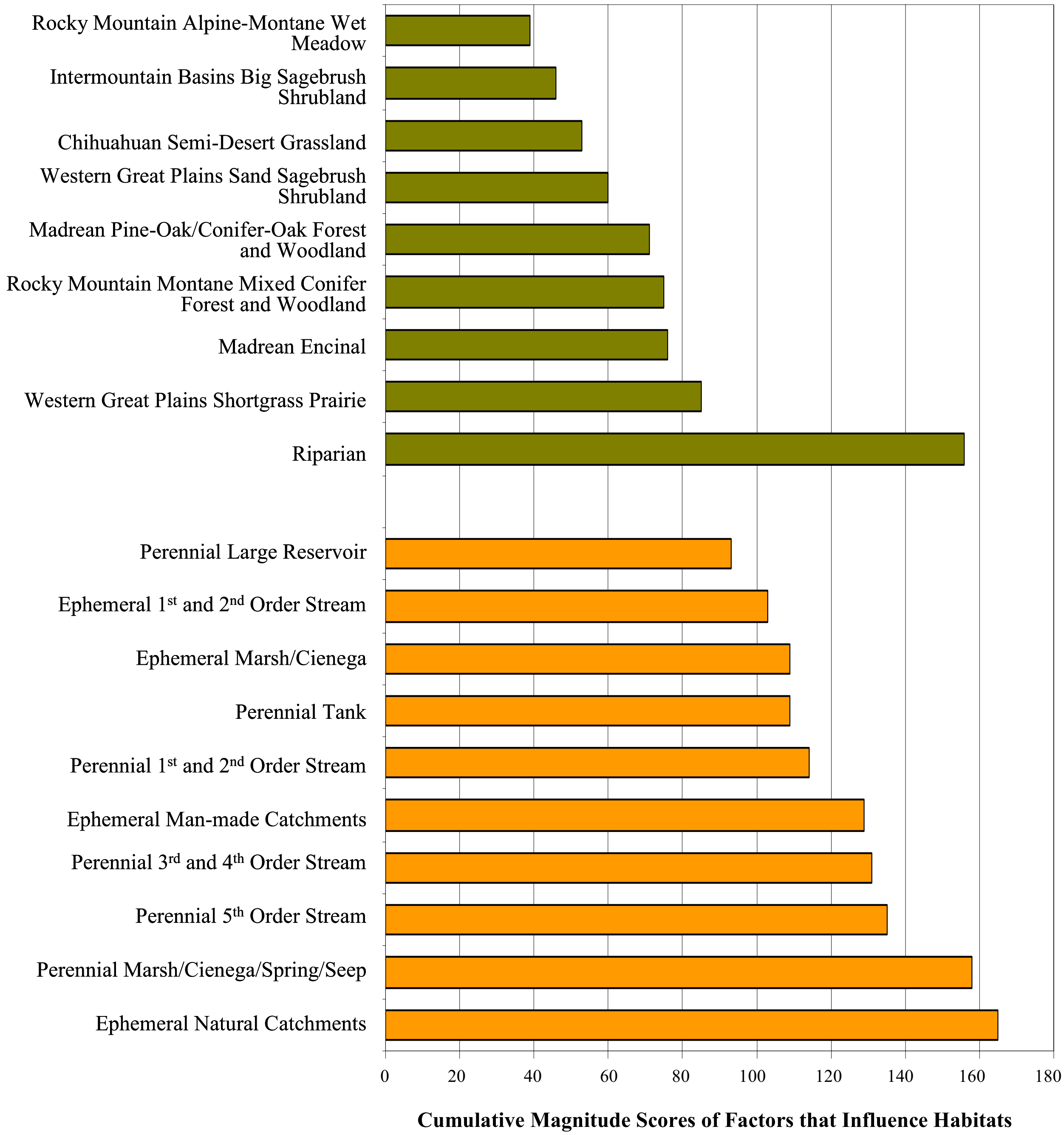


Figure 4-6. Cumulative magnitude scores of 43 factors that influence key habitats in New Mexico. This analysis assists in the identification of key habitats which may have the highest risk of being altered by synergistic effects of factors that influence habitats. Methods of calculating magnitude scores are presented in the Approach chapter. Magnitude scores for each key habitat by category of factors that influence habitats are provided in Appendix L.

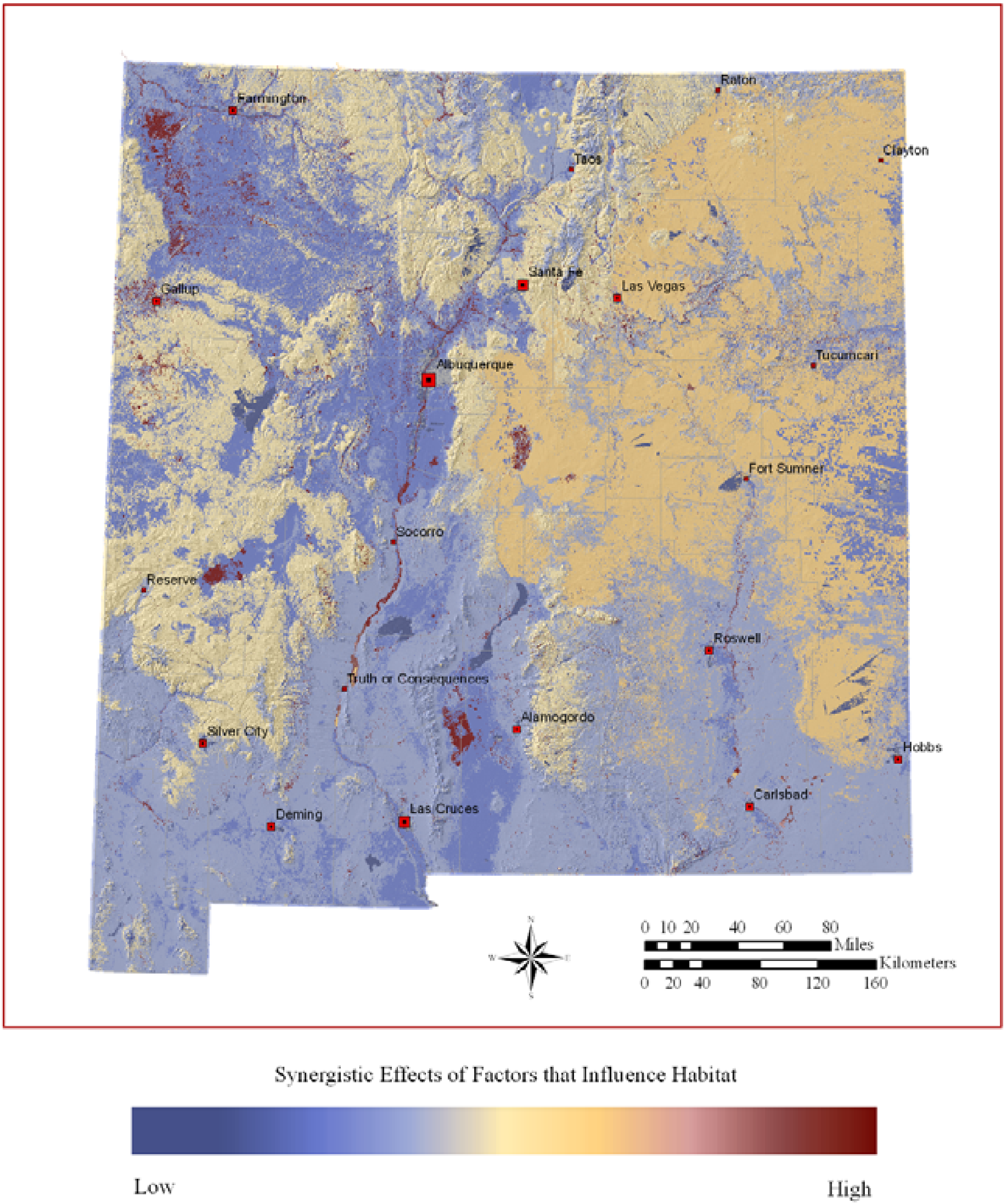


Figure 4-7. Magnitude scores of factors that influence habitats associated with terrestrial and aquatic land cover types. This spatial representation is designed to enhance our understanding of geographic areas where synergistic effects of potential factors may influence some habitats more than others. This analysis should not be used to locate small parcels of land.

Information Gaps

There are numerous information gaps that limit our ability to make informed conservation decisions in New Mexico. Appendices M and N summarize information gaps identified in each ecological framework (terrestrial and aquatic, respectively) and key habitat. Information gaps that, if filled, would enhance our ability to make informed conservation decisions in New Mexico are outlined below.

- The extent to which land use activities (e.g., grazing, human development, road-building, and energy exploration and development, etc...) fragment and alter habitats in relation to size, edge effect, and use by SGCN is unknown.
- Life history of most of the SGCN, including distribution, abundance, status and trends, habitat requirements, and movement information is poorly understood.
- Effects and extent of habitat fragmentation on SGCN are unknown.
- Extent to which invasive and non-native species may alter habitat community structure and preclude populations of SGCN is unknown.
- The role of natural fire and differing intensities of fire within key habitats and the long-term affect of altered fire regimes on SGCN are poorly understood.
- More information is needed on the existing conditions that limit populations of SGCN or otherwise inhibit their resiliency for adapting to human disturbances.
- The affects of altered hydrological patterns on aquatic habitats and their SGCN, including modifications to current hydrological patterns that may benefit native SGCN are unknown.
- Little is known about water quality and its affects upon associated SGCN or sources of pollution and the extent to which pollution alters habitats.
- Our information base on the factors causing pathogen outbreaks and the potential for diseases needs to be expanded.
- We have an inadequate understanding of the overall impact of the synergistic effects of the multiple factors influencing key habitats or SGCN.
- Additional information is needed on the suitability of selected key habitats and SGCN for restoration.
- More information is needed on methods for detecting landscape degradation, especially the identification of attributes for early detection.

- There are no accurate data for creating spatial depictions of suitable habitats for molluscs, crustaceans, and other arthropods in New Mexico, including the locations and quality of ephemeral habitats, marsh, springs, seeps, cienegas, or perennial ponds.

- Comprehensive evaluative information is lacking regarding the status and trends pertaining to the occupation of New Mexico by non-native plant and animal species.

- We lack information needed to evaluate the collective effectiveness of multi-agency conservation actions such as riparian and terrestrial habitat restoration projects on a statewide basis.

- We lack the information necessary to detect changes in key habitats at a landscape level within ecoregions.

Research, Survey, and Monitoring Needs

Summaries of specific research, survey, and monitoring needs identified for each ecological framework and key habitat are provided in Appendices O and P (terrestrial and aquatic, respectively). Research, survey, and monitoring initiatives found to be needed across ecological framework and key habitat boundaries and that would assist in filling information gaps and informing conservation efforts on a statewide scale are aggregated below.

- Conduct research to enhance knowledge of the natural history, population biology, and community ecology of SGCN within key habitats, including SGCN distribution, abundance, habitat use, and population trend information.

- Research is needed to quantify the extent to which land use activities (e.g., grazing, human development, road-building, and energy exploration and development, etc...) fragment and alter habitats in relation to size, edge effect, composition and structure, and use by SGCN.

- Investigate hydrologic relationships and their effects on SGCN to provide a better understanding of the physicochemical and hydrologic processes that will allow for sustainable watershed conservation and management practices.

- Determine conditions that limit populations of SGCN and their resiliency in adapting to human disturbances.

- Conduct research to anticipate how climate change or drought will affect vegetation patterns and community and ecosystem-level dynamics.

- Determine the extent to which invasive and non-native species may alter community structure and preclude populations of SGCN and identify methods to minimize impacts from non-native species.

- Investigate invasive species early detection protocols and identify potential vectors and pathways.
- Assess and continually monitor habitat condition and water quality.
- Investigate methods to reduce the spread of pathogens through aquatic and terrestrial environments.
- Investigate hydrologic relationships in key habitats.
- Identify or develop protocols and monitoring standards for consistently describing landscape health and condition.
- Investigate methodology that might be employed for early detection of transitions in habitat type and determining indicators of biological integrity.
- Develop collaborative survey and monitoring protocols for invertebrate SGCN that are not currently being monitored.
- Identify SGCN travel corridors and assess habitat connectivity.
- Investigate the role of natural fire and the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires and maintaining habitats for SGCN.
- Determine and monitor the location and condition of ephemeral aquatic habitats, marshes, springs, seeps, cienegas, and perennial ponds and develop spatial depictions of habitats predicted as suitable for molluscs, crustaceans, and other arthropods in New Mexico.
- To our knowledge, no systematic, standardized monitoring of introduced, non-native plant and animal species is occurring in New Mexico. Introduced non-native species are a primary cause of the decline of native biological diversity globally, and should be addressed at a state, regional and national level, in part by instituting monitoring programs at these different scales. Monitoring and efforts to identify new invasions (both deliberate and accidental) are technically feasible, but lack sufficient funding and coordination (Simberloff *et al.* 2005). This information should be incorporated into a dynamic statewide Geographical Information System (GIS) database to allow tracking of these trends.
- A more efficient monitoring program needs to be developed to track the effectiveness of conservation actions such as riparian and terrestrial habitat restoration programs at a statewide level. This information should be incorporated into a dynamic statewide GIS database to allow the tracking and assessment of project performance at a landscape level.

- Other than the efforts of the USGS Southwest Regional Gap Analysis Project (SWReGAP) to map vegetation and wildlife species distribution of the southwestern United States, to our knowledge, no formal, systematic, standardized monitoring of key habitats at a landscape level within ecoregions is occurring in New Mexico. Development of the capacity to detect habitat changes and compare them directly with SGCN monitoring results is essential to evaluating the effectiveness of our conservation actions.

- There is a need to continue monitoring the incidence of whirling disease and chronic wasting disease on a statewide basis.

Desired Future Outcome

Since New Mexico is a diverse state with a variety of habitats, it is reasonable that there would be multiple desired future outcomes for its key habitats and SGCN. However, the overriding desired future outcome driving biodiversity conservation in New Mexico is that our key habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts. More spatially specific desired future outcomes are provided in Chapter 5 for the key habitats within each ecological framework.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific levels alone are inadequate for long-term conservation of SGCN. Rather, conservation strategies should be ecosystem-based and include broad public input and support (Galeano-Popp 1996). Prioritized conservation actions that we believe will assist in achieving desired future outcomes are aggregated below at a statewide scale. NMDGF will monitor species and habitats to evaluate the effectiveness of these conservation actions and those found to be ineffective will be modified and re-deployed in accordance with the principles of adaptive management.

Terrestrial Habitats

1. Work with federal and state agencies, tribes, private landowners, research institutions, and universities to design and implement research, survey, or monitoring projects to enhance our understanding of SGCN and key habitats. Research pertaining to SGCN distribution and abundance and the condition and connectivity of habitats is especially desirable as are studies that monitor SGCN status and identify factors limiting SGCN populations.

2. Work with land management agencies, private land managers, and the agriculture industry to identify and promote rangeland grazing methodologies that ensure long-term plant and animal productivity, ecological sustainability and integrity, and are cost effective for livestock interests.

3. Collaborate with state and federal agencies, tribes, private organizations, research institutions, universities, and private landowners to identify and protect riparian and other habitat corridors that are important for sustaining SGCN. This should include identifying areas that have historic or potential value as connecting habitat corridors and for which willing private landowners can obtain conservation easements.

4. Form partnerships with affected communities and federal land management agencies to facilitate and encourage the conservation, protection, maintenance, and restoration of key habitats and unique microhabitats within key habitats. Watershed management practices that reduce soil erosion, and maintain biodiversity are encouraged.

5. Collaborate with state and federal agencies and private landowners to develop measures to reduce habitat fragmentation within and adjacent to key habitats. Closures of unnecessary roads or minimizing new roads in key habitats are potential approaches.

6. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts important to SGCN. Promote community based support and involvement in decisions related to ecological sustainability and integrity of key habitats and SGCN viability.

7. Work with federal and state agencies, tribes, private agencies and institutions to maintain tracts of native vegetation and to identify additional sources of funding for long-term conservation of SGCN. Actions that create incentive based or voluntary partnerships with private landowners to conserve and manage properties to sustain SGCN are desirable.

8. Maintain awareness of the introduction and spread of invasive, non-native, and exotic plants and animals and encourage control or eradication where necessary to maintain or restore biodiversity.

9. Collaborate with affected interests to pursue enactment of state laws or policies to protect closed basins within key habitats from the impacts of dredge and fill activities and future development.

10. Work with public and private land managers to reduce woody vegetation encroachment in grassland and meadow habitats that are important to SGCN and to maintain grassland and meadow functionality.

11. Work with public and private land managers and the energy industry to encourage conducting energy development in a manner that preserves the integrity and functionality of key habitats and to rehabilitate abandoned well pads and access roads.

12. Collaborate with federal and state agencies and private landowners to ensure the ecological sustainability and integrity of key habitats. Methods may include: establishing conservation agreements, inter-agency memoranda of understanding, or land acquisition projects.

13. Work with land management agencies and private landowners to develop a fire management regime that promotes restoration of vegetative communities more nearly approximating those that historically supported SGCN.

14. Work with federal and state agencies to liberalize burn policies in the wilderness areas surrounding meadow habitats to allow future fires to burn up to a meadow's edge rather than being suppressed.

15. Work with the US Forest Service to promote compliance with the principles of ecological forestry for any land management activities conducted within woodland or forested habitats.

16. Investigate opportunities to strengthen conditions of approval and reclamation standards for oil and gas development and develop partnership programs and funding mechanisms for implementing improved reclamation.

17. Work with public and private land managers and the energy industry to adopt adaptive management strategies that minimize disturbance to SGCN caused by industrial infrastructure, grazing, and recreation in key habitats.

18. Work with private landowners, counties, municipalities, federal land management agencies, and the State Land Office to mitigate and reduce impacts related to urbanization and develop consistent reclamation standards that ensure future key habitat integrity and functionality.

Aquatic Habitats

1. Work with federal and state agencies, tribes, private landowners, research institutions, and universities to design and implement research, survey, or monitoring projects to enhance our understanding of SGCN and key habitats. Research pertaining to SGCN distribution and abundance and the condition and connectivity of habitats is especially desirable as are studies that monitor SGCN status and identify factors limiting SGCN populations.

2. Coordinate with state and federal land managers, tribes, and private landowners to protect, restore, conserve, and create aquatic habitats and surrounding natural vegetation.

3. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of aquatic habitats functions, services, and values. Emphasize educating anglers about the risks posed by undesirable non-native fishes.

4. Collaborate with federal and state agencies, private landowners, research institutions, and universities to develop strategies to prevent emigration of non-native species or invasive species (including plants) into surrounding areas; seek partnerships that encourage the removal of harmful non-native species and the prevention of further introductions; and monitor habitat communities to assess and eliminate potential adverse effects posed by introduced species.

5. Collaborate with involved government agencies to implement existing management plans, conservation agreements, and recovery plans.

6. Collaborate with federal and state agencies, tribes, and affected publics to adopt standardized monitoring and survey methods to track gains and losses of aquatic habitats.

7. Work with federal and state agencies and affected publics to develop techniques to maintain natural hydrologic flows in aquatic habitats that maintain minimum conservation pools sufficient to support sport fisheries, SGCN, and year-round recreational opportunities; minimize the effect of diversion structures and water withdrawals on native fish SGCN; and design and implement irrigation water withdrawal structures that balance needs of aquatic SGCN communities.

8. Seek acceptance of "instream flow" water rights for wildlife conservation needs.

9. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing methodologies on rangelands that ensure long-term plant and animal productivity, ecological sustainability and integrity, and are cost effective for livestock interests.

10. Collaborate with federal and state agencies and affected publics to complete and implement the Draft State Aquatic Nuisance Species Management Plan.

11. Collaborate with federal and state agencies, tribes, private landowners, research institutions, and universities to complete an inventory and conduct a regional risk assessment of the distribution of the whirling disease parasite (*Myxobolus cerebralis*) and suppress yellow grub parasite in affected habitats.

12. Actively pursue the cooperation of private landowners in the protection and recovery of the SGCN.

13. Collaborate with agencies and affected publics to adopt and encourage compliance with baitfish regulations that preclude introduction of non-native species.

14. Work with federal and state agencies, tribes, NGOs, and universities to improve the use of existing data management systems for tracking information pertinent to aquatic habitats.

15. Work with federal and state agencies and affected publics to identify actions to prevent lowering of groundwater levels and promote water conservation activities.

16. Collaborate with federal and state agencies to reduce the amount of aquatic habitat altered by logging and road building.

17. Work with state, federal and private land managers to mitigate and reduce impacts on aquatic habitats from land and water use practices.

18. Work with the US Forest Service to develop strategies to reduce the effects of wildfire induced ash flows on native fish assemblages and ensure that SGCN in aquatic habitats are not adversely affected by fire management practices.

19. Establish partnerships with other federal, state, local agencies and potentially affected interests to encourage monitoring local aquifers for water quantity and quality as it relates to specific habitat locations, to identify potential threats to habitats important to SGCN, and to identify and pursue alternatives to the Clean Water Act for restoring protection to aquatic habitats.

20. Work with law enforcement agencies to increase compliance with regulations regarding transport and release of undesired non-native fishes.

More spatially explicit conservation actions are provided in Assessments and Strategies for SGCN and Key Habitats (Chapter 5).

KEY AREAS FOR CONSERVATION ACTION

All landscapes in New Mexico are important for conserving the full suite of components that collectively comprise our state's biodiversity, while providing important social and economic benefits for our citizens. However, because time and resources are limited, it is important to identify and focus upon key areas for conservation action.

> All landscapes in New Mexico are important for conserving our state's biodiversity.

We used four criteria to identify key areas based on information gained in developing the CWCS for New Mexico; key habitats, SGCN presence, analyses of factors that influence habitats, and SWReGAP land status estimates. Our Approach chapter details methods used in this analysis, and provides information pertaining to the four model input variables. Findings to date suggest that key areas upon which to focus conservation efforts in New Mexico may include riparian and aquatic habitats throughout the state, areas in the "boot heel" region of southwestern New Mexico extending northward into the Madrean habitats, and areas of the shortgrass prairie and western mountain ranges where they converge with Chihuahuan Desert and Pecos River habitats (Fig. 4-8). These areas contain key habitats, have a high diversity of SGCN, are subjected to a moderate to high magnitude of multiple habitat altering factors, and lack legal constraints or long-term management plans protecting them from habitat conversion. Having identified these key areas it remains to engage appropriate federal, state, local, and tribal governments, NGOs, and private interests in determining where, when, what, and how conservation actions will be implemented.

> Landscapes in New Mexico to consider in planning conservation efforts were:
> - Areas within key habitats,
> - Areas that had a high diversity of terrestrial and aquatic SGCN taxa,
> - Areas that may be potentially altered by synergistic effects that influence habitats, and
> - Areas without long-term management plans or legal constraints that protect them from habitat conversion.

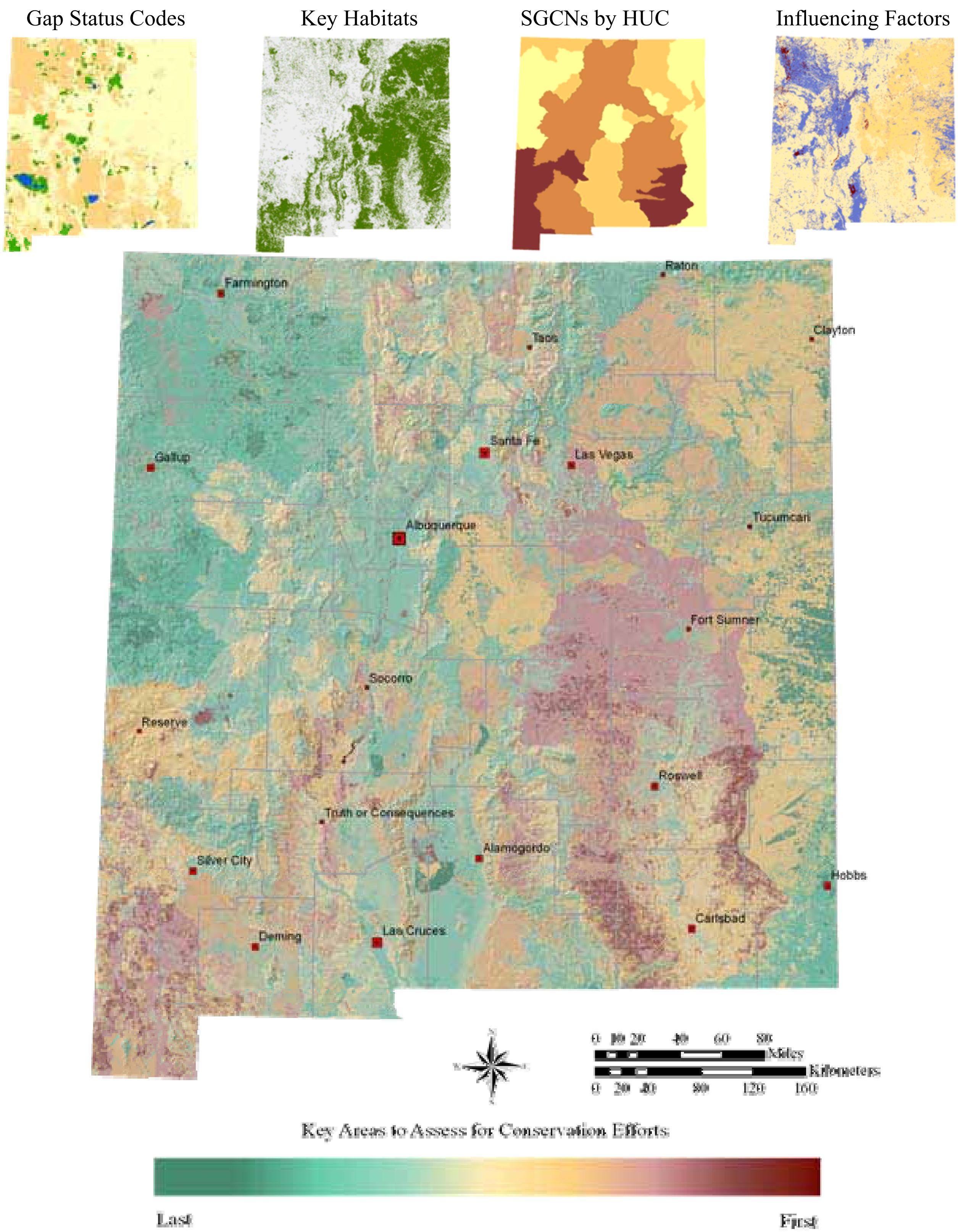


Figure 4-8. Key areas to consider for planning conservation efforts. This spatial representation is designed to enhance our understanding of geographic areas where conservation efforts may be needed. This analysis should not be used to locate small parcels of land.

Chapter 5

ASSESSMENTS AND STRATEGIES FOR SPECIES OF GREATEST CONSERVATION NEED AND KEY HABITATS

This chapter is organized by ecological frameworks at the scale of ecoregions for terrestrial habitats, watersheds for aquatic habitats, and statewide for riparian, ephemeral and perennial tank habitats. Component key habitats (**Element 2**), some of which cross ecoregion or watershed boundaries (Table 5-1, 5-2), are identified within each of these ecological frameworks. Each ecoregion or watershed section provides information on the SGCN associated with its component key habitats (**Element 1**), discusses the condition of key habitats (**Element 2**), describes problems affecting habitats and species (**Element 3**), and identifies information gaps and related research, survey, and monitoring needs (**Element 3**). Each section also provides a prioritized list of conservation actions necessary to overcome problems and achieve desired future outcomes (**Element 4**). Similar information for riparian, ephemeral and perennial tank habitats is provided in a statewide context. Also included is a discussion of SGCN, including arthropods other than crustaceans, that were not associated with key habitats (**Element 1**) and information gaps that limit our ability to associate these species with key habitats. Summarized information gaps and related research, survey, and monitoring needs are provided in Appendices M-P. Summarized conservation actions are discussed in Chapter 4.

Table 5-1. Key terrestrial habitats discussed in the ecoregion ecological framework.

	Key Terrestrial Habitats							
Ecoregion	Chihuahuan Semi-Desert Grasslands	Madrean Encinal	Madrean Pine-Oak / Conifer-Oak	Rocky Mountain Mixed Conifer	Short-grass Prairie	Sand Sage-brush	Big Sage-brush	Rocky Mountain Wet Meadow
Apache Highlands	X	X	X					
Arizona-New Mexico Mountains		X	X	X	X			
Chihuahuan Desert	X					X		
Colorado Plateau							X	
Southern Rocky Mountains				X			X	X
Southern Shortgrass Prairie					X	X		

Table 5-2. Key perennial aquatic habitats discussed in the watershed ecological framework.

	Perennial				
Watershed	Large Reservoir	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Canadian	X	X	X	X	
Gila		X	X	X	X
Mimbres		X	X	X	
Pecos	X	X	X	X	X
Rio Grande	X	X	X	X	X
San Juan	X			X	X
Tularosa		X	X		
Zuni			X	X	

Our assessment of factors that influence species or habitats is primarily focused at the habitat scale, as these factors directly affect wildlife communities and SGCN populations.
We also identified individual factors that are most influential in affecting each SGCN. We provide this information in Appendix I. Given that most of the species-specific factors that influence the long-term persistence of SGCN were habitat conversion, loss, and degradation, fire (burning and suppression), and improper grazing practices, we do not discuss species-specific factors separately from habitat factors.

In our discussion of factors that influence species and habitats, we primarily consider those practices that are harmful to wildlife at certain levels of use or extent. We recognize that many human activities across today's landscapes have the potential to be either beneficial or detrimental to wildlife. Many factors that influence New Mexico landscapes are based on legal and accepted practices. We also understand that it is the manner in which a human activity or practice is conducted that determines if it has a negative or positive effect on wildlife populations. For example, livestock grazing can be a valuable tool to improve wildlife habitat. However, if livestock grazing is applied improperly, it can be detrimental to plant communities and wildlife.

At times, we reference historic land management practices, as these practices have helped shape today's landscapes. In doing so, we do not intend to imply that historic land management practices still occur today. Our intent is to evaluate landscapes as they exist today and develop strategies on how best to make meaningful improvements to benefit species of greatest conservation need.

Human activities have the potential to be either beneficial or detrimental to wildlife. It is the manner in which a human activity or practice is conducted that determines if it has a negative or positive effect on wildlife populations.

APACHE HIGHLANDS ECOREGION

The Apache Highlands Ecoregion extends from central and southeastern Arizona into southwestern New Mexico and northern Mexico. Within the New Mexico portion of the ecoregion, three key habitats types were identified: Chihuahuan semi-desert grasslands, Madrean Encinal and Madrean Pine-Oak, Conifer-Oak Forest and Woodland (Fig. 5-1).

Semi-desert grasslands in the Apache Highlands Ecoregion have been recognized for their regional biological value, especially their importance to grassland birds (Biodiversity Support Program *et al*. 1995). The Madrean woodlands and forest in the Apache Highlands ecoregion represents a confluence of temperate North American and neo-tropical tree species assemblages, with intrusions of Sonoran and Chihuahuan desert flora at lower elevations. The legume (*Fabaceae*), oak (*Fagaceae*), and pine (*Pinaceae*) families are very diverse within this region (Felger and Johnson 1995).

Woodland and forest habitat types in this ecoregion occur within the greater Madrean Archipelago/Sky Islands complex, which are so-named because of the many isolated mountain ranges spread across the region. These isolated mountain ranges are essentially "islands" of upland habitats separated from one another by plains and valleys of desert and semi-desert grasslands. Desert grasslands and scrublands in the valleys limit genetic interchange between the elevated "island" mountain range habitats, creating isolation with high evolutionary potential within plant and animal populations (Warshall 1995).

The plant and animal communities of the Apache Highlands Ecoregion reflect the meeting, merging, co-evolution and co-adaptation of species representative of the northern Rocky Mountains region in the north and the Sierra Madre Occidental and neo-tropical regions of Mexico to the south. This high level of diversity and unusual community structure has appropriately been described as a stacking of biotic communities on each mountain "island" (Marshall 1957).

The Sierra Madre Occidental and isolated mountain ranges have facilitated plant and animal migrations northward and southward, and many species in the Madrean pine-oak and oak-conifer forests and woodlands are at the northern or southern extent of their distributions (Gehlbach 1981, Felger and Wilson 1995). This phenomenon is true more for tropical organisms than for temperate species, in part because of the northward increasing gradients of winter frost and summer drought that limit the northern distribution of neo-tropical species. As a result, fewer plant and animal species encounter their southern limits than those that are at their northern-most distribution.

This phenomenon involves a wide array of species, including trees, orchids, moths, birds (Felger and Wilson 1995), and bats. Plant species diversity within Apache Highlands Ecoregion is complex because of important floral influences from the Californian, Sonoran, Intermountain, Cordilleran, and Sierra Madrean provinces (Warshall 1995).

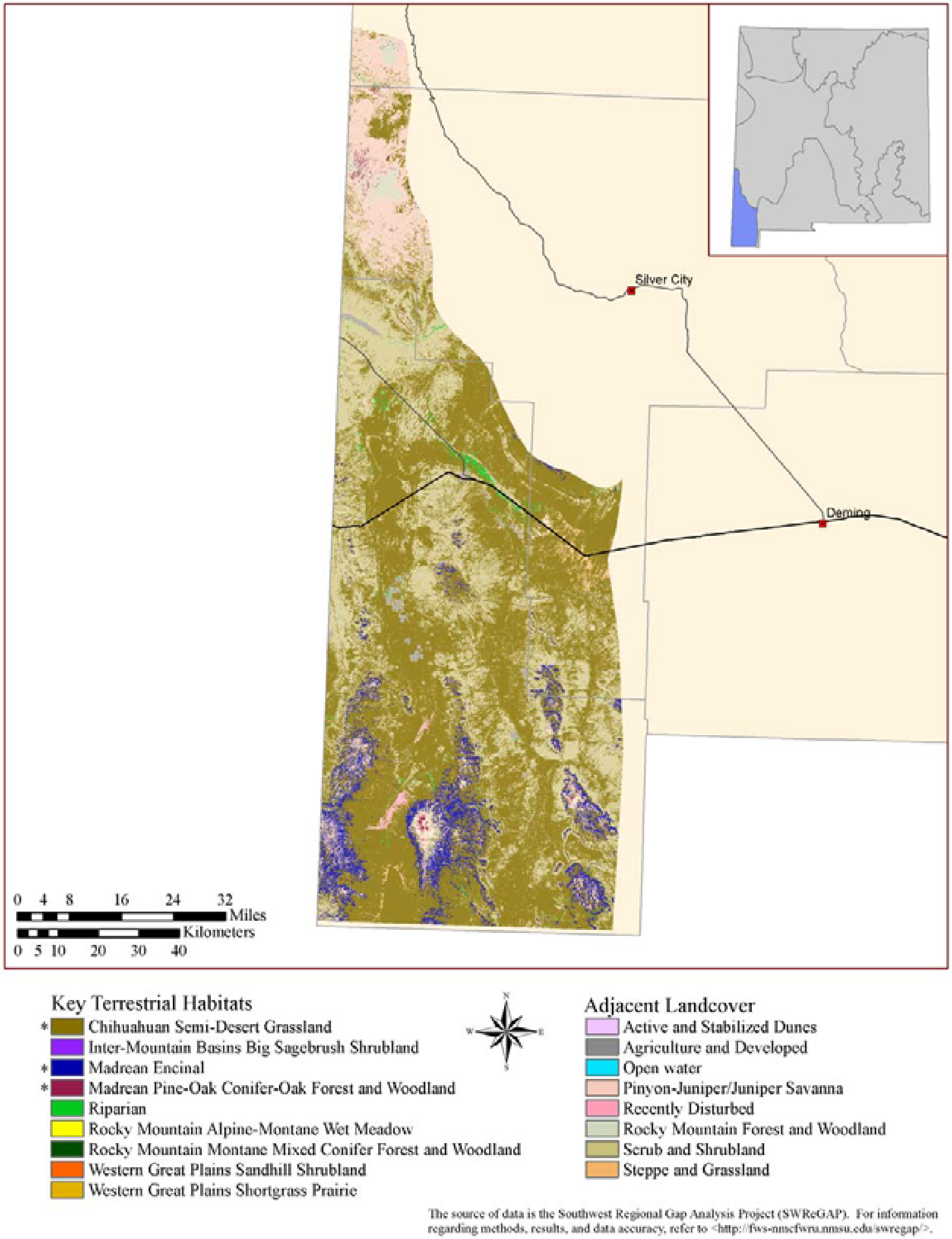


Figure 5-1. Key terrestrial habitats in the Apache Highlands Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Species of Greatest Conservation Need

The Apache Highlands Ecoregion supports a high number of endemic species, game species, and threatened and endangered species (Warshall 1995). Approximately 102 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, occur in the Apache Highlands Ecoregion (Table 5-3). Of these, 60 (59%) are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Twenty-six species (25%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 16 species (16%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Madrean Encinal and the Madrean Pine-Oak Conifer-Oak habitats had 61 SGCN, while the Chihuahuan semi-desert grasslands had 48 SGCN. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

Table 5-3. Species of Greatest Conservation Need in the Apache Highlands Ecoregion in New Mexico.

Common Name	Chihuahuan Semi-Desert Grasslands	Madrean Encinal	Madrean Pine-Oak / Conifer-Oak
Birds			
Ferruginous Hawk	X	X	
Northern Goshawk			X
Golden Eagle	X		X
Bald Eagle	X		
Peregrine Falcon			X
Aplomado Falcon	X		
Northern Harrier	X		
Gould's Wild Turkey		X	X
Montezuma Quail	X	X	X
Scaled Quail	X		X
Sandhill Crane	X		
Band-Tailed Pigeon		X	X
Mourning Dove	X	X	X
Common Ground-Dove	X		
Mexican Spotted Owl			X
Whiskered Screech-Owl		X	X
Elf Owl		X	X
Burrowing Owl	X		
Broad-Billed Hummingbird			X
Lucifer Hummingbird			X
Elegant Trogon		X	
Williamson's Sapsucker			X
Greater Pewee		X	X
Olive-Sided Flycatcher			X
Thick-Billed Kingbird			X
Loggerhead Shrike	X	X	X
Gray Vireo	X	X	X
Sage Thrasher	X		
Bendire's Thrasher	X		

Table 5-3 Cont.

Common Name	Chihuahuan Semi-Desert Grasslands	Madrean Encinal	Madrean Pine-Oak / Conifer-Oak
Birds Cont.			
Sprague's Pipit	X		
Pinyon Jay			X
Juniper Titmouse		X	X
Red-Faced Warbler			X
Lucy's Warbler			X
Yellow Warbler			X
Black-Throated Gray Warbler		X	X
Grace's Warbler			X
Painted Redstart		X	X
Botteri's Sparrow	X		
Baird's Sparrow	X		
Grasshopper Sparrow	X		
Varied Bunting	X		
Hooded Oriole	X		
Yellow-Eyed Junco		X	X
Mammals			
Mexican Long-Tongued Bat	X	X	X
Mexican Long-Nosed Bat	X	X	X
Lesser Long-Nosed Bat	X	X	X
Western Red Bat		X	X
Arizona Myotis Bat	X		
Allen's Big-Eared Bat		X	X
Pocketed Free-Tailed Bat	X	X	
Arizona Shrew		X	X
White-Sided Jack Rabbit	X		
Southern Pocket Gopher		X	X
Black-Tailed Prairie Dog	X		
Northern Pygmy Mouse	X		
Yellow-nosed Cotton Rat	X	X	X
Mexican Gray Wolf	X	X	X
Black Bear		X	X
White-Nosed Coati	X	X	X
Jaguar	X	X	X
Desert Bighorn Sheep	X		X
Mule Deer	X	X	X
Coues' White-Tailed Deer	X	X	X
Amphibians			
Colorado River Toad		X	
Chiricahua Leopard Frog		X	X
Lowland Leopard Frog	X	X	
Reptiles			
Sonoran Mud Turtle		X	X
Ornate Box Turtle	X	X	
Regal Horned Lizard		X	

Table 5-3 Cont.

Common Name	Chihuahuan Semi-Desert Grasslands	Madrean Encinal	Madrean Pine-Oak / Conifer-Oak
Reptiles Cont.			
Madrean Alligator Lizard		X	X
Collared Lizard	X	X	X
Bunch Grass Lizard	X		
Giant Spotted Whiptail		X	
Gray-Checkered Whiptail	X		
Mountain Skink		X	
Reticulate Gila Monster	X	X	
Sonoran Mountain Kingsnake		X	X
Milk Snake	X		
Green Rat Snake		X	
Yaqui Blackhead Snake		X	
New Mexico Ridgenose Rattlesnake		X	X
Western Diamondback Rattlesnake	X	X	
Banded Rock Rattlesnake		X	X
Desert Massasauga	X		
Molluscs			
Shortneck Snaggletooth Snail		X	
Sonoran Snaggletooth Snail		X	X
Heart Vertigo		X	
Vallonia Snail			X
Cross Holospira Snail		X	X
Metcalf Holospira Snail	X		
Animas Mts. Holospira Snail		X	
Hacheta Mountainsnail		X	X
Fringed Mountainsnail		X	X
Big Hatchet Woodlandsnail		X	X
Animas Peak Woodlandsnail		X	X
Grande Hacheta Woodlandsnail		X	X
Three-Toothed Column Snail	X	X	X
San Luis Mountains Talussnail	X		
Animas Talussnail		X	X
Big Hatchet Mountain Talussnail		X	X
Peloncillo Mountain Talussnail		X	

Chihuahuan Semi-Desert Grassland

Habitat Condition

The Chihuahuan semi-desert grassland is a discontinuous mosaic of desert scrub and grassland distributed from the "boot heel" of New Mexico southwest through Arizona into Mexico (Dick-Peddie 1993). This intermingled and naturally fragmented habitat type contains a highly varied flora and fauna. Soils are equally varied. Thin soils with low organic matter and high amounts of calcium carbonate are found on upland slopes and hilltops and finer alluvial soils are deposited at the bottoms of slopes in depressions, playas, or bolsons (Schmutz *et al.* 1991). Chihuahuan sem-desert grasslands experienced a marked shift from perennial grassland to shrub dominated desert scrub in the mid-1800s, as with other grassland communities in the western United States (Barnes 1936, Buffington and Herbel 1965, Branson 1985, Archer 1989). The exact cause of this shift is debated, but excessive livestock grazing, climatic change, and fire suppression are contributors to this change (Barnes 1936, Allred 1996, Fredrickson *et al.* 1998). In turn, grassland conversion and human-caused fragmentation have increased runoff and erosion, decreased biological diversity through isolation, reduced carrying capacity (Saunders *et al.* 1991), caused shifts in avian assemblages, increased invasion by non-native species, and decreased livestock and wildlife forage (Branson 1985, Vickery *et al.* 1999). Today, portions of the Chihuahuan semi-desert grassland appear to be undergoing additional desertification (Asner 2005).

Problems Affecting Habitat or Species

Biodiversity in Chihuahuan semi-desert grasslands is influenced by habitat conversion factors and non-consumptive and consumptive resources uses. Dinerstein *et al*. (2000) also reported that livestock grazing, fire suppression, and urban development were factors leading to loss of biodiversity in the northern Chihuahuan Desert.

Grazing Practices
Domestic livestock grazing is an extensive land use activity in the Chihuahuan Desert (See Chapter 3, New Mexico's Biodiversity). Grazing of Chihuahuan Desert grasslands may not always lead to altered habitats. Impact of livestock grazing on rangeland wildlife is largely dependent on the grazing management practices used. However, improper grazing practices (grazing practices that reduce long-term plant and animal productivity) on native grasslands may lead to the loss of grassland cover, mortality of plant species, and increased erosion (Wilson and MacLeod 1991). Further, improper grazing practices and increased intense agriculture production may lead to habitat fragmentation and loss by promoting conditions favorable for shrub encroachment and through increased infrastructure development, such as roads and fences (Dinerstein *et al*. 2000). The effects of these land management activities are compounded by extended drought periods and altered hydrological functions in the Chihuahuan Desert. An additional discussion of grazing practices is offered in the Statewide Assessment and Strategies (Chapter 4).

Fire Regimes
Altered fire regimes, resulting from both fire suppression and the removal of fine fuels by domestic grazers and wildlife, may have also promoted the establishment of both woody vegetation and introduced non-native species. However, the extent to which fire occurred in southwestern grasslands varied geographically and is related to climatic variables such as seasonal and annual rainfall and physiographic variables such as elevation, slope and aspect (Archer 1994). Fire may have been rare in desert grasslands and limited in extent due to low biomass and a lack of continuity in fine fuels (Hastings and Turner 1965, York and Dick-Peddie 1969).

Development and Exploration
Housing developments and agriculture are increasing in areas around Deming and Lordsburg. Development contributes to the loss of native vegetation and erosion through soil compaction and the concentration of runoff. Agricultural production results in loss of natural plant and animal communities and fragmentation of landscapes through habitat conversion, roads, fences, and groundwater pumping. Chihuahuan semi-desert grasslands in the "boot heel" portion of Hidalgo County are now being explored for geothermal energy and oil and gas potential. This activity can ultimately cause habitat fragmentation and loss through conversion (clearing), road building with increased vehicular traffic, and groundwater pumping (Dinerstein *et al.* 2000).

Borderland Security Activities
Security measures are being implemented throughout the United States/Mexico borderlands region to intercept drug shipments, illegal immigrants, and other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Increased road building and traffic along the borderlands causes habitat destruction, loss, and fragmentation, diminishes the utility of habitat for wildlife, and increases road kill (Forman *et al.* 2003).

Off-Road Vehicles
Recreational off-road vehicle use has also increased in the Chihuahuan semi-desert grasslands. While the impacts of these activities on the Chihuahuan semi-desert grasslands are poorly understood, increased off-road vehicle use negatively impacts wildlife by destroying and fragmenting habitat, causing direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Invasive Species
Many ecologists have acknowledged the problems caused by invasion of non-native species into ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plants and animals, including threatened and endangered species, disrupt nutrient and fire cycles, and alter the character of the native community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Little is known about the extent of invasive species in Chihuahuan semi-desert grasslands. As such, the development of early detection protocols, and estimators of vectors and pathways of potential invasive species may assist in the development of strategies to control invasive species.

Information Gaps

Although there is a large body of literature on Chihuahuan semi-desert grasslands, there are numerous information gaps (outlined below) that limit our ability to make informed decisions.

- The intensity, scale, extent, and causes of grassland fragmentation in the Chihuahuan Desert are unknown.
- The response of SGCN to human disturbances is poorly understood.
- The effects of habitat fragmentation on SGCN are unknown.

- Environmental conditions or thresholds that limit populations of SGCN are poorly understood.

- Methods to identify early detection landscape degradation attributes that would inform land managers of when grasslands were approaching transitional thresholds are needed, to alleviate the need for expensive restoration projects.

- The extent to which invasive species may alter semi-desert grasslands and limit populations of SGCN is unknown.

- The full extent in which border patrol activities or military maneuvers alters semi-desert grasslands and limits populations of SGCN is unclear.

- Information is needed on grazing management practices that produce sustainable levels, composition, and structure of native grasses needed by SGCN.

- The extent to which off-road vehicle use is impacting Chihuahuan semi-desert grassland SGCN populations is unknown.

- Our understanding of the role of fire in sustaining the Chihuahuan semi-desert grasslands and appropriate fire management protocols is poor.

- Short and long-term effects of land management practices or uses such as energy exploration and development, grazing systems, invasive species and shrub encroachment management are unclear. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Chihuahuan semi-desert grasslands are primarily derived from our perception of factors that influence the integrity of semi-desert grasslands. Research, survey, and monitoring needs include:

- Estimate the extent, fragmentation, and structural characteristics of Chihuahuan semi-desert grasslands to provide greater predictive power and applicability to an ecosystem management approach.

- Research is needed to obtain basic life history information for SGCN inhabiting Chihuahuan semi-desert grasslands to develop effective species/habitat monitoring and conservation strategies.

- Studies are needed on the type and extent of human-caused fragmentation in Chihuahuan semi-desert grasslands and how such habitat alterations influence patch size, edge effect, and use by wildlife. This information is also important in understanding how different intensities and frequencies of disturbances effect small-mammal species, avifauna, and herpetofauna.

- Since this habitat type has experienced a shift from perennial grassland to shrub-dominated desert scrubland (Buffington and Herbel 1965, Archer 1989), early detection methods are needed that indicate when grasslands habitats are shifting to another habitat type. In addition, cost effective measures need to be investigated that restore semi-desert grasslands to functional mosaics.

- Consistent rangeland health and condition descriptions or protocols need to be developed across the states, regions, and nations (National Research Council 1994). These protocols would facilitate land management decisions by establishing standardized indicators and reference points.

- Investigate invasive species early detection protocols, and estimate vectors and pathways of potential invasive species.

Desired Future Outcomes

Desired future outcomes for the Chihuahuan semi-desert grasslands include:

- That the Chihuahuan semi-desert grasslands exists in the condition, connectivity and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Ecological conditions that sustain viable populations of the SGCN are established and garner wide public support.

- That colonization of Chihuahuan semi-desert grasslands by invasive plant species is stopped and existing populations are controlled or eliminated.

- That energy development on Chihuahuan semi-desert grasslands is managed to preserve habitat integrity and functionality and that disturbed sites are restored to native habitats.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage

availability is inadequate, and promoting “grass banking” opportunities that allow degraded rangelands to recover.

2. Work with public and private land managers to reduce shrub encroachment in Chihuahuan semi-desert grasslands habitats important to SGCN. Implementation of this conservation action may include chemical or mechanical manipulation, reseeding with native grasses, or reduction of processes that promote shrub encroachment.

3. Work with federal, state, private organizations, research institutions, and universities to design and implement projects outlined in the Research, Survey, and Monitoring Needs or Information Gaps section outlined above.

4. Work with public and private land managers and the energy industry to encourage energy development in a manner that preserves the integrity and functionality of Chihuahuan semi-desert grasslands and restores disturbed sites.

5. Form partnerships with effected communities and federal land management agencies to facilitate and encourage maintenance and restoration of Chihuahuan semi-desert grasslands.

6. Collaborate with federal and state agencies to designate areas for off-road vehicle use that avoid disturbance to SGCN or their habitats and discover ways to mitigate such disturbance where it currently occurs.

7. Collaborate with federal and state land management agencies and other publics to identify legislative actions, land acquisition and easement protection that will conserve the Chihuahuan semi-desert grasslands.

8. Work with federal, state, and private organizations to develop public education projects that increase awareness and understanding of the fragility of Chihuahuan semi-desert grasslands and their importance to a wide array of species.

Madrean Encinal and Madrean Pine-Oak Conifer-Oak Forest and Woodland

The Madrean Encinal and Madrean Pine-Oak, Conifer-Oak Forest and Woodland in the Apache Highlands Ecoregion have similar problems, information gaps, research, survey, and monitoring needs, desired future outcomes, and conservation actions. We present information on these two habitat types collectively.

Habitat Condition

Madrean Encinal oak woodlands in the Apache Highlands ecoregion generally occur at elevations between 4,000 ft (1,220 m) and 4,986 ft (1,520 m). At the lower ecotone where conditions are drier, Madrean Encinal oak woodlands merge with oak savanna and eventually semi-desert grassland. At middle elevations, Madrean Encinal oak woodlands grade into

Madrean pine-oak forests, and at the highest elevations into conifer-oak and pine forests (Ffolliott 2002).

Emory oak (*Quercus emoryi*) is the most common tree species in Madrean Encinal and is found in associations with varying intermixtures of Mexican blue oak (*Q. oblongifolia*), gray oak (*Q. grisea*) silverleaf oak (*Q. hypoleucoides*), and Arizona white oak (*Q. arizonica*) (Ffolliott 1980, Brown 1982, McPherson 1992, 1997, McClaran and McPherson 1999). Interspersed within the Madrean Encinal are shrubs, grasses, forbs and succulents.

Within Madrean pine-oak and oak-conifer forests and woodlands, pines or other conifers generally form the overstory while oaks generally form the understory. There are extensive areas of pine-oak woodland in the Apache Highlands Ecoregion of the southwestern United States. Pine-oak woodland is included within the concept of Madrean evergreen woodland. The pine forest is called Madrean Montane Conifer Forest (Brown 1982). Within this habitat type, the abundance of oaks may be a consequence of over harvesting of pines (Felger and Johnson 1995).

At higher elevations within the pine-oak forest and woodland, pines become more dominant as their density increases so that the vegetation could be called forest rather than woodland. This pine-oak forest is dominated by one species of pine, usually Arizona pine (*Pinus ponderosa* var. *arizonica*), ponderosa pine (*P. ponderosa* var. *scopulorum*), or white pine (*P. strobiformis*). Scattered individuals or small groups of oaks, primarily Gambel oak (*Q. gambelii*), and net-leaf oak (*Q. rugosa*), occur with these pine stands. Gambel oak is the only winter-deciduous oak in this area. In the northernmost of the isolated mountain ranges, Arizona pine is replaced by ponderosa pine at higher elevations (Felger and Johnson 1995).

Precipitation in the Madrean woodlands and forests ranges from 12 - 40 in (305 - 1,015 mm) per year, with generally half of this precipitation occurring between May and August. The frequency of freezing temperatures increases northward within the Madrean woodlands and forest, which limits plant species diversity (Gottfried *et al.* 1995). Bi-modal emergence of perennial and annual plants occurs in early spring following winter rains and during the summer monsoons (McPherson 1994, 1997).

The distribution, structure and health of Madrean woodlands and forest in the Apache Highlands Ecoregion have been affected by human activities since prehistoric times. The Madrean woodlands and forest were important to prehistoric people (Propper 1992), who gathered fuel wood for fires and construction materials, acorns for food and ceremonial purposes, and piñon nuts and juniper berries for winter food (Gottfried *et al.* 1995). Settlers, miners, and ranchers utilized woodlands in the late 1800s and early 1900s, for timber and smelter fuel (Bahre and Hutchinson 1985). Madrean woodlands and forest were heavily grazed by livestock in the 1880s and continue to be grazed today, although at much lower stocking rates (Weltzin and McPherson 1995). However, Madrean woodlands and forests have not been subjected to large-scale range improvement practices (Ffolliott and Guertin 1987, McClaran *et al.* 1992).

Natural mortality of oak trees appears to be low, possibly due to the long history of harvesting older trees. All evergreen oak tree species in the Madrean Encinal of New Mexico and Arizona are susceptible to infection by a fungus, *Inonotus andersonii*, a major cause of wood decay (Fairweather and Gilbertson 1992). Oak densities within Madrean woodlands and forest vary considerably, and range from a few scattered individuals to several hundred stems per hectare. Volumes of wood vary from less than 1, to more than 53 yd^3 per ac (2 to more than 100 m^3 per ha) (Ffolliott and Gottfried 1992). Annual growth rate is relatively slow, ranging from 0.13 - 0.26 yd^3 per ac (0.25 - 0.50 m^3 per ha), with an annual growth rate of less than 1% (Gottfried *et al.* 1995).

Tree density and openness is related to local site characteristics such as soils, fire disturbance and land use histories (Gottfried *et al.* 1995, Ffolliott 2002). Tree species composition and density changes with elevation gradients, latitude, previous disturbances, slope, and aspect. Stand-level disturbances by fire, disease, vegetation control, and land-clearing activities have been relatively minor in Madrean woodlands and forests (Kruse *et al.* 1996). However, these disturbances when they do occur are likely to affect stand structure and productivity (Ffolliott and Gottfried 1992, Gottfried *et al.* 1995, McClaran and McPherson 1999). Historically, fires effected species composition, stand density, and size-class distributions (Niering and Lowe 1984, Barton 1991, Kruse *et al.* 1996).

The Madrean woodlands and forests are an area of exceptionally high biological diversity and biogeographical interest (DeBano and Ffolliott 1995). These habitat types occur within a topographically and geologically complex region (Felger and Johnson 1995). The complex topography and steep elevation gradients within the Madrean pine-oak and oak-conifer forests and woodlands result in a rich assemblage of floral and faunal species. The complex geology and topography of the region creates unusual and striking assemblages of habitats and plant and animal associations. Floral and faunal species occur here that are more commonly associated with the New World tropics than with the southwestern borderlands. Plant and animal species co-mingle here that would otherwise be separated by large distances and climatic regimes (Felger and Wilson 1995).

Problems Affecting Habitats or Species

A general analysis based on the scientific literature and NMDGF staff opinion reveals that climate change, fire management, urban and residential development and habitat loss and fragmentation associated with roads/highways/utility corridors are the greatest factors adversely affecting Madrean woodlands and forests in the Apache Highlands ecoregion.

Climate Change and Drought

Climate change may occur in the Southwest from increased atmospheric concentrations of CO_2 and other greenhouse gases. Effects may include increased surface temperatures, changes in the amount, seasonality, and distribution of precipitation, more frequent climatic extremes, and a greater variability in climate patterns. Such changes effect vegetation at the individual, population, or community level, precipitate changes in ecosystem function and structure (Weltzin and McPherson 1995), and will likely affect competitive interactions between plant and animal species currently co-existing under equilibrium conditions (Ehleringer *et al*. 1991) (See Chapter 4 for greater details).

Subsequent specific outcomes for Madrean forest and woodland habitats are unpredictable and remain uncertain (Weltzin and McPherson 1995). However, plants respond differently to changes in atmospheric gases, temperature and soil moisture, in part based on their C_3 or C_4 photosynthetic pathways (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson *et al*. 1993). For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses, while increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin *et al*. 1986). Recent research has investigated shifts in the Madrean Encinal oak woodland/semi-desert grassland boundary (Hastings and Turner 1965, Bahre 1991, McPherson *et al.* 1993). Paleo-ecological data gathered from packrat middens suggest that Madrean Encinal oak woodland have moved higher in elevation as a result of warmer and drier climatic conditions since the Pleistocene. Bahre (1991) suggests that the distribution of Madrean Encinal oak woodland has been stable since the 1860s.

Drought, defined as an extended period of abnormally dry weather, is one of the principal factors limiting seedling establishment and forest productivity (Schulze *et al*. 1987, Osmond *et al*. 1987). Soil moisture is directly altered by drought conditions. The distribution and vigor of some oak woodlands and savannas is controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993). Drought and climate change can have a substantial effect on the Madrean forest and woodland habitats. Further, these factors can alter fire frequency, intensity, and timing by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994). Unfortunately, due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors, and political decisions at national and international levels, the effects of climate change on fire regimes in the Madrean forests and woodlands are difficult to predict (Weltsin and McPherson 1995).

Natural Disturbance Regimes

Natural disturbances in the Madrean woodland and forests are fire, wind, and insects. Changes in the frequency, intensity, and timing of natural fires have altered the distribution of current vegetation. Madrean woodland and forest density was relatively low prior to European settlement (Moody *et al*. 1992, Covington and Moore 1994). In these less dense woodlands, most fires were low intensity ground fires that tended to reduce understory vegetation (Gottfried *et al*. 1995). The elimination of episodic fires after 1893 may be attributed to livestock grazing and fire suppression (Grissino-Mayer *et al*. 1995, Weltzin and McPherson 1995). Historic (late 1800s) improper grazing practices in Madrean woodlands and forests eliminated the herbaceous fine fuels layer. The reduction of these fine fuels prevented the spread of low-intensity, ground-hugging fires, and reduced grass competition, thereby allowing tree establishment (Gottfried *et al*. 1995). Fire suppression has further eliminated the natural fire regime that historically kept stand densities relatively low. Fire suppression allowed the increase of ladder fuels and heavy fuel loading conditions. Catastrophic, stand-replacing crown fires have become more common because of these changes (Covington and Moore 1994).

Grazing Practices

Livestock grazing has economic and cultural values that are important to individuals, communities and the State. Impacts to rangeland wildife by livestock grazing are largely dependent on the grazing management practices used. Domestic and wildlife grazing practices that reduce the ability of the land to sustain long term plant and animal production (Wilson and

MacLeod 1991) have influenced plant communities and fish and wildlife habitat in New Mexico for more than a century. Peer-reviewed scientific literature implies that livestock grazing has impacted terrestrial and riparian/aquatic habitats in New Mexico (Armour *et al*. 1994, Fleischner 1994, The Wildlife Society 1996, Belsky and Blumenthal 1997). Improper grazing by livestock can reduce vegetative cover, increased soil erosion, and aggravated local flooding (Felger and Wilson 1995).

Many of these impacts began as early as the late 1800s when large herds of livestock were present. Impacts of improper grazing practices have included: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by altering vegetation composition and structure; 3) impacts on stream hydrology, siltation, and water quality; and 4) reduced soil permeability and potential to support plants due to soil compaction. Improper grazing can diminish wildlife habitat in Madrean woodland and forest. In contrast, prescribed grazing is a management tool that can be used to benefit wildlife (Holechek *et al*. 1982, Kirby *et al*. 1992, Holecheck *et al.* 2004).

Animal Herbivory

Animal herbivory is the most common source of mortality for low-elevation oaks of southern Arizona (McPherson 1993, Peck and McPherson 1994). Herbivory by invertebrates is a potentially important source of seedling mortality that is commonly overlooked in field studies. Invertebrates have been found to defoliate oak seedlings primarily during the summer (Peck and McPherson 1994, Weltzin and McPherson 1995). Vertebrates kill Emery oak seedlings primarily during autumn and winter months (Weltzin and McPherson 1995). Differential population dynamics of herbivorous animal species, combined with temporal and spatial variability of herbivory (McPherson 1993, Peck and McPherson 1994, Weltzin and McPherson 1995) combine to determine the timing and intensity of herbivory-related mortality on young oaks (Weltzin and McPherson 1995).

Loss of Biological Diversity

Intact Madrean woodland and forest habitats once extended into the American tropics, but accelerating deforestation is fragmenting habitats and populations of plant and animal species (Felger and Johnson 1995). Trees within Madrean woodland and forest habitats are most often harvested for fuel wood and fence posts, but also for value-added wood products such as furniture and home construction (Ffolliott 1989, Ffolliott and Gottfried 1992, Maingi and Ffolliott 1992).

Natural regeneration of Madrean oak woodlands is low. Factors that may be responsible for low recruitment of oaks include herbivory by livestock and wildlife, competition for water, light and minerals from herbaceous plants, and climatic and edaphic conditions. A combination of these and possibly other unknown factors likely interact to produce low rates of seedling re-establishment (Weltzin and McPherson 1995). However, demands for oak woodlands are expected to increase (Conner *et al*. 1990, Van Hooser *et al*. 1990, Ffolliott and Gottfried 1992, Gottfried *et al*. 1995).

Biological diversity in the Madrean woodland and forest is rapidly eroding (DeBano and Ffolliott 1995). Cutting trees of the tallest height classes reduces the structural diversity of oak forests and woodlands stands (Sharman and Ffolliott 1992). Taller trees provide more habitat niches for non-game birds than do shorter trees (Balda 1969). Thus, tree harvesting can reduce bird diversity by simplifying woodland structural diversity (Ffolliott 2002).

Non-Native Species
In 1998, non-native species were implicated in the decline of 42% of species federally listed under the Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal communities, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Exotic species colonization of the Madrean Archipelago region is increasing, with more than 60 non-native plants having successfully established in the isolated mountain ranges of Arizona (Warshall 1995).

Habitat Alteration and Fragmentation
Human populations are increasing in the region and demands for fuel wood are accelerating. Privately owned forest and woodlands are being converted to residential areas, fragmenting wildlife habitats, increasing wildland/urban interface fire risks, and generally accelerating land management conflicts. Associated increasing demands for water in these communities are outpacing the ability of natural systems to provide new freshwater sources (Felger and Wilson 1995). Sustainability of Madrean woodland and forest habitats is questionable under increasing pressures from human activities and altered fire regimes (Gottfried *et al*. 1995).

Much of the Madrean woodlands and forests of southwestern New Mexico and southeastern Arizona is administered by the US Forest Service. It is charged with potentially conflicting mandates of multiple use including: 1) conservation of wildlife, habitats and ecosystem function; 2) generating revenue from timber sales; 3) maintaining livestock grazing leases; and 4) providing increasing opportunities for urban recreation (Felger and Wilson 1995). There is growing pressure to develop more Madrean woodland and forest habitats within national forests for camping, hiking, mountain biking, off-road vehicle use, and new or improved roads to access these sites (Warshall 1995).

Groundwater Depletion
Groundwater levels in the United States and regional wetlands have dropped significantly from groundwater pumping for agricultural irrigation of crops. One example in Madrean woodlands and forests is San Simon Cienega, which was once a functioning wetland, but has since been drying out due at least in part to groundwater pumping (Dinerstein *et al*. 2000).

Mining
Historic and current hard rock mining activities pose a threat to ecosystem function, resilience and sustainability within the Madrean woodland and forests in the Apache Highlands. Large underground bodies of primarily copper deposits have led to huge industrial mining complexes in the area. Associated ecosystem stressors include: 1) habitat fragmentation and loss; 2) acid rock drainage from chemical reactions to surface waste rock that create heavy metal contamination poisonous to wildlife (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995, Hilliard 1994); 3) huge permanent pit lakes that contain toxic water (a danger primarily to waterfowl) (Miller *et al.* 1996); 4) groundwater pollution; 5) air pollution and associated acid

rain fallout; 6) increased frequencies of road killed fauna; 7) the potential for bioaccumulation of heavy metals in soils and vegetation at levels dangerous to wildlife.

Borderland Security Activities
Security measures are being implemented throughout the United States/Mexico borderlands region to intercept drug shipments, illegal immigrants, and stop other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Increased road building and traffic along the borderlands causes habitat destruction, loss, and fragmentation, diminishes the utility of habitat for wildlife, increases road kill, poaching, and illegal collecting (Forman *et al.* 2003).

Recreation and Tourism
Recreation and tourism activities in the Madrean woodland and forests generate income for the region. Hunting for species such as deer, quail and collared peccary (*Tayassu tajacu*) has long been a dominant recreational use (McClaran and McPherson 1999). Non-consumptive recreational uses in Madrean woodland and forests include hiking, camping, sightseeing, bird watching, and picnicking (Conner *et al.* 1990). Although comprehensive statistics documenting the level of these recreational uses are lacking, it is clear that recreational uses of Madrean woodlands and forests are increasing and their impact on habitats and species should be considered in conservation planning (Conner *et al.* 1990, McClaran *et al.* 1992).

Information Gaps

Information gaps that impair our ability to make informed conservation decisions are outlined below.

- The location, timing, duration, frequency and intensity of all of the problems identified that potentially affects Madrean woodland and forest habitats and/or SGCN.

- The ongoing activities of the Joint Task Force Six activities on the borderland of New Mexico. These activities include maneuvers and encampments that can destroy habitat, spread invasive weed species, increase road kill, and alter sensitive wildlife behavior.

- The impacts on Madrean woodland and forest SGCN and habitats from increased daytime and nighttime traffic associated with Border Patrol surveillance and monitoring activities and illegal immigration.

Research, Survey, and Monitoring Needs

The processes that have impacted the Madrean forests and woodlands in the past and the anticipated levels of future development serve as a backdrop for defining current research, survey, and monitoring needs. Research, survey, and monitoring needs that would enhance conservation efforts in these habitats are outlined below.

- Enhance our understanding of habitat connectivity by acquiring population-level information of dispersal behavior, daily and seasonal movements of SGCN through

Madrean woodland and forest habitats, how different types of habitat fragmentation (such as timber removal, housing developments) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the extent, age class, structural characteristics, and regeneration rates of the Madrean woodlands and forests so as to provide predictive power and applicability to ecosystem-based management.

- Determine the minimum viable habitat size and forest age-class structure necessary to support SGCN that migrate vertically among the bands of Madrean habitats within the isolated mountain ranges of the Madrean Archipelago.

- Determine how global and regional climate change will affect vegetation patterns and community and ecosystem-level dynamics in Madrean pine-oak, conifer-oak forests and woodlands.

- Conduct research to enhance information of the natural history, population biology, and community ecology of SGCN within Madrean woodland and forest habitats.

- Conduct research to increase our knowledge of SGCN distribution, abundance, and population trends within the Madrean woodland and forest habitats of the Apache Highlands Ecoregion.

- Evaluate the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires in the Madrean woodlands and forests.

- Determine how SGCN of Madrean woodland and forests respond to prescribed livestock grazing, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population.

- Assess the impacts of prescribed livestock grazing on the structure of Madrean woodlands and forests.

- Determine how the timing, intensity, and duration of prescribed livestock grazing affect SGCN.

- Determine how prescribed grazing affects natural disturbance regimes such as wildland fire in Madrean woodland and forest habitats.

- Identify wildlife travel corridors connecting the Madrean woodland and forest habitats in isolated mountain ranges so they may be protected and managed to maintain connectivity. Information needed for understanding habitat connectivity includes population-level information of dispersal behavior, daily and seasonal movements of SGCN through Madrean habitats, how different types of habitat fragmentation (such as timber removal, housing developments, etc.) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the effects of natural and prescribed fire on the structure of vegetative communities in the Madrean woodlands and forests and the subsequent effects upon vertebrate and invertebrate populations. Evaluate the effectiveness of prescribed fire as a tool to reduce the potential for catastrophic fire (DeBano and Ffolliott 1995).

- Assess the potential impacts of fire on SGCN such as the Lucifer hummingbird (*Calothorax lucifer*), the New Mexico ridgenose rattlesnake (*Crotalus willardi obscurus*) and the whiskered screech owl (*Otus trichopsis*) and elegant trogon (*Trogon elegans*), two cavity-nesting birds that breed only in the Peloncillo Mountains. Assess impacts on the Mexican long-nosed bat (*Leptonycteris nivalis*) and the lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), which are exclusively dependent upon agave (*Agave parryi* and *A. palmeri*) for nectar.

- Determine if coppicing (post-cutting sprouting from roots and stumps) is an effective supplement to the episodic regeneration of oaks from seed. Is coppicing sufficient to maintain habitat composition, structure, and biological diversity?

- There is a need for additional investigations of hydrologic relationships in the Madrean woodlands and forests that will provide a better understanding of interception, transpiration, and infiltration processes (Lopes and Ffolliott 1992, Haworth and McPherson 1994, Baker *et al*. 1995, Ffolliott and Gottfried 1999). This information is crucial for determining effective and sustainable conservation and management practices at the watershed level (Ffolliott *et al*. 1993).

- There is a need to develop collaborative survey and monitoring protocols for invertebrate SGCN that are not currently being monitored.

Desired Future Outcomes

Desired future outcomes for Madrean forests and woodlands include:

- Madrean woodland and forest habitats exist in the condition, connectivity and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource conflicts.

- A scientific basis for ecosystem management has been established and implemented in the Madrean woodlands and forests. Systems management of the ecosystem, rather than functional management of individual species or other natural resources such as timber, is policy and is validated through forest plans ecosystem-wide.

- Long-term conservation strategies to restore viable native species population are established and garner wide public support.

- Special habitats within the Madrean woodland and forests, such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams are protected and are being monitored long-term for condition as necessary to ensure conservation for SGCN that rely on these habitats.

- Prescriptions for sustainable harvest have been developed that allow adequate levels of human harvest for fuel wood and other wood products and major harvest activities replicate natural disturbance patterns.

- Partnerships have been established among state and federal government agencies, non-governmental organizations and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the Madrean woodland and forest habitats upon which they depend.

- Colonization of Madrean woodland and forest habitats by exotic species is stopped. Existing populations of non-native species are controlled or eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with affected interests to pursue enactment of state laws or policies to protect closed basins within Madrean woodlands and forests from the impacts of dredge and fill activities and future development.

2. Work with willing private landowners to obtain conservation easements for lands that have historic or potential value as corridors connecting Madrean mountain ranges.

3. Collaborate with state and federal agencies, universities, Wildlands network, other NGOs and private landowners to identify and protect riparian corridors and other corridors linking Madrean mountain ranges.

4. Collaborate with state and federal agencies and private landowners to develop measures (such as closure of unnecessary roads) within and adjacent to Madrean woodlands and forests to reduce habitat fragmentation.

5. Promote protection and restoration of unique habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams that Madrean SGCN depend upon.

6. Encourage the US Forest Service to conserve the biological diversity of the Madrean woodland and forest habitat through development and implementation of an ecosystem management approach.

7. Work with government and private landowners to develop strategies for the sustainable harvest of wood products in Madrean woodland and forests that will maintain oak regeneration and native biodiversity.

8. Encourage thinning and fuel-reducing initiatives in Madrean woodland and forest habitats, where necessary, to open dense stands that have become susceptible to insects, diseases, or stand-replacing wildfires.

9. Encourage government and private land managers to protect and restore Madrean watersheds through management practices that reduce erosion, gully formation, soil loss, and maintain native biodiversity.

10. Maintain awareness of the introduction and spread of non-native plants and animals into Madrean woodlands and forests and encourage control or eradication where necessary to maintain or restore native biodiversity.

11. Provide the US Forest Service with recommendations regarding the timing of prescribed burning in Madrean woodlands and forests to protect breeding birds, avoid riparian areas, and otherwise conserve biodiversity.

12. Encourage the US Forest Service to schedule prescribed burns avoiding desert bighorn sheep lambing areas from mid-December through mid-February.

13. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting "grass banking" opportunities that allow degraded rangelands to recover.

14. Create public awareness and understanding of ecosystem functions, values, products and human impacts on Madrean habitats important to SGCN.

ARIZONA-NEW MEXICO MOUNTAINS ECOREGION

The Arizona-New Mexico Mountains Ecoregion encompasses the highlands of eastern Arizona and central and western New Mexico covering 29 million ac (12 million ha) of land. Most (78%) of the ecoregion occurs in New Mexico. This diverse physiographic region has elevations ranging from 4,500 ft - 12,600 ft (1,371 m - 3,840 m) and contains a number of mountain ranges, steep foothills, plateaus, and desert plains.

The more prevalent terrestrial habitats include Madrean pine-oak, conifer-oak forests and woodlands, Rocky Mountain forests and woodlands, and Rocky Mountain montane mixed conifer, in the higher elevations. Piñon-juniper/juniper savanna, steppe and grasslands, Chihuahuan semi-desert grasslands, and Western Great Plains shortgrass prairie are found in the lower elevations. Riparian forests, usually populated with ponderosa pine (*Pinus ponderosa*) and white fir (*Abies concolor*), are also found throughout. Key habitats identified in this ecoregion include: Madrean Encinal, Madrean Pine-Oak/Conifer-Oak Forests and Woodlands, Rocky Mountain Montane Mixed-Conifer Forests and Woodlands, and Western Great Plains Shortgrass Prairie (Fig. 5-2).

The Arizona-New Mexico Mountains Ecoregion contains the headwaters of a number of important streams and rivers, including the Little Colorado, Gila, San Francisco, and the Mimbres Rivers. Riparian habitats in this ecoregion host a variety of flora and fauna. This ecoregion is considered to host more species of birds and mammals than any other ecoregion in the Southwest (Bell *et al.* 1999).

<u>Species of Greatest Conservation Need</u>

The Arizona-New Mexico Mountains Ecoregion has 80 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans (Table 5-4). The majority (45 species) reside within the Madrean Pine-Oak / Conifer-Oak Forests and Woodlands. The Rocky Mountain Mixed-Conifer Forest and Woodland was also species rich with 37 SGCN. Approximately 37 species (46%) of the SGCN in the Arizona-New Mexico Mountains Ecoregion are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Twenty-one species (26%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 22 species (28%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Some associated SGCN, such as mule deer (*Odocoileus hemionus*) and mourning dove (*Zenaida macroura*), are common throughout the region while others, such as the Sacramento Mountain salamander (*Aneides hardii*) are uncommon and localized. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

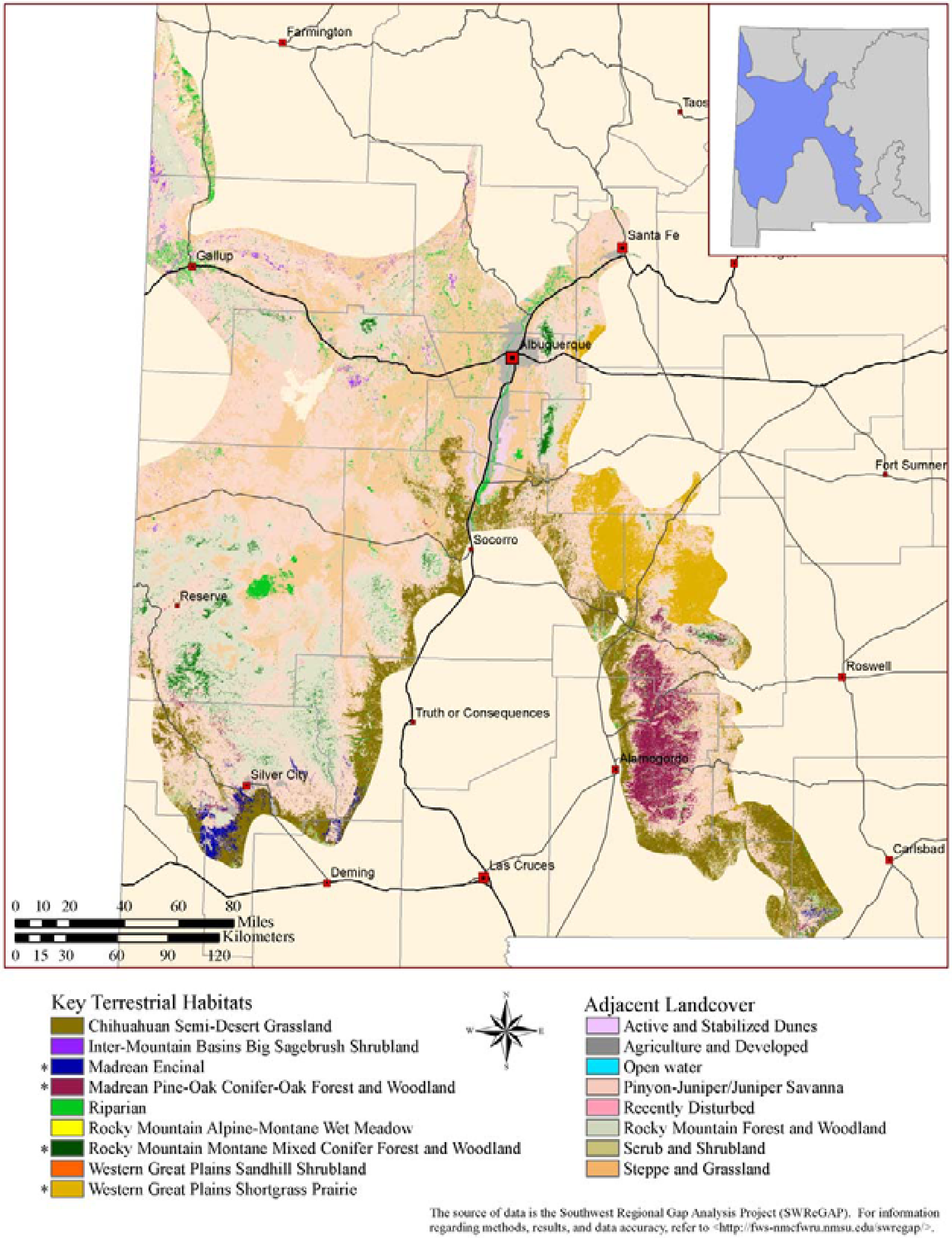


Figure 5-2. Key terrestrial habitats in the Arizona-New Mexico Mountains Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Table 5-4. Species of Greatest Conservation Need in the Arizona-New Mexico Mountains Ecoregion in New Mexico.

Common Name	Madrean Encinal	Madrean Pine-Oak / Conifer Oak	Rocky Mountain Mixed-Conifer Forest and Woodland	Western Great Plains Shortgrass Prairie
Birds				
Osprey			X	
Ferruginous Hawk	X			X
Northern Goshawk		X	X	
Golden Eagle		X	X	X
Bald Eagle			X	X
Peregrine Falcon		X	X	
Blue Grouse		X	X	
Montezuma Quail	X	X		
Scaled Quail		X		X
Sandhill Crane				X
Mountain Plover				X
Wilson's Phalarope				X
Band-Tailed Pigeon	X	X	X	
Mourning Dove	X	X		X
Mexican Spotted Owl		X	X	
Elf Owl	X	X		
Burrowing Owl				X
Black Swift			X	
Williamson's Sapsucker		X	X	
Greater Pewee	X	X		
Olive-Sided Flycatcher		X	X	
Loggerhead Shrike	X	X		X
Gray Vireo	X	X		
Pinyon Jay		X	X	
Juniper Titmouse	X	X		
Red-Faced Warbler		X		
Lucy's Warbler		X		
Yellow Warbler		X	X	
Black-Throated Gray Warbler	X	X		
Red-Faced Warbler			X	
Grace's Warbler		X	X	
Painted Redstart	X	X		
Baird's Sparrow				X
Grasshopper Sparrow				X
Yellow-Eyed Junco	X	X		
Mammals				
New Mexico Shrew			X	
Spotted Bat			X	
Arizona Myotis Bat				X
Allen's Big-eared Bat	X	X	X	
Black-Tailed Prairie Dog				X
Yellow-Nosed Cotton Rat	X	X		

Table 5-4 Cont.

Common Name	Madrean Encinal	Madrean Pine-Oak / Conifer Oak	Rocky Mountain Mixed-Conifer Forest and Woodland	Western Great Plains Shortgrass Prairie
Mammals Cont.				
Penasco Least Chipmunk		X		
Abert's Squirrel			X	
American Beaver			X	
Arizona Montane Vole			X	
Mexican Gray Wolf	X	X	X	
Black Bear	X	X	X	
White-Nosed Coati		X		
Jaguar		X		
Mule Deer	X	X	X	X
Coues' White-Tailed Deer	X	X		
Amphibians				
Chiricahua Leopard Frog	X	X		
Plains Leopard Frog	X			X
Tiger Salamander	X	X	X	X
Sacramento Mountains Salamander			X	
Reptiles				
Sonoran Mud Turtle	X	X		
Ornate Box Turtle				X
Madrean Alligator Lizard	X	X		
Collared Lizard	X	X		X
Sonoran Mountain Kingsnake	X	X		
Milk Snake	X			X
Western Diamondback Rattlesnake	X			X
Banded Rock Rattlesnake	X	X		
Mexican Garter Snake	X			
Desert Massasauga				X
Molluscs				
Cockerell Holospira Snail	X			
Jemez Mountains Woodlandsnail			X	
Dry Creek Woodlandsnail		X		
Cook's Peak Woodlandsnail		X		
Iron Creek Woodlandsnail	X	X	X	
Silver Creek Woodlandsnail		X	X	
Rocky Mountainsnail			X	
Mineral Creek Mountainsnail			X	
Black Range Mountainsnail			X	
Black Range Mountainsnail			X	
Socorro Mountainsnail	X		X	
Amber Glass Snail			X	
Marsh Slug Snail			X	
Three-Toothed Column Snail	X	X		
Spruce Snail			X	

Madrean Encinal and Madrean Pine-Oak Conifer-Oak Forests and Woodlands

The Madrean Encinal and the Madrean pine-oak, conifer-oak forest and woodland habitat types in the Arizona-New Mexico Mountains Ecoregion have similar problems, information gaps, research, survey, and monitoring needs, desired future outcomes, and conservation actions. Therefore, we present information on these two habitat types collectively and call them "Madrean Forests and Woodlands."

Habitat Condition

Madrean Encinal oak woodlands in the Arizona-New Mexico Mountains Ecoregion generally occur at elevations between 4,000 ft - 4,986 ft (1,520 m - 1,220 m). At the lower ecotone, where conditions are drier, Madrean Encinal oak woodlands merge with oak savanna and eventually semi-desert grassland. At middle elevations, Madrean Encinal oak woodlands grade into Madrean pine-oak forests, and at the highest elevations into conifer-oak and pine forests (Ffolliott 2002).

Emory oak (*Quercus emoryi*) is the most common tree species in Madrean Encinal and is found in associations with varying intermixtures of Mexican blue oak (*Q. oblongifolia*), gray oak (*Q. grisea*) silverleaf oak (*Q. hypoleucoides*), and Arizona white oak (*Q. arizonica*) (Ffolliott 1980, Brown 1982, McPherson 1992, 1997, McClaran and McPherson 1999). Interspersed within the Madrean Encinal are shrubs, grasses, forbs and succulents.

Within Madrean pine-oak, conifer-oak forests and woodlands, pines or other conifers generally form the overstory while oaks generally form the understory. There are extensive areas of pine-oak woodland in the Arizona-New Mexico Mountains Ecoregion of the Southwest. Pine-oak woodland is included within the concept of Madrean evergreen woodland. The pine forest is called Madrean Montane Conifer Forest (Brown 1982). Within this habitat type, the abundance of oaks may be a consequence of over harvesting of pines (Felger and Johnson 1995). At higher elevations within the pine-oak forests and woodlands, pines become more dominant as their density increases so that the vegetation could be called forest rather than woodland. This pine-oak forest is dominated by one species of pine, usually Arizona pine (*Pinus ponderosa* var. *arizonica*), ponderosa pine (*P. ponderosa* var. *scopulorum*), or white pine (*P. strobiformis*). Scattered individuals or small groups of oaks, primarily Gambel oak (*Q. gambelii*), and net-leaf oak (*Q. rugosa*), occur with these pine stands. Gambel oak is the only winter-deciduous oak in this area. In the northernmost of these isolated mountain ranges, Arizona pine is replaced by ponderosa pine at higher elevations (Felger and Johnson 1995).

Precipitation in the Madrean forests and woodlands ranges from 12 - 40 in (305 - 1,015 mm) per year. Generally half of this precipitation occurs between May and August. The frequency of freezing temperatures increases northward within the Madrean forests and woodlands that limits plant species diversity (Gottfried *et al.* 1995). Bi-modal emergence of perennial and annual plants occurs in early spring following winter rains and during the summer monsoons (McPherson 1994, 1997).

The distribution, structure and health of Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion have been affected by human activities for millennia. The Madrean forests and woodlands were important to prehistoric people (Propper 1992), who gathered wood for fires and construction materials, acorns for food and ceremonial purposes, and piñon nuts and juniper berries for winter food (Gottfried *et al.* 1995). Settlers, miners, and ranchers used woodlands in the late 1800s and early 1900s for timber and smelter fuel (Bahre and Hutchinson 1985). Madrean forests and woodlands were heavily grazed by livestock in the 1880s and continue to be grazed today, although at much lower stocking rates (Weltzin and McPherson 1995). However, Madrean forests and woodlands have not been subjected to large-scale range improvement practices (Ffolliott and Guertin 1987, McClaran *et al.* 1992).

Natural mortality of oak trees appears to be low, possibly due to the long established practice of harvesting older trees. All evergreen oak tree species in the Madrean forests and woodlands are susceptible to infection by fungi, especially *Inonotus andersonii*, a major cause of wood decay (Fairweather and Gilbertson 1992). Oak densities vary considerably, and range from a few scattered individuals to several hundred stems per hectare. Volumes of wood vary from less than 1 to more than 53 yd^3 per ac (2 to more than 100 m^3 per ha) (Ffolliott and Gottfried 1992). Annual growth rate is relatively slow, ranging from 0.13 to 0.26 yd^3 per ac (0.25 to 0.50 m^3 per ha), with an annual growth rate of less than 1% (Gottfried *et al.* 1995). Tree density is related to local site characteristics such as soils, fire disturbance and land use histories (Gottfried *et al.* 1995, Ffolliott 2002). Tree species composition and density varies with elevation, latitude, disturbance regime, slope, and aspect. Stand-level disturbances caused by fire, disease, vegetation control, and land-clearing activities have been relatively minor in Madrean forests and woodlands (Kruse *et al.* 1996). However, when they do occur, these disturbances are likely to affect stand structure and productivity (Ffolliott and Gottfried 1992, Gottfried *et al.* 1995, McClaran and McPherson 1999). Historically, fires affected species composition, stand density, and size-class distributions (Niering and Lowe 1984, Barton 1991, Kruse *et al.* 1996).

The Madrean forests and woodlands are an area of exceptionally high biological diversity and biogeographical interest (DeBano and Ffolliott 1995). These habitat types occur within a topographically and geologically complex region (Felger and Johnson 1995). The complex topography and steep elevation gradients within the Madrean forests and woodlands result in a rich assemblage of floral and faunal species. The complex geology and topography of the region creates unusual and striking assemblages of habitats and plant and animal associations. Floral and faunal species occur that are more commonly associated with the New World tropics than with the Southwestern Borderlands and plant and animal species co-mingle here that would otherwise be separated by large distances and climatic regimes (Felger and Wilson 1995).

Problems Affecting Habitats or Species

Analyses using the scientific literature and New Mexico Department of Game and Fish (NMDGF) staff suggest that climate change, fire management, fragmentation and loss of habitat from urban/residential/commercial industrial development, large-scale mining, roads, highways and utility corridors, and off-road vehicle use are the primary factors adversely affecting the conservation of SGCN of Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion.

Climate Change and Drought
Climate change may occur in the Southwest from increased atmospheric concentrations of CO_2 and other greenhouse gases. Effects may include increased surface temperatures, changes in the amount, seasonality, and distribution of precipitation, more frequent climatic extremes, and a greater variability in climate patterns. Such changes affect vegetation at the individual, population, or community level, precipitate changes in ecosystem function and structure (Weltzin and McPherson 1995), and will likely affect competitive interactions between plant and animal species currently co-existing under equilibrium conditions (Ehleringer *et al*. 1991) (See Statewide Assessments and Strategies, Chapter 4, for greater details).

Subsequent specific outcomes for Madrean forest and woodland habitats are unpredictable and remain uncertain (Weltzin and McPherson 1995). However, plants respond differently to changes in atmospheric gases, temperature and soil moisture, in part based on their C_3 or C_4 photosynthetic pathways (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson *et al*. 1993). For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses, while increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin *et al*. 1986). Recent research has investigated shifts in the Madrean Encinal oak woodland/semi-desert grassland boundary (Hastings and Turner 1965, Bahre 1991, McPherson *et al.* 1993). Paleo-ecological data gathered from packrat middens suggest that Madrean Encinal oak woodland have moved higher in elevation as a result of warmer and drier climatic conditions since the Pleistocene. Bahre (1991) suggests that the distribution of Madrean Encinal oak woodland has been stable since the 1860s.

Drought, defined as an extended period of abnormally dry weather, is one of the principal factors limiting seedling establishment and forest productivity (Schulze *et al*. 1987, Osmond *et al*. 1987). Soil moisture is directly altered by drought conditions. The distribution and vigor of some oak woodlands and savannas is controlled primarily by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993). Drought and climate change can have a substantial effect on the Madrean forest and woodland habitats. Further, these factors can alter fire frequency, intensity, and timing by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994). Unfortunately, due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors, and political decisions at national and international levels, the effects of climate change on fire regimes in the Madrean forests and woodlands are difficult to predict (Weltsin and McPherson 1995).

Natural Disturbance Regimes
The primary natural disturbances (non-anthropogenic forces that alter habitats) in the Madrean woodland and forests are fire, wind, and insects. Changes in the frequency, intensity, and timing of natural fires have altered the distribution of current vegetation. Madrean woodland and forest density was relatively low prior to European settlement (Moody *et al*. 1992, Covington and Moore 1994). In these less dense woodlands, most fires were low intensity ground fires that tended to reduce understory vegetation (Gottfried *et al*. 1995). The elimination of episodic fires after 1893 may be attributed to excessive livestock grazing and fire suppression (Grissino-Mayer *et al*. 1995, Weltzin and McPherson 1995). Historic (late 1800s) improper grazing practices in Madrean woodlands and forests eliminated the herbaceous fine fuels layer. The reduction of these fine fuels prevented the spread of low-intensity, ground-hugging fires, and reduced grass

competition, thereby allowing tree establishment (Gottfried *et al*. 1995). Fire suppression has further eliminated the natural fire regime that historically kept stand densities relatively low. Fire suppression allowed the increase of ladder fuels and heavy fuel loading conditions. Catastrophic, stand-replacing crown fires have become more common because of these changes (Covington and Moore 1994).

Grazing Practices
Livestock grazing has economic and cultural values that are important to individuals, communities and the State. Impacts to rangeland wildlife by livestock grazing are largely dependent on the grazing management practices used. Domestic and wildlife grazing practices that reduce the ability of the land to sustain long term plant and animal production (Wilson and MacLeod 1991) have influenced plant communities and fish and wildlife habitat in New Mexico for more than a century. Peer-reviewed scientific literature implies that livestock grazing has impacted terrestrial and riparian/aquatic habitats in New Mexico (Armour *et al*. 1994, Fleischner 1994, The Wildlife Society 1996, Belsky and Blumenthal 1997). Improper grazing by livestock can reduce vegetative cover, increase soil erosion, and aggravate local flooding (Felger and Wilson 1995).

Many of these impacts began as early as the late 1800s when large herds of livestock were present. Impacts of improper grazing practices have included: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by altering vegetation composition and structure; 3) impacts on stream hydrology, siltation, and water quality; and 4) reduced soil permeability and potential to support plants due to soil compaction. Improper grazing can diminish wildlife habitat in Madrean woodland and forest. In contrast, prescribed grazing is a management tool that can be used to benefit wildlife (Holechek *et al*. 1982, Kirby *et al*. 1992, Holecheck *et al.* 2004).

Animal Herbivory
Animal herbivory is the most common source of mortality for low-elevation oaks of southern Arizona (McPherson 1993, Peck and McPherson 1994). Herbivory by invertebrates is a potentially important source of seedling mortality that is commonly overlooked in field studies. Invertebrates have been found to defoliate oak seedlings primarily during the summer (Peck and McPherson 1994, Weltzin and McPherson 1995). Vertebrates kill Emery oak seedlings primarily during autumn and winter months (Weltzin and McPherson 1995). Differential population dynamics of herbivorous animal species, combined with temporal and spatial variability of herbivory (McPherson 1993, Peck and McPherson 1994, Weltzin and McPherson 1995) combine to determine the timing and intensity of herbivory-related mortality on young oaks (Weltzin and McPherson 1995).

Loss of Biological Diversity
Intact Madrean forest and woodland habitats once extended into the American tropics, but accelerating deforestation is fragmenting habitats and populations of plant and animal species (Felger and Johnson 1995). Trees within Madrean forest and woodland habitats are most often harvested for fuel and fence posts, but also for value-added wood products such as furniture and home construction (Ffolliott 1989, Ffolliott and Gottfried 1992, Maingi and Ffolliott 1992).

Natural regeneration of Madrean oak woodlands is low. Factors that may be responsible for low recruitment of oaks include herbivory by livestock and wildlife, competition for water, light and minerals, and climatic and edaphic conditions. A combination of these and possibly other unknown factors likely interact to produce low rates of seedling re-establishment (Weltzin and McPherson 1995). However, demands for oak woodlands are expected to increase (Conner *et al*. 1990, Van Hooser *et al*. 1990, Ffolliott and Gottfried 1992, Gottfried *et al*. 1995).

Biological diversity in the Madrean forests and woodlands is rapidly eroding (DeBano and Ffolliott 1995). Cutting trees of the tallest height classes reduces the structural diversity of oak forest and woodland stands (Sharman and Ffolliott 1992). Taller trees provide more habitat niches for non-game birds than do shorter trees (Balda 1969). Thus, tree harvesting can reduce bird diversity by simplifying woodland structural diversity (Ffolliott 2002).

Non-Native Species
In 1998, non-native species were implicated in the decline of 42% of species listed under the federal Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal communities, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Exotic species colonization of the Madrean Archipelago region is increasing, with more than 60 non-native plants having successfully established themselves in the isolated mountain ranges of Arizona (Warshall 1995).

Habitat Alteration and Fragmentation
Human populations are increasing in the region and demands for fuel wood are accelerating. Privately owned forest and woodlands are being converted to residential areas, fragmenting wildlife habitats, increasing wildland/urban interface fire risks, and generally accelerating land management conflicts. Associated increasing demands for water in these communities are outpacing the ability of natural systems to provide new freshwater sources (Felger and Wilson 1995). Sustainability of Madrean woodland and forest habitats is questionable under increasing pressures from human activities and altered fire regimes (Gottfried *et al*. 1995).

Much of the Madrean forests and woodlands of southwestern New Mexico and southeastern Arizona is administered by the US Forest Service. They are charged with potentially conflicting mandates of “multiple use” that include: 1) conserving wildlife, habitats and ecosystem function; 2) generating revenue from timber sales; 3) maintaining livestock grazing leases; and 4) providing ever increasing opportunities for urban recreation (Felger and Wilson 1995). There is growing pressure to develop more Madrean forest and woodland habitats within national forests for camping, hiking, mountain biking, off-road vehicle use, and new or improved roads for access (Warshall 1995).

Groundwater Depletion
Groundwater levels in Southwest and regional wetlands have dropped significantly because of pumping for agricultural crop irrigation. One example in Madrean forests and woodlands is San Simon Cienega, which was once a functioning wetland, but has since been drying out due at least in part to groundwater pumping (Dinerstein *et al*. 2000).

Mining
Historic and current hard rock mining activities may adversely affect ecosystem function, resilience and sustainability within the Madrean forests and woodlands in the Arizona-New Mexico Mountains Ecoregion. Large underground bodies of primarily copper ore have led to extensive industrial mining complexes in the area. Associated ecosystem stressors include: 1) habitat fragmentation and loss; 2) acid drainage from chemical reactions with surface waste rock that create heavy metal contamination poisonous to wildlife (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995, Hilliard 1994); 3) large permanent pit lakes that contain toxic water (a danger primarily to waterfowl) (Miller *et al.* 1996); 4) groundwater pollution; 5) air pollution and associated acid-rain fallout; 6) increased frequencies of road killed fauna; and 7) the potential for bioaccumulation of heavy metals in soils and vegetation at levels dangerous to wildlife.

Borderland Security Activities
Increasing security measures are being implemented throughout the United States/Mexico borderlands region to intercept illegal drug shipments, illegal immigrants, and other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Increased road building and traffic along the borderlands causes habitat destruction, loss, and fragmentation, diminishes the utility of habitat for wildlife, increases road kill, poaching, and illegal collecting of wildlife (Forman *et al.* 2003).

Recreation and Tourism
Recreation and tourism activities in the Madrean forests and woodlands generate income for the region. Hunting for species such as deer, quail and collared peccary (*Tayassu tajacu*) has long been a dominant recreational use (McClaran and McPherson 1999). Non-consumptive recreational uses in Madrean forests and woodlands include hiking, camping, sightseeing, bird watching, and picnicking (Conner *et al.* 1990). Although comprehensive statistics are lacking that document the level of these recreational uses, it is clear that recreational uses of Madrean forests and woodlands are increasing and their impact on habitats and species should be considered in conservation planning (Conner *et al.* 1990, McClaran *et al.* 1992).

Information Gaps

Information gaps that impair our ability to make informed conservation decisions are outlined below.

- The location, timing, duration, frequency and intensity of all of the problems identified that potentially affects Madrean forest and woodland habitats and/or SGCN.

- The impacts of the ongoing activities of the Joint Task Force Six activities on the borderlands of New Mexico. These activities include maneuvers and encampments that can destroy habitat, spread invasive weed species, increase road kill, and alter sensitive wildlife behavior.

- The impacts on Madrean forest and woodland SGCN and habitats from increased daytime and nighttime traffic associated with Border Patrol surveillance and monitoring activities and illegal immigration is unknown.

Research, Survey, and Monitoring Needs

The processes that have impacted the Madrean forests and woodlands in the past and the anticipated levels of future development serve as a backdrop for defining current research, survey, and monitoring needs. Research, survey, and monitoring needs that would enhance our understanding of these habitats are outlined below.

- Enhance our understanding of habitat connectivity by acquiring population-level information of dispersal behavior, daily and seasonal movements of SGCN through Madrean woodland and forest habitats, how different types of habitat fragmentation (such as timber removal, and housing developments) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the extent, age class, structural characteristics, and regeneration rates of the Madrean woodlands and forests so as to provide predictive power and applicability to ecosystem-based management.

- Determine the minimum viable habitat size and forest age-class structure necessary to support SGCN that migrate vertically among the bands of Madrean habitats within the isolated mountain ranges of the Madrean Archipelago.

- Determine how global and regional climate change will affect vegetation patterns and community and ecosystem-level dynamics in Madrean pine-oak, conifer-oak forests and woodlands.

- Conduct research to enhance our knowledge of the natural history, population biology, and community ecology of SGCN within Madrean woodland and forest habitats.

- Conduct research to increase our knowledge of SGCN distribution, abundance, and population trends within the Madrean woodland and forest habitats of the Arizona-New Mexico Mountains Ecoregion.

- Evaluate the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires in the Madrean woodlands and forests.

- Determine how SGCN of Madrean woodland and forests respond to prescribed livestock grazing, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population.

- Assess the impacts of prescribed livestock grazing on the structure of Madrean woodlands and forests.

- Determine how the timing, intensity, and duration of prescribed livestock grazing affect SGCN.

- Determine how prescribed grazing affects natural disturbance regimes such as wildland fire in Madrean woodland and forest habitats.

- Identify wildlife travel corridors connecting the Madrean woodland and forest habitats in isolated mountain ranges so they may be protected and managed to maintain connectivity. Information needed for understanding habitat connectivity includes population-level information on dispersal behavior, daily and seasonal movements of SGCN through Madrean habitats, how different types of habitat fragmentation (such as timber removal, housing developments, etc.) affect these movements, and how climate change may ultimately affect species distributions.

- Determine the effects of natural and prescribed fire on the structure of vegetative communities in the Madrean woodlands and forests and the subsequent effects upon vertebrate and invertebrate populations. Evaluate the effectiveness of prescribed fire as a tool to reduce the potential for catastrophic fire (DeBano and Ffolliott 1995).

- Determine if coppicing (post-cutting sprouting from roots and stumps) is an effective supplement to the episodic regeneration of oaks from seed. Is coppicing sufficient to maintain habitat composition, structure, and biological diversity?

- There is a need for additional investigations of hydrologic relationships in the Madrean woodlands and forests that will provide a better understanding of interception, transpiration, and infiltration processes (Lopes and Ffolliott 1992, Haworth and McPherson 1994, Baker *et al*. 1995, Ffolliott and Gottfried 1999). This information is crucial for determining effective and sustainable conservation and management practices at the watershed level (Ffolliott *et al*. 1993).

- There is a need to develop collaborative survey and monitoring protocols for invertebrate SGCN that are not currently being monitored.

Desired Future Outcomes

Desired future outcomes for Madrean forests and woodlands include:

- Madrean forest and woodland habitats exist in the condition, connectivity and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource conflicts.

- Partnerships have been established among state and federal government agencies, NGOs and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the Madrean forest and woodland habitats upon which they depend.

- Special habitats within the Madrean forests and woodlands, such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams, are protected and monitored long-term for condition as necessary to ensure conservation for SGCN that rely on these habitats.

- A scientific basis for ecosystem management in the Madrean forest and woodland habitats has been established and implemented. Systems management of the ecosystem, rather than functional management of individual species or other natural resources such as timber, is policy and is validated through region-wide forest plans.

- Wide public support is garnered for long-term conservation strategies to restore native species and SGCN to viable populations within Madrean forest and woodland habitats.

- Sustainable harvest prescriptions are developed that allow adequate levels of harvest for fuel wood and other wood products. Major harvest activities replicate natural disturbance patterns.

- Stand-replacing wildfires have become less common in the Madrean forest and woodland habitats and no longer alter existing habitats beyond the range of natural variation under which SGCN evolved.

- Colonization of exotic species is stopped. Existing populations of exotic species are controlled or eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts important to SGCN.

2. Collaborate with governmental agencies, land conservation NGOs and private landowners to identify and conserve riparian and other important wildlife habitat corridors linking Madrean Archipelago isolated mountain ranges by implementing conservation easements and/or land purchases for wildlife conservation.

3. Encourage government and private land managers to conserve and restore Madrean watersheds through management practices that reduce erosion, gully formation and soil loss, and maintain native biodiversity.

4. Maintain awareness of the introduction and spread of exotic plants and animals and encourage control or eradication where necessary to maintain or restore native biodiversity.

5. Collaborate with government agencies and private landowners to develop measures, such as closure of unnecessary roads within and adjacent to Madrean forest and woodland habitats, so that habitat fragmentation might be reduced.

6. Encourage the US Forest Service to conserve biological diversity through development and implementation of an ecosystem management approach.

7. Encourage thinning and fuel-reducing initiatives to open dense stands of trees that have become susceptible to insects, diseases, or stand-replacing wildfires that may alter conditions to which SGCN are adapted.

8. Work with the US Forest Service in conducting prescribed burning in Madrean forest and woodland habitats to protect breeding birds, avoid riparian areas, and otherwise conserve SGCN.

9. Work with government and private landowners to develop strategies for the sustainable harvest of wood products that will maintain oak regeneration and protect native biodiversity.

10. Pursue enactment of laws or policies that protect closed basins within Madrean forest and woodland habitats from the impacts of dredge and fill activities and future development.

11. Encourage the land management agencies to schedule prescribed burns that avoid desert bighorn sheep (*Ovis canadensis mexicana*) lambing areas from mid-December through mid-February.

12. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting “grass banking” opportunities that allow degraded rangelands to recover.

Rocky Mountain Montane Mixed-Conifer Forests and Woodlands

Habitat Condition

Rocky Mountain Montane Mixed-Conifer Forests and Woodlands form an indiscrete vegetation band dominated by Douglas fir (*Pseudotsuga menziesii*) that blends with true firs and spruces in the sub-alpine coniferous forest between elevations from 8,000 - 10,000 ft (2,438 - 3,048 m). The montane mixed-conifer forests and woodlands blends into ponderosa pine (*Pinus* *ponderosa*) forests at lower elevations. However, within the montane mixed-conifer forest, Douglas fir seldom grows in pure stands, but mixes with blue spruce (*Picea pungens*) and white fir (*Abies concolor*). Blue spruce is often associated with frost pockets and is found along stream sides and on lower slopes where cold air drains. Following disturbances, Gambel oak (*Quercus gambelii*) and aspen (*Populus tremuloides*) are often prominent. Dick-Peddie (1993) described the Rocky Mountain montane mixed-conifer forest as being among the most widespread and productive vegetative types in New Mexico. Ample precipitation maintains well-watered soils for most of the long growing season.

Fire and logging are the primary disturbances within the mixed-conifer woodlands. Natural fires historically occurred about every 10 years up until the late 1800s when fire suppression policies were implemented (USGS 1998). Dick-Peddie (1993) speculated that erratic fire behavior created a patchy mosaic of stands in various successional stages. These fires might flare up into crown fires in some areas and miss other areas completely. Aspen are often present at sites where high intensity fires have occurred. The elimination of fire in southwestern mixed-conifer forests has caused a major change in species composition and structure in the past century (Samson *et al.* 1994).

In the Southwest, lower elevation mixed-conifer forests with more open stand structures had ponderosa pine as a co-dominant species. However, dense sapling understories of the more fire-sensitive Douglas fir and white fir species developed in the mixed-conifer forest as a result of fire suppression and subsequent tree regeneration. Forest stand inventory data from Arizona and New Mexico show an 81% increase in the areal extent of mixed-conifer forests between 1962 and 1986. This is explained by the trend toward more fire-sensitive tree species (US Forest Service 1993). Fire suppression has also contributed to reduced aspen stands and the habitat they provide for a variety of wildlife species. Logging in Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats has created extensive road networks, furthered habitat fragmentation, and replaced fire as a determinant of stand succession.

Improper grazing practices (grazing practices that reduce long-term plant and animal productivity) in Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats have created competition with wildlife for water, forage, and space. These practices have altered vegetation composition and structure, increased siltation, affected stream hydrology and water quality, and reduced soil permeability and the potential to support plants due to soil compaction. Further, both excessive domestic livestock and native ungulate browsing may damage aspen suckers and weaken aspen clones, in turn making trees more susceptible to invasion from disease and insects.

Problems Affecting Habitats or Species

Review of the scientific literature indicates that associated effects of climate change, drought, changes to natural fire regimes, and insect attack are the factors most adversely affecting mixed-conifer habitats in the Arizona-New Mexico Mountains Ecoregion. High biological productivity within montane mixed-conifer forests explains why extractive resource use, such as logging and grazing have been an important economic consideration. Sustained or increased intensities of these activities may reduce biodiversity and productivity (Dick-Peddie 1993).

The synergistic effects of factors that influence habitats make it difficult, or perhaps impossible, to separate out individual factors that influence habitats or the SGCN. Multiple factors are closely linked in cause and effect relationships. Adverse consequences from multiple ecosystem stressors can have cumulative effects that are more significant than additive effects. One or more stressors may predispose biotic organisms to additional stressors (Paine *et al.* 1998). A greater discussion of the synergistic effects is provided in Chapter 4.

Climatic Change and Drought

The effects of climatic change on the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are difficult to predict, largely due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors (Weltsin and McPherson 1995). However, the effects of climatic change on habitat types in New Mexico are significant and are presented in detail in Chapter 4.

Drought, defined as an extended period of abnormally dry weather, is considered to be one of the most significant factors affecting Rocky Mountain Montane Mixed-Conifer Forests and Woodlands because it alters landscape and atmospheric conditions in favor of habitat conversion processes. Drought can limit seedling establishment and forest productivity by altering soil moisture gradients (Osmond *et al*. 1987, Schulze *et al*. 1987). Further, drought alters fire frequency, intensity, and timing in forest habitats by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994).

Fire Suppression

The disruption of natural fire cycles caused by fire suppression can significantly alter Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats in New Mexico (see Chapter 4). Mac *et al.* (1998) estimated the mean fire occurrence interval in the montane mixed-conifer forest at about every 10 years up until the late 1800s when fire suppression policies were implemented. Prior to that time, historic wild-land fires within ponderosa pine and lower Rocky Mountain Montane Mixed-Conifer Forests and Woodlands were frequent and naturally occurring. They were low-intensity ground fires that helped maintain stands of older trees with open, park-like structure (Moir and Dieterich 1988). Within higher elevation mixed conifer and spruce-fir forests, wildfires were less frequent and generally of the higher intensity, stand-replacing type.

Insects and Disease

Native insects and diseases are an integral part of forest ecosystems. They help recycle forests by decomposing trees and releasing nutrients necessary for forest growth. However, insect and disease outbreaks can seriously impede conifer regeneration and affect resources valued by humans for aesthetic, recreational, water, and wildlife considerations (see Chapter 4).

Many different species of bark beetles affect southwestern mixed-conifer forests. Most bark beetle species are relatively host-specific, limiting their activities to primarily one tree species. Some of the more important species that attack ponderosa pine trees in New Mexico include the mountain pine beetle (*Dendroctomus ponderosae*), western pine beetle (*D. brevicomis*), roundheaded pine beetle (*D. adjunctus*), and pine engraver (*Ips pini*). The Douglas fir beetle (*D. pseudotsugae*), and the fir engraver (*Scolytus ventralis*) prefer white fir, while the spruce beetle

(*Dendroctomus rufipennis*) attacks Engelmann spruce (*Picea englemannii*) (Wilson and Tkaz 1994). The direct effects of bark beetle infestation on trees include mortality and top-killing (Stark 1982). The US Forest Service, in 2003, mapped conifer mortality attributed to bark beetles on about 2,700,000 ac (1,092,653 ha) in Region 3 alone (US Forest Service 2004).

White fir and Douglas fir are also the preferred host species for western spruce budworm (*Choristoneura occidentalis*). When fire is suppressed, the density of these tree species increases and they become more susceptible to intense and synchronous outbreaks of spruce budworm. Between the 1920 and 1993, there were five major outbreaks of western spruce budworm in New Mexico. The most recent outbreak covered approximately 700,000 ac (283,280 ha) at its peak (Fellin *et al.* 1990).

Aspen is subject to fungus including white tree rot (*Phellinus* spp.), sooty-bark cankers (*Encoelia pruinosa*), and several root rots. Sooty-bark canker is the most lethal canker on aspen in the West and tends to occur on the larger trees at all sites (Johnson *et al.* 1995). A study conducted in Colorado and New Mexico indicated that trunk cankers, developed from logging injuries, were the major cause of aspen death (Johnson *et al.* 1995). Approximately 20% of residual trees in partially cut stands died five years after the stand was harvested. Two years later, 40% of the remaining residual trees were infected with various cankers, indicating that tree mortality would increase. Insect attacks can come from aspen tortrix (*Choristoneura conflictana*) and western tent caterpillar (*Malacosoma californicum*).

On a positive note, several SGCN of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are likely to benefit from the occurrence of native insects and diseases, or their effects on the habitat. These include Williamson's sapsucker (*Sphyrapicus thyroideus*), olive-sided flycatcher (*Contopus cooperi*), yellow warbler (*Dendroica petechia*), red-faced warbler (*Cardellina rubrifrons*), Grace's warblers (*Dendroica graciae*), Mexican spotted owl (*Strix occidentalis lucida*), Jemez Mountains salamander (*Plethodon neomexicanus*), black bear (*Ursus americanus amblyceps*), and Allen's big-eared bat (*Idionycteris phyllotis*).

Extractive Resource Uses

The high productivity of the montane mixed-conifer forest creates a place where extractive resource use, such as grazing and logging, is relatively common. Further, this habitat type is open for increased oil and gas exploration. Sustained uses for these activities may reduce biodiversity and productivity.

Livestock grazing has economic and cultural values that are important to individuals, communities, and to the state. Improper grazing practices are considered those practices that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), and include domestic livestock and wildlife. Improper grazing practices have influenced vegetation communities and fish and wildlife habitat in New Mexico for more than a century (See Chapter 4 for greater details). Improper grazing has reduced vegetative cover, increased soil erosion, and aggravated local flooding (Felger and Wilson 1995). Impacts of improper grazing practices in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands include: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by the altering of vegetative composition and structure; 3) alteration of stream hydrology and water quality; 4) increased siltation; 5) and reduced soil permeability and the potential to support plants due to soil compaction. Further, both excessive domestic livestock and native ungulate browsing may damage aspen suckers and weaken aspen clones, in turn making trees more susceptible to invasion from disease and insects.

Logging has been one of the primary disturbance factors in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands in the Southwest. Conifer forests and woodlands in New Mexico now generally occur in early and middle successional stages. Stand succession that would have occurred due to fires has been replaced through logging. However, the patchy mosaic that erratic fire behavior creates is usually not successfully duplicated through logging. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993). Logging has created extensive road networks furthering habitat fragmentation in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and other New Mexico forests.

Fuel wood collection in and of itself is not recognized as a factor significantly affecting the mixed-conifer habitat type. However, woodcutters sometimes remove standing snags and downed logs that are important for wildlife habitat and ecosystem function. Roads developed for fuel wood collection fragment habitat and may function as artificial firebreaks. The Carson National Forest had approximately 3,587 mi (5,772 km) of open road and the Santa Fe National Forest had approximately 3,750 mi (6,035 km) of existing road in the late 1980s.

Currently, the amount of oil and gas exploration that occurs within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands within the Arizona-New Mexico Mountains Ecoregion is very limited. Oil and gas exploration is not considered a substantial factor affecting SGCN at this time.

Recreational Use

Recreational uses of the mixed-conifer habitat type include skiing, hiking, mountain biking, horseback riding, snowmobiling, off-road vehicles, rock climbing, and camping. The overall effect of these activities is not fully understood, nor is there full comprehension of how much recreational use can be tolerated before wildlife or wildlife habitats are adversely effected. Commercial ski areas are usually located within this habitat type, and their presence clearly results in habitat conversion.

Non-Native Species

As of 1998, non-native or invasive species have been implicated in the decline of 42% of species listed under the federal Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). The occurrence or rate of spread of non-native or invasive species within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands is unknown. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Information Gaps

Information gaps are outlined below that impair our ability to make informed conservation decisions regarding mixed-conifer forest and woodland habitats and SGCN.

- Abundance, distribution and trend information is absent or sparse for many SGCN. There is no central clearinghouse for biological information and no one agency has ready access to all available information. In addition, the requirements for area-sensitive species have not been clearly defined.

- The location, timing, duration, frequency and intensity of most factors influencing Rocky Mountain Montane Conifer Forests and Woodlands and associated SGCN are poorly understood. For example, information is needed on the effects that location, timing, intensity, and duration of prescribed burns and fuel reduction/logging activities have on SGCN, such as the Sacramento Mountain salamander. Further, there is a long history of grazing by domestic livestock and native ungulates in this habitat type. Perceived effects include subsequent soil erosion and altered fire cycles. However, there is little understanding of the mechanisms by which these effects occur.

- It is not clear how the Healthy Forest Initiative and Healthy Forest Restoration Act will affect SGCN such as northern goshawks (*Accipiter gentilis*), and Mexican spotted owls, which rely on old-growth mixed-conifer forests.

- While many aspects of fire are understood, the role that natural fire, particularly the differing intensities of fire, has played within the entire ecosystem is not well understood. Site-specific fire histories and methods are unknown regarding natural fire regimes.

- The intensity, scale, extent, and causes of forest fragmentation have not been determined in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and the effects of forest fragmentation on associated SGCN are unknown.

- Community structure and many life history attributes of SGCN are unknown.

- Environmental conditions that limit populations of SGCN are unknown.

- The intensity, scale, extent, and causes of man-caused habitat fragmentation are unknown.

- Information of area-sensitive species requirements is needed, including the location of key migration corridors, degree of habitat fragmentation, and spatial locations of fragmented areas.

- The extents to which invasive species alter disturbance regimes and population viability are unknown within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

- There is little known about aspen succession (Dick-Peddie 1993). In aspen stands that have predominantly changed to conifers, information is lacking about how many aspen should remain in order to provide adequate regeneration after a fire removes the conifers. The occurrence of aspen succession resulting in montane and sub-alpine grasslands is not well understood.

Research, Survey, and Monitoring Needs

Research and survey topics are outlined below that would enhance our understanding of Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats and SGCN.

- Abundance, distribution and trend information needs to be determined for many SGCN and area-sensitive species.

- Research is needed to assess the attributes of habitats that are required so that viable populations of SGCN may persist.

- Basic research is needed on SGCN vertebrate and invertebrate community structures, natural history, and ecological relationships.

- Determine how SGCN respond to prescribed livestock grazing, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population growth (DeBano and Ffolliott 1995).

- Determine the necessary habitat size and forest age-class structure needed to support SGCN that migrate vertically during daily and seasonal movements to fulfill their ecological needs for food, shelter, water and space.

- Environmental conditions that limit populations of SGCN need to be determined.

- Much work is needed to understand the relationships between climate change, drought, fire and fire suppression activities, phytophagous insect attacks, and habitat fragmentation resulting from roads and increased human developments.

- Determine how global and regional climate change will affect vegetation and community and ecosystem-level dynamics.

- Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are disturbance forests with predominantly seral communities (Dick-Peddie 1993). To adequately restore fire as a management tool, there must be a clear understanding of historic fire regimes from regional to site-specific scales.

- There is a continuing need to increase our understanding of the effects of post-fire treatments within the context of ecological and societal goals for forested public lands of the West (Beschta *et al.* 2004).

- Research is needed to evaluate the effectiveness of prescribed burns in reducing the potential for catastrophic stand-replacing fires.

- Determine the effects of natural and prescribed burns on the structure of vegetative communities and the subsequent effects upon vertebrate and invertebrate populations.

- Research is needed regarding the ecological effects of logging as compared with fire. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993).

- Research is needed to explore the best methods of mimicking natural disturbance regimes within the historic natural range of variability. Ecological forestry assumes that native species evolved under natural conditions. Management within this natural range of variability should ensure that native species persist (Seymour and Hunter 1999).

- Research is needed to determine how SGCN respond short-term and long-term to phytophagous insect outbreaks and the potential habitat fragmentation caused by these attacks at the community, species, population and individual levels.

- Studies are needed to identify wildlife travel corridors that connect the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands to different mountain ranges of the Arizona-New Mexico Mountains Ecoregion. Information needed for understanding and managing for habitat connectivity includes: 1) population-level information of dispersal behavior, seasonal movements of SGCN; 2) how different types of habitat fragmentation affect movements; and 3) how climate change may ultimately affect species distributions.

- Research is needed to determine the intensity, scale, extent, and causes of forest fragmentation and how SGCN respond to habitat fragmentation at the community, species, population and individual levels.

- The species-specific effects of natural and human-caused habitat fragmentation on SGCN need to be determined.

- Research is needed to assess the impacts of prescribed livestock grazing on the structure of Rocky Mountain Montane Mixed-Conifer Forests and Woodland habitats.

- Research is needed to determine how the timing, intensity, and duration of prescribed grazing affect SGCN life history.

- Determine how grazing ultimately affects natural disturbance regimes (McPherson 1992).

- Determine the areal extent, age class, structural characteristics, and regeneration rates to provide predictive power and inform an ecosystem management approach.

- The extent to which invasive species may alter disturbance regimes and population viability needs to be determined.

- There is a need for additional investigations of hydrologic relationships that will provide better understanding of infiltration, interception, and transpiration processes, and how disturbances such as drought and fire affect these processes. This information is necessary for determining effective and sustainable conservation and management practices (Ffolliott *et al*. 1993).

Desired Future Outcomes

Desired future outcomes for the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands include:

- Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Partnerships have been established among government agencies, NGOs and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the habitats upon which they depend.

- Long-term conservation strategies that restore native species to viable populations garner wide public support.

- Stand-replacing wildfires have become less common and no longer alter existing habitats beyond the range of natural variability under which SGCN evolved.

- Post-fire management activities that are detrimental to SGCN and/or ecosystem function and recovery are no longer practiced.

- Prescriptions have been developed for the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands that allow adequate and sustainable levels of human harvest of fuel wood and other wood products, are compatible with the tenets of ecological forestry, and replicate natural disturbance patterns.

- Decisions to implement control measures for phytophagous insect outbreaks are informed and balanced by considerations of the role of these events in maintaining forest health and ecosystem function (Schowalter 1994).

- Consistent standards that ensure future habitat integrity and functionality for the wildland urban interface are jointly established and adopted by private landowners, counties, municipalities, federal and state land management agencies.

- Local zoning regulations are in place to help reduce wildfire threats to private residences at the wildland urban interface in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and funds that are currently directed toward these threats have been redirected to re-establishing naturally functioning ecosystems in forest interiors.

- Major migration/movement corridors are intact and maintaining connectivity and availability of SGCN habitats.

- Oil and gas extraction activities have not compromised the condition, connectivity, and quantity of Rocky Mountain Montane Mixed-Conifer Forests and Woodlands on the Valle Vidal. The capacity of this property to sustain viable and resilient populations of SGCN has not been diminished.

- Livestock and large ungulate grazing are maintained at levels that sustain the full range of ecosystem functions and persistence of SGCN.

- Aspen stands are maintained at a sufficient level to sustain obligate SGCN and associated plant and wildlife species.

- Special habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams are protected and are being monitored long-term for condition to ensure conservation for SGCN that rely on these habitats.

- Scientific ecosystem management has been established and implemented and is evidenced in forest management plans.

- Colonization by exotic species is stopped and existing populations of exotic species are controlled or eliminated.

- Activities implemented under the Healthy Forest Initiative and Healthy Forest Restoration Act are focused on removing ladder fuels and smaller diameter trees and protecting human structures and neighborhoods in the wildland urban interface. These activities avoid the unnecessary removal of large, old-growth trees and snags important as wildlife habitat.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies and private landowners to develop a fire management regime that promotes restoration of vegetative communities more nearly approximating those that historically supported SGCN. Approaches might include encouraging the US Forest Service to supplement lightning-caused fires with prescribed burning.

2. Collaborate with state and federal agencies, the New Mexico State Legislature, NGOs, and private landowners to conserve riparian and other important wildlife habitat corridors linking Rocky Mountain Montane Mixed-Conifer Forests and Woodlands between other habitats and ecoregions. Approaches might include conservation easements and/or fee-simple purchases from willing sellers.

3. Collaborate with state and federal agencies and private landowners to reduce habitat fragmentation. Approaches might include the closure of unnecessary interior and adjacent roads and minimizing new road building on associated national forests.

4. Work with the US Forest Service to promote compliance with the principles of ecological forestry for any land management activities conducted within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands outlined in the Research, Survey, and Monitoring Needs section above.

6. Work with the US Forest Service and effected publics to develop strategies for the sustainable harvest of wood products that will retain old-growth trees and large diameter snags needed by SGCN and the communities that support them.

7. Encourage thinning and fuel-reducing initiatives, where necessary, to open dense stands that have become susceptible to insects, diseases, or stand-replacing wildfires that may alter conditions to which SGCN are adapted.

8. Work with the US Forest Service to ensure that fuel reduction treatments are focused upon removing smaller diameter ladder fuels and thickets to protect human structures and neighborhoods in the wildland urban interface. These interventions should avoid removal of large old-growth trees and snags important as wildlife habitat.

9. Encourage government and private land managers to conserve and restore the watersheds, wetlands, and wet meadows of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands through management practices that maintain native biodiversity and reduce erosion, gully formation, and soil loss.

10. Work with the US Forest Service and effected livestock and hunting interests to ensure that livestock and large ungulate grazing occur at levels compatible with sustaining viable populations of SGCN.

11. Monitor the introduction and spread of exotic plants and animals into Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and encourage control or eradication where necessary to maintain or restore native biodiversity.

12. Work with the US Forest Service in conducting prescribed burning in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to protect breeding birds, avoid riparian areas, and otherwise conserve SGCN.

13. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

14. Work with the US Forest Service to ensure that livestock and large wild ungulate grazing levels are managed to avoid disruption of natural disturbance regimes.

15. Collaborate with US Forest Service to designate areas for off-road vehicle use that avoid disturbance to SGCN or their habitats and to discover ways to mitigate such disturbance where it presently occurs.

16. Work in partnership with private landowners, counties, municipalities, federal and state land management agencies to mitigate and reduce impacts related to urbanization of Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats. Approaches might include establishment of development standards that ensure continued habitat integrity and functionality.

17. Work with counties and municipalities to create local zoning regulations that help reduce wildfire threats to private residences in areas of wildland urban interface and to direct financial resources to re-establishing naturally functioning ecosystems in forest interiors.

18. Work with the US Forest Service and oil and gas companies to minimize oil and gas development and associated effects in the Rocky Mountain Montane Mixed-Conifer Forests and Woodland.

19. Encourage the US Forest Service to conserve the biological diversity of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands through development and implementation of an ecosystem management approach.

20. Work with the US Forest Service to employ prescribed burns and let-burn policies that will promote return of aspen groves to their historic distribution and abundance within the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

21. Collaborate with state and federal agencies to minimize installation of developed recreation sites in aspen stands to reduce exposure of aspens to injury and fungal infections.

22. Develop projects and partnerships to assess SGCN distribution, abundance, population trends, basic life history attributes, population biology, community ecology, and responses to anthropogenic and natural habitat disturbances.

23. Partner with US Forest Service, NGOs, and private landowners to identify, protect, and monitor special SGCN habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams.

24. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts on the condition of Rocky Mountain Montane Mixed-Conifer Forests and Woodland important to SGCN.

25. Collaborate with land management agencies, conservation organizations, and educational groups to teach the public about the potential adverse effects of continued climate change on SGCN and their habitats.

26. Work with the US Forest Service and NM State Forestry Division to teach the public about of the ecology of phytophagous insects and their role in sustaining healthy ecosystem function.

27. Work with the US Forest Service, NM State Forestry Division, and private landowners to prevent the conduct of post-fire management activities that are detrimental to SGCN and/or ecosystem function.

Western Great Plains Shortgrass Prairie

Habitat Condition

The majority of literature associated with the Western Great Plains Shortgrass Prairie describes the entire land cover type and is not specific to New Mexico. Thus, the information presented in this section should be considered within this broad context.

The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Kaufman *et al.* 1988). The combined effects of these factors created an extensive mosaic of environments that accommodated a rich diversity of plant and animal species (Collins and Barber 1985, Plumb and Dodd 1993).

Disturbances created by prairie mammals significantly affected the diversity of the prairie ecosystem. Several authors (Anderson 1982, Plumb and Dodd 1993, Rickets *et al.* 1999) suggest that the dominant, sod-forming perennial grassland plants of this region evolved under intensive grazing by wild ungulates. As a result, woody vegetation was suppressed and the evolution of grazing-tolerant plants was favored. The disturbances created by foraging bison (*Bison bison*), pronghorn (*Antilocapra americana*) and elk (*Cervus elaphus*) significantly affected vegetation, nutrient cycles, soil structure and composition and, as some areas were heavily grazed and others left untouched, created a mosaic of habitats across the prairie.

In this ecoregion, Callenbach (1996) reported that bison seasonally ranged as far west as the San Augustine Plains and the grasslands of northeastern Arizona in the late prehistoric period. Herds of bison within the Estancia Valley and the Galisteo Basin were either exterminated or driven eastward by pressure from Navajo, Apache, Pueblo and early Hispanic hunters (Bailey 1971, Hammond and Rey 1966, Weber 1988). It is estimated that prairie dogs occupied roughly 154,441 mi^2 (400,000 km^2), or 20% of the available shortgrass and midgrass prairies (Benedict 1996). Their presence also altered vegetation, created open habitat, and modified soil, nutrient, and energy cycles. Prairie dog burrows turned the soils, allowed annual forbs and grasses a foothold in the dominant perennial grassland, and sustained prairie biodiversity. Wild bison have since been extirpated and prairie dogs significantly reduced as the prairie ecosystem has been converted, fragmented and otherwise altered (Benedict 1996) by human activities.

Despite the shortgrass prairie's apparent evolutionary adaptation to grazing, historic grazing by domestic livestock has been an agent of change. Much of this effect occurred in the late 1880s when livestock numbers peaked and shortgrass prairies were grazed beyond their sustainable use. Barbour (1988) stated, "When the shortgrass prairie was first grazed by domestic livestock, the original grasses persisted probably because of their low stature and natural resistance to grazing pressure. As abuses occurred and the grasses declined, weedy perennial species such as cacti (*Opuntia* spp.), snakeweed (*Gutierrezia sarothrae*) and yucca (*Yucca* spp.) increased. Invading annual plants included brome (*Bromus* spp.), Russian thistle (*Salsola tragus*), barley (*Hordeum* spp.), and fescue grasses (*Festuca* spp.)." The frequency of natural fires diminished due to the resultant reduction in fuels and by increased fire suppression. The compounding effects fostered an invasion of shrubs and trees into historic shortgrass prairies (Brown 1982).

As for the current state of the shortgrass prairie, Dick-Peddie (1993) wrote, "The succession from plains-mesa grassland to juniper savanna will probably continue in many areas of the state. At the lower (drier) boundaries of plains-mesa grassland, many acres of grama grassland will become desert grassland, and much of the present desert grassland will become Chihuahuan or Great Basin desert shrubland. On many sites, these successional trends, which range users consider deterioration of grassland, were set in motion early in this century; subsequent range management efforts are unlikely to halt, let alone reverse the trend."

Agricultural cultivation has also affected the shortgrass prairie. The dust bowl of the 1930s originated in southeastern Colorado, southwestern Kansas, and the panhandles of Texas, Oklahoma, and eastern New Mexico, where the shortgrass prairie was plowed for dryland farming. These fields remain discernable today, decades after cultivation ceased and the fields were abandoned. The persistence of threeawn species in these areas may be the result of plowing-induced changes in the soil. These changes require long periods of time for restoration. An accompanying reduction in soil phosphorus may leave the site more suitable for these species than for the climax plants that are so slow to reestablish (Barbour and Billings 1988).

Where irrigation augments natural precipitation, high levels of crop production continue to be attained (Stoddart 1975). This observation is supported by Ricketts (1999) who stated, "Much of the area was severely affected by largely unsuccessful efforts to develop dryland cultivation. The dustbowl of the 1930s was centered in this ecoregion and stands as proof of the unsuitability of this area for farming, unless heavily irrigated." However, water pumped from the aquifer is not replaced at the same rate that it is removed and the water table has receded. Gleick (1993) reported that the aquifer is sustaining an overdraft rate that is approximately 140% above its recharge rate.

Problems Affecting Habitats or Species

Analyses based on the scientific literature and NMDGF staff suggests that modification of disturbance regime, loss of keystone species, and conversion of the prairie to agriculture are factors that are influencing the biodiversity of Western Great Plains Shortgrass Prairie habitats.

Loss of Keystone Species
The capacity of the Western Great Plains Shortgrass Prairie to sustain its composition, structure, and ecological processes has been diminished through the loss or reduction of keystone species and subsequent alteration of the historic disturbance regimes of which they were part. Keystone species are those animals that have a significant overall effect on the structure or function of habitat types or ecosystems. Their effect is disproportionate to their abundance.

Free-ranging bison have been extirpated from the shortgrass prairie and domestic livestock have taken their place. Bison foraged on different plants than domestic livestock (Peden *et al.* 1974, Plumb and Dodd 1993). Bison removed vegetation in a way that often created patches of open habitat that differed in vegetative composition from the surrounding ungrazed areas (Benedict 1996). Disturbance from cattle grazing tends to produce a more uniform effect. The construction of water developments for livestock has expanded grazing into historically inaccessible areas. Prairie dogs also created large patches of habitat that differed from the surrounding landscape and provided essential habitat for many other animals (Benedict 1996). Although they still exist on the landscape, prairie dogs are much reduced and are susceptible to elimination from poisonings and outbreaks of sylvatic plague (*Yersinia pestis*) (Miller *et al.* 1994). Further, their potential to maintain viable and resilient populations and to sustain the biodiversity they create is in doubt because, according to Pizzimente (1981), colonies are becoming isolated and genetic exchange through immigration is becoming less likely.

Grazing Practices
Grazing practices on the Western Great Plains Shortgrass Prairie are varied and may potentially alter grassland habitats. The intensity and length of the grazing season, in combination with extant environmental conditions, has the potential to change plant species composition, the percent of vegetative cover, and the physical habitat structure (Bock *et al.* 1984). Modifications to vegetative parameters affect associated fauna and cause subsequent changes in plant diversity and structure affecting animal diversity. Sites subjected to improper grazing practices, those that reduce the ability of the land to support long-term animal and plant production, may lose faunal specialist species that may or may not be replaced with generalist species (Bock *et al.* 1984). Excessive livestock grazing may also encourage shrub encroachment through the reduction in grasses and the competition they provide to woody plant seedlings (Humphrey 1958). However, Mack and Thompson (1982) reported that grazed areas in the shortgrass prairie tend to be recolonized by predominantly native plants. The specific effects of current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie are poorly understood.

Invasive Species
Invasive species can be plants, animals, or other organisms including microbes. The US Department of State (1999) cautioned that the introduction of non-native species has the

potential to cause economic, environmental, or human health problems. Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing susceptibility to additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Lee (1999) and Mitchell (2000) noted that the invasion of non-native species is similar to a biological wildfire that is rapidly spreading across the West. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004). Little is known about the extent or specific effects of invasive species in the Western Great Plains Shortgrass Prairie, making it difficult to assess related problems and develop effective interventions.

Recreational and Off-Road Vehicle Use
The *New Mexico Statewide Comprehensive Outdoor Recreation Plan* (Henkel 2004) identified a moderately increasing trend in off-road vehicle use in New Mexico from the 1996-2001. Recreational off-road vehicle use has also increased in the Western Great Plains Shortgrass Prairie along rivers, lakes and streams, wherever public access is available. Federal and state lands that are not adjacent to water sources receive highly dispersed and varied recreational use.

Problems associated with dispersed recreation include indiscriminate driving on interior undeveloped roads or in roadless areas. The specific effects of recreation and off-road vehicle use on the Western Great Plains Shortgrass Prairie are unknown. However, off-road vehicle travel can cause damage to soils and vegetation (Holechek *et al.* 1998) and impact wildlife by destroying and fragmenting habitat, causing direct mortality, or altering behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Habitat Fragmentation
The ecological implications of habitat fragmentation have lead many ecologists to identify the process as one of the most significant factors affecting biodiversity (Harris 1984, Wilcox and Murphy 1985, Noss and Cooperrider 1994). Saunders *et al.* (1991) note that urban expansion, agricultural development, power line construction, and road construction have accelerated over the past century, subdividing the natural world into disjunctive remnants of native ecosystems embedded in a matrix of anthropogenic land uses. Such development has caused large areas of formerly contiguous landscapes to become increasingly fragmented and isolated (Finch 2004).

Some authors (Barbour and Billings 1988, Ricketts 1999) believe that the primary factor affecting the Western Great Plains Shortgrass Prairie is conversion to agriculture. Areas that were once difficult to cultivate may now be pressed into service due to new technologies such as four-wheel drive tractors, precision farming, herbicides, and irrigation.

Urban and commercial developments also contribute to the loss of native vegetation, increased water use, ground water depletion, and increased erosion through soil compaction and runoff concentration. These activities may ultimately increase clearing, roads, and vehicular traffic. Subsequent habitat fragmentation may affect SGCN within the shortgrass prairie by: 1) reducing the habitat area for interior species, 2) imposing barriers to dispersal, colonization, and maintenance of meta-population dynamics, 3) altering demographic and genetic structure as a result of isolation and small population size, 4) increasing habitat edge and thereby facilitating predation, parasitism, and invasion by exotic species or habitat generalists, 5) altering biotic relationships, such as plant and pollinator interactions, and 6) altering the physical environment, ecological processes, and natural disturbance regimes (Finch 2004).

Fire Management

The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Wright and Bailey 1982, Kaufman *et al.* 1988, Anderson 1990, Debano *et al.* 1998, Rickets *et al.* 1999). Fire frequency and intensity appear to be synchronized by climate conditions, physiographic, edaphic and vegetation conditions (Daubenmire 1968, Swetnam and Betancourt 1990). Historically, grassland fires were caused by lightning and Native Americans (Payne 1982, Bahre 1985). However, widespread cultivation, livestock grazing, and transportation corridors reduced standing biomass of fine fuels, and fragmented the landscape in prairie ecosystems, which decreased grassland fire frequency and intensity (Ford and McPherson 1996, 1998, Hart and Hart 1997, DeBano *et al.* 1998, Frank *et al.* 1998). These changes have virtually eliminated fire as an ecological process and have had a negative overall impact to prairie ecosystems (Engle and Bidwell 2000). Brockway *et al.* (2002) investigated the effects of growing season and dormant season prescribed fire on the Kiowa National Grasslands in New Mexico. Their results indicated that prescribed fire in shortgrass prairie during the growing season appears to place the plant community at a greater risk of decline. Conversely, prescribed fires during the dormant season provided several immediate benefits to the plant species present and increased species diversity. However, Launchbaugh (1964, 1972) believes fire in the shortgrass prairie to be detrimental because it lowers forage yields by diminishing the number of soil tillers and reduces water infiltration and soil moisture. The roll of fire in sustaining the shortgrass prairie has been well researched, yet results are conflicting (Stewart 1951, Launchbaugh 1973, Wilson and Shay 1990, Knoft 1994, Umbanhowar 1996, Kirchner 1997, McDaniel *et al.* 1997, Knopf 1998, Ford 1999, 2001; among others). Thus, this topic warrants additional attention by research scientists.

Energy Exploration and Development

The most common mineral extractions in the Western Great Plains Shortgrass Prairie are oil and natural gas. Oil and gas leasing on federal lands follow standards established by the Bureau of Land Management (BLM) and are subject to further regulation by the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division. The infrastructure of oil and gas extraction (pads, roads, pipelines pump stations, compressors) and related human activities has resulted in habitat fragmentation, disturbance from vehicle traffic, hauling, and maintenance activities, point source pollution, noise, and habitat conversion.

Wind energy facilities are not yet widespread in the Western Great Plains Shortgrass Prairie. However, as alternative sources of energy become more important and as related technology improves, there is potential for more wind energy sites to be developed. Wind-generated electrical energy is environmentally friendly in that it does not create air-polluting and climate-modifying emissions. Nevertheless, wind turbines in large arrays can affect wildlife and habitats. Roads and pads fragment habitat and bats and birds (particularly raptors) are killed in collisions with the moving blades of the wind turbines. Lighted wind towers greater than 200 ft (61 m) tall have the same potential as communication towers to attract and kill night-flying migratory birds and bats through collisions with moving blades (NMDGF 2004b).

Water Withdrawal
Ground water in the shortgrass prairie is currently extracted for residential, agricultural, and industrial uses. As demands for water increase, additional deeper wells are needed. Ground water pumped from the Ogallala Aquifer is not replaced at the same rate as it is removed. There has been a subsequent reduction of the water table. Aquatic habitats are the first to be effected. Further reduction in the water table may alter the extent and species composition of Western Great Plains Shortgrass Prairie.

Military Maneuvers
The military uses portions of air space over the Western Great Plains Shortgrass Prairie for tactical air training. These maneuvers involve low level fights resulting in noise issues in specific areas that may affect some SGCN, especially during the breeding season.

Pollution
Agricultural chemicals, livestock and dairy ground water contamination, and solid waste have the potential to create localized pollution in portions of the Western Great Plains Shortgrass Prairie. The current sources, extent, and effects of such pollution, however, remain to be determined.

Information Gaps

Given the size of the shortgrass prairie in New Mexico and the variety of potential factors that may alter prairie habitats, it is not surprising that there are a number of information gaps related to this ecoregion and SGCN. Information gaps that limit the ability to make informed conservation decisions for the Western Great Plains Shortgrass Prairie are outlined below.

- Minimum biotic and abiotic measurements are lacking that insure habitat sustainability, integrity and current land cover habitat and SGCN condition.

- Specific range or ecological condition information is lacking for the shortgrass prairie. The BLM uses a standardized methodology to estimate ecological condition on their lands. However, much of the Western Great Plains Shortgrass Prairie is not federally managed and there are no estimates of ecological condition on private lands or consistent information between the US Forest Service and BLM.

- The intensity, scale, extent, and causes of fragmentation are largely unknown.

- Information is needed on the specific effects of current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie.

- Information is needed on grazing management practices necessary to sustain appropriate levels, composition, and structure of native plants and grasses in the shortgrass prairie for SGCN.

- Short and long-term effects of land management practices such as oil, gas, and wind development; grazing systems, lovegrass monocultures on CRP lands, invasive species, and shrub encroachment on SGCN is poorly understood. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

- There is little information on the abundance, distribution, and trends for most of the SGCN and the environmental conditions or thresholds that limit their populations.

- The response of SGCN to human disturbances is unclear.

- Information is lacking on the effects of habitat fragmentation and requirements for wide-ranging SGCN.

- There is no central clearinghouse for biological information on the Western Great Plains Shortgrass Prairie and SGCN associated with this habitat type that allows all agencies and private landowners to access information to develop conservation actions.

- The extents to which invasive and non-native species occupy, alter, and limit populations of SGCN and into which interventions may be effective, are poorly understood.

- The extent to which off-road vehicle use is affecting SGCN populations is unknown.

- There is a poor understanding of the sources of pollution and the extent to which pollution is altering the Western Great Plains Shortgrass Prairie.

- There is limited information on the role of fire and appropriate fire management protocols in sustaining the shortgrass prairie.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Western Great Plains Shortgrass Prairie are primarily derived from our lack of information about factors that influence the integrity of this habitat type and associated information gaps. Research, survey, and monitoring needs that would enhance our understanding of this habitat type and SGCN are outlined below.

- Investigate the extent to which land use activities fragment and alter habitats in relation to patch size, edge effect, temporal needs, and use by SGCN. Examples of these activities include: 1) livestock grazing timing, intensity, and duration; 2) urban development; 3) gas, oil, and water exploration; 4) off-road vehicle use; and 5) non-native species invasions. This information is important in understanding how different land use intensities and frequencies disturb SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships within the Western Great Plains Sand Shortgrass Prairie. Life history and habitat needs of most of the SGCN and their use of this habitat type are poorly understood.

- Investigate the potential impact that wind energy facilities may have on avian and bat populations. Studies should define important migration/movement corridors for these taxa on both a landscape and local area scale.

- Identify the impacts of fire, grazing, and drought on the Western Great Plains Shortgrass Prairie. Optimal studies would define the roles, mechanisms and impacts via manipulative field-based experiments. Methods that mimic natural disturbance regimes and consider economic impact can be valuable to land managers.

- Investigate the impacts, benefits or detrimental effects of habitat restoration practices, such as tree and shrub removal, reseeding, fire, etc. Millions of dollars are made available annually through various grant programs to federal, state, and private land managers. All restoration methods should be closely evaluated and suggested modification of these practices should be made available to land managers.

- Investigate and recommend invasive species early detection protocols, methods to estimate vectors and pathways of potential invasive species, and effective interventions.

- Define spatial and temporal requirements of wide-ranging SGCN. The identification of habitat corridors is essential for long-term conservation planning.

- Investigate and monitor black-tailed prairie dog populations including rates of town growth, establishment and decline, and the effects of plague and control efforts on prairie dog populations (Johnson *et al.* 2003).

- Investigate options for developing a centralized database of information regarding the condition of the Western Great Plains Shortgrass Prairie. This database would identify data gaps, compare differing methodologies of data collection, and encourage the implementation of national monitoring standards.

Desired Future Outcomes

Desired future outcomes for the Western Great Plains Shortgrass Prairie are focused upon achieving ecological sustainability and integrity of this land cover type. Desired future outcomes include:

- Western Great Plains Shortgrass Prairie persists in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- In order to garner public support and recognition of the importance of the shortgrass prairie in New Mexico, economic and social ties to the Western Great Plains Shortgrass Prairie are recognized and accommodated in the quest for ecological sustainability.

- Large natural areas are designated and managed for dispersal, genetic mixing of populations and to accommodate wide-ranging species.

- Partnerships have been established to identify and implement adequate funding for conservation planning, education, and technical, reclamation, survey, and research projects that ensure the future integrity and functionality of the shortgrass prairie for SGCN and resource extraction needs.

- Consistent grassland reclamation standards are established that ensure future habitat integrity and functionality and are adopted by private landowners, counties, municipalities, and federal and state land management agencies.

- Land management plans for federal and state lands include sustainable grazing practices that are fully implemented and complied with.

- A fully funded comprehensive statewide noxious weed control planning committee and program is established. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and private landowners to ensure the ecological sustainability and integrity of the shortgrass prairie. Methods may include: establishing conservation agreements, agency memorandum of understanding, or land acquisition projects.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Western Great Plains Shortgrass Prairie outlined in the Research, Survey, and Monitoring Needs section above.

3. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such

practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting "grass banking" opportunities that allow degraded rangelands to recover.

4. Support actions that create incentive based or voluntary partnerships with private landowners to conserve and manage their properties to sustain SGCN.

5. Work with federal, state, and private agencies and institutions to identify sources of funding for long-term conservation of SGCN and to maintain tracts of native vegetation as an alternative to converting land to agriculture or urban development. Funding should create incentives for habitat maintenance and improvement on private lands and conservation easements. Employ existing incentive programs to facilitate partnerships with private landowners. These programs include the Conservation Reserve Program (CRP), Landowner Incentive Program, Wetland Reserve Program, Wildlife Habitat Incentives Program, State Wildlife Grants, Private Stewardship Grants Program, Safe Harbor Agreements, and Environmental Quality Incentive Program.

6. Initiate centralization of available data regarding condition of the shortgrass prairie should for the purpose of identifying data gaps, to compare current methodologies of data collection and to encourage the implementation of national monitoring standards.

7. Collaborate with federal and state agencies and affected publics to identify legislative actions, land acquisition, and easement access management protections for the Western Great Plains Shortgrass Prairie. Practices to consider for legislative attention include the regulation of toxicants to control prairie dogs, removal of prairie dogs, regulation of exploitative activities such as rattlesnake roundups, and off-road vehicle management.

8. Counter habitat fragmentation by working with federal, state, and private land managers to modify management of roadside rights-of-way and fencerows to provide useful habitat and corridors that allow wildlife to travel between existing patches of prairie.

9. Collaborate with federal, state, and private agencies and institutions in gaining support for additional open space lands, mitigation mechanisms, and management strategies.

10. Monitor and respond appropriately to proposals to modify programs, such as CRP, that support conservation management and incentives to preclude conversion of wildlife habitat to alternative uses.

11. Identify and pursue opportunities to develop agreements among state and federal agencies that clearly outline responsibilities regarding conservation of shortgrass habitats and resident SGCN.

12. Promote grassland restoration that encourages increased native herbaceous cover.

13. Collaborate with federal and state agencies and effected publics to develop management practices that would increase populations and nesting success of avian species in the shortgrass prairie. Possible management practices may include: 1) maintaining a network of grassland reserves that can act as refugia for grassland birds during periods when agricultural needs reduce the amount of land available to them; 2) maintaining areas that are not grazed or burned for at least three years to provide habitat for species that require taller, denser vegetation; 3) minimize early-season mowing or cutting of hayfields or fields on lands in the CRP; and 4) aggregate fields in CRP to create a few large grasslands.

14. Assist with implementation of *New Mexico's Strategic Plan for Managing Noxious Weeds,* 2000-2001 (http://www.swstrategy.org/library/NM Strategic Plan for Managing weeds.htm). New Mexico's weed management strategy is intended to complement the objectives of agency and inter-agency weed management strategies, including the BLM, *Partners Against Weeds* action plan, the US Forest Service, *Stemming The Invasive Tide*, and the national interagency strategy, *Pulling Together*), as well as *the National Invasive Species Management Plan*, but with a specific focus on opportunities and problems in this state.

15. Collect and distribute information regarding assessments of the short and long-term effects of land management practices such as prescribed fire, habitat rehabilitation. These practices include methods of converting lovegrass monocultures on CRP lands, habitat restoration, shrub removal, wind generation site interventions, oil and gas reclamation, and invasive species management, and grazing systems.

16. Provide a general guide for landowners to restore and maintain a mosaic of vegetative structure that provide habitat for a variety of native wildlife, particularly SGCN, and which contribute to landscape-level habitat restoration.

17. Provide or facilitate public education and wildlife viewing opportunities to raise awareness and appreciation of grassland SGCN, gain support for additional open space lands, build mechanisms for mitigation, and develop management strategies.

18. Work with entities planning development of wind energy facilities in the Western Great Plains Shortgrass Prairie to reduce the potential for adverse effects on SGCN.

CHIHUAHUAN DESERT ECOREGION

The Chihuahuan Desert Ecoregion is dominated by Chihuahuan semi-desert grasslands and desert scrub vegetation (Bell *et al.* 2004). In New Mexico, this ecoregion encompasses approximately 15.2 million ac (6.1 million ha) in Luna, Dona Ana, Sierra, and Eddy counties, and portions of Socorro, Lincoln, Otero, Chaves, and Lea counties. Approximately 66% of the Chihuahuan Desert Ecoregion in New Mexico is privately managed. Federal agencies (primarily Bureau of Land Management and Department of Defense) administer approximately 26% while state agencies administer approximately 8% of the ecoregion (Thompson *et al*. 1996).

Two key terrestrial habitat types were identified in this ecoregion, Chihuahuan Semi-desert Grasslands, and the Western Great Plains Sandhill Sagebrush Shrubland (Fig. 5-3). Grassland habitats in the ecoregion have been identified and prioritized for conservation by the World Wildlife Fund (Dinerstein *et al*. 2000). Semi-desert grasslands are recognized for their regional biological value, especially their importance to grassland birds (Biodiversity Support Program *et al*. 1995). Grassland bird populations have been declining across the North American continent for over the last 50 years (Knopf 1994, Peterjohn and Sauer 1999, Vickery and Herkert 2001). The aplomado falcon (*Falco femoralis*) is a grassland adapted bird that was once considered extirpated from the southwest. However, recent sightings of falcons, a successful breeding pair, and potential reintroductions in New Mexico increases optimism for the reestablishment of this bird into historic habitats. Nevertheless, grassland conservation is paramount in conserving aplomado falcons and other grassland birds in the Chihuahuan Desert (Young *et al.* 2004). The Western Great Plains Sandhill Sagebrush Shrubland hosts a variety of resident native wildlife. The lesser prairie-chicken (*Tympanuchus pallidicinctus*), and sand dune lizard (*Sceloporus arenicolus*) have received much attention in this habitat type. Conservation efforts directed at the lesser prairie-chicken are excellent examples of collaborative efforts between federal, state and private land managers and environmental organizations.

Reptile collection and trade in the Chihuahuan Desert Ecoregion is factor that influences the integrity of reptile and amphibian populations. Reptile and amphibian biodiversity in the Chihuahuan Desert Ecoregion alone consists of approximately 217 species (Fitzgerald *et al.* 2004). In the United States portion of the Chihuahuan Desert Ecoregion, approximately 120 reptile and amphibian species are subject to domestic and international trade. Although collection for the commercial trade may impact these populations, the magnitude of this impact has not been thoroughly investigated and is poorly understood.

<u>Species of Greatest Conservation Need</u>

Of all the ecoregions in New Mexico, the Chihuahuan Desert Ecoregion was the third highest in regard to the number of Species of Greatest Conservation Need (SGCN). Excluding arthropods other than crustaceans, 57 SGCN have been identified in this ecoregion. Chihuahuan Semi-desert grasslands hosts 55 SGCN, and the Western Great Plains Sandhill Sagebrush Shrubland hosts 14 SGCN (Table 5-5). Thirty-six species (63%) were classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Ten species (18%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 11 species (19%) are secure both statewide and nationally.

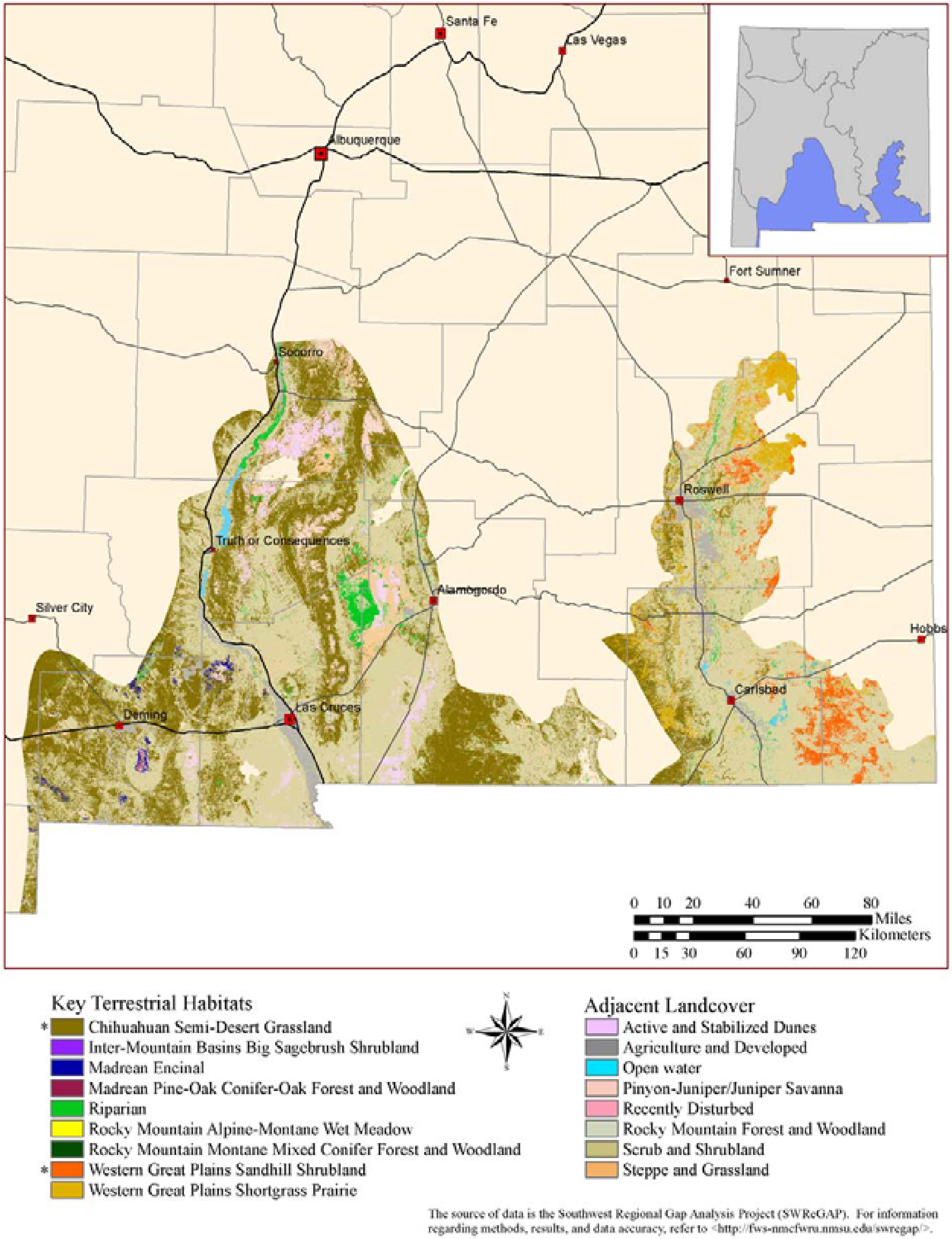


Figure 5-3. Key terrestrial habitats in the Chihuahuan Desert Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Table 5-5. Species of Greatest Conservation Need in the Chihuahuan Desert Ecoregion in New Mexico.

Common Name	Chihuahuan Semi-Desert Grasslands	Western Great Plains Sandhill Sagebrush Shrubland
Birds		
Bald Eagle	X	
Northern Harrier	X	
Ferruginous Hawk	X	X
Golden Eagle	X	
Aplomado Falcon	X	
Lesser Prairie-Chicken		X
Montezuma Quail	X	
Scaled Quail	X	
Sandhill Crane	X	
Mourning Dove	X	X
Common Ground-Dove	X	
Burrowing Owl	X	X
Loggerhead Shrike	X	X
Gray Vireo	X	
Sage Thrasher	X	
Bendire'sThrasher	X	
Sprague's Pipit	X	
Botteri's Sparrow	X	
Baird's Sparrow	X	
Grasshopper Sparrow	X	
Varied Bunting	X	
Hooded Oriole	X	
Mammals		
Mexican Long-Tongued Bat	X	
Lesser Long-Nosed Bat	X	
Arizona Myotis Bat	X	
Pocketed Free-Tailed Bat	X	
White-sided Jack Rabbit	X	
Black-tailed Prairie Dog	X	X
Northern Pygmy Mouse	X	
Yellow-Nosed Cotton Rat	X	
Mexican Gray Wolf	X	
Swift Fox	X	X
Mule Deer	X	X
Coues' White-Tailed Deer	X	
Desert Bighorn Sheep	X	
Amphibians		
Great Plains Narrowmouth Toad	X	
Tiger Salamander	X	X
Reptiles		
Ornate Box Turtle	X	

Table 5-5 Cont.

Common Name	Chihuahuan Semi-Desert Grasslands	Western Great Plains Sandhill Sagebrush Shrubland
Reptiles cont.		
Collared Lizard	X	X
Sand Dune Lizard		X
Bunch Grass Lizard	X	
Texas Banded Gecko	X	
Gray-Checkered Whiptail	X	
Gray-Banded Kingsnake	X	
Milk Snake	X	X
Western Diamondback Rattlesnake	X	X
Desert Massasauga	X	X
Molluscs		
New Mexico Ramshorn Snail	X	
Three-Toothed Column Snail	X	
Distorted Metastoma Snail	X	
Whitewashed Radabotus Snail	X	
Woodlandsnail	X	
Organ Mountain Talussnail	X	
Franklin Mountain Talussnail	X	
Dona Ana Talussnail	X	
San Luis Mountains Talussnail	X	
Northern Treeband Snail	X	

Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

Chihuahuan Semi-Desert Grasslands

Habitat Condition

Chihuahuan semi-desert grasslands are found throughout the Chihuahuan Desert Ecoregion. As with other grassland communities in the western United States, this habitat type experienced a marked shift from perennial grassland to shrub-dominated desert scrubland around the mid-1800s (Barnes 1936, Buffington and Herbel 1965, Branson 1985, Archer 1989). The exact cause of this shift is debated, but excessive livestock grazing, climatic change, and fire suppression have been implicated (Fredrickson *et al.* 1998). In turn, grassland conversion and human-caused fragmentation have caused increased runoff and erosion, decreased biological diversity through isolation and reduced carrying capacity (Saunders *et al*. 1991), shifts in avian species assemblages, increased invasion by non-native species, and decreased livestock and wildlife forage (Branson 1985, Vickery *et al*. 1999, Desmond *et al*. 2005). Today, portions of the type appear to be undergoing additional desertification (Asner 2005).

Problems Affecting Habitat or Species

Biodiversity in Chihuahuan semi-desert grasslands is influenced by habitat conversion factors and non-consumptive and consumptive resources uses. Dinerstein *et al*. (2000) also reported that livestock grazing, fire suppression, and urban development were factors leading to loss of biodiversity in the northern Chihuahuan Desert.

Grazing Practices
Livestock grazing has economic and cultural values that are important to individuals, and communities in the Chihuahuan Desert. Impacts of livestock grazing on rangeland wildlife in the Chihuahuan Desert are largely dependent on the grazing management practices used. Domestic livestock and wildlife grazing practices that reduce the ability of the land to sustain long term plant and animal production (Wilson and MacLeod 1991), may lead to the loss of grassland cover, mortality of plant species, and increased erosion. Further, improper grazing practices and increased agriculture production may lead to habitat fragmentation and loss by promoting conditions favorable for shrub encroachment and through increased infrastructure development, such as roads and fences (Dinerstein *et al*. 2000). These land management activities are compounded by extended drought periods and altered hydrological functions.

Fire Regimes
Altered fire regimes, resulting from both fire suppression and the removal of fine fuels by domestic grazers and wildlife may also promote the establishment of both woody vegetation and introduced non-native species. However, the extent to which fire occurred in southwestern grasslands varied geographically and is related to climatic variables such as seasonal and annual rainfall and physiographic variables such as elevation, slope and aspect (Archer 1994). Fire may have been rare in desert grasslands and limited in extent due to low biomass and a lack of continuity in fine fuels (Hastings and Turner 1965, York and Dick-Peddie 1969).

Development and Exploration
Human population is increasing in the Chihuahuan desert in southern New Mexico. With this increase in population, urban, commercial, and rural development has increased. These developments and subdivisions contribute greatly to the loss of native vegetation and increased erosion through soil compaction and runoff concentration. In addition, Chihuahuan semi-desert grasslands in the vicinity of Otero Mesa and Crow Flats are currently being explored for natural gas. Within the same areas, activities related to drilling and pumping of deep groundwater for El Paso and Las Cruces are also being proposed. These activities may ultimately cause further habitat fragmentation and loss through landscape conversion (clearing), roads, and increased vehicular traffic (Dinerstein *et al*. 2000).

Off-Road Vehicles
Recreational off-road vehicle use has also increased in the Chihuahuan semi-desert grasslands. These activities are found in Dona Ana and Socorro counties where several organized events are held each year. While the impacts of these activities on the Chihuahuan semi-desert grasslands are poorly understood, increased off-road vehicle use may negatively impact wildlife by destroying and fragmenting habitat, direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Military and Borderland Security Activities
White Sands Missile Range and Fort Bliss Military Reservation both host extensive areas of Chihuahuan semi-desert grasslands. Military maneuvers and infrastructure development may destroy and fragment existing grassland habitats. Border security efforts and associated road building and road improvement activities are occurring throughout the US/Mexico borderlands region to intercept drug shipments, illegal immigrants, and stop other unauthorized activities (US Department of Justice, Immigration and Naturalization Service 2000). Increased road building and traffic in the borderlands region causes additional habitat loss and fragmentation, reduces effective (useable) habitat for wildlife populations, increases roadkill mortality, poaching, illegal collecting of wildlife and causes general habitat destruction (Forman *et al.* 2003).

Non-Native Species
Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plant and animal species (including threatened and endangered species), disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Little is known about the extent of invasive species in Chihuahuan semi-desert grasslands. As such, the development of early detection protocols, and estimators of vectors and pathways of potential invasive species may inform conservation strategies related to invasive species.

Diseases and Pathogens
A total of nine cases of chronic wasting disease have been confirmed in New Mexico as of September 2005. All were mule deer (*Odocoileus hemionus*) located in the Organ Mountains east of Las Cruces. Two mule deer subjected to tonsillar biopsies and released in December of 2004 in southern New Mexico as part of a research project were later found to be positive for chronic wasting disease. Additional information on the extent and risk of chronic wasting disease is necessary to understand the extent of this problem.

Information Gaps

Although there is a large body of literature on the ecology of the Chihuahuan semi-desert grasslands, there are numerous information gaps that limit our ability to make conservation decisions. Information gaps are outlined below.

- The intensity, scale, extent, and causes of grassland fragmentation in the Chihuahuan Desert are unknown.
- The response of SGCN to human disturbances is poorly understood.
- The effects of habitat fragmentation on SGCN are unknown.
- Environmental conditions or thresholds that limit populations of SGCN are poorly understood.

- Methods to identify early detection landscape degradation attributes that would inform land managers of when grasslands were approaching transitional thresholds are needed, to alleviate the need for expensive restoration projects.

- Specific information on viable approaches to restore semi-desert grasslands to functional mosaics is lacking.

- The extent to which invasive species may alter semi-desert grasslands and limit populations of SGCN is unknown.

- The full extent in which border patrol activities or military maneuvers alters semi-desert grasslands and limits populations of SGCN is unclear.

- Information is needed on grazing management practices that produce sustainable levels, composition, and structure of native grasses.

- The extent to which off-road vehicle use is impacting Chihuahuan semi-desert grassland SGCN populations is unknown.

- Our understanding of the role of fire in sustaining the Chihuahuan semi-desert grasslands and appropriate fire management protocols is poor.

- Short and long-term affects of land management practices or uses (such as energy exploration and development, grazing regimes, invasive species and shrub encroachment management) are unclear. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

- The extent and distribution of chronic wasting disease is currently poorly understood.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Chihuahuan semi-desert grasslands are primarily derived from our perception of factors that influence the integrity of semi-desert grasslands and associated information gaps. Research, survey, and monitoring needs include:

- Estimate the areal extent, fragmentation, and structural characteristics of Chihuahuan semi-desert grasslands to provide greater predictive power and applicability to an ecosystem management approach.

- Research is needed on the extent to which land use activities (such as livestock grazing timing, intensity, and duration; human development; gas, oil, and water exploration; off-road vehicle use; military and borderland security activities; and exotic species invasions) fragment and alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships in Chihuahuan semi-desert grasslands. Although there is growing body of ecological research on this semi-desert grasslands, life history and habitat needs of most of the SGCN and their use of this semi-desert grasslands are poorly understood.

- Examine how global and regional climate change coupled with resource uses will affect community and ecosystem-level dynamics in the Chihuahuan semi-desert grasslands.

- Investigate hydrologic relationships in the Chihuahuan semi-desert grasslands to provide a better understanding of interception, transpiration, and infiltration processes for sustainable watershed conservation and management practices.

- Given that this habitat type has experienced a shift from perennial grassland to shrub-dominated desert scrubland (Buffington and Herbel 1965, Archer 1989), the identification of early detection attributes that informs land managers of when grasslands habitats are approaching other community types is needed. In addition, cost effective approaches to restore semi-desert grasslands to functional mosaics need to be investigated.

- Consistent rangeland health and condition descriptions or protocols need to be developed across the state, region, and nation (National Research Council 1994). These descriptions and protocols would facilitate land management decisions by establishing standardized indicators and reference points.

- Investigate invasive species early detection protocols, and estimate vectors and pathways of potential invasive species.

- SGCN populations and their habitats should be estimated and monitored (where possible) to determine long-term population trends and to correlate population trends to ecosystem dynamics and habitat changes.

- Investigate the roll of natural fire and prescribed fire in maintaining grassland habitats.

- Research is needed on the extent of chronic wasting disease and the long-term effects of this disease on SGCN.

Desired Future Outcomes

Desired future outcomes for the Chihuahuan semi-desert grasslands include:

- Chihuahuan semi-desert grasslands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- Ecological conditions necessary to sustain viable populations of the SGCN in semi-desert grassland habitats are established and garner wide public support.

- Working groups have been established composed of county, municipal, state, and federal land management agencies, and public landowners dedicated to prioritizing and addressing conservation and habitat issues at the grassland-urban interface.

- Partnerships have been established to identify and implement adequate funding for conservation planning; education, and technical, reclamation, survey, or research projects that ensure the future integrity and functionality of semi-desert grasslands for SGCN and resource extraction needs.

- Consistent grassland reclamation standards are established that ensure future habitat integrity and functionality and are adopted by private landowners, counties, municipalities, and federal and state land management agencies.

- Land management plans for federal and state lands include sustainable grazing practices that are fully implemented and enforced.

- A fully funded comprehensive state-wide noxious weed control planning committee and program is established. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests. Such practices may include collaborative development of grazing management plans, altering domestic and wildlife stocking rates, time and use, and distribution where forage availability is inadequate, and promoting "grass banking" opportunities that allow degraded rangelands to recover.

2. Work with public and private land managers to reduce shrub encroachment in Chihuahuan semi-desert grasslands habitats important to SGCN. Implementation of this conservation action may include chemical or mechanical manipulation, reseeding with native grasses, or reduction of processes that promote shrub encroachment.

3. Work with federal, state, private organizations, research institutions, and universities to design and implement projects outlined in the Research, Survey, and Monitoring Needs or Information Gaps section outlined above.

4. Work with public and private land managers and the energy industry to encourage energy development in a manner that preserves the integrity and functionality of Chihuahuan semi-desert grasslands and restores disturbed sites.

5. Form partnerships with effected communities and federal land management agencies to facilitate and encourage maintenance and restoration of Chihuahuan semi-desert grasslands.

6. Collaborate with federal and state agencies to designate areas for off-road vehicle use that avoid disturbance to SGCN or their habitats and discover ways to mitigate such disturbance where it currently occurs.

7. Collaborate with federal and state land management agencies and other publics to identify legislative actions, land acquisition and easement protection that will conserve the Chihuahuan semi-desert grasslands.

8. Work with federal, state, and private organizations to develop public education projects that increase awareness and understanding of the fragility of Chihuahuan semi-desert grasslands and their importance to a wide array of species.

Western Great Plains Sandhill Sagebrush Shrublands

Habitat Condition

The Western Great Plains Sandhill Sagebrush Shrublands are a mosaic of hummock and coppice dunes dominated by sand sage (*Artemisia filifolia*) and/or shinnery oak (*Quercus havardii*) with a mixed grass and tallgrass composition. The habitat type is found in the Chihuahuan Desert and the Southern Shortgrass Prairie Ecoregions. In the Chihuahuan Desert Ecoregion, sites dominated by sand sage and purple pea (*Dalea scoparia*) are largely found in central New Mexico adjacent to the middle Rio Grande corridor. Grasses in these sites consist of Indian ricegrass (*Oryzopsis hymenoides*), little bluestem (*Andropogon scoparium*), and sand dropseed (*Sporobolus cryptandrus*).

The Western Great Plains Sandhill Sagebrush Shrublands habitat is considered a climax vegetation (Rosiere 2000) although, there is anecdotal evidence suggesting that the dense stands of shinnery-oak and sand sage on the high plains of eastern New Mexico are a result of intense grazing pressure. Soils in this habitat type are typically deep and well drained with surface textures consisting of aeolian fine sands or loamy aeolian fine sands. These soils often extend to a depth of 60 in (152 cm) or more. Water holding capacity is low, and the soils are highly erodible. When organic residues and vegetative cover are removed, landscapes typically are converted to unstabilized dunes (Natural Resource Conservation Service 1997; Ecological Site Description, Sandhills). Soils in dune areas are well drained and grade to a shallower calcic hardpan overlayed by a shallow sand at the southwestern and southern boundaries of this ecological site. Shallow soil sites are typically dominated by buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*) and threeleaf sumac (*Rhus trilobata*) or littleleaf sumac (*Rhus microphylla*).

Continuous year-round or season-long summer grazing (April through October) have reduced the once dominant tall- and mixed cool season grass species including New Mexico feathergrass (*Stipa neomexicana*), needle and thread grass (*Hesperostipa comata*), and Indian ricegrass. Today, large portions of the type are dominated by sand dropseed, sand sage, soaptree yucca (*Yucca elata*), and threeawn species (*Aristida* spp.) with lower cover and productivity values (Natural Resource Conservation Service 1997; Ecological Site Description, Deep Sand). Season-long summer use by livestock has also reduced both the amount of forbs and warm season grasses found in this habitat type and their concomitant production of organic litter on the soil surface. This reduction has increased the sand dunes' vulnerability to wind erosion and blowouts. In the northern reaches of the Chihuahuan Desert Ecoregion, Rosiere (2000) noted that sand sage has increased on overgrazed ranges and abandoned farmlands to densities similar to those of the Intermountain West's big sagebrush steppe. However, shrub components of this type remain important in terms of nutrient cycling and ecosystem function where sagebrush, shinnery oak, and subdominant shrubs trap and accumulate nutrients around their bases forming "islands of fertility" (Schlesinger and Pilmanis 1998). This accretion of organic matter and nutrients is especially important to insects and ultimately to rodents, herpetofauna, and birds that consume them (Whitford *et al*. 1998).

Problems Affecting Habitat or Species

Factors that are most likely to influence SGCN and the Western Great Plains Sandhill Sagebrush Shrublands in the Chihuahuan Desert Ecoregion are habitat conversion factors, abiotic resource use, and consumptive uses. Since the early 1950s, this habitat has been altered in the more southerly areas of the High Plains by agricultural conversion and practices, oil and gas development, excessive livestock grazing, and brush and weed control (through the use of herbicides) (Jackson and DeArment 1963, Hunt and Best 2004). These factors have contributed to the decrease in habitat and increase in fragmentation for lesser prairie-chickens and sand dune lizards.

Agriculture and Livestock Production
Improper grazing practices (those that reduce long-term plant and animal productivity) and increased agriculture production in the Western Great Plains Sandhill Sagebrush Shrublands may lead to habitat fragmentation and loss by promoting conditions favorable for shrub encroachment and through increased infrastructure development, such as roads, fences, subdivisions, agricultural lands (Dinerstein *et al*. 2000). The effects of these land management activities are compounded by extended drought periods and altered hydrological functions in the Chihuahuan Desert. Altered fire regimes, resulting from both fire suppression and the removal of fine fuels by domestic grazers and wildlife, also promote the establishment of both woody vegetation and introduced non-native species.

Development and Exploration
Oil and gas exploration and extraction activities typically have localized effects on sand dune lizards' populations. Sias and Snell (1998) reported a negative relationship between well density and abundance of sand dune lizards. Oil and gas development activities reduced populations approximately 40% when compared to control areas that were approximately 200 m distant from a pad (Sias and Snell 1996). In addition to low population numbers, oil and gas development activities may cause further habitat fragmentation and loss through landscape conversion (clearing), roads, and increased vehicular traffic (Dinerstein *et al.* 2000).

Invasive and Non-Native Species
Soil Bank programs of the 1950s and 1960s also made use of non-native lovegrasses (*Eragrostis curvula*, *E. lehmannii*) to stabilize topsoil. In the mid-1980s, the Conservation Reserve Program (CRP) was initiated to reduce the number of cultivated grain fields. At this time, lovegrasses were again planted. Older established plantings of weeping lovegrass (*E. curvula*) are particularly persistent if grazed or burned. In some instances, range fires in these established grass stands have become more frequent, further reinforcing the persistence of this fire-adapted non-native grass.

Chemical Shrub Control
Shinnery oak is a management concern when it grows in dense stands, particularly where it comprises 80% of the annual plant production and competes with native grasses and forbs for water and nutrients (Pettit 1986). Shrub control in the 1980s made use of the herbicide tebuthiuron and nearly 40,500 ha (100,000 ac) of BLM lands in southeastern New Mexico were treated to reduce shinnery oak and to increase grass production for livestock grazing (Massey 2001).

Control of shinnery oak affects lesser prairie-chickens and sand dune lizards. Lesser prairie-chickens may use stands of dense shinnery oak; however, they prefer areas dominated by perennial mid and tall-grass species (Cannon and Knopf 1981). While Johnson (2000) found a greater concentration of lesser prairie-chickens nesting in areas that were not treated with herbicide, Olawsky and Smith (1991) reported similar densities of lesser prairie-chicken on herbicide treated and untreated areas. The sand dune lizard appears to be confined to areas of active sand dunes vegetated by shinnery oak and their peripheries where the uneven sandy terrain and wind-eroded blowouts meet their habitat requirements (Degenhardt and Jones 1972, Degenhardt and Sena 1976, Sena 1985, Snell *et al*. 1994, NMDGF 1996). Control of shinnery oak by tebuthiuron in the Mescalero Sands, Chaves County, New Mexico indicated reductions between 70-94% in the number of sand dune lizards in treated pastures. In many sites, lizards were not observed in the treated pastures despite suitable populations in adjacent untreated pastures. Snell *et al*. (1993, 1994) and Gorum *et al*. (1995) noted that populations have declined since the initiation of tebuthiuron treatments and that following treatment, sand dune lizard habitat can be considered either lost or greatly reduced in quality.

The persistence of herbicide and other environmental contaminants and their effects on fish and wildlife have been reviewed by Schmitt and Bunck (1995) and Glaser (1995). However, the magnitude and effects of herbicide use in the Western Great Plains Sandhill Sagebrush Shrublands has not been well assessed (Mac *et al*. 1998).

Off-Road Vehicles
The frequency and intensity of recreational off-road vehicle use has also increased in the Western Great Plains Sandhill Sagebrush Shrublands; however, the extent of these activities is unknown. While the impacts of these activities on the sand sagebrush shrublands are poorly understood, increased off-road vehicles may negatively impact wildlife by destroying and fragmenting habitat, direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Information Gaps

There is little literature on the ecology of the Western Great Plains Sandhill Sagebrush Shrublands. Current literature is primarily based on habitat needs for lesser prairie-chickens and sand dune lizards. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The intensity, scale, extent, and causes of Western Great Plains Sandhill Sagebrush Shrublands fragmentation are unknown.

- Little is known on grazing management practices that maintain appropriate levels and compositions of native grasses in this habitat type.

- The response of SGCN to human disturbances is poorly understood.

- The effects of habitat fragmentation on SGCN are unknown.

- Little is known on the environmental conditions or thresholds that limit populations of SGCN.

- The extent to which invasive and non-native species alter Western Great Plains Sandhill Sagebrush Shrublands and limit populations of SGCN is unknown.

- Short and long-term effects of land management practices or uses (such as energy exploration and development, grazing regimes, invasive species and vegetation management) are unclear. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

- The extent to which off-road vehicle use is impacting Western Great Plains Sandhill Sagebrush Shrublands SGCN populations is unknown.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Western Great Plains Sandhill Sagebrush Shrublands are primarily derived from our perception of factors that influence the integrity of this habitat type and associated information gaps. Research, survey, and monitoring needs that enhance our ability to make informed conservation decisions are outlined below.

- Investigate the extent to which land use activities (such as livestock grazing timing, intensity, and duration; human development; gas, oil, and water exploration; off-road vehicle use; and non-native species invasions) fragment and alter habitats in relation to patch size, edge effect, and use by SGCN. This information is important in understanding how different land use intensities and frequencies of disturbance effect SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships in the Western Great Plains Sandhill Sagebrush Shrublands. Life history and habitat needs of most of the SGCN and their use of this habitat type are poorly understood.

- Examine how global and regional climate change coupled with resource uses affect community and ecosystem-level dynamics in the Western Great Plains Sandhill Sagebrush Shrublands.

- Investigate the use of tebuthiuron for reducing shinnery oak cover and SGCN response to spatially diverse applications of herbicides with respect to SGCN habitat requirements.

- Identify thresholds of shinnery oak and/or sand sage cover or density at which reproduction and brood success of lesser prairie-chickens and sand dune lizards are reduced or eliminated.

- Investigate how natural fire regimes and the role of fire in the Western Great Plains Sandhill Sagebrush Shrublands can help in restoring and maintaining shinnery oak habitats and can be used as a shrub control methodology.

- Identify grazing management practices that maintain appropriate levels and compositions of native grasses within shinnery oak habitat types.

- Explore the influence of CRP on landscape structure and SGCN habitat.

- Investigate how habitat fragmentation by oil and gas development and the concomitant effects on the size and connectivity of habitat patches affects population energetics and persistence of SGCN.

- Identify nationally standardized indicators that could be used for inventory and monitoring the health of the Western Great Plains Sandhill Sagebrush Shrublands.

Desired Future Outcomes

Desired future outcomes for the Western Great Plains Sandhill Sagebrush Shrublands include:

- Western Great Plains Sandhill Sagebrush Shrublands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- Reclamation standards that ensure habitat integrity and function are established and implemented for land use practices that alter habitat condition.

- Partnerships are established with NRCS and landowners to establish and implement ecologically sound restoration of CRP and abandoned croplands to native shrub/grasslands.

- Land management plans for federal and state lands include sustainable grazing practices that are fully implemented and enforced.

- Natural fire cycles are restored in this habitat.

- Herbicide treatments optimize structurally diverse habitats for wildlife and livestock.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

2. Collaborate with federal and state agencies, and private landowners in restoration of the Western Great Plains Sandhill Sagebrush Shrublands. Restoration actions may include: mitigation and reduction of impacts related to oil and gas development; restoration and return of abandoned croplands to native shrub/grassland; managed sustainable grazing on public lands that accounts for SGCN habitat concerns; and active research programs on the use of tebuthiuron coupled with controlled burns for reducing shinnery oak cover.

3. Work with federal and state agencies, private landowners, and oil and gas development companies to rehabilitate abandoned well pads and access roads. Rehabilitation efforts may include the removal of caliche and/or reseeding with a mix of native species with supplemental watering.

4. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the Western Great Plains Sandhill Sagebrush Shrublands outlined in the Research, Survey, and Monitoring Needs section.

5. Work with federal, state, and private agencies, NGOs, and institutions to create financial incentives for habitat maintenance and improvement on private lands and conservation easements.

6. Work with willing landowners to increase the size and connectivity of designated prairie-chicken areas.

7. Work with federal, state, and private agencies, institutions and landowners to provide financial incentives to maintain tracts of native vegetation, as an alternative to converting land to agriculture or urban development.

8. Collaborate with federal and state agencies to designate areas for off-road vehicle activities that avoid disturbance to SGCN or their habitats and to discover ways to mitigate such disturbance where it currently occurs.

9. Encourage Conservation Reserve Program land managers to promote use of native seed mixes for soil stabilization and increased value to SGCN.

10. Encourage land managers to establish and maintain a diverse mosaic of interspersed patches of shinnery oak and residual bunchgrasses.

11. Work with federal, state, and private agencies and institutions in developing an education and public awareness program that emphasizes the fragility of this habitat type and its importance to a wide array of species.

COLORADO PLATEAU ECOREGION

The Colorado Plateau Ecoregion is a complex of badlands, sheer-walled canyons, buttes, mesas, plains, dunes, and isolated mountain ranges that encompasses the Four Corners region of Arizona, Colorado, New Mexico, and Utah. The Colorado, Little Colorado, San Juan, and Escalante rivers carve large canyons as they pass through the plateau. The ecoregion contains 48.5 million ac (19.6 million ha) of mostly public and tribal lands. One million ac (0.4 million ha), or 2% of the ecoregion are in the northwestern corner of New Mexico. Elevations range from 1,200 ft (370 m) within the Grand Canyon to 12,700 ft (3,870 m) in the La Sal Mountains.

This wide range of elevations produces diverse habitats. The more prevalent habitats are piñon-juniper/juniper savanna, riparian, big sagebrush shrublands, steppe, and grasslands. The ecological significance of this ecoregion is its diverse flora and fauna. More than 300 plant species are unique to the area and found nowhere else in the world (Tuhy *et al.* 2002). The climate within the Colorado Plateau ecoregion is often described as “desert” because annual precipitation averages less than 10 in (25 cm). Most of this occurs in the winter as snow and subsequently infiltrates the soil (Tuhy *et al.* 2002). The Intermountain Basins Big Sagebrush Shrubland is the only key terrestrial habitat type occurring in the Colorado Plateau Ecoregion (Fig. 5-4).

Sage grouse (*Centrocercus urophasianus*) once occupied sagebrush habitats in this ecoregion. Around 1919 they were apparently extirpated from New Mexico. Reintroduction efforts have failed, likely because habitat conditions are no longer suitable. The California kingsnake (*Lampropeltis getula californiae*) is rare in New Mexico, and has only been found near the Colorado border. Little is known on the ecology of this species in New Mexico. The Gunnison's prairie dog (*Cynomys gunnisoni*) is one of the two species of prairie dogs that occurs in New Mexico. The Gunnison's prairie dog occurs in the Four Corners area of Arizona, New Mexico, Colorado, and Utah and is considered a keystone species of the sagebrush ecosystem. Gunnison's prairie dog populations have declined across their New Mexico range, in part due to historic and current poisoning and shooting, sylvatic plague (*Yersinia pestis*), and habitat destruction (Miller *et al.* 1994).

<u>Species of Greatest Conservation Need</u>

Although there were only 15 Species of Greatest Conservation Need (SGCN) (excluding arthropods other than crustaceans) associated with the Colorado Plateau Ecoregion (Table 5-6), this ecoregion has ecological importance due to its geologic features and diverse and unique fauna and flora. More than 300 plant species alone are found nowhere else in the world (Tuhy *et al.* 2002). Of the 15 SGCN, only 6 (40%) species were considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Five (33%) species are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and four other species (27%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

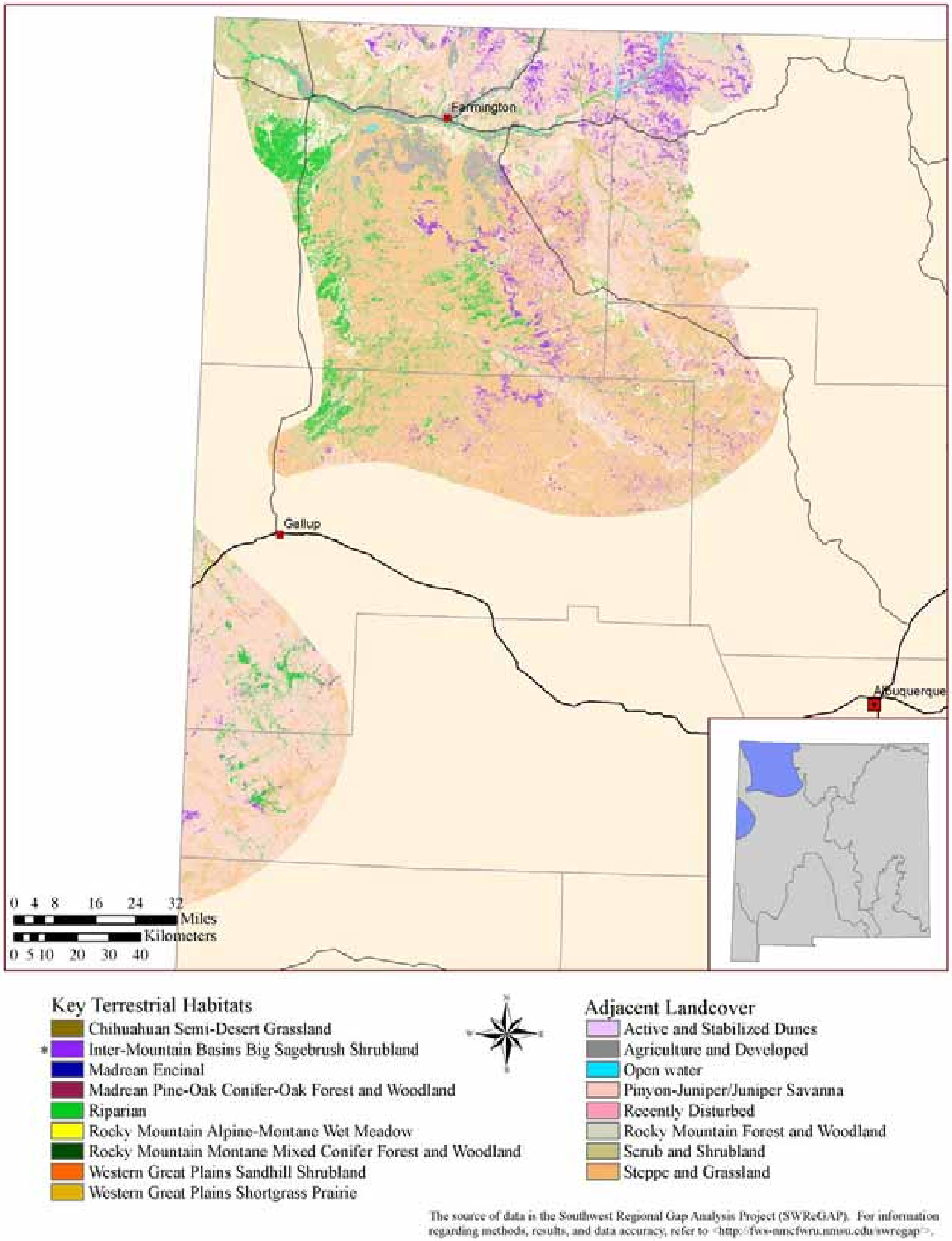


Figure 5-4. Key terrestrial habitats in the Colorado Plateau Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*)

Table 5-6. Species of Greatest Conservation Need in the Colorado Plateau Ecoregion in New Mexico.

Common Name	Intermountain Basins Big Sagebrush Shrubland
Birds	
Ferruginous Hawk	X
Golden Eagle	X
Scaled Quail	X
Mourning Dove	X
Loggerhead Shrike	X
Sage Thrasher	X
Bendire's Thrasher	X
Sage Sparrow	X
Mammals	
Arizona Myotis Bat	X
White-Tailed Jack Rabbit	X
Gunnison's Prairie Dog	X
Black Bear	X
Mule Deer	X
Reptiles	
Collared Lizard	X
California Kingsnake	X

Intermountain Basins Big Sagebrush Shrubland

Habitat Condition

The Intermountain Basins Big Sagebrush Shrubland occurs in northern New Mexico in both the Colorado Plateau and the Southern Rocky Mountains ecoregions. Cole (1995) studied vegetation changes over the last 5,450 years using pollen profiles in the Capitol Reef National Park, Hartnett Draw area of the Colorado Plateau. Vegetation composition appears to have been fairly stable until the last few hundred years. After this time, plants preferred by cattle and sheep, such as winterfat (*Kraschenninnikovia lanata* or *Ceratoides lanata*) and ricegrass (*Oryzopsis hymenoides*), disappeared from pollen profiles and were replaced by plants associated with improper grazing practices, such as rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia* spp.), and greasewood (*Sarcobatus* spp.) (Cole 1995).

Livestock use of New Mexico rangelands in the late nineteenth century exceeded the grazing capacity of the big sagebrush shrublands and precipitated the loss of native perennial grasses and an expansion of shrubs within 10 to 15 years (Hull 1976). As a result of grazing pressure and prolonged drought, the forbs component of today's big sagebrush shrublands is not especially diverse.

It is likely that bird and small mammal assemblages have been affected by this change in the structure and composition of the vegetative community. Greater sage grouse are obligate residents of the sagebrush ecosystem, usually inhabiting sagebrush-grassland or juniper sagebrush-grassland communities. Efforts to re-introduce this species, extirpated in 1919, probably failed because habitat conditions were no longer suitable. Many small mammals also rely on the native grass component of sagebrush habitats. A study of Townsend's ground squirrel on the Snake River Birds of Prey Study Area of southeastern Idaho showed that squirrel density generally increased with increasing native grass cover (Knick 1993).

The greatest historic alteration in this sagebrush habitat type has occurred through the invasion of cheatgrass (*Bromus tectorum*). Although grazing pressure in sagebrush communities throughout the western United States has declined in recent times, virtually no remnant virgin sagebrush steppe exists in New Mexico. Many sites have lost their native perennial grasses altogether and have been invaded by cheatgrass and introduced perennials.

The Intermountain Basins Big Sagebrush Shrubland has been significantly affected by energy development in the form of oil and natural gas extraction and surface coal mining. Coal bed methane development in the San Juan Basin is currently a major land use. The *Farmington Resource Management Plan and Environmental Impact Statement* (BLM 2003) estimated that there are currently approximately 18,000 active wells in the San Juan Basin. Depending on the scale, density, and arrangement of each well site in relation to other sites, habitat loss and fragmentation in the portions of this habitat type subjected to energy development are extensive. At this high level of development, effects may not be successfully mitigated.

Much of the big sagebrush shrubland is found on erosive sandy clays and receives most of its precipitation in the winter as snow. Wind and water erosion play a major role in degrading this habitat type. In these arid lands, microscopic soil organisms are essential to system productivity (Belnap 1994). In the Colorado Plateau, *Microcolues vaginatus* (cyanobacteria) dominates the crust structure. Lichens (*Collema* spp.) and mosses (*Tortula* spp.) are common (Belnap *et al.* 2001). These organisms have likely been adversely affected by disturbances to the soil crust caused by off-road vehicle use and energy development.

It is probable that the combined effects of drought, improper grazing, invasion of annual grasses and noxious weeds, and a changing fire regime have affected the prey base of top-level predators, such as raptors, carnivores, and rattlesnakes. A study in Idaho found that small mammal biomass was highest in habitats characterized by tall sage cover, low grass cover, and high biological crust cover. Rattlesnakes appeared to select areas with high small-mammal densities (Jenkins *et al*. 2004). Large predators such as grizzly bears, wolves, lynx, and river otters have been extirpated from this habitat for decades.

Problems Affecting Habitats or Species

Literature review and assessment of factors that influence habitats and SGCN suggest that abiotic resource use, habitat conversion activities, and consumptive biological use are the primary factors affecting big sagebrush habitats. Of particular concern are energy development, the invasion of non-native species, and improper livestock grazing practices.

Energy Development
In addition to the 18,000 active gas and oil wells currently in the San Juan Basin, approximately 12,500 new wells are anticipated in the northern and eastern part of San Juan County within the next 10 years (BLM 2003). Another 750 new wells are anticipated in the Jicarilla Ranger District of the Carson National Forest in Rio Arriba County. The new development will allow gas wells at one well per 160 ac (65 ha), an anticipated 50% increase in density.

Energy development infrastructure including roads, tanks, equipment staging areas, compressor stations, shops, pipelines, power line corridors, associated traffic, and human activity have the potential to affect wildlife more than just the wells themselves. For example, when impact zones surrounding each well pad, facility, and road corridor begin to overlap, habitat effectiveness is reduced over a much larger contiguous area. Development at this level reduces the ability of wildlife to use the habitat. Mule deer in particular are precluded from accessing their winter ranges.

Current mitigation policy on the Jicarilla Ranger District of the Carson National Forest requires that re-vegetation meet current US Forest Service standards. Reclamation will be approved when vegetative cover is equal to 70% of the adjacent areas and soil has been stabilized. This policy allows a post development decrease of 30% in forage availability and quality.

Invasive Species
Cheatgrass threatens to dominate 62 million ac (25 million ha), an area greater than 50% of today's total sagebrush range. In New Mexico, other significant non-native invasive species of sagebrush habitats include leafy spurge (*Euphorbia eusula*), thistles (*Cirsium* spp.) and knapweed (*Centaurea* spp.). These species uniformly reduce the vegetative productivity, diversity, and cover of the Intermountain Basins Big Sagebrush type and, in the case of cheatgrass, influence the intensity and frequency of fires (West 1988, Kurdila 1995, Vitousek *et al*. 1997). The *Resource Management Plan for the Farmington Field Office* (BLM 2003) identified 25 invasive and non-native plant species of concern.

Grazing Practices
Livestock grazing has occurred in this habitat type for decades, with the greatest numbers of animals and associated disturbance occurring in the second half of the nineteenth century. Since then, grazing pressure in these sagebrush communities has declined. There are currently few remaining examples of intact sagebrush steppe in New Mexico. These are found as relict stands in the foothills of the Sangre de Cristo Mountains of Taos County. In this habitat type, even moderate levels of livestock grazing can remove the herbaceous understory that in turn, releases sagebrush seedlings from competition with herbaceous and graminaceous plants. This process results in excessively dense sagebrush stands with a sparse understory of annuals and unpalatable perennials (Havstad and Vavra 2004). However, studies in northern New Mexico have indicated that the total elimination of grazing for 22 years did not improve range condition on upland or lowland sites when compared with adjacent moderately grazed areas (Holechek and Stephenson 1985).

Fire Management
Prior to European settlement, wildfires probably occurred less than once every 100 years in this and other arid sagebrush habitats. However, in the last century, fire frequency has increased in sagebrush communities throughout the west. Today, frequent wildfires in the Intermountain Basins Big Sagebrush Shrubland promote the decline of native grasses in favor of non-native annual grasses (Whisenant 1990). Control of these fires and reduction of livestock grazing will not result in a return to historic conditions because much of the soil seed bank has been lost (Anderson and Holte 1981).

Off-Road Vehicles
Recreational off-road vehicle use has increased in this habitat type in the Colorado Plateau. Most of this use occurs in San Juan County where large-scale off-road vehicle activities have become organized annual events. While the specific extent of these activities is unknown, off-road vehicles may destroy and fragment habitat, cause direct mortality of wildlife, and alter wildlife behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Information Gaps

Although there is a large body of literature on the sagebrush communities in the West, particularly in reference to sage grouse, remaining information gaps that constrain our ability to make informed conservation decisions include:

- The implementation and effectiveness of energy development mitigation in conserving habitats and species within the northern portions of the Intermountain Basins Big Sagebrush is unknown. This precludes evaluation of industry impacts and subsequent improvement of land management agency energy development policies.

- The effects of energy development in big sagebrush shrubland on resident SGCN, especially mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), and ferruginous hawk (*Buteo regalis*) are unknown.

- The specific effects of human-caused habitat fragmentation on SGCN within the Intermountain Basins Big Sagebrush Shrubland are poorly understood.

- The extent to which invasive species may alter big sagebrush shrubland and limit populations of SGCN is unclear.

- Information is needed on grazing management practices that produce sustainable levels, composition, and structure of native vegetation associated with SGCN.

- The extent to which off-road vehicle use is impacting big sagebrush shrubland SGCN populations is unknown.

- Our understanding of the role of fire in sustaining the big sagebrush shrubland and appropriate fire management protocols is poor.

Research, Survey, and Monitoring Needs

The historic land management of the Intermountain Basins Big Sagebrush Shrubland and the relatively new invasion of non-native vegetation, combined with increasingly extensive energy development hasten the need for the following research:

- Studies are needed on how oil and gas development and associated road construction affects habitat fragmentation and influences habitat patch size, edge effect, and use of Intermountain Basins Big Sagebrush Shrubland by wildlife. This information is also important in understanding how fragmentation and patch dynamics affect small mammal species, avifauna, and herpetofauna.

- Collection of basic life history information is needed for SGCN whose basic biology is poorly understood to develop effective monitoring and conservation actions.

- In order to develop effective habitat manipulation activities, studies are needed on how the invasion of cheatgrass has affected SGCN habitat structure, foraging behaviors, nutrition, and reproductive success.

- Investigate invasive species early detection protocols and estimate vectors and pathways of potential invasive species.

- Increase monitoring and research regarding appropriate grazing practices and habitat restoration methods in the Intermountain Basins Big Sagebrush Shrubland. With a large percentage of this land cover type under federal management, efforts should be made to identify modifications that will improve range condition and be economically feasible for permittees. Both monitoring and research efforts should include consideration of biological soil crusts.

- Useful descriptions of habitat condition and health require that consistent language and survey monitoring protocols be used. There is a need to establish standardized national indicators that would be used for the inventory, survey, and monitoring of the condition and health of this and other rangeland habitat types. Indicators along with standardizing methods of measuring site health and condition have been advocated by the National Research Council (1994) but have not been uniformly adopted.

Desired Future Outcomes

Desired future outcomes for the Intermountain Basins Big Sagebrush Shrubland include:

- The Intermountain Basins Big Sagebrush Shrublands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Close monitoring and collaboration between NMDGF, BLM, USFS, private landowners and the energy industry result in minimal adverse effects upon SGCN as a result of oil and gas development.

- Grazing practices that are cost effective are implemented that ensure the sustainability and integrity of the Intermountain Basins Big Sagebrush Shrubland.

- A fully funded, comprehensive, statewide noxious weed control program is established and implemented. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

- Protected areas have been established as wildlife corridors to reduce habitat fragmentation and provide SGCN access to necessary habitat.

- Local communities are involved in and support decisions related to conserve the SGCN and biodiversity of the Intermountain Basins Big Sagebrush Shrubland.

- Consistent reclamation standards that ensure future habitat integrity and functionality for Intermountain Basins Big Sagebrush Shrublands are jointly established and adopted by private landowners, counties, municipalities, and federal and state land management agencies.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Define an effective process to work with all stakeholders to conserve the biodiversity of the Intermountain Basins Big Sagebrush Shrubland.

2. Collaborate with public and private land managers to identify and protect wildlife corridors necessary to maintain or restore the connectivity of Intermountain Basins Big Sagebrush Shrubland habitats. Particular attention should be given to sagebrush habitats in rapidly urbanizing areas northeast of the city of Farmington and in those areas under extensive oil and gas development. All factors affecting habitat connectivity and fragmentation, such as off-road vehicles and road management, should be considered.

3. Investigate opportunities to improve conditions of approval and reclamation standards for oil and gas development and develop partnership programs and funding mechanisms for their implementation with the oil and gas industry.

4. Work with public and private land managers and the energy industry to adopt adaptive management strategies that minimize disturbance to SGCN caused by industrial infrastructure, grazing, and recreation in Intermountain Basins Big Sagebrush Shrubland habitats.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the Intermountain Basins Big Sagebrush Shrubland habitats outlined in the Research, Survey, and Monitoring Needs section above.

6. Pursue partnerships with affected communities and federal and state land management agencies to facilitate and encourage restoration of Intermountain Basins Big Sagebrush Shrubland habitats.

7. Collaborate with public and private land managers to develop, adopt, fund, and implement a program to aggressively eradicate and stop the spread of noxious weeds, regardless of jurisdictional boundaries. Programs should be based on the *New Mexico Strategic Plan for Managing Noxious Weeds 2000-2001*; BLM*, Partners Against Weeds Action Plan*; USFS, *Stemming The Invasive Tide*; National Interagency Strategy*, Pulling Together* and the *National Invasive Species Management Plan*.

8. Convene *ad hoc* working groups composed of municipal, county, state, and federal land management agencies and affected publics to resolve conservation issues at wildland/urban interface areas. Additional funding should be identified for conservation planning, on-the-ground projects, education, and technical assistance.

9. Develop an education program to impart understanding of the fragility of the Intermountain Basins Big Sagebrush Shrubland habitat and its importance to a wide array of species.

SOUTHERN ROCKY MOUNTAINS ECOREGION

The Southern Rocky Mountains Ecoregion covers most of north central New Mexico extending from the state line southward to Santa Fe and Albuquerque and includes the southern San Juan Mountains, Sangre de Cristo Mountains, and Jemez Mountains. Important New Mexico rivers that flow through this ecoregion include the Rio Grande, San Juan River, Rio Chama, and the Vermejo River. Three key terrestrial habitat types, the Intermountain Basins Big Sagebrush Shrubland, Rocky Mountain Alpine-Montane Wet Meadow, and Rocky Mountain Montane Mixed-Conifer Forest and Woodland (Fig. 5-5) occur in this ecoregion. Neely *et al.* (2001) identified the Southern Rocky Mountains Ecoregion as one of the few areas that remains relatively intact and provides broad scale conservation opportunities. However, increasing residential and recreational development presents a potential source of change.

Species of Greatest Conservation Need

Fourty-nine Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, are associated with the Southern Rocky Mountain Ecoregion (Table 5-7). The majority reside within the Rocky Mountain Montane Mixed-Conifer Forest and Woodland (31 species), which covers significantly more area within the ecoregion than the other two component key habitats. Of the 49 SGCN in the ecoregion, 16 species (33%) are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Approximately 17 species (35%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 16 species (33%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Some associated SGCN, such as mule deer (*Odocoileus hemionus*) and mourning dove (*Zenaida macroura*), are common throughout the region while others, such as the American marten (*Martes americana*) and Jemez Mountain salamander (*Plethodon neomexicanus*), are uncommon and localized. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

Intermountain Basins Big Sagebrush Shrubland

Habitat Condition

In the Southern Rocky Mountains Ecoregion, the Intermountain Basins Big Sagebrush Shrubland is found north and west of Taos and Questa, specifically in northwestern Rio Arriba, and western Taos counties. Within this ecoregion is a cold desert (Dick-Peddie 1993). The shrub layer consists of rubber rabbitbrush (*Chrysothamnus nauseousus*) and sagebrush (*Artemisia tridentata, and A. bigelovii*). Sage, with other brush species, comprises more than 70% of the vegetative cover and more than 90% of the plant biomass (West 1988). Sagebrush is dominant with little or no grass understory, even in late seral stages. Associated perennial grasses include Western wheatgrass (*Agropyron smithii*), needle and thread grass (*Stipa neomexicana*), ring muhly (*Muhlenbergia torreyi*), and alkali sacaton (*Sporobolus airoides*) in heavy clay sites.

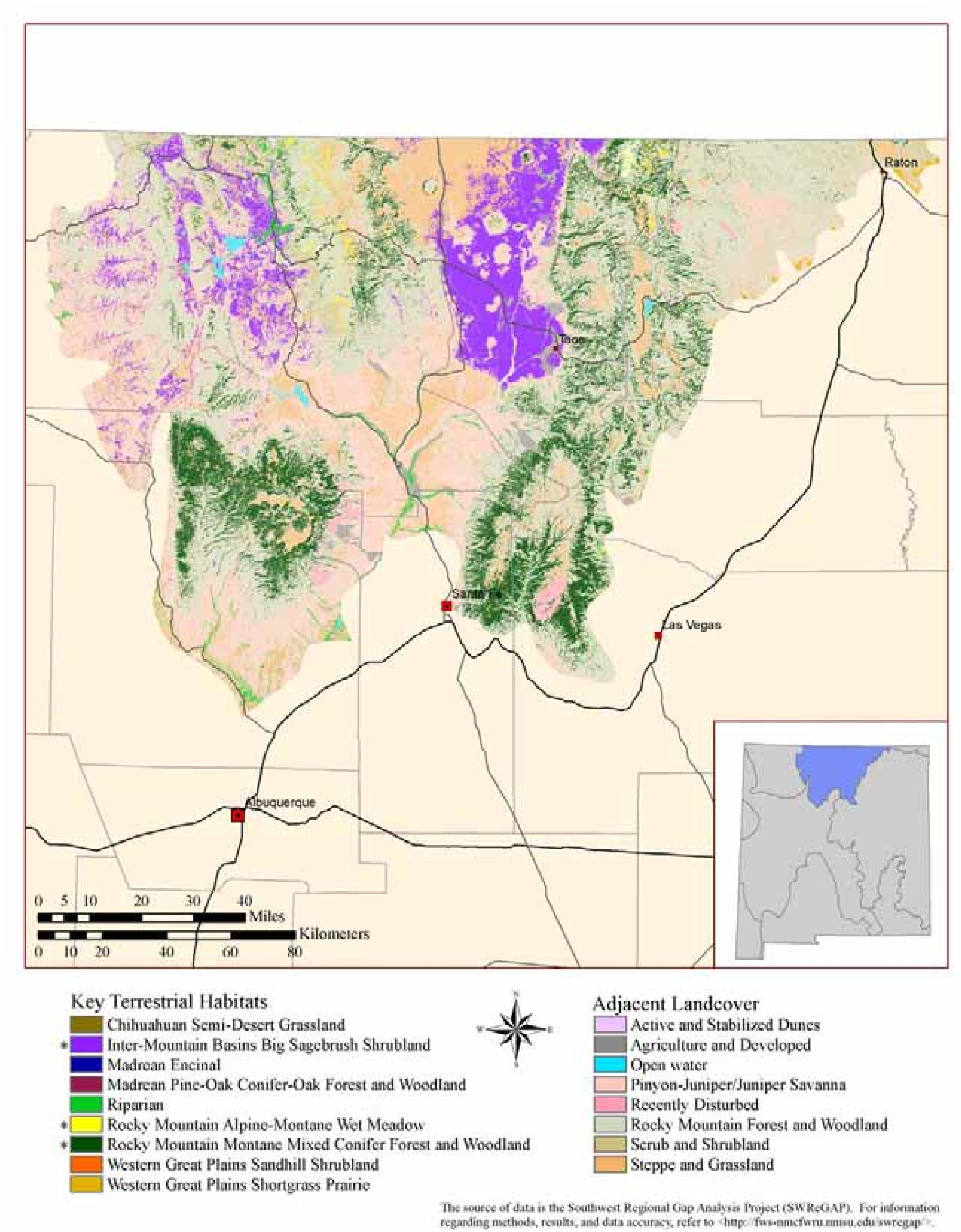


Figure 5-5. Key terrestrial habitats in the Southern Rocky Mountains Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Table 5-7. Species of Greatest Conservation Need in the Southern Rocky Mountains Ecoregion in New Mexico.

Common Name	Intermountain Basins Big Sagebrush Shrublands	Rocky Mountain Alpine-Montane Wet Meadow	Rocky Mountain Montane Mixed-Conifer Forest and Woodland
Birds			
American Bittern		X	
White-Faced Ibis		X	
Northern Pintail		X	
White-Tailed Ptarmigan		X	
Ferruginous Hawk	X		
Mourning Dove	X		
Loggerhead Shrike	X		
Sage Thrasher	X		
Bendire's Thrasher	X		
Sage Sparrow	X		
Osprey			X
Bald Eagle			X
Northern Goshawk			X
Golden Eagle		X	X
Peregrine Falcon			X
Blue Grouse		X	X
Band-Tailed Pigeon		X	X
Mexican Spotted Owl			X
Black Swift			X
Williamson's Sapsucker			X
Olive-Sided Flycatcher			X
Pinyon Jay			X
Yellow Warbler		X	X
Grace's Warbler			X
Red-Faced Warbler			X
Mammals			
Goat Peak Pika		X	
Arizona Myotis Bat	X		
White-Tailed Jack Rabbit	X		
Gunnison's Prairie Dog	X		
New Mexico Shrew			X
Spotted Bat			X
Allen's Big-Eared Bat			X
Snowshoe Hare			X
Abert's Squirrel			X
American Beaver		X	X
Black Bear	X	X	X
Rocky Mountain Bighorn Sheep		X	
American Marten			X
Mule Deer	X		X

Table 5-7 Cont.

Common Name	Intermountain Basins Big Sagebrush Shrublands	Rocky Mountain Alpine-Montane Wet Meadow	Rocky Mountain Montane Mixed-Conifer Forest and Woodland
Amphibians			
Tiger Salamander	X	X	X
Jemez Mountains Salamander			X
Reptile			
Collared Lizard	X		
Molluscs			
Crestless Column Snail		X	
Western Glass Snail		X	
Rocky Mountainsnail			X
Amber Glass Snail			X
Sangre de Cristo Woodlandsnail			X
Jemez Mountains Woodlandsnail			X
Spruce Snail			X

Much of this habitat type occurs on erosive sandy clay loams where wind and water erosion plays a major role in the degradation. In some sites west of Taos and north of Questa soils have in fact been removed through wind erosion, leaving a desert pavement of pebbles and rocks.

The current condition of the habitat is attributed to a long history of improper livestock grazing. Hull (1976) noted that by the late nineteenth century, the grazing capacity had been exceeded, resulting in a significant loss of native perennial grasses and an expansion of sagebrush and other shrubs within 10 to 15 years. Historic grazing use has also reduced the diversity of the forb component, which currently includes fleabanes (*Erigeron* spp.), buckwheats (*Eriogonum* spp.), and cheeseweeds (*Sphaeralcea* spp.). Many sites no longer have a soil seed bank sufficient to produce the native perennial grass component and now are invaded by non-native species including leafy spurge (*Euphorbia eusula*), cheatgrass (*Bromus tectorum*), and knapweeds (*Acroptilon* and *Centaurea* spp.). These species further reduce the productivity, diversity, and cover of the type, and in the case of cheatgrass, influence the intensity and frequency of fires (West 1988, Kurdila 1995, Vitousek *et al*. 1997).

It is likely that bird and small mammal assemblages have been affected by this change in the structure and composition of the vegetative community. Greater sage grouse (*Centrocercus urophasianus*) are obligate residents of the sagebrush ecosystem, usually inhabiting sagebrush-grassland or juniper sagebrush-grassland communities. Efforts to re-introduce this species, extirpated in 1919, probably failed because habitat conditions were no longer suitable. The effects of livestock grazing, invasion of noxious plants and a changing fire regime have also affected the prey base of top-level predators in the system, such as raptors, carnivores, and rattlesnakes (Jenkins *et al*. 2004).

Problems Affecting Habitat or Species

The primary disturbance factor within the Intermountain Basins Big Sagebrush Shrubland has been historical grazing with subsequent habitat conversion. This land cover type has also been affected by habitat fragmentation and conversion due to urban, residential, commercial, and recreational development. The future effects of these developmental factors may increase as human populations in the area continue to grow.

Grazing Practices
Livestock grazing has occurred in this habitat type for decades, with the greatest numbers of animals and associated disturbance occurring in the second half of the nineteenth century. Since then, grazing pressure in these sagebrush communities has declined. There are currently few remaining examples of intact sagebrush steppe in New Mexico. These are found as relict stands in the foothills of the Sangre de Cristo Mountains of Taos County. In this habitat type, even moderate levels of livestock grazing can remove the herbaceous understory that in turn, releases sagebrush seedlings from competition with herbaceous and graminaceous plants. This process results in excessively dense sagebrush stands with a sparse understory of annuals and unpalatable perennials (Havstad and Vavra 2004). However, studies in northern New Mexico have indicated that the total elimination of grazing for 22 years did not improve range condition on upland or lowland sites when compared with adjacent moderately grazed areas (Holechek and Stephenson 1985).

Urban/Residential, Commercial/Industrial, and Recreational Development
The continued encroachment of subdivisions and roads into previously undisturbed areas is a significant factor in the fragmentation of this habitat type. Between 1930 and 2000, the population of Taos County more than doubled (Williams 1986, US Census Bureau 2001). Related development is most evident near the communities of Taos and Questa where the proliferation of roads, pipelines, power line corridors, traffic, and human activity is clearly visible. Such development reduces landscape connectivity (Kiett *et al*. 1997) and affects the ability of wildlife to use habitats.

For example, changes in landscape patterns affect the energy balance, foraging behavior, and use of winter ranges by mule deer. In a study of two mule deer winter ranges in Taos County, Dunn and Milne (In Prep.) found that roads and home sites alter connectivity and act as barriers to animal movements. They also found that, between 1935 and 1996, total available habitat greater than 200 m from all roads and home sites decreased 83% in the El Rito and 46% in the Lama areas of Taos County. Exploration for natural gas in the Sunshine Valley area of northwestern Taos County is also ongoing and may presage future energy development and related impacts to this important mule deer winter range.

Non-Native Species
As noted in the above assessment of habitat condition, invasion of non-native plants is ongoing and likely to reduce the productivity, diversity, and cover of this habitat type and alter the intensity and frequency of fire.

Fire Management
Prior to European settlement, wildfires probably occurred less than once every 100 years in this and other arid sagebrush habitats. However, in the last century, fire frequency has increased in sagebrush communities throughout the West. Today, frequent wildfires in the Intermountain Basins Big Sagebrush Shrubland promote the decline of native grasses in favor of non-native annual grasses (Whisenant 1990). Control of these fires and reduction of livestock grazing will not result in a return to historic conditions because much of the soil seed bank has been lost (Anderson and Holte 1981).

Disease and Toxins
Most the avian and mammal SGCN are potentially affected by diseases and toxins (See the Statewide Assessment and Strategies chapter). The growing wildland urban interface, particularly in the vicinities of the communities of Taos and Questa, may expose wildlife to domestic pets and feral animals and contribute to the spread of these diseases. Increased exposure to refuse, pesticides, and parasites may also affect wildlife at this interface.

Information Gaps

Although there is a large body of literature on the sagebrush communities in the West, particularly in reference to sage grouse, remaining information gaps that constrain our ability to make informed conservation decisions include:

- Data are lacking regarding SGCN distribution, life history, spatial needs, and seasonal use patterns in the Intermountain Basins Big Sagebrush Shrubland.

- Important migration corridors, areas of habitat fragmentation, and area-sensitive species needs requirements have yet to be identified in the Intermountain Basins Big Sagebrush Shrubland.

- Little is currently known about the extent and distribution of invasive species in the Intermountain Basins Big Sagebrush Shrubland and effective interventions.

- The implementation and effectiveness of energy development mitigation in conserving habitats and species within the northern portions of the Intermountain Basins Big Sagebrush is unknown. This precludes evaluation of industry impacts and subsequent improvement of land management agency energy development policies.

- Information is needed on grazing management practices that produce sustainable levels, composition, and structure of native vegetation.

- The extent to which off-road vehicle use is impacting big sagebrush shrubland SGCN populations is unknown.

- Our understanding of the role of fire in sustaining the big sagebrush shrubland and appropriate fire management protocols is poor.

Research, Survey, and Monitoring Needs

The processes that have affected the Intermountain Basins Big Sagebrush Shrubland in the past and the anticipated levels of future development hasten the need for additional information. Research and Survey efforts that would inform conservation decisions are outlined below.

- Studies are needed to define current habitat use by SGCN of the Intermountain Basins Big Sagebrush Shrubland so that important areas of big sagebrush habitat may be identified and conserved, habitat fragmentation prevented, and migration corridors retained or restored. This information is also important in understanding how fragmentation and patch dynamics affect small mammal species, avifauna, and herpetofauna and how wildlife diseases and parasites are contracted at the wildland urban interface and transmitted through wildlife populations.

- Collection of basic life history information is needed to develop effective monitoring and conservation actions for SGCN whose basic biology is poorly understood.

- Studies are needed on how the invasion of cheatgrass has affected SGCN habitat structure, foraging behaviors, nutrition, and reproduction to develop effective habitat manipulations.

Desired Future Outcomes

Desired future outcomes for the Intermountain Basins Big Sagebrush Shrubland include:

- The Intermountain Basins Big Sagebrush Shrublands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Modified grazing management results in improved ecological conditions for Intermountain Basins Big Sagebrush Shrubland habitats and improved economic viability for the ranching community of northern New Mexico.

- A fully funded, comprehensive, statewide noxious weed program is established and implemented. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

- Protected areas have been established as wildlife corridors to reduce habitat fragmentation and provide SGCN access to necessary habitat.

- Local communities are involved in and support decisions related to conserving to the SGCN and biodiversity of the Intermountain Basins Big Sagebrush Shrubland.

- Consistent reclamation standards that ensure future habitat integrity and functionality for Intermountain Basins Big Sagebrush Shrubland are jointly established and adopted by private landowners, counties, municipalities, federal land management agencies and the State Land Office.

- Working groups comprised of local, state, and federal government agencies, landowners and the public have been established to address conservation issues at the wildland urban interface.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies and the agriculture industry to define and implement prescribed grazing systems that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

2. Work with local, state, and federal government agencies and land owners to establish wildlife corridors, to reduce habitat fragmentation, and provide necessary habitat for SGCN. Approaches may include protecting sagebrush habitat west of Taos and Questa and management of road development and off-road vehicle use.

3. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the Intermountain Basins Big Sagebrush Shrubland habitats outlined in the Research, Survey, and Monitoring Needs section above.

4. Work with private landowners, counties, municipalities, federal land management agencies and the State Land Office to mitigate and reduce impacts related to urbanization and develop consistent reclamation standards that ensure future habitat integrity and functionality for Intermountain Basins Big Sagebrush Shrubland.

5. Encourage comprehensive and vigorous noxious weed control efforts throughout the Intermountain Basins Big Sagebrush Shrubland and the strengthening of the state's invasive weed control capacity through applied science and promotion.

6. Promote establishment of nationally standardized indicators that would be used for the inventory, survey, and monitoring of the condition and health of this and other rangeland habitat types. Such indicators, along with standardizing methods of measuring site health and condition have previously been advocated by the National Research Council (1994), but have not been uniformly adopted.

7. Promote community based support and involvement in decisions related to ecological sustainability and integrity of the Intermountain Basins Big Sagebrush Shrubland and SGCN viability.

8. Develop an education program that imparts an understanding of the fragility of this habitat type and its importance to a wide array of species.

Rocky Mountain Alpine-Montane Wet Meadow

Habitat Condition

Alpine-montane wet meadows cover a relatively small area of land in the Southern Rocky Mountains Ecoregion. They occur in the high mountain valleys of the northern Sangre de Cristo Mountains (Latir, Pecos, and Wheeler Peak wilderness areas) at elevations of 9,000 ft (2,743 m) or greater. The extent of this land cover type is determined by the amount of annual snow accumulation, solar radiation, freeze-thaw cycles, and tree encroachment. In the Southern Rocky Mountains Ecoregion, these wet meadows are distinguished from classic tundra by the absence of permafrost and of deep organic mature soils (Rosiere 2000). While the soils in these alpine meadows are typically deeper and richer in organic matter than those found on fellfields and steep slopes, coarse rock fragments are found throughout soil profiles. Burrows built by pocket gophers (*Thomomys botteri*) result in a significant amount of soil mixing that facilitates soil aeration, nutrient cycling, water infiltration, and new sites for vegetation establishment.

Much of the variation in surface topography in this habitat type is caused by alternate freezing, thawing, and flow of water saturated soil over less permeable layers of rock and frozen ground (solifluction). Freeze-thaw processes produce a landscape of mounds and depressions at elevations above 12,000 ft (3,657 m). These depressions and the larger cirque lakes and marshes support micro-habitats and conditions supporting willow (*Salix* spp.). These meadows are also dominated by a thick turf composed of graminoids including sedges (Cyperaceae), rushes (Juncaceae), and grasses (Poaceae), especially tufted hairgrass (*Deschampsia caespitosa*). The forb species common to this type are more abundant on sites in earlier seral stages. Similarly, in rockier sites, vegetation is dominated by forbs including yellow stonecrop (*Sedum lanceolatum*) rose crown (*S. rhodanthum*), king's crown (S. *ingegrifolium*), stonecrop (*S. etenopetalum*), saxifrages (*Saxifrage* spp.), American bistort (*Polygonum bistortoides*), whiproot clover (*Trifolium dasyphyllum*), and dwarf clover (*T. nanum*). One of the most diagnostic indicator species of the alpine meadow is bogsedge (*Elyna bellardii* or *Kobresia myosuroids*). Weber and Wittmann (2001) described this species as the "climax dominant on mature soils of relatively dry but peaty alpine tundra." Beidleman *et al.* (2000) declared *Kobresia* "the dominant plant on mature, snow-free areas of tundra that have deep soils" while Kershaw *et al.* (1998) described it's habitat as "dry, open, wind-blown sites".

Despite the perception that water availability is high in these meadows, they are actually harsh environments with short growing seasons, high solar incidence, cold temperatures, and strong winds. The most important factor controlling the distribution and growth of alpine plants is soil moisture (Billings and Mooney 1968). Wind speeds of 25 to 30 mph (40 to 50 kmph) are common and may exceed 100 mph (60 kmph), particularly during the winter (Thilenius 1975).

Fuel loads in the sub-alpine and montane forests surrounding these meadows are unnaturally high and present a risk of catastrophic fire. Montane wet meadows are also strongly influenced by the encroachment of trees, which may increase with global warming. It is estimated that roughly one-third to one-half of this habitat type has been lost to human development (Southern Rockies Ecosystem Project 2003). Historical manipulation of the meadow habitats through root plowing and reseeding with non-native tame pasture species has significantly altered the composition and hydrology of the montane meadows in the northern Jemez Mountains. Many of these wet meadows were converted to more xeric grazing lands and no longer maintain the necessary hydrology to support the characteristic vegetation of this type. Throughout the ecoregion, wetlands have been intentionally drained to make the area more conducive for planting crops. Poorly placed and constructed roadways have also led to the drainage of wetland areas. Alpine meadows are particularly important to those species that are obligates within these habitats, such as ptarmigan (*Lagopus leucurus*) and Goat Peak pika (*Ochotona pinceps*). Rocky Mountain bighorn sheep (*Ovis canadensis canadensi*s) also use the alpine meadow habitat year-round and, in winter, become obligates to windswept slopes above timberline. The loss of alpine meadow habitats would result in the extirpation of ptarmigan and Goat Peak pika statewide and the extirpation of bighorn sheep from the Pecos, Latir, and Wheeler Peak sites.

Problems Affecting Habitats or Species

Fire Management
The accumulation of fuels in sub-alpine and montane forests adjacent to these meadows is the most serious factor potentially affecting these meadows. Fuel loads in the sub-alpine and montane forests surrounding these meadows are unnaturally high and, in combination with global warming induced encroachment of trees, may result in catastrophic stand-changing fire.

Drainage of Wetlands
Manipulation of wet meadows to replace native vegetation with pasture species and poor placement and construction of roadways remain land-use factors with the potential to drain the wetlands of Rocky Mountain Alpine-Wet Meadow habitats.

Grazing Practices
The wet meadows of the Southern Rocky Mountains Ecoregion provide some of the most attractive vegetation areas for grazing animals. Unconstrained access to the wet meadows may lead to loss of cover, mortality of plant species, increased erosion, and wetland drainage.

Recreational Use
The presence of roads and trails in and near alpine-montane wet meadows may result in reduced water quality, increased erosion, and eventual drainage of the wetlands.

Information Gaps

Information gaps are outlined below that impair our ability to make informed conservation decisions regarding alpine-montane wet meadow habitats and SGCN.

- Data are lacking pertaining to SGCN use and dependence upon Rocky Mountain Alpine-Montane Wet Meadow habitat.
- There are no accurate maps depicting long term historical changes in the location and extent of montane wet meadows that might be used to prioritize management actions.
- There is limited information on prescriptions for restoration of montane wet meadows.
- Information is needed on grazing management practices that produce sustainable levels, composition, and structure of native vegetation.
- The extent to which recreational use is impacting montane wet meadows SGCN populations is unknown.
- Our understanding of the role of fire in sustaining the montane wet meadows and appropriate fire management protocols is poor.

Research, Survey, and Monitoring Needs

The processes that have affected the Rocky Mountain Alpine-Montane Wet Meadow habitats in the past and the anticipated levels of future development provide the context for defining current research, survey, and monitoring needs:

- Research is needed to determine how forest encroachment and water use affect Rocky Mountain Alpine-Montane Wet Meadow habitats and how global warming induced tree encroachment has changed the spatial dynamics and persistence of this type in New Mexico.
- Research is needed to compile a comprehensive review of all known records and management actions affecting New Mexico's Rocky Mountain Alpine-Montane Wet Meadow habitats so as to better understand the effects of conversion to xeric grazing lands, conifer encroachment, and competition for water with dense conifer stands.

Desired Future Outcomes

Desired future outcomes for the Rocky Mountain Alpine-Montane Wet Meadow include:

- The Rocky Mountain Alpine-Montane Wet Meadows persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Wetlands and meadows are restored to conditions approximating those that occurred before significant human impacts altered species composition, function, structure and morphology.

- Existing grazing practices ensure the sustainability and integrity of Rocky Mountain Alpine-Montane Wet Meadows and preserve cost effectiveness for private interests.

Prioritized Conservation Actions

Because of the importance and limited acreage of Rocky Mountain Alpine-Montane Wet Meadows, planning efforts should make the maintenance and restoration of these habitats a priority. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies to liberalize burn policies in the wilderness areas surrounding montane and alpine meadow habitats to allow future fires to burn up to a meadow's edge rather than being suppressed.

2. Collaborate with federal and state agencies to mechanically remove (in the absence of fire) encroaching conifer stands to the extent necessary to retain the functionality of Rocky Mountain Alpine-Montane Wet Meadows. Pursue enabling legislative actions where wilderness status presents an obstacle.

3. Work with federal, state, and private land managers to adopt prescribed grazing practices that ensure the sustainability and integrity of Rocky Mountain Alpine-Montane Wet Meadows and preserve cost effectiveness for private interests.

4. Promote community based support and involvement in decisions related to ecological sustainability and integrity of Rocky Mountain Alpine-Montane Wet Meadow habitats and SGCN viability.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Rocky Mountain Alpine-Montane Wet Meadow habitats outlined in the Research, Survey, and Monitoring Needs section above.

6. Work with federal, state, and private land managers to reduce replacement of natural vegetation with pasture species and discontinue poor placement and construction of roadways within Rocky Mountain Alpine-Montane Wet Meadow habitats.

7. Develop and implement an information and education project to gain public acceptance for managed fire, wildfires, and mechanical cutting of trees in designated wilderness areas where these are needed to sustain or restore Rocky Mountain Alpine-Montane Wet Meadows.

Rocky Mountain Montane Mixed-Conifer Forest and Woodland

Habitat Condition

Rocky Mountain Montane Mixed-Conifer Forests and Woodlands form an indiscrete vegetation band dominated by Douglas fir (*Pseudotsuga menziesii*) that blends with true firs and spruces in the sub-alpine coniferous forest between elevations from 8,000 to 10,000 ft (2,438 to 3,048 m). The montane mixed-conifer forests and woodlands blends into ponderosa pine (*Pinus ponderosa*) forests at lower elevations. However, within the montane mixed-conifer forest Douglas fir seldom grows in pure stands, but mixes with blue spruce (*Picea pungens*) and white fir (*Abies concolor*). Blue spruce is often associated with frost pockets and is found along stream sides and on lower slopes where cold air drainage occurs. Following disturbances, Gambel oak (*Quercus gambelii*) and aspen (*Populus tremuloides*) are often prominent. Dick-Peddie (1993) described the montane mixed-conifer forest as being among the most widespread and productive vegetative types in New Mexico. Ample precipitation maintains well-watered soils for most of the long growing season when temperatures are favorable for tree growth.

Fire and logging are the primary disturbances within the mixed-conifer woodland. Natural fires historically occurred about every 10 years up until the late 1800s when fire suppression policies were implemented (Mac *et al.* 1998). Dick-Peddie (1993) speculated that erratic fire behavior created a patchy mosaic of stands in various successional stages. These fires might flare up into crown fires in some areas and miss other areas completely. Aspen is often present at sites where high intensity fires have occurred and subsequent open meadow succession processes seem to take one of two paths. Observations in the Pecos Wilderness indicate meadow replacement by aspen suckering while in areas of the Valle Vidal and Cruces Basin former aspen stands have died out and been replaced by montane and sub-alpine grasses. The elimination of fire in southwestern mixed-conifer forests has caused a major change in species composition and structure in the past century (Samson *et al.* 1994).

Historically, lower elevation mixed-conifer forests in the Southwest with more open stand structures had ponderosa pine as a co-dominant species. However, dense sapling understories developed in the mixed-conifer forest as a result of fire suppression and subsequent tree regeneration by the more fire-sensitive Douglas-fir and white-fir species. Forest stand inventory data from Arizona and New Mexico show an 81% increase in the area of mixed-conifer forests between 1962 and 1986, which is explained by this trend toward more fire-sensitive tree species (US Forest Service 1993). Fire suppression has also contributed to reduced aspen stands and the habitat they provide for a variety of wildlife species. Logging in mixed-conifer habitats has created extensive road networks, furthered habitat fragmentation, and replaced fire as a determinant of stand succession.

Improper grazing practices (those that reduce the ability of the land to sustain long-term plant and animal production) in mixed-conifer habitats have created competition with wildlife for water, forage, and space. These practices have altered vegetation composition and structure, increased siltation, affected stream hydrology and water quality, and reduced soil permeability and soil compaction.

Problems Affecting Habitats or Species

Analyses based on the scientific literature and NMDGF staff opinion indicates that the associated effects of climate change, drought, man-caused changes to natural fire regimes, and insect attacks are the factors most adversely affecting Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats in the Southern Rocky Mountain Ecoregion. High biological productivity within Rocky Mountain montane mixed-conifer forests explains why extractive resource uses, such as logging and grazing, have been an important economic consideration in this habitat type. Sustained or increased intensities of these activities may reduce biodiversity and productivity (Dick-Peddie 1993).

The synergistic effects of factors that influence habitats make it difficult, and perhaps impossible, to separate out individual causal factors that influence habitats or the SGCN. Multiple factors are closely linked in cause and effect relationships across spatial and temporal scales. Adverse consequences from multiple ecosystem stressors can have cumulative effects that are more than additive effects. One or more stressors may predispose biotic organisms to additional stressors (Paine *et al.* 1998). A greater discussion of the synergistic effects is provided in Statewide Assessment and Strategies (Chapter 4).

Climatic Change and Drought

The effects of climatic change on the Rocky Mountain Montane Mixed-Conifer Forest and Woodland are difficult to predict, largely due to the complexity of interactive relationships between global, regional and local biotic and abiotic factors (Weltsin and McPherson 1995). However, the effects of climatic change on habitat types in New Mexico are significant and are presented in detail in Chapter 4.

Drought (an extended period of abnormally dry weather) is considered to be one of the most significant factors affecting Rocky Mountain Montane Mixed-Conifer Forest and Woodland because it alters landscape and atmospheric conditions and leads to habitat conversion. Drought can limit seedling establishment and forest productivity by altering soil moisture gradients (Osmond *et al*. 1987, Schulze *et al*. 1987). Further, drought alters fire frequency, intensity, and timing in forest habitats by changing the amount and accumulation of fine fuels (Clark 1990, Haworth and McPherson 1994).

Fire Suppression

The disruption of natural fire cycles caused by fire suppression can significantly alter Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats in New Mexico (see Chapter 4). Mac *et al.* (1998) estimated the mean fire occurrence interval in the montane mixed-conifer forest at about every 10 years up until the late 1800s when fire suppression policies were implemented. Prior to that time, frequent, naturally occurring, low-intensity ground fires helped maintain stands of older trees with open, park-like structure within ponderosa pine and lower Rocky Mountain Montane Mixed-Conifer Forest and Woodland (Moir and Dieterich 1988). Within higher elevation mixed-conifer and spruce-fir forests, wildfires were less frequent and of the generally higher-intensity, stand-replacing type. An historic and relevant example is the Aspen Basin fire of 1891, above Santa Fe in the Santa Fe National Forest, which created thousands of acres of aspen that still exist (Dick-Peddie 1993).

Insects and Disease
Native insects and diseases are an integral part of forest ecosystems. They help recycle forests by decomposing trees and thereby releasing nutrients necessary for forest growth. However, insect and disease outbreaks can seriously impede conifer regeneration and affect resources valued by society, such as aesthetics, recreation, water, and wildlife (see Chapter 4 for more details).

Many different species of bark beetles affect southwestern mixed-conifer forests. Most bark beetle species are relatively host-specific, limiting their activities to primarily one tree species. Some of the more important species for mixed-conifer forests that attack ponderosa pine trees in New Mexico include the mountain pine beetle (*Dendroctomus ponderosae*), western pine beetle (*D. brevicomis*), roundheaded pine beetle (*D. adjunctus*), and pine engraver (*Ips pini*). The Douglas fir beetle (*D. pseudotsugae*), and the fir engraver (*Scolytus ventralis*) prefer white fir, while the spruce beetle (*Dendroctomus rufipennis*) attacks Engelmann spruce (*Picea englemannii*) (Wilson and Tkaz 1994). The direct effects of bark beetle infestation on trees include tree mortality and top-killing (Stark 1982). The US Forest Service, in 2003, mapped conifer mortality attributed to bark beetles on about 2,700,000 ac (1,092,653 ha) in Region 3 alone (US Forest Service 2004).

White fir and Douglas fir are also the preferred host species for western spruce budworms (*Choristoneura occidentalis*). When fire is suppressed, the density of these tree species increases and they are more susceptible to intense and synchronous outbreaks of spruce budworm. Between the 1920s and 1993 there were five major outbreaks of western spruce budworm in New Mexico. The most recent outbreak covered approximately 700,000 ac (283,280 ha) at its peak (Fellin *et al.* 1990).

Aspen is subject to fungus including white tree rot (*Phellinus* spp.), sooty-bark cankers (*Encoelia pruinosa*), and several root rots. Sooty-bark canker is the most lethal canker on aspen in the West and tends to occur on the larger trees (Johnson *et al.* 1995). A study conducted in Colorado and New Mexico indicated that trunk cankers (developed from infected logging injuries) were the major cause of aspen death (Johnson *et al.* 1995). Approximately 20% of residual trees in partially cut stands died five years after the stand was harvested. Two years later, 40% of the remaining residual trees were infected with various cankers, indicating that tree mortality would increase. Insects that attack aspen include tortrix (*Choristoneura conflictana*) and western tent caterpillar (*Malacosoma californicum*).

Several SGCN of the Rocky Mountain Montane Mixed-Conifer Forest and Woodland are likely to benefit from the occurrence of native insects and diseases or their effects on the habitat. These include: Williamson's sapsucker (*Sphyrapicus thyroideus*), olive-sided flycatcher (*Contopus cooperi*), yellow warbler (*Dendroica petechia*), red-faced warbler (*Cardellina rubrifrons*), Grace's warblers (*Dendroica graciae*), Mexican spotted owl (*Strix occidentalis lucida*), Jemez Mountains salamander, black bear (*Ursus americanus amblyceps*), and Allen's big-eared bat (*Idionycteris phyllotis*).

Extractive Resource Uses
The high productivity of the montane mixed-conifer forest creates a place where extractive resource use, such as grazing and logging, is relatively common. Further, this habitat type is open for increased oil and gas exploration. Sustained uses for these activities may reduce biodiversity and productivity.

Livestock grazing has economic and cultural values that are important to individuals, communities, and to the state. Improper grazing practices are considered practices that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), and include domestic livestock and wildlife. Improper grazing practices have influenced vegetation communities and fish and wildlife habitat in New Mexico for more than a century (See Chapter 4 for greater details). Improper grazing has reduced vegetative cover, increased soil erosion, and aggravated local flooding (Felger and Wilson 1995). Impacts of improper grazing practices in Rocky Mountain Montane Mixed-Conifer Forests and Woodlands include: 1) competition with wildlife for water, forage, and space; 2) degradation of forage and cover by the altering of vegetative composition and structure; 3) alteration of stream hydrology and water quality; 4) increased siltation; 5) and reduced soil permeability and the potential to support plants due to soil compaction. Further, excessive domestic livestock and native ungulate browsing may damage aspen suckers and weaken aspen clones, in turn making trees more susceptible to invasion from disease and insects.

Logging has been one of the primary disturbance factors in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands in the Southwest. Conifer forest and woodlands in New Mexico now generally occur in early and middle successional stages. Stand succession that would have occurred due to fires has been replaced through the silvicultural practices of logging. However, the patchy mosaic that erratic fire behavior would create is usually not successfully duplicated through logging. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993). Logging has created extensive road networks furthering habitat fragmentation in the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and other New Mexico forests.

Fuel-wood collection is not recognized as a factor significantly affecting the mixed-conifer habitat type. However, woodcutters sometimes remove standing snags and downed logs that are important for wildlife habitat and ecosystem function. Roads developed for fuel-wood collection fragment habitat and may function as artificial firebreaks. The Carson National Forest had approximately 3,587 mi (5,772 km) of open road and the Santa Fe National Forest had approximately 3,750 mi (6,035 km) of existing road in the late 1980s.

Currently, the amount of oil and gas exploration that occurs in this habitat type in the Southern Rocky Mountain Ecoregion is limited to coal-bed methane drilling on the Vermejo Park Ranch. Coal-bed methane exploration is under consideration for the US Forest Service Valle Vidal Unit located adjacent to Vermejo Park. There are a variety of impacts that could be associated with coal bed methane exploration on the Valle Vidal, including increased mileage of roads, increased disturbance, and potential impacts to water quality, big game, and other wildlife habitat. Similar impacts to the adjacent privately owned Vermejo Park have been mitigated through costly methods. Mitigation on the Valle Vidal may not be cost effective and therefore not be employed.

Recreational Use
Current recreational uses of the mixed-conifer habitat type include skiing, hiking, mountain biking, snowmobiling, off-road vehicles, rock climbing, and camping. The overall effect of these activities is not fully understood, nor is there a full comprehension of how much recreational use can be tolerated before wildlife or wildlife habitats are adversely affected. Commercial ski areas are usually located within this habitat type and clearly result in habitat conversion.

Non-Native Species
As of 1998, non-native or invasive species have been implicated in the decline of 42% of species federally listed under the Endangered Species Act (Center for Wildlife Law 1999). Once established, non-native species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). The occurrence or rate of spread of non-native or invasive species within Rocky Mountain Montane Mixed-Conifer Forest and Woodland is unknown.

Information Gaps

Information gaps are outlined below that impair our ability to make informed conservation decisions regarding mixed-conifer forest and woodland habitats and SGCN.

- Abundance, distribution, and trend information is absent or sparse for many SGCN. There is no central clearinghouse for biological information and no one agency has ready access to all available information. In addition, the requirements for area-sensitive species have not been clearly defined.

- While many aspects of fire are understood, the role that natural fire plays, particularly differing intensities of fire within the entire ecosystem is not well understood. Site-specific fire histories and methods to initiate more natural fire regimes within the Rocky Mountain Montane Conifer Forest and Woodland are unknown.

- There is little known about aspen succession (Dick-Peddie 1993). In aspen stands that have predominantly changed to conifers, information is lacking on how many aspen should remain in order to provide adequate regeneration after a fire removes conifers. The occurrence of aspen succession resulting in montane and sub-alpine grasslands is not well understood.

- The location, timing, duration, frequency, and intensity of all the factors influencing Rocky Mountain Montane Conifer Forest and Woodland and associated SGCN are unknown. For example, information on the location, timing, intensity, and duration of prescribed fire and fuel reduction/logging activities is needed for conservation of SGCN, such as the Jemez Mountain salamander. Further, there is a long history of grazing by domestic livestock and native ungulates in this habitat type. Perceived effects include subsequent soil erosion and altered fire cycles. However, there is little understanding of the mechanisms by which these effects occur.

- The intensity, scale, extent, and causes of forest fragmentation in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and the effects of forest fragmentation on associated SGCN have not been determined.

- Community structure and many life history attributes of SGCN that use Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are unknown.

- Environmental conditions that limit populations of SGCN associated with Rocky Mountain Montane Mixed-Conifer Forests and Woodlands are unknown.

- The intensity, scale, extent, and causes of human-caused habitat fragmentation are unknown in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

- Information on requirements of area-sensitive species is needed, including the location of key migration corridors, degree of habitat fragmentation, and spatial locations of fragmented areas.

- It is not clear how the Healthy Forest Initiative and Healthy Forest Restoration Act will affect SGCN including Northern goshawks (*Accipiter gentilis*), Mexican spotted owls, Jemez Mountain salamanders, and American martens that rely on old growth, mixed-conifer forests.

- It is unknown the extent to which invasive species alter disturbance regimes and population viability of SGCN within Rocky Mountain Montane Mixed-Conifer Forests and Woodlands.

Research, Survey, and Monitoring Needs

Ruggiero (1991) defined how species and their habitats should be viewed when considering research needs: "Because requirements can change over time, the focus of research should not only be on the features of the environment that are required for a population to exist, under a given set of conditions, but also on the requirements necessary for the population to persist over time under varying environmental conditions. The profound difference between existence and persistence must be clearly recognized." Current research, survey, and monitoring needs that would inform conservation decisions are outlined below.

- Abundance, distribution, and trend information needs to be determined for many SGCN. The requirements for area-sensitive species need to be determined.

- Research is needed to assess the attributes of Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats that are required for the persistence of associated SGCN so that viable populations may persist.

- Basic research is needed to enhance currently incomplete information of SGCN vertebrate and invertebrate community structures, natural history, and ecological relationships in Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats.

- Determine how SGCN of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands respond to prescribed livestock grazing practices, fuel wood harvesting, increased recreational use, exotic species invasions and increased human population growth (DeBano and Ffolliott 1995).

- Determine the necessary habitat size and forest age-class structure needed to support SGCN of the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands that migrate vertically during daily and seasonal movements to fulfill their ecological needs for food, shelter, water and space.

- Environmental conditions that limit populations of SGCN within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands need to be determined.

- Much work is needed to understand the relationships between climate change, drought, fire and fire suppression activities, phytophagous insect attacks, and habitat fragmentation resulting from roads and increased human developments.

- Determine how global and regional climate change will affect vegetation and community and ecosystem-level dynamics in mixed-conifer forests and woodlands.

- Mountain Montane Mixed-Conifer Forests and Woodlands are disturbance forests with predominant seral communities (Dick-Peddie 1993). To adequately restore fire as a management tool, there must be a clear understanding of historic fire regimes at regional- to site-specific scales.

- There is a continuing need to increase our understanding of the effects of post-fire treatments within the context of ecological and societal goals for forested public lands of the western US (Beschta *et al.* 2004).

- Research is needed to evaluate the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires in the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

- Work is needed to determine the effects of natural and prescribed fire on the structure of vegetative communities in the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and the subsequent effects upon vertebrate and invertebrate populations.

- Research is needed regarding the ecological effects of logging as compared with fire in the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands. The natural processes associated with fire are not fully understood and it is not clear what effects may result from replacing fire with logging (Dick-Peddie 1993).

- Research is needed to explore the best methods of mimicking natural disturbance regimes within the historic natural range of variability. Ecological forestry assumes that native species evolved under natural conditions and management within this natural range of variability should ensure that these species persist (Seymour and Hunter 1999).

- Research is needed to determine how SGCN respond short-term and long-term to phytophagous insect outbreaks in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and the potential habitat fragmentation caused by these attacks at the community, species, population and individual levels.

- Studies are needed to identify wildlife travel corridors that connect the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to different mountain ranges of the Southern Rocky Mountain Ecoregion. The information needed for understanding and managing for habitat connectivity includes population-level information of dispersal behavior, daily and seasonal movements of SGCN through this habitat type, how different types of habitat fragmentation affect movements, and how climate change may ultimately affect species distributions.

- Research is needed to determine the intensity, scale, extent, and causes of forest fragmentation in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and how SGCN respond to habitat fragmentation at the community, species, population and individual levels.

- The species-specific effects of natural and human-caused habitat fragmentation on SGCN within the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands need to be determined.

- Research is needed to assess the impacts of prescribed livestock grazing on the structure of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

- Research is needed to determine how grazing timing, intensity, and duration affect SGCN life history attributes in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

- Determine how prescribed grazing ultimately affects natural disturbance regimes (McPherson 1992) in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

- Research is needed to better understand aspen succession in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and the effects of prescribed grazing by domestic sheep, cattle, and native ungulates.

- Determine the areal extent, age class, structural characteristics, and regeneration rates of the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands so as to provide predictive power and inform an ecosystem management approach.

- The extent to which invasive species may alter disturbance regimes and population viability of SGCN within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands needs to be determined.

- There is a need for additional investigations of hydrologic relationships in the mixed-conifer forest and woodlands that will provide a better understanding of infiltration, interception, and transpiration processes, and how disturbances such as drought and fire affect these processes. This information is necessary for determining effective and sustainable conservation practices (Ffolliott *et al*. 1993).

Desired Future Outcomes

Desired future outcomes for the Rocky Mountain Montane Mixed-Conifer Forest and Woodland include:

- Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of SGCN and host a variety of land uses with reduced resource use conflicts.

- Partnerships have been established among state and federal government agencies, non-governmental organizations and private landowners for the implementation of collaborative and coordinated initiatives to conserve SGCN and the functionality of the Rocky Mountain Montane Mixed-Conifer Forest and Woodland habitats upon which they depend.

- Long-term conservation strategies to restore native species to viable populations within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands garner wide public support.

- Stand-replacing wildfires have become less common in the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands and no longer alter existing habitats beyond the range of natural variability under which SGCN evolved.

- Post-fire management activities that are detrimental to SGCN and/or ecosystem function and recovery are no longer practiced in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

- Prescriptions have been developed for the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands that allow adequate and sustainable levels of human harvest of fuel wood and other wood products, are compatible with the tenets of ecological forestry, and replicate natural disturbance patterns.

- Decisions to implement control measures for phytophagous insect outbreaks in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands are informed and balanced by considerations of the role of these events in maintaining forest health and ecosystem function (Schowalter 1994).

- Consistent development standards that ensure future habitat integrity and functionality for the wildland urban interface of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands are jointly established and adopted by private landowners, counties, municipalities, federal land management agencies and the State Land Office.

- Local zoning regulations are in place to help reduce wildfire threats to private residences at the wildland urban interface in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and funds that are currently directed toward these threats have been redirected to re-establishing naturally functioning ecosystems in forest interiors.

- Major migration/movement corridors of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands are intact and maintain connectivity and availability of SGCN habitats.

- Oil and gas extraction activities have not compromised the condition, connectivity, and quantity of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands on the Valle Vidal or the capacity of this property to sustain viable and resilient populations of SGCN.

- Livestock and large ungulate grazing levels are maintained at levels that sustain the full range of ecosystem functions and persistence of SGCN.

- Aspen stands within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands are maintained at a sufficient level to sustain obligate SGCN and associated plant and wildlife species.

- Special habitats within the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams are protected and are being monitored on a long-term basis to ensure conservation for SGCN that rely on these habitats.

- Scientific ecosystem management has been established and implemented in the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and is evidenced in forest management plans.

- Colonization by exotic species in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands is stopped and existing populations of exotic species are controlled or eliminated.

- Activities implemented in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands under the Healthy Forest Initiative and Healthy Forest Restoration Act are focused on removing ladder fuels and smaller diameter thickets and protecting human structures and neighborhoods in the wildland urban interface and avoid unnecessary removal of large old-growth trees and snags important as wildlife habitat.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies and private landowners in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to develop a fire management regime that promotes restoration of vegetative communities more nearly approximating those that historically supported SGCN. Approaches might include encouraging the US Forest Service to supplement lightning-caused fires with prescribed burning.

2. Collaborate with state and federal agencies, the New Mexico Legislature, NGOs, and private landowners to conserve riparian and other important wildlife habitat corridors linking Rocky Mountain Montane Mixed-Conifer Forest and Woodlands within and between other ecoregions. Approaches might include conservation easements and/or fee-simple purchases from willing sellers.

3. Collaborate with state and federal agencies and private landowners to reduce habitat fragmentation within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands. Approaches might include closure of unnecessary interior and adjacent roads and minimizing new road building on associated national forests.

4. Work with the US Forest Service to promote compliance with the tenets of ecological forestry for any land management activities conducted within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Rocky Mountain Montane Mixed-Conifer Forests and Woodlands outlined in the Research, Survey, and Monitoring Needs section above.

6. Work with the US Forest Service and affected publics to develop strategies for the sustainable harvest of wood products in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands that will retain old-growth trees and large diameter snags needed by SGCN and the communities that support them.

7. Encourage thinning and fuel-reducing initiatives in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands where necessary to open dense stands that have become susceptible to insects, diseases, or stand-replacing wildfires that may alter conditions to which SGCN are adapted.

8. Work with the US Forest Service to ensure that fuel reduction treatments in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands are focused on removing smaller diameter ladder fuels and dog-hair thickets and protecting human structures and neighborhoods in the wildland urban interface and that these interventions avoid unnecessary removal of large old-growth trees and snags important as wildlife habitat.

9. Encourage government and private land managers to protect and restore watersheds, wetlands, and wet meadows of the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands through management practices that maintain native biodiversity and reduce erosion, gully formation, and soil loss.

10. Work with the US Forest Service and affected livestock and hunting interests to ensure that livestock and large ungulate grazing occur at levels compatible with sustaining viable populations of SGCN.

11. Monitor the introduction and spread of exotic plants and animals into Rocky Mountain Montane Mixed-Conifer Forest and Woodlands and encourage control or eradication where necessary to maintain or restore native biodiversity.

12. Work with the US Forest Service in conducting prescribed burning in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to protect breeding birds, avoid riparian areas, and otherwise conserve SGCN.

13. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

14. Collaborate with US Forest Service to designate areas for off-road vehicle use that avoid disturbance to SGCN or their habitats and to discover ways to mitigate such disturbance where it currently occurs.

15. Work in partnership with private landowners, counties, municipalities, federal land management agencies and the State Land Office to mitigate and reduce impacts related to urbanization of Rocky Mountain Montane Mixed-Conifer Forest and Woodlands habitats. Approaches might include establishment of development standards that ensure continued habitat integrity and functionality.

16. Work with counties and municipalities in Rocky Mountain Montane Mixed-Conifer Forest and Woodlands to create local zoning regulations that help reduce wildfire threats to private residences in areas of wildland urban interface and to direct financial resources to re-establishing naturally functioning ecosystems in forest interiors.

17. Work with the US Forest Service and oil and gas companies to minimize oil and gas development and associated effects in the Rocky Mountain Montane Mixed-Conifer Forest and Woodland, especially the Valle Vidal.

18. Encourage the US Forest Service to conserve the biological diversity of the Rocky Mountain Montane Mixed-Conifer Forest and Woodland through development and implementation of an ecosystem management approach.

19. Work with the US Forest Service to employ prescribed burns and let-burn policies that will promote return of aspen groves to their historic distributions and abundances within the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

20. Collaborate with state and federal agencies to minimize installation of developed recreation sites in aspen stands so as to reduce exposure of aspens to injury and fungal infections.

21. Develop projects and partnerships to assess SGCN distribution, abundance, population trends, basic life history attributes, population biology, community ecology, and responses to anthropogenic and natural habitat disturbances within Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

22. Partner with US Forest Service, NGOs, and private landowners to identify, protect, and monitor special SGCN habitats such as cienegas, limestone outcrops, talus slopes, caves, and perennial streams within the Rocky Mountain Montane Mixed-Conifer Forest and Woodlands.

23. Create public awareness and understanding of ecosystem function, values, and products and the scope and scale of human impacts on the condition of Rocky Mountain Montane Mixed-Conifer Forest and Woodland important to SGCN.

24. Collaborate with land management agencies, conservation organizations, and educational groups to inform the public about the potential adverse effects of continued climate change on SGCN and their habitats.

25. Work with the US Forest Service and NM State Forestry Division to inform land managers and affected publics of the ecology of phytophagous insects and their role in sustaining ecosystem function.

26. Work with the US Forest Service, NM State Forestry Division, and private landowners to prevent conducting post-fire management activities that are detrimental to SGCN and/or ecosystem function.

SOUTHERN SHORTGRASS PRAIRIE ECOREGION

Approximately 22.2 million ac (9 million ha) or approximately 33% of the Southern Shortgrass Prairie Ecoregion occurs in New Mexico, where it is characterized by high plains plateaus broken by escarpments (TNC 2005). The shortgrass prairie was historically dominated by expanses of blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Within this ecoregion, two key terrestrial habitat types have been identified: The Western Great Plains Sandhill Sagebrush Shrubland, and the Western Great Plains Shortgrass Prairie (Fig. 5-6). The Western Great Plains Sandhill Sagebrush Shrubland hosts a variety of native wildlife. The lesser prairie-chicken (*Tympanuchus pallidicinctus*) and sand dune lizard (*Sceloporus arenicolus*) in particular have received much attention in this habitat type. Conservation efforts directed at the lesser prairie-chicken are excellent examples of collaborative efforts between federal, state and private land managers and environmental organizations.

The Western Great Plains Shortgrass Prairie links grasslands from Canada to Mexico and is an important system to grassland-associated species. Grassland bird populations have been declining across the North American continent for over the last 50 years (Knopf 1994, Peterjohn and Sauer 1999, Vickery and Herkert 2001) and populations of keystone species in this habitat type have been eliminated or considerably reduced.

Species of Greatest Conservation Need

The Southern Shortgrass Prairie Ecoregion is home to 30 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans (Table 5-8). Twenty-nine SGCN associated with this ecoregion occur in the Western Great Plains Shortgrass Prairie. Only 15 SGCN occur in the Western Great Plains Sandhill Sagebrush Shrubland. Of the 30 SGCN, 13 (43%) are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Approximately 10 (33%) species are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 7 species (23%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Additional conservation concerns for taxa associated with this ecoregion are addressed in 1) Statewide Distributed Ephemeral Habitats and Perennial Tanks, 2) Statewide Distributed Riparian Habitats, or 3) Watersheds with aquatic key habitats sections.

Conservation efforts directed at the lesser prairie-chicken are excellent examples of collaborative efforts between federal, state and private land managers and environmental organizations.

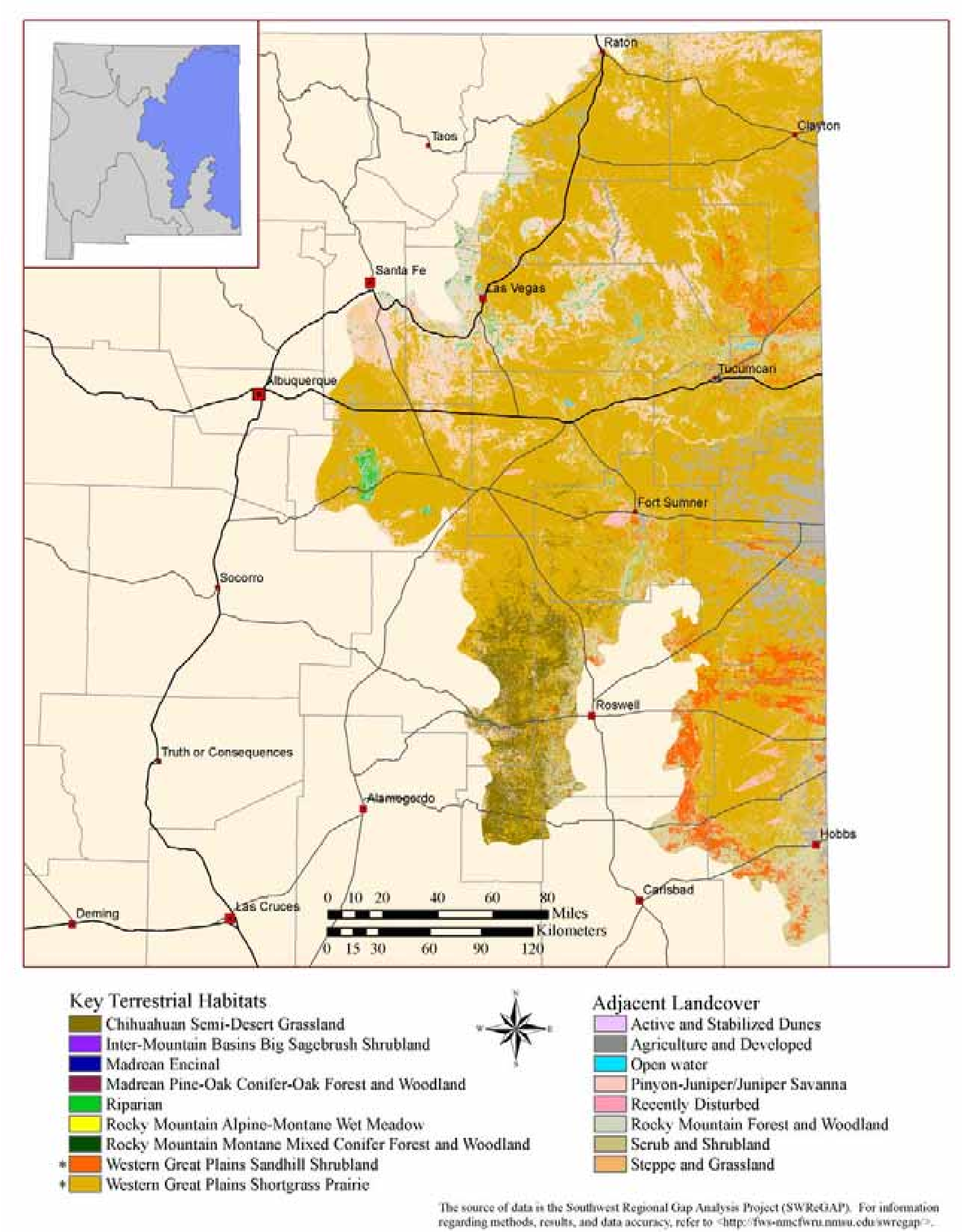


Figure 5-6. Key terrestrial habitats in the Southern Shortgrass Prairie Ecoregion in New Mexico. Adjacent land cover types are given to provide an indication of vegetation surrounding key habitats. Key habitats are designated with an asterisk (*).

Table 5-8. Species of Greatest Conservation Need in the Southern Shortgrass Prairie Ecoregion in New Mexico.

Common Name	Western Great Plains Sandhill Sagebrush Shrubland	Western Great Plains Shortgrass Prairie
Birds		
Bald Eagle		X
Golden Eagle		X
Scaled Quail		X
Sandhill Crane		X
Mountain Plover		X
Long-Billed Curlew		X
Wilson's Phalarope		X
Sprague's Pipit		X
Baird's Sparrow		X
Grasshopper Sparrow		X
Ferruginous Hawk	X	X
Lesser Prairie-Chicken	X	X
Mourning Dove	X	X
Burrowing Owl	X	X
Loggerhead Shrike	X	X
Mammals		
Least Shrew		X
Arizona Myotis Bat		X
Prairie Vole		X
Black-Tailed Prairie Dog	X	X
Swift Fox	X	X
Mule Deer	X	X
Amphibians		
Western Chorus Frog		X
Plains Leopard Frog		X
Tiger Salamander	X	X
Reptiles		
Ornate Box Turtle	X	X
Collared Lizard	X	X
Sand Dune Lizard	X	
Milk Snake	X	X
Western Diamondback Rattlesnake	X	X
Desert Massasauga	X	X

Western Great Plains Sandhill Sagebrush Shrublands

Habitat Condition

The Western Great Plains Sandhill Sagebrush Shrublands are a mosaic of hummock and coppice dunes dominated by sand sage (*Artemisia filifolia*) and/or shinnery-oak (*Quercus havardii*) with a mixed-grass composition. Grasses consist largely of little bluestem (*Schizachyrium nees*), sand bluestem (*Andropogon hallii*), sand dropseed, and needle and threadgrass (*Stipa comata*). Soils in this habitat type are typically deep and well drained. They extend to a depth of 60 in (1.5 m) or more and have surface textures consisting of fine aeolian sands or loamy aeolian sands. Their water holding capacity is low and they are highly erodible. They become unstable dunes when organic residues and vegetative cover are removed (Natural Resource Conservation Service 1997; Ecological Site Description, Sandhills). Soils in the dune areas are also sharply drained sands and at the southwestern and southern boundaries of the type, the soils grade to a shallower calcic hardpan overlaid by shallow sand. These shallow soil sites are dominated by buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*) and threeleaf sumac (*Rhus trilobata*) or littleleaf sumac (*Rhus microphylla*).

The Western Great Plains Sandhill Sagebrush Shrublands habitat is considered climax vegetation (Rosiere 2000); although there is anecdotal evidence suggesting that the dense stands of shinnery-oak and sand sage on the high plains of eastern New Mexico are a result of intense grazing pressure. Continuous year-round and season-long summer grazing (April through October) have reduced the once dominant cool season grasses such as New Mexico feathergrass (*Stipa neomexicana*), needle and thread grass, and Indian ricegrass. Large portions of this habitat type are now dominated by sand dropseed, sand sage, yucca (*Yucca elata*), and threeawn species (*Aristida* spp.) that have lower cover and productivity values (Natural Resource Conservation Service 1997, Ecological Site Description, Sandhills).

Season-long summer use by livestock has also reduced the amount of forbs and warm season grasses found in this habitat type and their contribution to the production of organic litter on the soil surface. The vulnerability of the sand dunes to wind erosion and blowouts has subsequently increased. Shrub components of this type remain important in terms of nutrient cycling and ecosystem function where sagebrush, shinnery-oak, and subdominant shrubs trap and accumulate particulates and nutrients around their bases forming “islands of fertility” (Schlesinger and Pilmanis 1998). This continuing accretion of organic matter and nutrients is especially important to insects and ultimately to the rodents, herpetofauna, and birds that consume them (Whitford *et al*. 1998).

Problems Affecting Habitats or Species

Analyses based on the scientific literature and NMDGF staff opinion suggests that abiotic resource use, habitat conversion, and consumptive biological use are the primary factors affecting Western Great Plains Sandhill Sagebrush Shrublands. The Nature Conservancy (2004) noted that fire and grazing practices constitute processes that most affect this system. Oil and gas development are also agents of change within this land cover type.

Since the early 1950s, southerly portions of this habitat have been altered by agricultural conversion and practices, oil and gas development, improper livestock grazing practices, and brush and chemical weed control activities (Jackson and DeArment 1963, Hunt and Best 2004). Habitats of the lesser prairie-chicken and sand dune lizard have subsequently diminished in extent and become increasingly fragmented.

Agriculture and Livestock Production
Improper grazing practices and increased agricultural production in the Western Great Plains Sandhill Sagebrush Shrublands may lead to habitat fragmentation and loss by promoting conditions favorable for shrub encroachment and through increased infrastructure development (roads, fences, subdivisions, agricultural lands) (Dinerstein *et al.* 2000). The effects of these land management activities are compounded by extended drought periods and altered hydrological functions. Altered fire regimes, resulting from both fire suppression and the removal of fine fuels by domestic grazers and wildlife, also promote the establishment of both woody vegetation and introduced non-native species.

Energy Development and Exploration
Oil and gas exploration and extraction activities typically have localized effects on sand dune lizard populations. Sias and Snell (1998) reported an inverse relationship between well density and abundance of sand dune lizards. Oil and gas development activities reduced populations approximately 40% when compared to control areas that were approximately 200 m distant from a well pad (Sias and Snell 1996). In addition to lowering population numbers, oil and gas development activities may cause further habitat fragmentation and loss through associated clearing, roads, and increased vehicular traffic (Dinerstein *et al.* 2000).

Invasive and Non-Native Species
Soil Bank programs of the 1950s and 1960s introduced non-native weeping and Lehmann lovegrasses (*Eragrostis curvula*, and *E. lehmanniana*) to the Western Great Plains Sandhill Sagebrush Shrublands to stabilize topsoil. In the mid-1980s, the Conservation Reserve Program (CRP) was initiated to reduce the number of cultivated grain fields. At this time, lovegrasses were again planted. Older established plantings of weeping lovegrass are particularly persistent if grazed or burned. In some instances, range fires in these established grass stands have become more frequent, further reinforcing the persistence of this fire-adapted non-native grass. Displacement of native vegetation by non-native grasses has reduced the value of this habitat to SGCN.

Chemical Shrub Control
Shinnery oak is a management concern when it grows in dense stands, particularly where it comprises 80% of the annual plant production and competes with native grasses and forbs for water and nutrients (Pettit 1986). Shrub control in the 1980s made use of the herbicide tebuthiuron and nearly 40,500 hectares (100,000 acres) of BLM lands in southeastern New Mexico were treated to reduce shinnery oak and to increase grass production for livestock grazing (Massey 2001).

The effects of tebuthiuron upon lesser prairie-chicken populations are uncertain. Lesser prairie-chickens may use stands of dense shinnery oak. However, they prefer areas dominated by perennial mid and tall-grass species (Cannon and Knopf 1981). While Johnson (2000) found a greater concentration of lesser prairie-chickens nesting in areas that were not treated with herbicide, Olawsky and Smith (1991) reported similar densities of lesser prairie-chicken on herbicide treated and untreated areas.

The sand dune lizard appears to be confined to areas of active sand dunes vegetated by shinnery oak and to the uneven sandy terrain and wind-eroded blowouts of their peripheries (Degenhardt and Jones 1972, Degenhardt and Sena 1976, Sena 1985, Snell *et al*. 1994, NMDGF 1996). Reductions of 70 to 94% in the presence of sand dune lizards were observed in the Mescalero Sands of Chaves County where tebuthiuron was used to control shinnery oak. Some treated sites contained no lizards despite the presence of suitable populations in adjacent untreated pastures. Snell *et al*. (1993, 1994) and Gorum *et al*. (1995) noted that populations have declined since the initiation of tebuthiuron treatments and that following treatment, sand dune lizard habitat can be considered either lost or greatly reduced in quality.

The persistence of herbicide and other environmental contaminants and their effects on fish and wildlife have been reviewed by Schmitt and Bunck (1995) and Glaser (1995). However, the magnitude and effects of herbicide use in the Western Great Plains Sandhill Sagebrush Shrublands has not been well assessed (Mac *et al*. 1998).

Off-Road Vehicles
The frequency and intensity of recreational off-road vehicle use has increased in the Western Great Plains Sandhill Sagebrush Shrublands, but to an unknown extent. While the impacts on the sand sagebrush shrublands are poorly understood, off-road vehicle use may destroy and fragment habitat, cause direct mortality of wildlife, or alter wildlife behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Information Gaps

There is little literature on the ecology of the Western Great Plains Sandhill Sagebrush Shrublands. Current literature is primarily based on habitat needs for lesser prairie-chickens and sand dune lizards. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The intensity, scale, extent, and causes of Western Great Plains Sandhill Sagebrush Shrublands fragmentation and knowledge of lands that may present opportunities for mitigation are unknown.

- Little is known on prescribed grazing management practices that maintain appropriate levels and compositions of native grasses in this habitat type.

- The response of SGCN to human disturbance is poorly understood.

- Little is known on the distribution, abundance, and population trend for several of the SGCN associated with Western Great Plains Sandhill Sagebrush Shrublands.

- Specific knowledge is needed regarding factors affecting SGCN, especially the environmental conditions or thresholds limiting populations.

- Consistent habitat health (ecological sustainability and integrity) and condition descriptions and protocols are needed to inform land management decisions for the Western Great Plains Sandhill Sagebrush Shrublands is lacking.

- The extent to which invasive and non-native species alter Western Great Plains Sandhill Sagebrush Shrublands and limit populations of SGCN is unknown.

- Short and long-term affects of land management practices or uses (such as energy exploration and development, grazing systems, invasive species and vegetation management) are unclear. Availability and distribution of this information would allow land managers to make more informed conservation decisions.

- The extent to which off-road vehicle use is impacting Western Great Plains Sandhill Sagebrush Shrublands SGCN populations is unknown.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs for the Western Great Plains Sandhill Sagebrush Shrublands are primarily derived from our perception of factors that influence the integrity of this habitat type and associated information gaps. Research, survey, and monitoring needs that enhance our ability to make informed conservation decisions are outlined below.

- Investigate the extent to which land use activities (such as livestock grazing timing, intensity, and duration, human development, gas, oil, and water exploration, off-road vehicle use, and non-native species invasions) fragment and alter habitats in relation to patch size, edge effect, and use by SGCN. The desired product understands how land use intensity and frequency of disturbance affect SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships in the Western Great Plains Sandhill Sagebrush Shrublands. Life history and habitat needs of most of the SGCN and their use of this habitat type are poorly understood.

- Examine how global and regional climate change coupled with resource uses affect community and ecosystem-level dynamics in the Western Great Plains Sandhill Sagebrush Shrublands.

- Investigate the use of tebuthiuron for reducing shinnery oak cover and investigate SGCN response to spatially diverse applications of herbicides.

- Identify thresholds of shinnery oak and/or sand sage cover or density at which reproduction and brood success of lesser prairie-chickens and sand dune lizards are reduced or eliminated.

- Evaluate the effectiveness and utility of fire in controlling shrubs and restoring and maintaining shinnery oak habitats in Western Great Plains Sandhill Sagebrush Shrublands.

- Identify grazing management practices that maintain appropriate levels and compositions of native grasses within shinnery oak habitat types.

- Evaluate the influence of Conservation Reserve Program (CRP) activities on landscape structure and SGCN habitat.

- Evaluate the impacts of easements permitting unimpeded access to Lesser Prairie-Chicken Areas (PCAs).

- Determine the effects oil and gas development induced habitat fragmentation upon the population dynamics and persistence of SGCN.

- Identify nationally standardized indicators that could be used for inventory and monitoring the health of the Western Great Plains Sandhill Sagebrush Shrublands.

Desired Future Outcomes

Desired future outcomes for the Western Great Plains Sandhill Sagebrush Shrublands include:

- Western Great Plains Sandhill Sagebrush Shrublands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- Reclamation standards that ensure habitat integrity and function are established and implemented for land use practices that alter habitat condition.

- Partnerships are established with NRCS and landowners to restore CRP and abandoned croplands to functioning native shrub/grasslands.

- Land management plans for federal and state lands include sustainable grazing practices that are fully implemented and complied with.

- Natural fire cycles are restored in this habitat.

- Herbicide treatments employed to control shinnery oak result in structurally diverse habitats.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

2. Collaborate with federal and state agencies, and private landowners in restoration of the Western Great Plains Sandhill Sagebrush Shrublands. Restoration actions may include: mitigation and reduction of impacts related to oil and gas development; restoration and return of abandoned croplands to native shrub/grassland; managed sustainable grazing on public lands that accounts for SGCN habitat concerns; and active research programs on the use of tebuthiuron coupled with controlled burns for reducing shinnery oak cover.

3. Work with federal and state agencies, private landowners, and oil and gas development companies to rehabilitate abandoned well pads and access roads. Rehabilitation efforts may include the removal of caliche and/or reseeding with a mix of native species with supplemental watering.

4. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the Western Great Plains Sandhill Sagebrush Shrublands outlined in the Research, Survey, and Monitoring Needs section.

5. Work with federal, state, and private agencies and institutions to create financial incentives for habitat maintenance and improvement on private lands and conservation easements.

6. Work with willing landowners to increase the size and connectivity of designated prairie-chicken areas.

7. Work with federal, state, and private agencies, institutions and landowners to provide financial incentives to maintain tracts of native vegetation, as an alternative to converting land to agriculture or urban development.

8. Collaborate with federal and state agencies to designate areas for off-road vehicle activities in areas that avoid disturbance to SGCN or their habitats and to discover ways to mitigate such disturbance where it occurs.

9. Encourage Conservation Reserve Program land managers to promote use of native seed mixes for soil stabilization and increased value to SGCN.

10. Encourage land managers to establish and maintain a diverse mosaic of interspersed patches of shinnery oak and residual bunchgrasses.

11. Work with federal, state, and private agencies and institutions in developing an education and public awareness program that emphasizes the fragility of this habitat type and its importance to a wide array of species.

Western Great Plains Shortgrass Prairie

Habitat Condition

The majority of literature associated with the Western Great Plains Shortgrass Prairie describes the entire land cover type and is not specific to New Mexico. Thus, the information presented in this section should be considered within this broad context.

The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Kaufman *et al.* 1988). The combined impact of these factors created a wide-reaching mosaic environment that accommodated a rich diversity of plant and animal species (Collins and Barber 1985, Plumb and Dodd 1993). Several authors (Anderson 1982, Plumb and Dodd 1993, Rickets 1999) suggest that the dominant, sod-forming perennial grassland plants of this region evolved under intensive grazing by wild ungulates. As a result, woody vegetation was suppressed and grazing tolerant plants flourished. The disturbance created by foraging bison (*Bison bison*), pronghorn (*Antilocapra Americana*) and elk (*Cervus elaphus*) significantly affected vegetation, nutrient cycles, soil structure and composition and, as some areas were heavily grazed and others left untouched, created a diversity of habitat conditions across the prairie. It is estimated that prairie dogs occupied roughly 154,441 mi^2 (400,000 km^2), or 20% of the available shortgrass and midgrass prairies (Benedict 1996). Their presence altered vegetation, created open habitat, and modified soil, nutrient, and energy cycles. Their burrowing turned the soils and allowed annual forbs and grasses a foothold in the dominant perennial grassland. This action sustained prairie biodiversity. Wild bison have since been extirpated and prairie dogs significantly reduced as the prairie ecosystem has been converted, fragmented and otherwise altered (Benedict 1996) by human activities.

Despite the shortgrass prairie's apparent evolutionary adaptation to grazing, livestock use has been an agent of change. Much of this effect occurred in the late 1880s when livestock numbers peaked and shortgrass prairies were grazed beyond their sustainable use. Barbour (1988) stated, "When the shortgrass prairie was first grazed by domestic livestock, the original grasses persisted probably because of their low stature and natural resistance to grazing pressure. As abuse occurred (due to improper grazing use) and the grasses declined, weedy perennial species of cacti (*Opuntia* spp.)*,* snakeweed (*Gutierrezia sarothrae*) and yucca (*Yucca)* increased. Invader annuals have come from the brome (*Bromus* spp.), Russian thistle (*Salsola tragus*), barley (*Hordeum spp*.), and fescues (*Festuca* spp.) genera." The frequency of natural fires declined first due the resultant reduction in fuels and later by intentional suppression. The compound effects fostered an invasion of shrubs into some historic shortgrass prairie areas (Brown 1982).

As for the current state of the shortgrass prairie, Dick-Peddie (1993) wrote, "The succession from plains-mesa grassland to juniper savanna will probably continue in many areas of the state. At the lower (drier) boundaries of plains-mesa grassland, many acres of grama grassland will become desert grassland, and much of the present desert grassland will become Chihuahuan or Great Basin desert shrubland. On many sites, these successional trends, which range users consider deterioration of grassland, were set in motion early in this century; subsequent range management efforts are unlikely to halt, let alone reverse the trend."

Agricultural cultivation has also affected the shortgrass prairie. The dust bowl of the 1930s originated in southeastern Colorado, southwestern Kansas, and the panhandles of Texas Oklahoma, and New Mexico, where the shortgrass prairie was plowed for dryland farming. These fields remain discernable today, decades after cultivation ceased and they were abandoned to re-vegetate naturally. The persistence of threeawn species in these areas may be the result of plowing-induced changes in the soil that require long periods of time for restoration and a reduction in soil phosphorus may leave the site more suitable for these species than for the climax plants that are so slow to reestablish (Barbour and Billings 1988). Where irrigation augments natural precipitation, high levels of crop production were and continue to be attained (Stoddart 1975). This observation is supported by Ricketts *et al.* (1999) who states, "Much of the area was severely affected by largely unsuccessful efforts to develop dryland cultivation. The dustbowl of the 1930s was centered in this ecoregion and stands as proof of the unsuitability of this area for farming, unless heavily irrigated."

The Ogallala Aquifer underlies approximately 174,000 mi^2 (4.5 million ha) across parts of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas. Approximately 10,000 mi^2 (0.3 million ha) of the Ogallala Aquifer occurs in New Mexico. It is the primary source of water for agriculture and urban development on a large portion of those lands defined as the Western Great Plains Shortgrass Prairie. Over eons of geologic time, changing climatic conditions created erosion patterns that have separated the Ogallala Aquifer from its original supply of water and formation materials. The southern portion of the formation in Texas and New Mexico is now a plateau. Natural recharge to the Ogallala Aquifer now occurs primarily through the percolation of precipitation to the water table. Playa lakes play a significant role in recharging the aquifer. Natural recharge from land surface area outside the playa basins is possible and probable in rare events when the top 4-5 ft (1.2 to 1.5 m) of soil is wetted to capacity by irrigation or unusual precipitation. Water can also move from the surface into the aquifer through the micropores created by worms, burrows, and decayed plant roots.

In the 1930s, people began to realize the potential of the vast aquifer that lay beneath them and by 1949 about 2 million acres of the southern high plains were irrigated. Water removal for irrigation increased almost four fold from 1949 to 1980. Since water pumped from the aquifer is not replaced at the same rate that it is removed, the water table began to recede. Gleick (1993) reported that the aquifer is suffering an overdraft rate that is approximately 140% above recharge rate.

Problems Affecting Habitats or Species

Analyses of factors that influence habitats indicated that biodiversity in portions of the Western Great Plains Shortgrass Prairie may be influenced by habitat conversion, abiotic resource use, pollution, and non-consumptive biological uses.

Energy Exploration and Development
The most common form of mineral extraction in the Western Great Plains Shortgrass Prairie is oil and gas. Oil and gas leasing on federal lands follow standards established by the Bureau of Land Management and are subject to further regulation by the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division. The infrastructure of oil and gas extraction (pads, roads, pipelines pump stations, compressors) and related human activities has resulted in habitat fragmentation, disturbance from traffic for hauling and maintenance activities, point source pollution, noise, and habitat conversion.

Wind energy facilities are not yet widespread in the Western Great Plains Shortgrass Prairie. However, as alternative sources of energy become more important and as related technology improves, there is potential for more wind energy sites to be developed. Wind-generated electrical energy is environmentally friendly in that it does not create air-polluting and climate-modifying emissions. Nevertheless, wind turbines, particularly in the large arrays, can significantly affect wildlife and habitats. Roads and pads fragment habitat and bats and birds (particularly raptors) are killed in collisions with the moving blades of the wind turbines. Lighted wind towers greater than 200 ft (61 m) tall have the same potential as communication towers to attract and kill night-flying migratory birds and bats, although collisions occur with moving blades rather than guy wires (NMDGF 2004b).

Pollution
Agricultural chemicals, livestock and dairy groundwater contamination, and solid waste have the potential to create localized pollution in portions of the Western Great Plains Shortgrass Prairie. The current sources, extent, and effects of such pollution, however, remain to be determined.

Habitat Fragmentation
The implications of habitat fragmentation have lead many ecologists to identify the process as one of the most significant factors affecting biodiversity (Harris 1984, Wilcox and Murphy 1985, Noss and Cooperrider 1994). Saunders *et al.* (1991) note that urban expansion, agriculture, power lines, and road construction have accelerated over the past century, subdividing the natural world into disjunctive remnants of native ecosystems embedded in a matrix of anthropogenic land uses. Such development has caused large areas of formerly contiguous landscapes to become increasingly fragmented and isolated (Finch 2004).

Some authors (Barbour and Billings 1988, Ricketts 1999) believe that the primary factor affecting the Western Great Plains Shortgrass Prairie is conversion to agriculture. Areas that were once difficult to cultivate may now be used due to new technologies such as four-wheel drive tractors, precision farming, herbicides, and irrigation. Urban and commercial developments also contribute to the loss of native vegetation, increased water use, ground water depletion, and increased erosion through soil compaction and runoff concentration. These activities may ultimately increase clearing, roads, and vehicular traffic. Subsequent habitat fragmentation may affect SGCN within the shortgrass prairie by: 1) reducing the habitat area for interior species, 2) imposing barriers to dispersal, colonization, and maintenance of meta-population dynamics, 3) altering demographic and genetic structure as a result of isolation and small population size, 4) increasing habitat edge and thereby facilitating predation, parasitism, and invasion by exotic species or habitat generalists, 5) altering biotic relationships, such as plant-pollinator interactions, and 6) altering the physical environment, ecological processes, and natural disturbance regimes (Finch 2004).

Grazing Practices
Grazing practices on the Western Great Plains Shortgrass Prairie are varied and may potentially alter grassland habitats, depending on the grazing management practices used. The intensity and length of the grazing season, in combination with extant environmental conditions has the potential to change plant species composition, percent of vegetative cover, and physical habitat structure (Bock *et al.* 1984). Modifications to vegetative parameters affect associated fauna and subsequent changes in plant diversity and structure affect animal diversity. Sites subjected to improper grazing practices, those that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), may lose faunal specialist species that may or may not be replaced with generalist species (Bock *et al.* 1984). Exececssive livestock grazing may also encourage shrub encroachment through the reduction in grasses and the competition they provide for woody plant seedlings (Humphrey 1958), although Mack and Thompson (1982) reported that grazed areas in the shortgrass prairie tend to be recolonized by predominantly native plants. The extent and specific effects of historic and current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie are poorly understood.

Loss of Keystone Species
The capacity of the Western Great Plains Shortgrass Prairie to sustain its composition, structure, and ecological processes has been diminished through the loss or reduction of keystone species and subsequent alteration of the historic disturbance regimes of which they were part. Free-ranging bison have been extirpated from the shortgrass prairie and domestic livestock have been introduced. Bison foraged on different plants than cattle (Peden *et al.* 1974, Plumb and Dodd 1993) and their removal of vegetation often created patches of open habitat that differed in vegetative composition from the surrounding ungrazed areas (Benedict 1996).

Disturbance from cattle grazing practices tends to produce a more uniform effect and construction of water developments for livestock has expanded grazing into historically inaccessible areas. Prairie dogs also created large patches of habitat that differed from the surrounding landscape and provided essential habitat for many other animals (Benedict 1996). Although they still exist on the landscape, prairie dogs are much reduced and are susceptible to elimination from poisonings and outbreaks of sylvatic plague (*Yersinia pestis*) (Miller *et al.* 1994). Further, their potential to maintain viable and resilient populations and to sustain the biodiversity they create is in doubt because, according to Pizzimente (1981), colonies are becoming isolated and genetic exchange through immigration is becoming less likely.

Fire Management

The current state of the shortgrass prairie is a product of both evolution and historical land use. Prairies in North America evolved with frequent disturbances, including fire, drought, grazing, and storms (Wright and Bailey 1982, Kaufman *et al.* 1988, Anderson 1990, Debano *et al.* 1998, Rickets *et al.* 1999). Fire frequency and intensity appear to be synchronized by climate conditions, physiographic, edaphic and vegetation conditions (Daubenmire 1968, Swetnam and Betancourt 1990). Historically, grassland fires were caused by lightning and Native Americans (Payne 1982, Bahre 1985). However, widespread cultivation, excessive livestock grazing, and transportation corridors reduced standing biomass of fine fuels, and fragmented the landscape in prairie ecosystems, which decreased grassland fire frequency and intensity (Ford and McPherson 1996, 1998, Hart and Hart 1997, DeBano *et al.* 1998, Frank *et al.* 1998). These changes virtually eliminated fire as an ecological process and have had a negative overall impact to prairie ecosystems (Engle and Bidwell 2000). Brockway *et al.* (2002) investigated the effects of growing season and dormant season prescribed fire on the Kiowa National Grasslands in New Mexico. Their results indicated that prescribed fire in shortgrass prairie during the growing season appears to place the plant community at a greater risk of decline. Conversely, prescribed fires during the dormant season provided several immediate benefits to the plant species present and increased species diversity. However, Launchbaugh (1964, 1972) believes fire in the shortgrass prairie to be detrimental because it lowers forage yields by diminishing the number of soil tillers and reduced water infiltration and soil moisture. The roll of fire in sustaining the shortgrass prairie has been well researched, yet results are conflicting (Stewart 1951, Launchbaugh 1973, Wilson and Shay 1990, Knoft 1994, Umbanhowar 1996, Kirchner 1997, McDaniel *et al.* 1997, Knopf 1998, Ford 1999, 2001; among others). Thus, this topic warrants additional attention by research scientists.

Invasive Species

Invasive species can be plants, animals, or other organisms (such as microbes). The US Department of State (1999) cautioned that introduction of non-native species has the potential to cause economic, environmental, or human health problems. Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren *et al.* 1999). Once established, invasive species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing susceptibility to additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). Lee (1999) and Mitchell (2000) noted that the invasion of non-native species is similar to a biological wildfire that is rapidly spreading at a rate of 200 acres/hour across the west. Little is known about the extent or specific effects of invasive species in the Western Great Plains Shortgrass Prairie, making it difficult to assess related problems and develop effective interventions.

Military Maneuvers

Various military entities use portions of air space over the Western Great Plains Shortgrass Prairie for tactical air training. These maneuvers involve low level fights resulting in noise issues in specific areas and may impact specific species. During the breeding season these low-level flights may impact the lesser prairie-chicken, especially while males are vocalizing on leks.

Recreational and Off-Road Vehicle Use
The *New Mexico Statewide Comprehensive Outdoor Recreation Plan* (Henkel 2004) identified a moderately increasing trend in off-road vehicle use in New Mexico from the 1996-2001. Recreational off-road vehicle use has also increased in the Western Great Plains Shortgrass Prairie along rivers, lakes and streams, wherever public access is available. Federal and state owned acreages not adjacent to water sources also receive highly dispersed and varied recreational use. On the Kiowa National Grasslands there is a single developed campground at Mills Canyon adjacent to the Canadian River. Problems associated with dispersed recreation include indiscriminate driving and parking on interior, undeveloped roads or in roadless areas. The specific effects of recreation and off-road vehicle use on the Western Great Plains Shortgrass Prairie are unknown. However, off-road vehicle travel can cause damage to soils and vegetation (Holechek *et al.* 1998) and impact wildlife by destroying and fragmenting habitat, direct mortality of wildlife, or altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983).

Information Gaps

Given the expansiveness of shortgrass prairie in New Mexico, and the variety of potential factors that may alter shortgrass prairie habitats, it is not surprising that there are a number of information gaps related to this ecoregion and SGCN. Information gaps for the Western Great Plains Shortgrass Prairie are outlined below.

- Minimum biotic and abiotic measurements to insure habitat sustainability and integrity have yet to be defined and current land cover habitat condition and SGCN information is lacking.

- Specific range or ecological condition information for the shortgrass prairie is lacking. The Bureau of Land Management (BLM) uses a standardized methodology to estimate ecological condition on BLM managed lands. However, much of the Western Great Plains Shortgrass Prairie is not federally managed, and there are no estimates of ecological condition on private lands or consistent information between the US Forest Service and BLM.

- The intensity, scale, extent, and causes of shortgrass prairie fragmentation are largely unknown.

- Information is needed on the specific effects of current grazing practices on the biodiversity of the Western Great Plains Shortgrass Prairie.

- Information is needed on grazing management practices necessary to sustain appropriate levels, composition, and structure of native grasses in the shortgrass prairie.

- Short and long-term affects of land management practices or uses (such as oil, gas, and wind development, prescribed grazing systems, lovegrass monocultures on CRP lands, invasive species and shrub encroachment management) are unclear.

- There is little information on the abundance, distribution, and trend information for most of the SGCN and the environmental conditions or thresholds that limit populations of SGCN.

- The response of SGCN to human disturbances is unclear.

- Information on the effects of habitat fragmentation and requirements for wide-ranging SGCN is lacking.

- A central clearinghouse for biological information on the Western Great Plains Shortgrass Prairie and SGCN associated with this habitat type is needed to allow all agencies and private landowners to access information to inform development of conservation actions.

- The extent to which invasive and non-native species invade and alter the Western Great Plains Shortgrass Prairie and limit populations of SGCN and the appropriate interventions is poorly understood.

- The extent to which off-road vehicle use is impacting Western Great Plains Shortgrass Prairie SGCN populations is unknown.

- There is a poor understanding of the sources of pollution and the extent to which pollution is altering the Western Great Plains Shortgrass Prairie.

- Our understanding of the role of fire in sustaining the Shortgrass prairie and appropriate fire management protocols is poor.

Research, Survey, and Monitoring Needs

Research, Survey, and Monitoring Needs for the Western Great Plains Shortgrass Prairie are primarily derived from our perception of factors that influence the integrity of this habitat type and associated information gaps. Research, survey, and monitoring needs that would enhance our understanding of this habitat type and SGCN are outlined below.

- Investigate the extent to which land use activities (such as livestock grazing timing, intensity, and duration; human development; gas, oil, and water exploration; off-road vehicle use; and non-native species invasions) fragment and alter habitats in relation to patch size, edge effect, temporal needs, and use by SGCN. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN.

- Conduct research to enhance our knowledge of vertebrate and invertebrate community structures, fundamental natural history requirements, and ecological relationships within the Western Great Plains Sand Shortgrass Prairie. Life history and habitat needs of most of the SGCN and their use of this habitat type are poorly understood.

- Investigate the extent of the impact that wind energy facilities have on avian and bat populations. Studies should also define important migration/movement corridors for these taxa on both a landscape and local area scale.

- Identify the impacts of fire, grazing, and drought on the Western Great Plains Shortgrass Prairie. Optimal studies would define the roles, mechanisms and impacts via manipulative field-based experiments. Methods that mimic natural disturbance regimes and consider economic impact are valuable to land managers.

- Investigate the impacts, benefits, or detrimental effects of habitat restoration practices (such as shrub removal, reseeding, fire, etc.). Millions of dollars are made available annually through various grant programs to federal, state, and private land managers. All restoration methods should be closely evaluated and suggested modification of these practices made available to land managers.

- Investigate and recommend invasive species early detection protocols, methods to estimate vectors and pathways of potential invasive species, and effective interventions.

- Define spatial and temporal requirements of wide-ranging SGCN. The identification of habitat corridors is essential for long-term conservation planning.

- Investigate and monitor black-tailed prairie dog populations in terms of rates of town growth, establishment and decline, and the effects of plague and control efforts on prairie dog populations (Johnson 2003).

- Investigate options for developing a centralized database of information regarding the condition of Southern Shortgrass Prairie Ecoregion habitats. This database would allow for the identification of data gaps, comparing differing methodologies of data collection, and encourage the implementation of national monitoring standards.

- Investigate the roll of natural fire and prescribed fire in maintaining grassland habitats.

Desired Future Outcomes

Desired future outcomes for the Western Great Plains Shortgrass Prairie are focused upon achieving ecological sustainability and integrity of this land cover type. Desired future outcomes include:

- Western Great Plains Shortgrass Prairie persists in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- Economic and social ties to the Western Great Plains Shortgrass Prairie are recognized and accommodated in the quest for ecological sustainability in order to garner public support and recognition of the importance of the shortgrass prairie in New Mexico.

- Large natural areas are designated and managed for dispersal, genetic mixing of populations, and to accommodate wide-ranging species.

- Partnerships have been established to identify and implement conservation planning, education, and technical, reclamation, survey, or research projects that ensure the future integrity and functionality of the Western Great Plains Shortgrass Prairie for SGCN.

- Consistent grassland reclamation standards are established that ensures future habitat integrity and functionality and are adopted by private landowners, counties, municipalities, and federal and state land management agencies.

- Land management plans for federal and state lands include implementation and compliance with sustainable grazing practices.

- A fully funded comprehensive statewide noxious weed control planning committee and program is established. Colonization of noxious weed species is stopped and extant weed populations are controlled or eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico’s biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and private landowners to ensure the ecological sustainability and integrity of the shortgrass prairie. Methods may include: establishing conservation agreements, agency memorandum of understanding, or land acquisition projects.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about SGCN and the Western Great Plains Shortgrass Prairie outlined in the Research, Survey, and Monitoring Needs section above.

3. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

4. Support actions that create incentive based or voluntary partnerships with private landowners to conserve and manage their properties to sustain SGCN.

5. Work with federal, state, and private agencies and institutions to identify sources of funding for long-term conservation of SGCN and to maintain tracts of native vegetation as an alternative to converting land to agriculture or urban development. Funding should create incentives for habitat maintenance and improvement on private lands and conservation easements. Employ existing incentive programs to facilitate partnerships with private landowners. These programs include the Conservation Reserve Program (CRP), Landowner Incentive Program, Wetland Reserve Program, Wildlife Habitat Incentives Program, State Wildlife Grants, Private Stewardship Grants Program, Safe Harbor Agreements, and Environmental Quality Incentive Program.

6. Initiate centralization of available data regarding condition of the shortgrass prairie should for the purpose of identifying data gaps, to compare current methodologies of data collection and to encourage the implementation of national monitoring standards.

7. Collaborate with federal and state agencies and affected publics to identify legislative actions, land acquisition, and easement access management protections for the Western Great Plains Shortgrass Prairie. Practices to consider for legislative attention include the regulation of toxicants to control prairie dogs, removal of prairie dogs, regulation of exploitative activities such as rattlesnake roundups, and off-road vehicle management.

8. Counter habitat fragmentation by working with federal, state, and private land managers to modify management of roadside rights-of-way and fencerows to provide useful habitat and corridors that allow wildlife to travel between existing patches of prairie.

9. Collaborate with federal, state, and private agencies and institutions in gaining support for additional open space lands, mitigation mechanisms, and management strategies.

10. Monitor and respond appropriately to proposals to modify programs, such as CRP, that support conservation management and incentives to preclude conversion of wildlife habitat to alternative uses.

11. Identify and pursue opportunities to develop agreements among state and federal agencies that clearly outline responsibilities regarding conservation of shortgrass habitats and resident SGCN.

12. Promote grassland restoration that encourages increased native herbaceous cover.

13. Collaborate with federal and state agencies and affected publics to develop management practices that would increase populations and nesting success of avian species in the shortgrass prairie. Possible management practices may include: 1) maintaining a network of grassland reserves that can act as refugia for grassland birds during periods when agricultural needs reduce the amount of land available to them; 2) maintaining areas that are not grazed or burned for at least three years to provide habitat for species that require taller, denser vegetation; 3) minimize early-season mowing or cutting of hayfields or fields on lands in the CRP; and 4) aggregate fields in CRP to create a few large grasslands.

14. Assist with implementation *of New Mexico's Strategic Plan for Managing Noxious Weeds, 2000-2001* (http://www.swstrategy.org/library/NM Strategic Plan for Managing weeds.htm). New Mexico's weed management strategy is intended to complement the objectives of agency and inter-agency weed management strategies, including the BLM, *Partners Against Weeds* action plan, the US Forest Service, *Stemming The Invasive Tide*, and the national interagency strategy, *Pulling Together*), as well as *the National Invasive Species Management Plan*, but with a specific focus on opportunities and problems in this state.

15. Collect and distribute information regarding assessments of the short and long-term effects of land management practices such as prescribed fire, habitat rehabilitation. These practices include methods of converting lovegrass monocultures on CRP lands, habitat restoration, shrub removal, wind generation site interventions, oil and gas reclamation, and invasive species management, and grazing systems.

16. Provide a general guide for landowners to restore and maintain a mosaic of vegetative structure that provide habitat for a variety of native wildlife, particularly SGCN, and which contribute to landscape-level habitat restoration.

17. Provide or facilitate public education and wildlife viewing opportunities to raise awareness and appreciation of grassland SGCN, gain support for additional open space lands, build mechanisms for mitigation, and develop management strategies.

18. Work with entities planning development of wind energy facilities in the Western Great Plains Shortgrass Prairie to reduce the potential for adverse effects on SGCN.

STATEWIDE DISTRIBUTED RIPARIAN HABITATS

"Riparian ecosystems" are defined as an assemblage of plant, animal, and aquatic communities whose presence can be either directly or indirectly attributed to stream induced or related factors (Kauffman and Krueger 1984). Riparian ecosystems support a greater diversity of plants and animals than upland habitats. A significant percentage of all wildlife in the Southwest uses riparian habitat (Thomas *et al.* 1979, Johnson *et al.* 1977) and approximately 80% of all sensitive vertebrate species in New Mexico depend upon riparian or aquatic habitats at some time during their life cycle (NMDGF 2000).

Wetlands and riparian ecosystems comprise less than 2% of our arid western landscape and less than 1% of New Mexico (Dahl 1990, Henrickson and Johnston 1986, Allen and Marlow 1992). Riparian habitats occur where water is perennial, intermittent, or ephemeral. Their relatively small size, linear configuration, complexity, and variation present a significant challenge to mapping their aerial extent through remote sensing technology. To date, there are only estimates of the acreage of riparian habitats in New Mexico. During the last century, New Mexico and Arizona have lost an estimated 90% of their original riparian ecosystems (Krzysik 1990). These habitats have been most negatively affected by human activities in the Southwest (NMDGF 1988). However, despite the relative scarcity of riparian habitat, its variety promotes considerable diversity in floral and resident and migratory faunal communities (Pase and Layser 1977).

Durkin *et al.* (1996) describe ecosystem processes that are essential to healthy, desirable riparian systems:

> "The riparian ecosystem encompasses the river and the adjacent floodplain, linking the aquatic ecosystem to the terrestrial ecosystem (Gregory *et al.* 1991, Crawford *et al.* 1993). It is a flood-driven environment where the effects of floods can be destructive or constructive to riparian plant communities (Szaro 1989). Riparian ecosystem composition and structure is dependent not only on surface flows, but also on subsurface stream flows that play an integral role in the ecology and evolutionary dynamics (Reichenbacher 1984) of seed dispersal, plant establishment, species replacement patterns, maintenance of species and "patch" diversity, as well as nutrient cycling and productivity (Leonard *et al.* 1992, Stromberg *et al.* 1993, 1996). The expression and spatial patterns of riparian vegetation and species distribution is naturally a result of the dynamics and configuration of channels, periodic flooding, the presence or absence of large woody debris, as well as geomorphology and soil moisture (Heede 1985, Hupp and Osterkamp 1985, Minckley and Rinne 1985, Hupp 1992, Malanson 1993, Muldavin and Mehlhop 1993). Riparian plant communities are naturally resilient to flood flows (Szaro 1989, Stromberg *et al.* 1993) and require appropriate seasonal flows of water for plant recruitment, growth, development, maintenance, and restoration (Bock and Bock 1985, Brady *et al.* 1985, Asplund and Gooch 1988, Szaro 1989, Siegel and Brock 1990, Leonard *et al.* 1992, Muldavin and Mehlhop 1993, Stromberg *et al.* 1993, Crawford *et al.* 1993, Durkin *et al.* 1994 and 1995)."

Dick-Peddie (1993) classified riparian habitats in New Mexico into: 1) alpine riparian, 2) montane riparian, 3) floodplain-plains riparian, 4) arroyo riparian, and 5) closed basin riparian. Alpine riparian areas are similar to subalpine grasslands (Dick-Peddie 1993) communities and are discussed in the Alpine Wet Meadow section in the Southern Rocky Mountain Ecoregion. Floodplain-Plains riparian communities occur primarily along the major rivers of New Mexico. We grouped arroyo riparian and closed basin riparian types into xeric riparian because of their similarity in New Mexico. Xeric riparian communities included basins, playas, alkali sinks, and arroyos. Many of New Mexico's riparian communities have been altered by invasive species. Their presence in riparian communities is sufficient enough to be mapped using remotely sensed data (SWReGAP; http://fws-nmcfwru.nmsu.edu/swregap/). While this community is likely more prevalent in the floodplain-plains riparian communities, invasive riparian communities are present throughout New Mexico riparian systems (Figure 5-7).

Species of Greatest Conservation Need

A large number of wildlife use riparian habitats extensively. The Rio Grande Valley wetlands provide habitat for 246 species of birds, 10 species of amphibians, 38 species of reptiles, and 60 species of mammals (USGS 1996, NMDGF 2000). Furthermore, of the 867 species of vertebrates known to occur in New Mexico, 479 (55%) rely wholly, or in part, on aquatic, wetland or riparian habitat for their survival. Of these species, 96 are listed by the state as endangered or threatened.

There were 138 SGCN, excluding arthropods other than crustaceans, associated with riparian habitats in New Mexico (Table 5-9). Of these, 57 species (41%) are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. Fifty-eight species (42%) are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 23 species (17%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Additional conservation concerns for these taxa are addressed in the Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and Terrestrial Habitat sections.

Riparian habitats support a large diversity of plants and animals and a significant percentage of all wildlife in New Mexico.

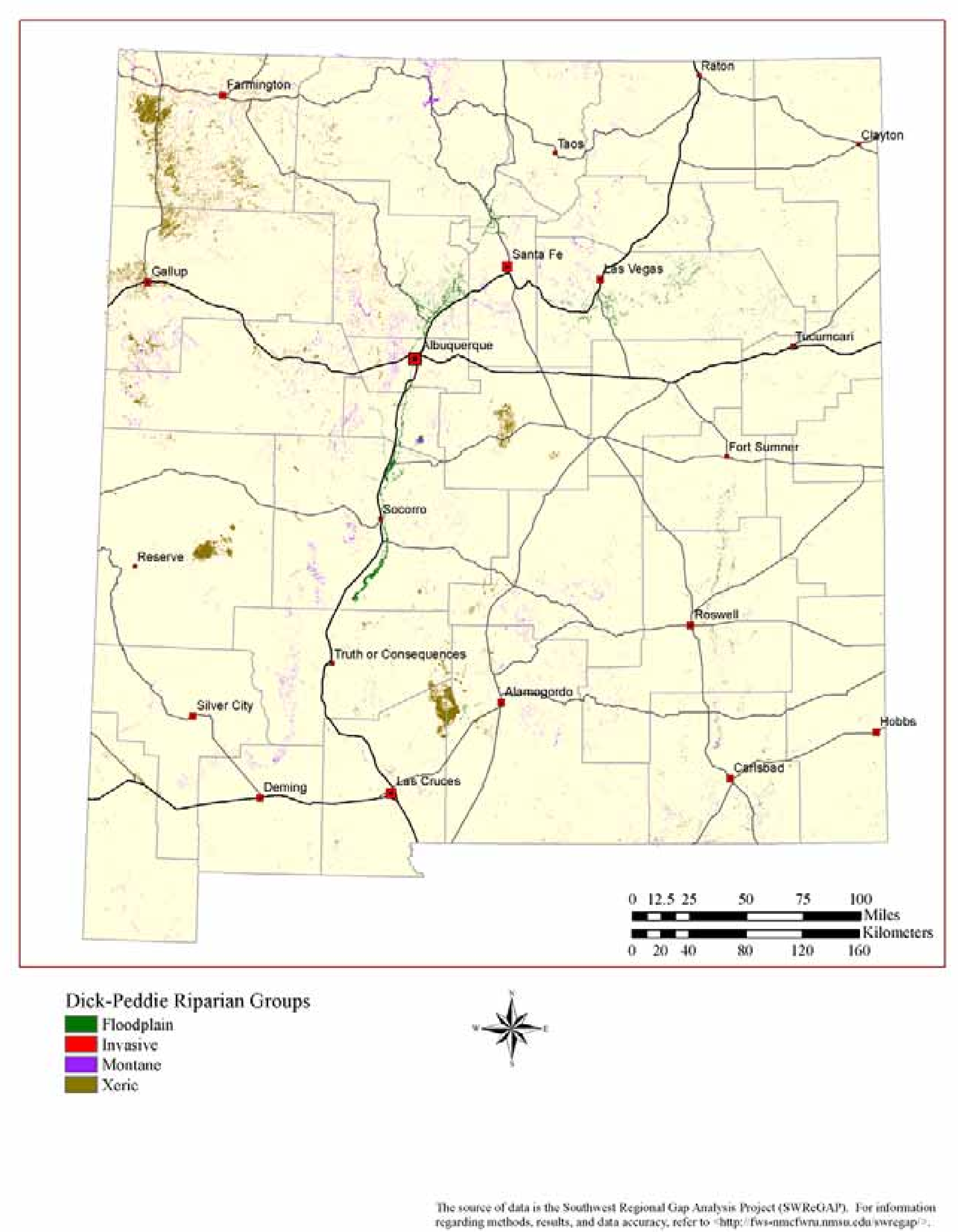


Figure 5-7. Key riparian habitats in New Mexico. Dick Peddie (1993) riparian groups are shown on map.

Table 5-9. Species of Greatest Conservation Need associated with Riparian Habitats in New Mexico.

Common Name		
Birds		
Eared Grebe	Interior Least Tern	Southwestern Willow Flycatcher
American Bittern	Band-Tailed Pigeon	Thick-Billed Kingbird
White-Faced Ibis	Mourning Dove	Loggerhead Shrike
Northern Pintail	Common Ground-Dove	Bell's Vireo
Osprey	Yellow-Billed Cuckoo	Gray Vireo
Bald Eagle	Whiskered Screech-Owl	Piñon Jay
Northern Harrier	Elf Owl	Bank Swallow
Northern Goshawk	Burrowing Owl	Juniper Titmouse
Common Black-Hawk	Mexican Spotted Owl	Sage Thrasher
Ferruginous Hawk	Black Swift	Bendire's Thrasher
Golden Eagle	Broad-Billed Hummingbird	Lucy's Warbler
Peregrine Falcon	Violet-Crowned Hummingbird	Yellow Warbler
Blue Grouse	Lucifer Hummingbird	Black-Throated Gray Warbler
Gould's Wild Turkey	Costa's Hummingbird	Grace's Warbler
Montezuma Quail	Elegant Trogon	Red-Faced Warbler
Scaled Quail	Lewis's Woodpecker	Abert's Towhee
Sandhill Crane	Red-Headed Woodpecker	Botteri's Sparrow
Snowy Plover	Gila Woodpecker	Sage Sparrow
Mountain Plover	Williamson's Sapsucker	Varied Bunting
Long-Billed Curlew	Northern Beardless-Tyrannulet	Painted Bunting
Wilson's Phalarope	Olive-Sided Flycatcher	Hooded Oriole
Mammals		
New Mexico Shrew	Mexican Long-Tongued Bat	Western Yellow Bat
Arizona Shrew	Mexican Long-Nosed Bat	Western Red Bat
Preble's Shrew	Lesser Long-Nosed Bat	Spotted Bat
Least Shrew	Arizona Myotis Bat	Allen's Big-Eared Bat
Pocketed Free-Tailed Bat	Northern Pygmy Mouse	American Marten
Peñasco Least Chipmunk	Arizona Montane Vole	River Otter
Gunnison's Prairie Dog	Prairie Vole	Jaguar
Arizona Gray Squirrel	New Mexico Meadow Jumping Mouse	Mule Deer
Abert's Squirrel	Mexican Gray Wolf	Coues' White-Tailed Deer
Southern Pocket Gopher	Black Bear	Rocky Mountain Bighorn Sheep
American Beaver	White-Nosed Coati	Desert Bighorn Sheep
Amphibians		
Tiger Salamander	Arizona Toad	Chiricahua Leopard Frog
Colorado River Toad	Rio Grande Leopard Frog	Northern Leopard Frog
Western Boreal Toad	Plains Leopard Frog	Lowland Leopard Frog
Reptiles		
Western Painted Turtle	Madrean Alligator Lizard	Mexican Garter Snake
Western River Cooter	Reticulate Gila Monster	Arid Land Ribbon Snake
Ornate Box Turtle	California Kingsnake	Narrowhead Garter Snake
Big Bend Slider	Sonoran Mountain Kingsnake	New Mexico Garter Snake
Sonoran Mud Turtle	Milk Snake	Banded Rock Rattlesnake

Table 5-9 Cont.

Common Name		
Reptiles Cont.		
Regal Horned Lizard	Blotched Water Snake	Mottled Rock Rattlesnake
Giant Spotted Whiptail	Green Rat Snake	New Mexico Ridgenose Rattlesnake
Mountain Skink	Yaqui Blackhead Snake	
Molluscs		
Pecos Assiminea Snail	Ovate Vertigo Snail	Texas Liptooth Snail
Obese Thorn Snail	Bearded Mountainsnail	Wrinkled Marshsnail
Sonoran Snaggletooth Snail	Blunt Ambersnail	
Blade Vertigo Snail	Marsh Slug Snail	

Riparian Habitats

Habitat Condition

The quantity and quality of riparian habitats essential for the survival of many of New Mexico's SGCN have been significantly diminished. It is estimated that fully one third of the wetlands that once existed in New Mexico have been lost (Dahl 1990). There was an 87% decrease in wetland acreage along the main stem of the Rio Grande from 1918 to 1982 (Hink and Ohmart 1984).

Many riparian systems have been extensively altered and/or fragmented because they occur in the broad valley floor and are therefore suitable for human occupation and agricultural uses. The integrity and quality of riparian habitats is variable due to development along river floodplains, channel modification, occurrence of scouring spring flows, and improper grazing practices that occur within riparian habitats. The result is a wide range of habitat quality ranging from very good to very poor (USFWS 1993).

Many wetland complexes support unique ecosystems allowing wildlife species, such as the northern leopard frog (*Rana pipiens*), to thrive in areas they would otherwise not be found (BOR 2002b). Wetlands and riparian vegetation have become established because of the installation of open ditch irrigation systems where significant seepage results in the development of small sedge/rush meadow or cattail (*Typha* spp.) wetlands or narrow corridors of willow (*Salix* spp.) or seepage-enhanced rabbitbrush (*Chrysothamnus nauseosus*), sagebrush (*Artemisia* spp.), or chokecherry (*Prunus virginiana*). Cottonwoods (*Populus* spp.) have become established and form open galleries at some locations. These systems possess only the minimal functional values of naturally occurring wetland/riparian areas and similar wildlife habitats.

Riparian and stream ecosystems have largely been degraded by ecosystem-wide, off-channel activities and, therefore, cannot be restored by focusing solely on manipulations within the channel. The greatest stressors to the system are regulated river flows, channelization, and invasive species (Fullerton and Batts 2003). Conservation protection is often lacking in riparian areas because these areas were often settled early. However, significant portions of the Rio

Grande bosque have been protected at the Bosque del Apache National Wildlife Refuge and Sevilleta National Wildlife Refuge and local and state parks afford some level of habitat protection along drainages.

Riparian systems, despite a popular perception of fragility, are often quite resilient (Baker *et al*. 1999). Numerous riparian areas are at risk because of various stresses, such as improper grazing by livestock and wildlife. Drought and flooding have caused many riparian areas to lose their dynamic equilibrium. However, once these stresses are relieved, many riparian systems can regain their equilibrium within a few years because of resilient, native, herbaceous, riparian plants such as sedges and rushes (C*arex* spp., *Eleocharis* spp., *Juncus* spp., and *Scirpus* spp.) (Medina 1996).

Dick-Peddie (1993) classified riparian habitats in New Mexico into: 1) Montane Riparian, 2) Floodplain - Plains Riparian, and 3) Xeric Riparian habitat types. Montane riparian habitats are found along mountain streams and rivers within New Mexico. Surface flow, ground water, and annual and episodic flooding are necessary to maintain montane riparian systems (Rondeau 2001). Alteration of the flooding regime due to water impoundment and diversions may produce changes to plant and community composition (Kittel *et al.* 1999). Upstream activities such as mining that effect water quality may be important to the vertebrate and invertebrate species that use these habitats. Montane riparian habitats are the most extensive and varied within New Mexico and are often resilient because of the variable conditions in which they have evolved (Dick-Peddie 1993). These systems can be highly fragmented and of low quality (Fullerton and Batts 2003). Resilience in this habitat type is lost due to the lack of floods and frequent mowing inside the levees. There are isolated pockets of remnant cottonwood–willow habitat, but saltcedar (*Tamarix* spp.) is dominant.

Floodplain-Plains riparian communities occur along the major rivers of New Mexico. The middle Rio Grande Corridor is a representative example of Floodplain-Plains riparian habitats. It encompasses a changing mosaic of habitats including: 1) natural riparian habitats dominated by native Fremont cottonwood (*Populus fremontii*) and/or willow with differing degrees of exotic saltcedar and/or Russian olive (*Eleagnus angustifolia*) encroachment, 2) monotypic stands of exotic saltcedar or Russian olive, 3) marshes primarily dominated by cattail (*Typha* spp.) and hardstem bulrush (*Scirpus acuta*), 4) mowed river edge areas dominated by grasses such as alkali sacaton (*Sporobolus airoides*), 5) active agricultural areas such as pecan (*Carya illinoinensis*) orchards and row crops, and 6) manipulated riparian areas associated with agricultural irrigation channels generally dominated by wolfberry (*Lycium barbarum*) and fourwing saltbush (*Atriplex canescens*) (Leal *et al.* 1996).

The riparian system of the middle Rio Grande is referred to as the Rio Grande cottonwood alliance (Muldavin *et al.* 2000), the Rio Grande bosque (Crawford *et al.* 1993), and the Floodplain Riparian classification (Dick-Peddie 1993). Mature, native Rio Grande cottonwood trees (*Populus deltoides* ssp. *wislizenii*) dominate the canopy of this riparian galley forest. The bosque usually appears as a narrow strip up to 650 ft (200 m) in width. Laterally, its distribution within the presently active floodplain is mostly constrained by levees and bluffs. Cottonwood stands range from fairly dense in frequently flooded locations, to relatively open in locations that are hydrologically disconnected. Canopy heights can reach 80 ft (25 m), but are frequently much lower. Trunk diameters vary among trees of approximately the same age. Small cottonwoods within the forest are probably root and stem sprouts (Crawford 2002).

Fullerton and Batts (2003) identified a number of community types in the Rio Grande cottonwood alliance with desirable communities including cottonwood/coyote willow (*Salix exigua*), cottonwood/Goodding's willow (*Salix goodingii*), and cottonwood/New Mexico olive (*Forestiera neomexicana*) (Hink and Ohmart 1984, and Muldavin *et al.* 2000). These communities are adapted to floodplain environments with significant available moisture from periodic flooding, shallow groundwater, standing surface water, and unstable substrata. Historically, floods caused multiple channels and sandbars, washed away stands of trees, and created wetlands resulting in heterogeneous patchworks of vegetation communities and age classes. Flood frequency and intensity has decreased due to the construction of dams. The water table has decreased in many areas, river channels have been straightened and bermed, banks have been stabilized, and the natural shifting of channels has been virtually halted. The river channel is narrowing and deepening in many locations, and vegetation is stabilizing the riverbank.

Historically, the riparian forest was probably a constantly changing mosaic of often discontinuous, uneven-aged cottonwood and willow communities. Most of the dominant trees would have originated during periods of over-bank flooding. At such times, open areas among the riparian forest communities would have contained wetlands such as marshes, wet meadows, and oxbows depending on the topography of the floodplain and the proximity of the river. During dry periods, drought resistant grasses and shrubs would have covered much of the landscape not populated by such stands. The middle Rio Grande cottonwood bosque is still a dynamic ecosystem, but one that differs markedly from its ancestral condition.

These combined conditions have had a significant effect on vegetative communities. An example is the middle Rio Grande (Fullerton and Batts 2003). In the northern portion there is little or no recruitment of native riparian plants outside of the immediate banks and sandbars of the river channel. Large amounts of sediment enter the river at the confluences of the Rio Puerco and Rio Salado (Lagasse 1980) and flow is insufficient to move this sediment farther downstream. Elephant Butte Dam has caused the base elevation to raise upstream enhancing channel widening, deposition, braiding, and aggrading. Sediment deposition creates a substrate for establishment of riparian vegetation, both native and exotic. Subsequently, the cottonwood bosque as a whole is being replaced by introduced species, including saltcedar, Russian olive, and Siberian elm (*Ulmus pumila*) (Fullerton and Batts 2003). Saltcedar is part of the sub-canopy at many sites and occurs in extensive, continuous open stands. Russian olive, on the other hand, not only dominates the sub-canopy in many places, but also often lines the riverbank to the near exclusion of other trees.

Other important components of the riparian system along the Rio Grande include wet meadows, palustrine marshes, spring seeps and perched wetlands, salt marshes, and sandbars (Fullerton and Batts 2003). Wet meadows were likely the most extensive floodplain habitat along the Rio Grande prior to installation of agricultural drain systems, and have experienced the greatest decline in surface area of all floodplain habitat types. Spring seeps and perched wetlands provide unusually persistent and long-lived wetlands. They occur where groundwater flow is intercepted above the level of the floodplain by impermeable layers of bedrock or clay, usually near the intersection of the floodplain and valley slopes. Wooded wetlands may include temporally flooded bosque, or any of the other persistent or ephemeral wetland habitats that occur within the riparian zone. Historical records refer to salt marshes at several locations in the Middle Rio Grande Valley, including Bernardo, La Joya, and Bosque del Apache. A few of these salt marsh areas persist today, although their hydrologic conditions may be greatly modified.

Obligate wetland plant communities along the Pecos River mostly consist of small herbaceous emergent wetlands dominated by common threesquare bulrush (*Schoenoplectus pungens*) and other wetland graminoids, or willow and baccharis (*Baccharis* spp.) stands with threesquare bulrush (Milford *et al.* 2001). The primary abiotic functions for all these riparian systems are flooding and channel avulsion (Fullerton and Batts 2003).

The condition of xeric riparian communities is largely unknown. Many of these types are linear strands except for playa types and greasewood flats. These communities are common throughout the state but can be highly fragmented due to natural and anthropogenic sources. Though acknowledged as important habitat, relatively few studies have focused on these riparian types. Few studies have looked at the condition of these sites and often condition procedures such as Proper Functioning Condition do not apply to these vegetation types.

Problems Affecting Habitat or Species

Water availability in New Mexico is extremely limited. Water must be provided for agricultural, industrial, and municipal use. Natural losses due to the arid nature of New Mexico, including evaporative losses from reservoirs and increased water use by non-native species are to be expected. Habitat conversion factors, abiotic resource uses, and consumptive uses are adversely influencing riparian habitats in New Mexico and non-consumptive uses (see Chapter 4). All of these impacts compromise the biological quality and ecological integrity of riparian/wetlands in New Mexico (Deardorff and Wadsworth 1996). Demand from an increasing population may further reduce flows and exacerbate current conditions.

Natural Flow Regime
Successfully conserving riparian biodiversity and a river's natural ecosystem function is strongly dependent on the ability to protect or restore natural flow regimes (Stanford *et al.* 1996, Poff *et al.* 1997, Richter *et al.* 1997). Natural stream flow variability is a primary organizing force within native riparian ecosystems (Richter and Richter 2000). Flow regimes structure riparian communities by shaping key environmental conditions and their variation within particular habitats, driving patch dynamics within riparian mosaics, and influencing the movements of organisms between habitats (Poff *et al.* 1997). Many riparian plants depend on natural disturbances for establishment, and rates of recovery or establishment following disturbances can be remarkably high (Gecy and Wilson 1990). While riparian ecosystems can be resilient to natural disturbance regimes, many rapidly degrade with the curtailment of these disturbances (Rood and Mahoney 1990, Howe and Knopf 1991).

Habitat conversion factors that alter natural flow regimes (such as drainage of wetlands, ground water depletion from agriculture and urban development, water withdrawal, and dewatering) have serious consequences to riparian habitats. The construction of reservoirs, conveyance canals, and drains can alter annual river hydrographs (Bullard and Wells 1992) and result in the loss of wetland and meadow habitats (Hink and Ohmart 1984). Changes in river flow management have curtailed the regeneration of native woody plants that historically released seed coinciding with late spring flooding events. The operation of dams, like Navajo Dam, has caused many downstream effects including changing the riparian community, diminishing peak flows, changing the timing of high and low flows, and reducing connectivity between rivers and their flood plains (BOR 2002a). Changes in sediment balance caused by diversions can leave a disproportionate amount of sediment in the channel below diversions deposited in the pooled water upstream. In some places deposition has also limited the channel capacity.

Changes in sediment balance have already been effected by reservoirs in the middle Rio Grande. The Rio Grande is sediment-starved immediately downstream of Caballo Reservoir, but further downstream, arroyos control the inflow of sediment and in many areas, main stem flows are unable to remove these tributary deposits. Increases in peak flows could exacerbate the sediment "starvation" in some reaches below Cochiti Reservoir. Thus, the implementation of higher peak discharge to increase floodplain connectivity and facilitate historic geomorphic processes must consider potential adverse impacts on the Rio Grande's sediment balance. Reduced water availability, due to riverbed degradation and low flows also lowers groundwater tables (Fullerton and Batts 2003). The combination restricts over-bank flooding and surface seepage.

The Rio Grande is particularly illustrative with respect to the challenges of maintaining natural flow regimes and riparian habitats. Under New Mexico water law, the Rio Grande is fully appropriated and there is no protection for in-stream flow. Water salvaged or acquired for restoration purposes can be pre-empted by other users, and its benefits may not be realized throughout the system. The Rio Grande Compact between the states of Colorado, New Mexico, and Texas provides a schedule of required water deliveries. Rio Grande Compact deliveries must be met. There is little, if any, surplus in most years, but the compact does ensure delivery of water from Colorado to New Mexico. The compact would have to be considered in almost any change in reservoir operations (Fullerton and Batts 2003).

Federal law prohibits conservation storage in upstream flood control reservoirs. Reauthorization along with an Environmental Impact Statement would likely be needed to change basic reservoir operations. Flows are a result of compact requirements to deliver water and storage in Elephant Butte Reservoir (Fullerton and Batts 2003) and are released at a fairly uniform rate during the irrigation season. This results in a lack of discharge variability and minimal river flows outside the irrigation season. This release pattern has little resemblance to a natural hydrograph. A natural hydrograph of the Rio Grande would have shorter and higher peaks during late spring, lower flows for the remainder of the summer and fall, and higher flows in the winter. Currently, almost all winter flows are stored in Elephant Butte for release during the irrigation season. Water usage in the reach reduces the inflow by 80-90% and only a fraction of the natural flow level remains in the lower half of the bioregion.

The natural flow regime has also been modified by the channel stabilization measures that prevent river migration. Stream flow depletions from irrigation diversions and channel straightening are prevalent. Despite these perturbations, riparian/wetland vegetation is usually well established, with Russian olive and tamarisk being the most common community type. Return flows and canal leakage either support or augment the hydrology of numerous riparian/wetlands throughout the river's zone of influence. In addition, very narrow, linear bands of riparian/wetland vegetation have become established along the banks of most canals.

Water Loss
High-intensity, short-duration, localized, convective thunderstorms are common in the Chihuahuan Desert. Because of the sparse vegetation and compacted soils, a large proportion of rain runs off into ephemeral drainage channels (arroyos) and ephemeral lakes (playas) (Atchley *et al.* 1999). This water may be stored (Ludwig and Whitford 1981), evapotranspirated, or used for recharge (Constantz *et al.* 1994). In the Chihuahuan Desert, arroyos and playas had the greatest amount of stored water (Ludwig and Whitford 1981). While the role of arroyos as conduits for water is relatively well known (Renard and Keppel 1966), less is known about their capacity to act as storage areas for water and nutrients. The distribution of moisture at various positions along arroyos may be variable and some plants are able to exploit these resources. Differences between arroyo and non-arroyo areas are often striking in species composition and in the greater size of arroyo plants (Balding and Cunningham 1974).

Habitat Conversion
Habitat conversion can be caused by both natural and anthropogenic sources. Conversion can be as severe as a type conversion (change from one vegetation community to a completely different community) or subtler such as changing dominant plant densities or changing plant strata composition. Habitat alteration from agricultural and livestock production or timber harvest can influence riparian habitats. Serious impacts contributing to the degradation of overall watershed conditions have come from excessive logging (Boles and Dick-Peddie 1983). Concentrated flow of surface runoff from dairy farms or agricultural chemicals may limit the capability of riparian buffers to remove pollutants and absorb and contain pollutants, allowing them to reach streams (Davis *et al.* 1999).

Roads and transportation corridors often redirect water, sediment, and nutrients between streams and their riparian ecosystems to the detriment of water quality and ecosystem health (Trombulak and Frissell 2000). Road construction and maintenance may also cause and perpetuate habitat fragmentation. Creation of roads can divide contiguous patches of habitat changing species territories, creating patches too small to support viable populations, or becoming barriers to species movement.

Development through urbanization and subdivision can also create habitat conversion or fragmentation. The effects can be subtle, as in exurbia where contiguous natural habitat is fragmented by low impact developments on large tracts of land, or immediately apparent as when a development changes natural habitat into a residential subdivision. Further, riparian areas receive high recreational use. Off-road vehicles may destroy riparian habitats or increase sedimentation.

Hydrological modifications along the Pecos River have reduced flooding and limited native vegetation regeneration. As a result, cottonwoods are rare along the Pecos River, and occur as either individuals or very open woodlands. The resulting fragmentation can eliminate large patches of suitable habitat for species. For example, the mixed cottonwood associations of the La Plata River are considered to be marginal habitat for the southwestern willow flycatcher (*Empidonax traillii extimus*) partly due to improper vegetative structure and habitat fragmentation (COE 1996). Similarly, riparian habitats along the Rio Grande downstream of Caballo Dam have experienced considerable change (Fullerton and Batts 2003) and fragmentation. River channelization, agriculture, urbanization, changes in flow regime and landscape vegetation, and security efforts along the border have altered native vegetation composition in favor of invasive species (see Invasive Species discussion below) or other plant communities. Thorny shrub plants such as honey mesquite (*Prosopis glandulosa*), buckthorn (*Rhamnus californica*), creosote bush (*Larrea tridentata*), and lechuguilla (*Agave lechuguilla*) have invaded the drier alluvial soils along the outside edge of the floodplain (Fullerton and Batts 2003).

Invasive Species

Invasive species can significantly influence the integrity of riparian areas. Invasive plants can disrupt the structure and stability of native plant communities and degrade native wildlife habitat by successfully competing with and replacing native plant species and consuming limited sources of moisture. Along the Rio Grande, exotic species represent more than 25% of herbaceous plant species and more than 40% of tree species (Muldavin *et al.* 2000). Several of the most aggressive exotic plant species in the United States are invaders of riparian areas. Stohlgren *et al*., (1998) suggested that the disturbance regimes characteristic of riparian areas might make riparian communities particularly vulnerable to invasion by non-native plant species.

Of the exotic plants listed as candidates for the worst weeds in North America, as many as a third are found in riparian areas or wetlands (Stein and Flack 1996, Plant Conservation Alliance 2000, The Nature Conservancy 2001). Prominent examples include saltcedar and Russian olive. Seed sources for Russian olive and saltcedar are virtually uncontrollable throughout the middle Rio Grande. Saltcedar has replaced cottonwood and other native riparian plants throughout much of the Southwest. Invasion by saltcedar is exacerbated by a reduction in flood flows caused by dams and by the lowering of water tables. Saltcedar has the potential to alter competitive hierarchies and disturbance regimes in riparian ecosystems (Busch and Smith 1995). The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004). Postulations of the effects of the continued range extension of Russian olive include over-bank deposition, degradation of the river channel, and decline in river stage level (Olson and Knopf 1986).

Reduced peak flows can facilitate the growth of exotic riparian vegetation, primarily saltcedar and Russian olive, (USFWS 2004). These non-native species have the potential to greatly alter riparian and aquatic biodiversity, ecosystem processes, and landscape structure/dynamics (Crawford *et al.* 1996). High spring releases may benefit cottonwood regeneration and reduce human encroachment into riparian areas. Adverse effects may impact species such as the southwestern willow flycatcher through the loss of riparian habitat.

In the Rio Grande Valley, a large-scale conversion has occurred from bosque (riparian woodlands) dominated by Fremont cottonwood and/or native willows to either saltcedar and/or

Russian olive dominated stands (Howe and Knopf 1991, Crawford *et al.* 1993). Cox (1999) reports that 90% of New Mexico's bosque is heavily modified and remnants are dominated by three species of saltcedar, along with many other invasive species. This alteration in vegetation composition has assisted in eliminating the seasonal scouring floods needed to promote regeneration of native vegetation (Howe and Knopf 1991, Sprenger *et al.* 2002). Scouring floods are required to create bare substrates for seed germination, followed by sustained high moisture conditions for establishment (Muldavin *et al.* 2000). Flooding needs to occur in the spring (around mid-May to June) to facilitate seed dispersion and germination, and requires a functioning floodplain-river connection.

Several bird species with declining populations in eastern New Mexico utilize saltcedar habitats. These include the yellow-billed cuckoo (*Coccyzus americanus*), painted bunting (*Passerina ciris*), blue grosbeak (*Guiraca caerulea*), and mourning dove (*Zenaida macroura*) (Hunter *et al.* 1988, IWAG 2004, Williams, S.O. Personal Communication 2005). Prior to invasion by saltcedar, the lower Pecos River had few tall, mature stands of vegetation. Thus, these birds probably expanded their local ranges as saltcedar expanded, and saltcedar became important habitat.

Models developed by Durkin *et al.* (1995) indicate that as a consequence of hydrological controls, communities dominated by aggressive invasive species will replace much of the lowland native riparian vegetation in the floodplain of the Rio Grande. Along the Pecos River, saltcedar has been identified as a threat to the Emory's baccharis/alkali (*Baccharis emoryi*), Emory's baccharis/common threesquare, common threesquare monotype, and coyote willow/common threesquare plant community types (Milford *et al.* 2001).

Crawford *et al.* (1993) suggest that as cottonwoods die and hydrological controls prevent natural regeneration, much of the upper end of the middle Rio Grande will become dominated by Russian olive and Siberian elm (*Ulmus pumila*) and much of the lower Rio Grande by saltcedar. They have shown a 46% decline in the cottonwood forest and associated shrub lands between 1918 and 1989. During the same time period, approximately 17,833 ac (7,216 ha) of saltcedar were gained. This decrease in riparian habitat by invasive species is compounded by over-utilization of riparian resources by improper grazing (both livestock and wildlife), firewood collecting, and recreational use. Without management changes in the next 50 years, the middle Rio Grande may look much like the lower reach below Elephant Butte Reservoir where, after 80 years of hydrological controls, only a few small, remnant groves of cottonwood remain.

Restoration Practices

In the 1980s, riparian restoration generally consisted of planting native species, primarily cottonwood and willow on floodplain surfaces or terraces where trees had been previously cleared or were no longer regenerating (Swenson and Mullins 1985). Research and development of restoration techniques focused on ways to increase the survival of planted material (Anderson 1989). By the 1990s, a substantial body of research on the natural processes that structure western riparian ecosystems had accumulated (Friedman *et al.* 1997, Braatne *et al.* 1996). In addition, a number of restoration planting projects were largely unsuccessful, despite availability of detailed site evaluations and intensive management (Briggs 1992). As a result, today's restoration practitioners are placing a much greater emphasis on the importance of natural processes and self-sustainability when assessing potential restoration sites and evaluating approaches (Rood *et al.* 2003).

Riparian habitats may be adversely affected by well-intentioned restoration initiatives. Native riparian vegetative communities can be successfully restored using either natural flooding processes or artificial seeding and planting (Taylor and McDaniel 2003, Taylor and McDaniel 2004). Cottonwood populations can be adversely affected by flow alteration and channel degradation caused by dams, water diversions, and groundwater pumping. Sher *et al.* (2002) describe abiotic and biotic factors associated with successful reestablishment of cottonwood in floodplain forests through reinstatement of flooding. In-stream structures, channelization, bank modification, and riprap can be used to provide flood control, irrigation development, and wetland conversion. Many restoration projects using these methodologies have resulted in further site degradation and reduction in the functioning condition of the affected streams (Baker and Medina 1997).

Developments within the floodplain, such as levees, urban, agriculture, and water or transportation infrastructures, can constrain restoration of floodplain connectivity and dynamic geomorphic channel processes like bank erosion, lateral migration, and avulsion. Levees may serve as a physical line between lands that can be developed and those that cannot. Thus, considerable corridors exist for floodplain reconnection and increased movement of the channel (Fullerton and Batts 2003). Under current regulations, physical restoration in areas designated by the Federal Emergency Management Agency as floodways cannot cause a rise in the 100-year flood plain elevation. Conversely, regulations allow construction in the floodplain if the structures are elevated above the 100-year flood elevation. This can result in developments within the floodplain that conflict with potential restoration activities.

During riparian restoration projects, the identification of plant species appropriate for particular sites and planting locations within sites is difficult. This is because the flora of degraded riparian areas is usually not indicative of the communities these sites could support when hydrology and geomorphology are restored (DeWald and Steed 2003). These riparian re-vegetation efforts often produce only marginal results because the factors responsible for the initial degradation of the site often hamper or prevent establishment of artificially planted vegetation (Briggs 1995). Only after the sources of degradation are identified, can mitigation strategies be developed that will directly address the causes, not just the symptoms, of degradation (Briggs 1992).

Loss of Keystone Species
Probably the first significant event that caused alteration from their historic conditions in stream and riparian systems in New Mexico was the arrival of beaver trappers in the higher elevations in the early 1800s (Baker and Boren 2000). By the late 1800s, beavers (*Castor canadensis*) were in danger of extinction throughout the United States. Evidence suggests they were virtually eliminated from every stream in New Mexico except for small populations on the upper Rio Grande and San Juan drainages (Berghofer 1967). In the past, beaver dams played a significant role in reducing the velocity and energy of stream flow (Gurnell 1998, Naiman *et al.* 1988, Parker *et al.* 1985).

The sequence of pools created by their series of dams along low-order headwater streams served to mitigate disturbance to channel shape. These pools also affected water tables, promoted conditions conducive to establishment and maintenance of riparian vegetation, controlled nutrient cycling processes along the stream, and affected terrestrial and aquatic wildlife habitat. As the beaver and their dams disappeared, water tables fell, floods went unimpeded, stream flow and high runoff events contributed to channel down cutting and alteration of stream shape (Parker *et al.* 1985, Naiman *et al.* 1988). Breck *et al.* (2003) suggest that beaver herbivory should be considered in any plans to enhance cottonwood populations along regulated rivers.

Grazing Practices
Improper grazing practices have been identified as a factor that can negatively affect riparian systems in New Mexico (Carothers 1977, Kennedy 1977, Szaro 1989, Durkin *et al.* 1996). We defined improper grazing practices as those grazing practices that reduce long-term plant and animal productivity (Wilson and Macleod 1991). Improper grazing practices that alter infiltration and runoff patterns in upland areas may ultimately influences river flow regimes by increasing frequency and intensity of floods (Wallace 1992), especially when coupled with other processes that have similar outcomes. Major ecological effects from improper grazing (both livestock and wildlife) include invasion by exotics species (Sivinski *et al.* 1990, Busch and Scott 1995, Medina 1996), an increase in soil compaction, reduced vegetative cover, changes in species composition (Kauffinan and Krueger 1984, Szaro 1989), stream bank erosion, changes in channel morphologies, increased sediment transport, and the lowering of the surrounding water tables (Clary and Webster 1990, Krueper 1996).

Ecological costs of improper livestock and wildlife grazing are magnified when animals congregate in riparian ecosystems (Fleischner 1994). Noss and Cooperrider (1994) considered improper grazing to be the most important land management issue impacting southwestern riparian ecosystems. Kennedy (1977) noted that some grazing practices may change the primary plant species in southwest riparian zones. Davis (1977) concluded that improper livestock grazing was "probably the major factor contributing to the failure of riparian communities to propagate themselves." Likewise, both Carothers (1977) and Szaro (1989) concluded that improper livestock grazing might be the major cause of excessive habitat disturbances in riparian communities. In the Gila Basin, improper grazing of the upper watersheds and floodplain for the past 100+ years has been shown to negatively affect riparian vegetative composition, ecosystem function and ecosystem structure (Marlow and Pogacnik 1985, Medina 1986, Chaney *et al.* 1991, Krueper 1996, Ohmart 1996a, Shaw and Clary 1996). The ecological condition of riparian habitats in parts of the Gila watershed was addressed by Ohmart (1996a) who identified improper grazing as the major cause of degradation of stream banks and plant communities. In the Zuni Basin, poor grazing management in some areas along the Zuni River has allowed cattle to remove all the riparian vegetation from stream reaches (Propst 1999).

Many authors have provided suggestions that minimize adverse effects of livestock and wildlife grazing in riparian areas. These suggestions include: 1) improving grazing practices, 2) herding or fencing cattle away from streams, 3) reducing livestock numbers, 4) increasing the period of rest from grazing, 4) changing the kind or class of grazing animals, 5) managing riparian zones as “special use pastures”, 6) installing in-stream structures, and 7) range improvement practices such as salting, providing alternative water sources, fencing, and range riders (Kauffman and

Krueger 1984, Vallentine 1989, Armour *et al.* 1994, Elmore and Kauffman 1994, Belsky *et al*. 1999, Holechek *et al*. 2001). With improved livestock management, previously denuded stream banks may revegetate and erosion may decline (Elmore and Kauffman 1994). In some cases, complete removal of grazing may prolong recovery (Myers and Swanson 1995, 1996a, Ohmart 1996b). Restoration of degrading channel systems may only require exclusion of grazing (domestic animals and wildlife) for a few years (Medina 1996). However, Sarr *et al*. (1996) found that ten full years of livestock exclusion was necessary to reverse a negative trend and allow stream conditions to begin to improve. Further, all discussions of improved grazing systems reviewed by Belsky *et al.* (1999), allude to the best prescription for stream recovery is a long period of rest from livestock grazing. Even those who strongly believe grazing to be compatible with healthy riparian ecosystems point out that 2-15 years of total grazing exclusion is required to initiate the recovery process (Duff 1977, Skovlin 1984, Clary and Webster 1989, Elmore 1996, Clary *et al.* 1996). Others conclude that streams that are permanently protected from grazing have the highest probability of successful recovery (Claire and Storch 1977, Chaney *et al.* 1990, Bock *et al.* 1993, Armour *et al.* 1994, Fleischner 1994, Rhodes *et al.* 1994, Ohmart 1996b, Case and Kauffman 1997). Outcomes, however, may differ. Systems can recover quickly and predictably with livestock removal, fail to recover due to changes in system structure or function, or recover slowly and remain more sensitive to livestock use than they were before grazing was initiated.

Lucas *et al.* (2004) argue that the scientific literature has not adequately addressed the effects of livestock grazing on riparian areas in New Mexico. They argue that most available information is observational, anecdotal, based on un-replicated experiments, or compares heavily grazed areas to areas from which livestock have been completely excluded. Sarr (2002) provides recommendations for the improvement of riparian livestock exclosure research, which has left considerable scientific uncertainty due to popularization of relatively few studies, weak study designs, a poor understanding of the scales and mechanisms of ecosystem recovery, and selective, agenda-laden literature reviews advocating for or against public lands livestock grazing. As such, there is still a lot of information to be gained by investigating grazing issues in New Mexico.

Fire Management

Forest fires in riparian systems of the southwest have been increasing in number and severity, due to increased litter-layer fuel accumulations from reduced flooding events, and more frequent natural and anthropogenic ignition events (Molles *et al*. 1995, Ellis *et al.* 1998, Bess *et al.* 2002). Several studies have addressed aspects of fire in this region (Howe and Knopf 1991, Busch and Smith 1993, Busch 1995, Molles *et al.* 1995, Steuver 1997, Ellis *et al.* 1998, Molles *et al.* 1998, Ellis *et al.* 1999, Ellis 2001). As a result of enhanced fuel loads, the severity of fire has changed from relatively cool, slow-moving ground fires, to extremely hot, rapidly moving stand-replacement fires, which often leave only dead standing trees and a surface layer of mineral ash (Steuver 1997, Steuver *et al.* 1997).

Molles (1982) reported that frequent burns in the Santa Fe National Forest have resulted in long-term changes in riparian vegetation. Minshall *et al.* (1989, 2001) reported that removal of riparian vegetation, sediment movement, and channel restructuring were directly related to the percentage of the catchments burned. They concluded that these factors over-rode changes in temperature and nutrients in terms of their impacts on stream ecosystems.

Fires historically were not a primary disturbance factor in the floodplain bosque forests, but are currently a major disturbance factor (USFWS 2002). Some of the dominant trees, notably Fremont cottonwood and Rio Grande cottonwood are not considered to be fire-adapted (Busch 1995) and show neither resistance nor resilience to fires. Conservation of taxa that live in riparian habitat has been a dominant management paradigm for the past two decades, but this emphasis is often incompatible with increased use of fire and mechanical thinning for ecosystem restoration (Cissel *et al.* 1999, McKenzie *et al.* 2004).

Disease

Even though many diseases affect riparian hardwood species, little is known about their influence on riparian function. Diseases are primarily inciting factors in riparian decline because they tend to weaken rather than kill, making plants more susceptible to other factors (Obedzinski *et al*. 2001). An example is infection by true mistletoe (*Phoradendron macrophyllum*) in Arizona and New Mexico, which lowers the vigor of (and occasionally kills) riparian species such as cottonwood, ash (*Fraxinus* spp.), and sycamore (*Platanus occidentalis*) (Sinclair *et al*. 1987, Dahms and Geils 1997).

Regulatory Protection

As of 2002, no reserved right has been legally recognized for protecting the riparian functions of a federal reservation, such as a national forest (NAS 2002). The federal government has asserted reserved right claims to water for environmental purposes with limited success, primarily because the US Supreme Court has determined that the water claimed must be necessary to achieve the primary purpose(s) for which the reservation was expressly created. Thus, the Supreme Court upheld the need for water to protect the desert pupfish (*Cyprinodon* spp.) in a national monument specifically set aside for this purpose (*Cappaert v. United States* 1976). But it denied an in-stream flow right for the Rio Mimbres in the Gila National Forest on the basis that the primary purpose for which national forests were established was not for environmental protection (*United States v. New Mexico* 1978). This decision is odd given that the two primary purposes in the 1897 Organic Act are “securing favorable conditions of water flows and furnishing a continuous supply of timber.” In the future, it may be possible for the US Forest Service to convince a court that “favorable conditions of water flows,” and hence downstream yields of water, depend on streams and riparian areas that are in good functioning condition.

Arroyos and ephemeral drainages with riparian features, which do not contain saturated soil conditions, do not qualify as wetlands by the Army Corps of Engineers (ACOE) definition (Cockman and Pieper 1997, National Research Council 2002). Confusion about the different types of arroyos and lack of understanding of the riparian habitat functions and values of arroyos can result in treating riparian arroyos as a land management problem rather than an important natural resource warranting protection. The Albuquerque District of ACOE has recently made jurisdictional decisions regarding waters of the State of New Mexico in closed basins on the basis of application of the interstate commerce clause that included some waters, Pinos Altos Creek, December 15, 2004, and excluded others, such as Pinos Altos Creek, January 19, 2005, from protection under Section 404 of the Clean Water Act.

Information Gaps

There are several restoration plans for riparian habitats in New Mexico (see TetraTech 2004, Fullerton and Batts 2003), as well as numerous studies that have been conducted in riparian habitats. There are still many gaps in the information needed to conserve the riparian communities. Information gaps that may impair our ability to make informed conservation decisions are outlined below.

- There are only estimates for the acreage of riparian habitats in New Mexico, but some have suggested that during the last century New Mexico and Arizona lost an estimated 90% of their original riparian ecosystems (Krzysik 1990).
- Information is lacking on the temporal change of riparian areas at multiple scales.
- There are no quantitative estimates of the river flow parameters necessary to sustain native species and natural ecosystem functions.
- There is no hydrologic simulation model that facilitates examination of human-induced alterations to river flow regimes.
- Scientific literature does not adequately address the effects of livestock grazing on riparian areas in New Mexico (Lucas, *et al.* 2004). Riparian livestock exclosure research has left considerable scientific uncertainty (Sarr 2002).
- The spatial and temporal aspects of conflicts with land use practices and riparian ecosystem stability are poorly understood.
- We are unaware of economic incentives and policies that most effectively motivate stakeholders to protect ecological processes and maintain desired ecosystem functions or regimes.
- The response of riparian SGCN to human disturbances is poorly understood.
- The specific extent and effects of riparian fragmentation on SGCN are poorly understood.
- Environmental conditions or thresholds that limit populations of riparian SGCN are currently unknown.
- Abundance, distribution, and trend information is absent or sparse for many SGCN.
- Habitat needs of obligate riparian SGCN are poorly understood.
- Measurable parameters indicative of early stage, easily repairable degradation in riparian habitats have yet to be identified.

- Methodologies that might be employed to restore riparian habitats with low risk of further site degradation or functional impairment are undefined.

- The extent to which invasive species are altering riparian habitats and limiting populations of SGCN is unknown.

- We have only an incomplete understanding of the ecological functions of small streams and their riparian zones, particularly their roles in larger watershed and landscape contexts. This contributes to confusion and debate about the levels of riparian vegetation retention required along small streams for the purpose of protecting aquatic ecosystems, riparian wildlife, and water quality.

- Information on amphibian responses to fire and fuel reduction practices in riparian areas is needed due to potential declines of species and the implementation of new, more intensive fire management practices (Pilliod *et al.* 2003).

- Effect and extent of diseases, parasites, and pathogens on riparian communities and SGCN are poorly understood.

- Most of the high-elevation headwater streams where the montane riparian communities are found are located on federal lands such as national forests, wilderness areas, and national preserves. Comprehensive information is needed on the riparian condition and trends of all watersheds, although national forests in northern New Mexico have conducted watershed analyses on some headwater streams.

- The impacts and susceptibility of alpine riparian areas to climate change or drought is unknown.

- Although alpine riparian areas host a large number of species, the spatial extent, species composition, condition, and continuity of these riparian areas and wildlife species associated with alpine riparian areas are largely unknown.

- Information is lacking on riparian systems in the Estancia Basin, Salt Lakes Basin, Tularosa Basin, Brokeoff Basin, San Augustin Plains, Southwestern Basin, and Playas Valley Basin.

- Factors affecting riparian habitats in closed basins have not been inventoried.

- The ecological services provided by closed basin riparian habitats are poorly understood.

- Flow regimes of closed basin drainages necessary to support riparian habitats are unknown.

- It is unknown as to the degree and type of alterations of the natural flow regime of closed basin drainages that might be tolerated without jeopardizing the viability of native species and the ability of the aquatic ecosystem to provide valuable products and services.

- Information is lacking on methods to store and divert water from closed basin streams for human use so as to avoid degradation and simplification of aquatic systems.

- The potential recovery of cottonwood trees following prescribed or wildfires in the Rio Grande bosque needs to be better understood so that survival and recovery of cottonwood trees can be maximized following prescribed fires.

- Little information is currently available concerning the impact of forest fires on the litter-layer arthropod assemblage of the floodplain cottonwood bosque along the Rio Grande (Bess *et al.* 2002).

- The effects of fire (that stimulate rapid re-growth of saltcedar and Russian olive) on cottonwood and willow re-growth have not undergone enough long-term study to make definitive conclusions in the middle Rio Grande Valley (Fullerton and Batts 2003).

- Information on riparian condition is lacking for the Dry Cimarron River and South Canadian River.

- In response to public interest, the State Game Commission has directed that NMDGF determine the feasibility of reintroducing river otters to New Mexico. Knowledge is currently incomplete regarding the biological, ecological, social, and economic considerations needed to inform such an assessment.

Research, Survey, and Monitoring Needs

There are many potential research and survey projects that seek to address information gaps in riparian habitats in New Mexico. Additional research, survey, and monitoring needs that would assist conservation decisions for riparian habitats are detailed below.

- Studies should be conducted to estimate existing acreage of riparian habitats in New Mexico and determine their status and trends.

- Research is needed to determine environmental factors that influence floristic patterns at multiple spatial scales in riparian habitats in order to improve re-vegetation success in the restoration of degraded riparian areas.

- Further research is needed to develop effective methods of restoring riparian ecosystem-level processes and functions. Limited water supply presents serious challenges to riparian restoration efforts and has led to the development of innovative control and re-establishment approaches. Riparian sites have been restored using a variety of techniques ranging from flood management mimicking natural river hydrographs to artificial re-vegetation on sites where flood management is not possible (Taylor and McDaniel 2003).

- Restoration projects need to incorporate monitoring treatment effects on wildlife to determine outcomes of restoration effects (Block *et al.* 2001).

- Fundamental research is needed to ascertain the basic principles for protecting and restoring riparian zones and for maintaining stream structural and biotic integrity (Molles *et al.* 1998, Haeuber and Michener 1998).

- Research and survey work is needed to complete a consistent assessment of the health of all of New Mexico's riparian habitats in accordance with the Proper Functioning Condition (PFC) methodology employed by Bureau of Land Management, US Forest Service, and the US Natural Resources Conservation Service.

- Research is needed to identify useful indicators of biological integrity for riparian habitats for SGCN (Verner 1984, Adamus and Brandt 1990, Croonquist and Brooks 1991, Haeuber and Michener 1998, Molles *et al.* 1998, Cartron *et al.* 2003).

- Information is needed on aquatic invertebrates and stream condition which could augment existing riparian classification systems used by the US Forest Service to develop monitoring tools useful for more thoroughly and comprehensively assessing aquatic ecosystem health (Kennedy *et al.* 2000).

- Research is needed to understand the interactions between invasions of riparian habitats by alien plant species and physical processes and competitive interactions between these species and native riparian plant species. Further research is necessary at a variety of spatial and temporal scales before the dynamics of riparian invasions and their impacts can be properly understood.

- Research is needed on the actual consumptive use of water by saltcedar and increases in water availability that are possible through saltcedar control. Such control must consider the current habitat value of saltcedar for wildlife such as southwestern willow flycatcher (Hildebrandt and Ohmart 1982, Hunter *et al.* 1988, Ellis 1995, Sogge *et al.* 2003). These habitat affinities have been documented and need to be better understood in order to put invasive species control programs into context.

- Further research is needed regarding primary production-limitation models of riparian areas and the role of saltcedar and other riparian vegetation in detritivore energetics including the contribution of saltcedar to aquatic ecosystem energetics (Thompson *et al*. 2002).

- Studies are needed to investigate the extent of riparian fragmentation in New Mexico and how SGCN are affected by riparian fragmentation, especially in terms of their dispersal.

- Studies on the response of riparian SGCN to human disturbances and specific environmental conditions or thresholds that limit populations of riparian SGCN are needed. Studies that quantify SGCN abundance, distribution, and trend information are especially desirable.

- Research is needed to determine habitat associations of obligate riparian SGCN and assemblages in order to develop successful conservation actions (Farley *et al.* 1994, Zwank 1997, Schweitzer *et al.* 1998, Ellis *et al.* 1997; 2000; 2001, Cartron *et al.* 2003). This information should be incorporated into models of riparian ecosystem function studies of bird associations with riparian systems that have been conducted along the Gila River (Stoleson and Finch 2001).

- Research is needed to provide an understanding of habitat selection patterns and the ability to identify potential breeding areas for species such as the southwestern willow flycatcher. Conservation efforts may need to focus on protecting occupied patches and surrounding riparian forests and floodplain (Hatten and Paradzick 2003).

- Determine the affects of regulated flows on riparian systems where stabilization of flows by upstream dams has allowed invasion of woody vegetation on stream banks where seasonal flooding would normally have prevented or limited establishment of such vegetation. In such settings, a common policy question may be whether to restore at least some of the natural seasonality of flow.

- Determine the hydrogeomorphological processes that influence the structure of riparian plant communities, which in turn affect hydrology and fluvial geomorphology (Tickner *et al.* 2001).

- Livestock and wildlife grazing research programs are needed to evaluate the affects of grazing on riparian habitats and SGCN. These research programs should: 1) incorporate meta-analyses and critical reviews, 2) employ restoration ecology as a unifying conceptual framework, 3) develop long-term studies, 4) improve exclosure placement/design, and 5) contain a stronger commitment to collection of pretreatment data (Sarr 2002).

- Riparian areas may have different fire environments, regimes, and properties (frequency, severity, behavior, and extent) in riparian areas relative to upland areas. Additional data are needed to understand and clarify interactions between wildland fire and fire management on riparian ecosystems. Data are needed to understand how riparian zones affect spatial and temporal patterns of fires at the landscape scale (Ellis 2001, Bisson *et al*. 2003, Dwire and Kauffman 2003). An improved understanding of fire ecology and affects in riparian areas is needed to prescribe ecologically sound rehabilitation projects following fire.

- Comparative studies are needed to determine regional differences in the response of riparian systems and stream communities to wildfires. Studies of the affects of wildfires outside the Southwest have shown that fire disturbance on riparian forests and erosion from denuded catchments and stream banks have long-term affects on the community structure in lotic systems (Molles 1982, Minshall *et al.* 1989, Minshall *et al.* 2001, Earl and Blinn 2003, McKenzie *et al.* 2004). These conditions were not observed in the Gila National Forest (Earl and Blinn 2003).

- Research is needed that describes the magnitude, frequency, timing, duration, and rate of change of flow and the affects of hydrologic alterations between different types of riparian systems and locations within the watershed in order to make informed conservation decisions. Studies that provide initial estimates of ecosystem flow requirements for habitats and SGCN are especially desirable.

- Xeric riparian areas support plant species that do not grow on other sites and these areas appear to be essential habitat for a variety of wildlife species. However, little research has been done to identify and quantify plant or animal species occurring in or associated with ephemeral drainages. Studies are needed to determine the extent to which ephemeral drainages support unique species compared to adjacent upland habitats. A review of the literature by Cockman and Pieper (1997) indicated that only three studies had been conducted prior to 1997 on the vegetation of xeric riparian drainages in New Mexico (Browning 1989, Dick-Peddie and Hubbard 1977, Freeman and Dick-Peddie 1970). Other studies that address xeric riparian habitats in New Mexico include Kear 1991, Pase and Layser 1977, Raitt and Maze 1968, and Singh 1964.

- Identify the ecological services provided by closed basin riparian habitats that warrant their conservation. Determine ecological functions of closed basin riparian habitats that are integral to their health and integrity.

- Assess and quantify the closed basin drainage flow regimes necessary to support xeric riparian habitats.

- Develop assessment protocols that use natural flow characteristics as a reference for determining flow requirements of closed basin streams.

- Determine the degrees and types of natural flow regime alterations that can be tolerated by closed basin drainages without jeopardizing the viability of native species and the ability of the aquatic ecosystem to provide valuable products and services.

- Design an ecologically sustainable water management program that may store water in and divert water from closed basin streams for human purposes in a manner that does not cause aquatic ecosystems to degrade or simplify.

- Further studies are needed to determine the biological, ecological, social, and economic feasibility of re-establishing self-sustaining river otter populations within potentially suitable reaches of the Rio Grande, Rio Chama, Gila River, and San Francisco Rivers.

Desired Future Outcomes

The US Forest Service and Bureau of Land Management (BLM 2000) have clearly defined desired future outcomes for management of riparian habitats on their lands. In addition, Shaw and Finch (1996) outlined desired future outcomes for the upper and middle Rio Grande while Fullerton and Batts (2003) presented summaries of biological conditions of riparian zones along the entire Rio Grande from its headwaters south to the Texas border. Several plans have already identified nearer-term desired future conditions for these floodplains. The riparian and floodplain restoration plan for the San Acacia to San Marcial reach of the middle Rio Grande (TetraTech 2004) focuses on river ecosystem and river process enhancement rather than attempting to restore the river to a known or prescribed historical condition. The desired future outcomes described below are consistent with those identified by previous agencies or authors.

- Riparian habitats exist in the condition, connectivity and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Riparian habitats persist that provide important ecosystem functions and values such as modulating hydrologic processes, ground-water recharge, erosion control, water quality and quantity enhancement, SGCN habitat, and recreational opportunity (Mitsch and Gosselink 1986, Fry *et al.* 1994, Patten 1998, Arid West Water Quality Research Project 2002).

- Flow regimes (quantity, quality, timing, and temporal variability of water flow) persist that maintain the ecological integrity of riparian ecosystems.

- Sustainable riparian habitats with native plant communities persist as the result of local geomorphic settings and natural hydrologic disturbance regimes.

- Riparian habitats exhibit spatially complex channel morphology that provides optimum habitat for all species and a wide range of physical environments that maintain diverse and productive biological communities.

- Self-sustaining diverse riparian plant communities persist in which woody riparian plant establishment and mortality are consistent with each species' life history strategy. They culminate in early successional population structures and species diversity characteristics of undisturbed rivers.

- Most of New Mexico's riparian habitats persist in an "A-rated condition" of quality in accordance with the indicators described by Fullerton and Batts (2003). These indicators include:
    - The natural hydrologic regime is intact, including an unaltered floodplain.
    - There is no or little evidence of alteration due to drainage, flood control, irrigation canals, improper livestock grazing, digging, burning, mining, or vehicle use.
    - No or very few exotic species are present, and there is no potential for their expansion. Species composition is primarily of native species, with a diverse physiognomic structure.
    - Stream banks are not overly steep, and the channel has not been widened or stripped of vegetation by improper grazing.
    - Buffered from edge effects and small hydrology alterations.

- Xeric Riparian habitats continue to serve as storage areas for runoff and nutrients and provide erosion control, ground-water recharge, and maintain hydrologic connectivity between riparian arroyos and downstream drainages.

- The Rio Grande cottonwood bosque has a flow regime that generates late spring over-bank flooding intervals and events sufficient to promote periodic cottonwood/willow seedling germination in cleared, open parts of the active floodplain. Periodic wetting of the soil column occurs to ensure sustainable rates of key biotic processes such as litter decomposition, mineralization, nutrient uptake, and nutrient cycling (Fullerton and Batts 2003).

- The Rio Grande cottonwood bosque has groundwater tables no deeper than 10 ft (3 m) and is monitored by using shallow groundwater wells (piezometers) to track groundwater depths at restoration and reference sites (Fullerton and Batts 2003).

- The Rio Grande cottonwood bosque has a moderate soil salinity, which varies with soil type and groundwater table depth to facilitate native tree establishment and maintenance (Fullerton and Batts 2003).

- Cottonwood-willow plant communities along the Rio Grande downstream of Caballo Dam has a river channel aggraded to within 3-5 ft (1-1.5 m) of the present primary floodplain with a raised water table to within 3-5 ft (1-1.5 m) of the soil surface (Fullerton and Batts 2003).

- Simulated spring or early summer floods occur in cottonwood-willow plant communities along the Rio Grande downstream of Caballo Dam to recharge the overbanks, disperse seeds, rejuvenate the alluvial soils, and encourage screwbean mesquite (*Prosopis pubescens*)/wolfberry plant communities (Fullerton and Batts 2003).

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions and universities to design and implement the projects that will provide the information about riparian habitats and associated SGCN outlined in the Information Gap or Research, Survey, and Monitoring Needs sections above.

2. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that protect specific types of riparian areas essential to the maintenance of SGCN.

3. Work with state agencies, federal cooperators, and NGOs to develop a state-level program of wetland inventory, assessment, and monitoring, with associated function and value standards, and protection and enforcement mechanisms.

4. Work with federal and state agencies, private landowners, and NGOs to design and implement riparian habitat restoration projects. These may include either passive (stopping the causes of degradation) or active (manipulating) approaches at a watershed or landscape level.

5. Work with land management agencies, private land managers, and the agriculture industry to define and implement grazing methodologies on rangelands that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

6. Cooperate with federal and state agencies in the implementation of Endangered Species Recovery Plans that address riparian restoration or management.

7. Work with federal and state agencies and private landowners to design and implement projects that restrict off road vehicle travel in sensitive riparian areas.

8. Work with federal and state agencies and private landowners to integrate fire and fuels management with riparian ecosystem conservation. To protect riparian ecosystems, it will be important to: 1) accommodate fire-related and other ecological processes that maintain riparian habitats and biodiversity, and not simply control fires or fuels, 2) prioritize projects according to risks and opportunities for fire control and the protection of aquatic ecosystems, and 3) develop consistency in management and regulatory process (Bisson *et al.* 2003).

9. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that reduce current fuel loads. This may be accomplished by restoring flooding or by mechanical removal to lessen the impact of fires on riparian forests along the Rio Grande (Ellis 2001).

10. Cooperate with state agencies to pursue measures to improve management of water. New Mexico water law can allocate scarce water resources among competing uses to promote economic growth and environmental sustainability. With the establishment of protections for riparian areas and in-stream flows, the state can also fulfill its fiduciary responsibilities to the public trust.

11. Collaborate in the re-introduction of beaver, where the potential for conflicts with other land uses is minimal. These re-introductions can be important tools in the restoration of riparian ecosystems (Baker and Cade 1995, McKinstry *et al*. 2001).

12. Support administrative or legislative action necessary to conserve riparian habitats.

13. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that establish a flow regime downstream of reservoirs. These flows should mimic some of the high-flow dynamics of the original river system that could serve as a major restoration tool for successful maintenance of gallery forests associated with the Rio Grande. Cottonwood re-establishment on the middle Rio Grande since 1993 shows that simulated flooding has led to the regeneration of riparian vegetation (Crawford *et al.* 1996).

14. Work with federal and state agencies, private landowners, NGOs, to include applicable portions of the *Conceptual Restoration Plan, Active Floodplain of the Rio Grande, San Acacia to San Marcial* (TetraTech 2004) as a model for riparian restoration efforts elsewhere along the Rio Grande and other locations in which large river floodplain restoration is taking place or is being considered.

15. Work with federal and state agencies, private landowners, and NGOs to incorporate stream flow requirements into restoration and management plans. This includes:

    - Producing quantitative estimates of key aspects of river flow necessary to sustain native species and natural ecosystem functions.

    - Developing and running hydrologic simulation models that facilitate examination of human-induced alterations to river flow regimes.

    - Identifying incompatibilities between human and ecosystem needs with particular attention to their spatial and temporal character.

    - Developing collaborative solutions to resolve incompatibilities.

    - Developing adaptive management programs to facilitate ecologically sustainable water management for the long term.

    - Developing economic incentives that influence policies and the actions of stakeholders to protect the ecological processes that maintain desired ecosystem functions or regimes.

16. Provide education regarding the value of riparian systems to specific types of landowners, managers, or federal lands lessees, such as ranchers, farmers, timber industry companies, mining industry companies, oil and gas companies, utility companies, transportation agencies, developers, federal water management agencies, irrigation districts, conservancy districts, acequia associations, tribes, pueblos, watershed groups, state and county planners, counties, municipalities, and legislators. Educating the general public can build support for riparian conservation and restoration efforts and increase public environmental awareness. Planning or implementation of specific actions in riparian areas can only be influenced if the entity planning or undertaking the action

understands the value of riparian systems and has sufficient information to carry out actions in appropriate ways that minimize or avoid adverse effects.

17. Insure that valuable riparian and wetland habitat protection guidelines are consulted and applied. The NMDGF, Environmental Protection Agency, and ACOE have produced several such guidelines. Cities, counties, extension services, state agencies, and federal agencies have produced manuals or handbooks describing best management practices specifically designed for riparian protection.

18. Insure technology transfer and sharing of scientific findings from research on riparian restoration projects is occurring. This should include using the NMDGF maintained BISON-M System that produces state-of-knowledge syntheses of species life history, and periodically updates them as new information accumulates.

19. Encourage riparian restoration approaches that employ a combination of replacing elements and processes, as opposed to replacing elements alone.

20. Riparian ecosystem management should be driven by adaptability through monitoring, and based on sound information of ecological processes that sustain ecosystem diversity and function (Christensen *et al*. 1996). It is essential that biologists emphasize the processes that sustain important faunal components of stream system diversity (Bodie 2001).

21. Identify and implement land management policies, standards, and guidelines that recognize xeric riparian communities as an important natural resource and conserve their functions and values.

22. Work with state agencies, federal cooperators, NGOs and affected interests to develop a state level program of inventory, assessment, and monitoring for xeric riparian habitats that establishes function and value standards and protection and enforcement mechanisms.

23. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that address restoration goals identified in Fullerton and Batts (2003) for the upper montane/sub-alpine riparian forest and woodland ecological system of the upper Rio Grande including:

    - Managing for sustainable resource use.
    - Minimizing or reducing vehicular stream crossings where feasible.
    - Re-establishing floodplain/river connections to create or enhance over-bank flooding to mimic historic levels.
    - Restoring the historic hydrologic regime, including timing, duration, and magnitude of historic peak flows and late season draw-down periods.

- Employing passive restoration where feasible with pole planting of narrowleaf cottonwood and willow in disturbed areas.
- Eliminating or minimizing the impact of non-native species.
- Supporting spring flooding for seed dispersion and germination.

24. Create riparian restoration opportunities by establishing favorable hydro-geomorphic conditions in the Rio Grande (TetraTech 2004). Such opportunities may take the form of providing a greater range of flow regimes, returning to a higher level of river dynamic behavior, removing constraints on channel processes such as invasive vegetation, expanding the active floodplain, increasing channel floodplain connectivity, physical reformation of the channel geometry, enhancement of the riparian system and management of the sediment load.

25. Support and cooperate with ongoing restoration efforts that implement techniques developed or evaluated as part of the Albuquerque Overbank Project.

26. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that address restoration goals identified in Fullerton and Batts (2003) for the Rio Grande cottonwood bosque, which include:

    - Creating mosaics of uneven-aged stands of native woody vegetation in parts of the active floodplain where periodic (but not necessarily annual) over-bank flooding or groundwater seepage in late spring can be expected to occur. Activities may include: 1) various combinations of removing and/or containing introduced tree species, 2) removing senescent or poorly growing native tree species, and 3) clearing and lowering selected near-bank sites to allow for flooding or groundwater seepage. These activities will help reduce the current heavy fuel loads in much of the bosque and create open spaces that, if well managed, will reduce evapo-transpiration at restoration sites.
    - Continue with ongoing fuel reduction efforts that include removal of dead and downed wood but retaining old dead cottonwoods that balance wildlife benefits and wildfire costs.
    - Improving hydrologic connectivity between restoration sites and the river by creating shallow side channels in the lowered near-bank sites.
    - Devising strategies for alternative soil wetting by pumping from shallow groundwater wells, irrigation return flows, or riverside drains.
    - Applying carefully developed monitoring protocols to both restoration and reference (control) sites. These protocols will undoubtedly vary according to

specific restoration objectives, but should include procedures already demonstrated to effectively track the biological affects of flooding and seepage on the bosque.

27. Work with federal and state agencies, private landowners, NGOs, and research institutions and universities to design and implement projects that address restoration goals identified in Fullerton and Batts (2003) for cottonwood/willow and screwbean mesquite/wolfberry plant communities along the Rio Grande downstream of Caballo Dam, which include reversing floodplain salinity with over-bank flooding and reversing stream entrenchment.

28. Collaborate with the Habitat Restoration Sub-committee of the Middle Rio Grande Endangered Species Act Collaborative Program in developing reach-specific habitat restoration plans, which will evaluate current habitat conditions in greater detail, define opportunities for improvement, and establish priorities for habitat restoration sites and/or activities along the defined priority reaches.

29. Support and encourage the use of restoration methods and techniques developed at the Bosque Del Apache National Wildlife Refuge.

30. Work with federal and state agencies and private landowners to design and implement saltcedar control treatments within areas along the Pecos River occupied by yellow-billed cuckoos and other declining species to avoid adverse impacts during their breeding season.

STATEWIDE DISTRIBUTED EPHEMERAL HABITATS AND PERENNIAL TANKS

In New Mexico, many diverse aquatic habitat types occur in geographically isolated, and closed (endorheic) basins. The most prominent basins include the Tularosa, Mimbres, Estancia, San Augustine, Salt, Southwestern, and North Plains (NMDGF 2003). More than 84 mi (135 km) of perennial rivers and 3,900 mi (6,276 km) of intermittent streams exist within the state's closed basins. Associated key aquatic habitats include ephemeral natural catchments, ephemeral marsh/cienegas, ephemeral 1st and 2nd order streams, ephemeral man-made catchments, and perennial tanks (Fig. 5-8).

For reasons of similarity, ephemeral natural catchments, ephemeral marsh/cienegas, and ephemeral 1st and 2nd order streams are collectively addressed under the heading Geographically Isolated Wetlands. "Geographically Isolated Wetlands" refers to wetlands that are completely surrounded by upland at the local scale (Tiner 2003). However, for this document, we included large endorheic basins, complexes of wetlands within a single basin, and individual isolated wetlands.

Geographically isolated wetlands and waters of closed basins have designated uses for fish and wildlife indigenous to New Mexico under Sections 20.6.4.801-805, NMAC 1978 (as amended in 2005) of the State Standards for Interstate and Intrastate Surface Waters. They provide a suite of functions and services (such as valuable commodities derived by natural processes) that benefit society (Bolen *et al.* 1989, Costanza *et al.* 1997, Tiner *et al.* 2002, Mitsch and Gosselink 2000, Leibowitz 2003, Smith 2003). In New Mexico, these functions and services are inextricably linked to intrastate, interstate, and foreign commerce by providing areas valued by hunters, anglers, and recreationists (NMDGF 2003). Hydrologic and mineral resources extracted from waters and wetlands of isolated basins in New Mexico provide significant sources of revenue for the state and private industries such as oil and gas extraction, potash mining, agriculture and livestock.

Species of Greatest Conservation Need

Of the 867 species of vertebrates known to occur in New Mexico, approximately 479 (55%) rely wholly, or in part on aquatic, riparian or wetland habitat for their survival (NMDGF 1994a). Nearly 25% (30 of 118) of the species and subspecies of wildlife listed as threatened and endangered in New Mexico (NMDGF 2004a) are restricted to or occur in wetlands, riparian areas, and waters of closed basins (NMDGF 2003).

Approximately 59 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, are associated with geographically isolated wetlands, ephemeral man-made catchments, and perennial tanks (Table 5-10). Of these 59 species, 23 (39%) are considered vulnerable, imperiled, or critically imperiled both statewide and nationally. An additional 25 (42%) species are nationally secure, but are considered vulnerable, imperiled, or critically imperiled in New Mexico, and 11 species (19%) are secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Additional conservation concerns for taxa listed in Table 5-10 are addressed in the riparian habitat and/or key terrestrial habitat discussion.

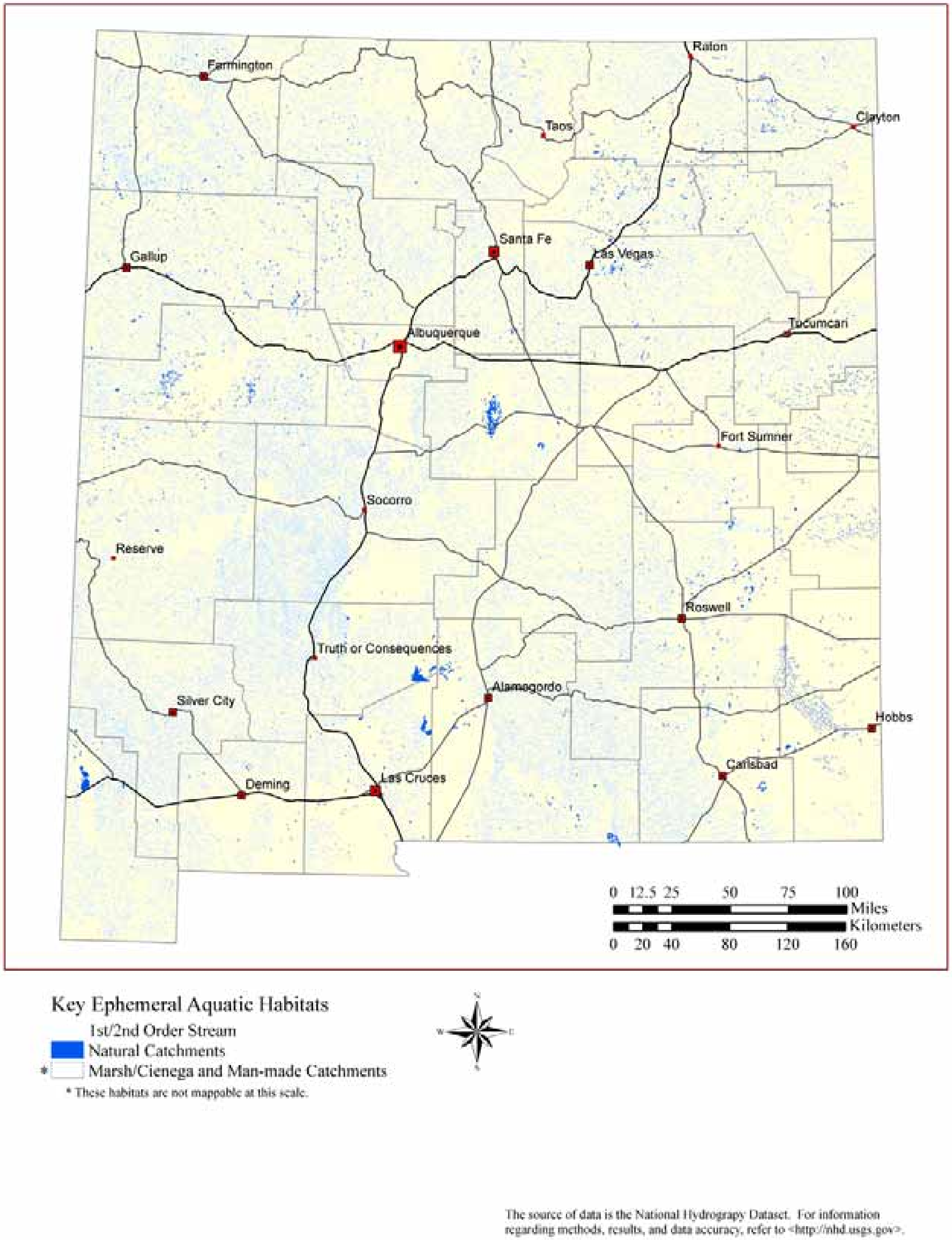


Figure 5-8. Key statewide aquatic habitats in New Mexico. Ephemeral marsh/cienega and man-made catchments are not shown.

Table 5-10. Species of Greatest Conservation Need associated with ephemeral aquatic habitats and perennial tank habitats in New Mexico.

	Perennial	*Ephemeral*			
Common Name or Scientific Name[1]	Tank	1^{st} and 2^{nd} Order Stream	Marsh/ Cienega	Man-made Catchments	Natural Catchments
Birds[2]					
American Bittern			X		X
Common Black-Hawk	X		X		
Sandhill Crane					X
Northern Pintail	X		X	X	X
Bald Eagle	X		X	X	X
Peregrine Falcon			X		
Southwestern Willow Flycatcher			X		
Eared Grebe	X				X
Northern Harrier			X		
White-Faced Ibis	X		X	X	X
Wilson's Phalarope	X		X	X	X
Interior Least Tern	X				
Mammals[2]					
Allen's Big-Eared Bat	X				
Pocketed Free-Tailed Bat	X				
Western Red Bat	X				
Spotted Bat	X				
NM Meadow Jumping Mouse			X		
Desert Bighorn Sheep	X		X	X	X
Prairie Vole			X		
Amphibian[2]					
Western Chorus Frog	X	X	X	X	X
Chiricahua Leopard Frog	X		X	X	X
Lowland Leopard Frog		X			
Northern Leopard Frog	X		X	X	X
Plains Leopard Frog	X			X	X
Rio Grande Leopard Frog	X				
Tiger Salamander	X		X	X	X
Arizona Toad		X		X	X
Colorado River Toad				X	X
Great Plains Narrowmouth Toad				X	X
Reptiles[2]					
Arid Land Ribbon Snake	X	X	X		X
Western Painted Turtle	X				
Big Bend Slider	X				
Mexican Garter Snake				X	
Sonoran Mud Turtle	X		X	X	X

Table 5-10 Cont.

	Perennial	*Ephemeral*			
Common Name or Scientific Name[1]	Tank	1st and 2nd Order Stream	Marsh/ Cienega	Man-made Catchments	Natural Catchments
Molluscs					
Wrinkled Marshsnail			X	X	X
New Mexico Ramshorn Snail		X			X
Crustaceans					
Brine Shrimp					X
Colorado Fairy Shrimp					X
Versatile Fairy Shrimp					X
Akali Fairy Shrimp					X
Packard's Fairy Shrimp					X
Cyzicus sp. (mexicanus?)				X	X
Eocyzicus concavus					X
Eocyzicus digueti				X	X
Knobblip Fairy Shrimp					X
Eulimnadia antlei					X
Eulimnadia cylindrova				X	X
Eulimnadia diversa				X	X
Eulimnadia follismilis				X	
Eulimnadia texana				X	X
Lepidurus lemmoni					X
Sublette's Fairy Shrimp					X
Moore's Fairy Shrimp				X	X
Streptocephalus n. sp. 1				X	X
Streptocephalus n. sp. 2				X	X
Great Plains Fairy Shrimp				X	X
Mexican Beavertail Fairy Shrimp				X	X
Beavertail Fairy Shrimp				X	X
Tadpole Shrimp				X	X

1 Scientific names are provided where common names for the species does not exist.
2 Conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats and/or Ecoregion and terrestrial habitat sections.

Many upland and big game species, threatened and endangered species, and non-game species have essential aspects of their life history linked to geographically isolated wetlands (NMDGF 2003). Ephemeral natural catchments such as playas and salt basins and their associated watersheds are considered self-contained, functional ecosystems (Belk 1998, Leibotwitz and Nadeau 2003, Tiner 2003) that provide habitats for a broad spectrum of plant and wildlife species (NatureServe 2004a). They serve as important feeding, resting and breeding areas for resident and migratory water birds (Ducks Unlimited 2001, Sibbing 2004) and support a great diversity of New Mexico’s SGCN.

All SGCN large branchiopod crustaceans (fairy shrimp, clam shrimp, and tadpole shrimp) are obligate aquatic species whose persistence across the landscape is wholly dependent on geographically isolated ephemeral wetlands. They do not occur in perennial waters. These crustaceans are important links in the aquatic food web of ephemeral wetlands (Proctor 1964, Silveira 1988, Thièry *et al.* 1989, Graham 1994, Woodward and Kiesecker 1994, Moorhead *et al.* 1998, Eriksen and Belk 1999, Wissinger *et al.* 1999). Branchiopod crustaceans rely on a seasonal hydrologic regime to complete their life cycle. The resting cysts (eggs) endure harsh environmental conditions during their dormant period of habitat desiccation. Under natural conditions, the diapausing (resting) cyst bank can remain dormant in sediments from 1 to 20 years or longer until the next period of inundation (Steiert 1995, Belk 1998). Because they are obligate aquatic macro-invertebrates, the presence and persistence of large branchiopods in ephemeral wetlands serves as a biological indicator of aquatic ecosystem health (Lackey 1995). Further, they indicate the integrity (Callicott 1994) and ultimately the affects of land use practices in the surrounding landscape.

The knobblip fairy shrimp (*Eubranchipus bundyi*), Colorado fairy shrimp (*Branchinecta coloradensis*), and Packard's fairy shrimp (*B. packardi*) are anostracans that are known from seasonally astatic, cool to cold-water habitats at high elevations of 7,500-9,370 ft (2,286-2,856 m). These species occur in, or near areas of mixed conifers in isolated wetlands of northern and west-central New Mexico (Lang and Rogers 2002, Lang 2005, Rogers *et al.* In Review). Several other species of fairy shrimp (*Streptocephalus dorothae*, *S. mackini*, *S. texanus*, *Thamnocephalus platyurus*), clam shrimp, and the tadpole shrimp (*Triops* sp.) occur rather ubiquitously in warm to cool water pools at low to moderate elevations in diverse ecoregions such as the Apache Highlands, Shortgrass Prairie, and Chihuahuan Desert (Sublette and Sublette 1967, Lang and Rogers 2002, Rogers *et al*. In Review). Moore's fairy shrimp (*Streptocephalus moorei*) and Mexican beavertail fairy shrimp (*Thamnocephalus mexicanus*) can be considered naturalized in the Chihuahuan Desert. They occur sporadically in warm water basins, dirt stock tanks, and pit tanks dug into alkali playas (Lang and Rogers 2002, Rogers *et al.* In Review). The brine shrimp, (*Artemia franciscana*), is common in astatic brackish to saline playas of eastern Eddy and Lea counties, e.g., Great Salt Lake, Williams Sink, Middle Lake, Laguna Walden (Davis and Hopkins 1993), Chaves County, e.g., Bitter Lake National Wildlife Refuge (Rogers *et al.* In Review), Doña Ana County, e.g., Lake Lucero and White Sands National Monument (Patrick *et al.* 1977), Grant County (Lang and Rogers 2002), and in the Laguna del Perro playa basin complex of Torrance County (Davis *et al.* 1996a).

In New Mexico unique records of large branchiopods documented by Lang and Rogers (2002) and Rogers *et al.* (In Review) include: 1) The International Union for the Conservation of Nature and Natural Resources (IUCN) (1994, 1996) endangered Moore's fairy shrimp and Sublette's fairy shrimp (*Phallocryptus sublettei*), 2) two new streptocephalid fairy shrimps; and 3) the first North American records of a Venezuelan clam shrimp tentatively identified as *Eulimnadia follisimilis*. Lang and Rogers (2002) identified specific sites that provide unique natural ephemeral wetland habitats for large branchiopod crustaceans and migratory water birds. Some of these areas are in *New Mexico Wetlands 1996* (NMEMNRD 1996) and the *New Mexico 2000 Wetlands Conservation Plan* (NMED 2000), and include the BLM Lordsburg Playa Special Management Area in Hidalgo County, BLM Alkali Lakes Area of Critical Concern in Otero County, and Laguna del Perro Salt Lakes in Torrance County.

Similar to natural catchments, ephemeral marshes and cienegas provide habitat for at risk wildlife in New Mexico. The state endangered wrinkled marshsnail (*Stagnicola caperata*) occurs in high-elevation ephemeral marsh/cienega habitats in the Valle Grande, Valles Caldera National Preserve, Sandoval County (Lang 2005). This species, like other molluscs (pulmonate aquatic and land snails, and sphaeriid clams), survive periods of inclement weather by burrowing into mesic soils. Currently, the New Mexico ramshorn snail (*Pecosorbis kansasensis*) (Taylor 1985) is known from exposed sedimentary rock (fractures, rock pools) in mesic, ephemeral drainages from 3,125 - 4,685 feet elevation in Chaves, Eddy, Guadalupe, Lincoln, Otero, and San Miguel counties (Smartt 1988). In such habitats, this species occurred commonly with aquatic insect larvae and large branchiopod crustaceans.

Ephemeral man-made catchments provide habitat suitable for a suite of SGCN that are considered ephemeral wetlands obligates (aquatic macro-invertebrates), and taxa that have requirements of both wet and dry conditions (amphibians, reptiles). Man-made catchments also provide habitat for SGCN that migrate between wetlands, such as water birds (Leibotwitz and Nadeau 2003, NMDGF 2003). Several branchiopod crustaceans occur commonly in ephemeral man-made catchments (Eng *et al.* 1990, Lang and Rogers 2002). In New Mexico, unique records of these crustaceans occurring in this habitat type include: the knobblip fairy shrimp from Clayton Corral Tank in the Valle Vidal, Carson National Forest; two new streptocephalid fairy shrimps; and the first North American records of a Venezuelan clam shrimp tentatively identified as *Eulimnadia follisimilis* (Rogers *et al.* In Review). Lang (2005) reported the state endangered wrinkled marshsnail in a roadside pool in Taos County.

Many amphibians and reptiles depend upon ephemeral man-made catchments, including the tiger salamander, Colorado river toad (*Bufo alvarius*), Arizona toad (*Bufo microscaphus*), mountain treefrog (*Hyla eximia*), western chorus frog (*Pseudacris triseriata*), Rio Grande leopard frog (*Rana berlandieri*), plains leopard frog (*R. blairi*), Chiricahua leopard frog (*R. chiricahuensis*), northern leopard frog (*Rana pipiens*), lowland leopard frog (*R. yavapaiensis*), and the Sonoran mud turtle (*Kinosternon sonoriense*) (Degenhardt *et al.* 1996). Summer monsoon rains fill catchments and stimulate breeding for these and numerous other amphibians. In southwestern New Mexico, the Sonoran mud turtle lives in these sites until seasonal drought causes drying and forces the turtle to move into the terrestrial habitats and seek other aquatic habitats or aestivate until the catchments once again fill with water. The western chorus frog and northern leopard frog also live in ephemeral marshes and cienegas, where they breed in shallow aquatic habitat formed by early spring rains or snowmelt. Tiger salamanders (*Ambystoma tigrinum*) may also breed in these habitats although suitable aquatic habitat is generally limiting.

Perennial tanks that do not support large populations of non-native predators (such as sunfish and catfish) afford important habitat stability for leopard frogs (Rio Grande, Chiricahua, and northern) western chorus frogs, and tiger salamanders. Tanks may also provide suitable habitat for the American bullfrog (*R. catesbeiana*), which is widespread in the muddy-bottomed freshwater habitats below 6,889 ft (2,100 m) in New Mexico. This voracious, non-native predator has been implicated in the decline of *Ranid* frogs in New Mexico and elsewhere (Degenhardt *et al.* 1996).

Geographically Isolated Wetlands

Ephemeral natural catchments, ephemeral marshes/cienegas, and ephemeral 1st and 2nd order streams share many similarities regarding the factors that adversely affect them, including information gaps, research, survey, and monitoring needs, desired future outcomes, and conservation actions. Thus, to avoid redundancy, we have elected to address these key habitats collectively as Geographically Isolated Wetlands.

Habitat Condition

The hydrology of ephemeral natural catchments is driven entirely by seasonal and localized precipitation patterns. Each isolated depression is filled by snowmelt or rainfall captured within the adjacent upland (watershed). The hydroperiod may vary from seasonally astatic pools that fill and desiccate one or more times during any year (or not at all during prolonged drought periods) to perennial sites that fluctuate significantly during the year (Eriksen and Belk 1999). These isolated wetlands may lack a hydrologic connection to other wetlands, or they may be connected to other waters through groundwater with occasional surface water connections (Tiner *et al.* 2002, Leibowitz and Nadeau 2003). Plants may or may not develop in ephemeral natural catchments depending on soil conditions, duration of hydroperiod, and the hydrochemical environment (Bradley *et al.* 1998, Muldavin *et al.* 2000, Smith 2003).

Ephemeral natural catchments are recognized for their importance for a variety of uses. They have biological significance as wildlife habitat (Simpson *et al.* 1981, Guthery 1981, Silveira 1988, Bolen *et al.* 1989, Cole 1996, Anderson 1997, Lang and Rogers 2002, Rogers *et al.* (In Review), NMDGF 2003, Smith 2003, Tiner *et al.* 2002, Sibbing 2004). They provide recharge points to groundwater aquifers, and positively affect water quality (Osterkamp and Wood 1987, Zartman 1987, Zartman *et al.* 1994, Gustavson *et al.* 1995, Leibowtiz and Nadeau 2003, Whigham and Jordan 2003). Ephemeral natural catchments also provide anthropogenic uses, such as seasonal water storage and surface water sources for livestock and irrigation (Branson *et al.* 1981, NMED 2000, NMDGF 2003, New 1979, Fish *et al.* 2002). This water source can increase agricultural productivity and function as catchment basins for point and non-point source discharges such as those from sediment traps, livestock feed lots, municipal waste facilities, potash production, and oil and gas field operations (Pence 1981, Irwin *et al.* 1996, Davis and Hopkins 1993, Dein *et al.* 1997, Bristol 1999, Luo *et al.* 1997, Bolen *et al.* 1989, Smith 2003).

In arid New Mexico, ephemeral marsh and cienega habitats are most common at higher elevations of inter-montane basins where wet meadows and grasslands promote prolonged periods of snowmelt and run-off. At lower elevations, rain filled depressions, often underlain by a clay or caliche hardpan, hold water for sufficient duration to promote growth of wetland plant communities. At the same time, they provide habitat for wildlife species tolerant of wet and dry periods. Intermittent streams convey run-off waters that recharge groundwater aquifers. Ephemeral 1st and 2nd order streams are also hydrologically connected to ephemeral natural and man-made catchments that retain seasonal surface water utilized wildlife and livestock.

In the wetlands and waters of isolated basins, discharge practices associated with agriculture and livestock management, municipal waste and storm water run-off management, and extractive-use industries have resulted in contamination of ground and surface water (Boyer 1986, Rail 1989, McQuillan and Parker 2000). Such practices have impaired aquatic ecosystem functions (Davis and Hopkins 1993, Davis *et al.* 1996a, 1996b), and caused wildlife mortality (Dein *et al.* 1997, Bristol 1999, Lang and Rogers 2002).

Invasive and non-native plants and animals have been identified as a concern in the ephemeral natural catchments of the Tularosa Basin. Further, the decline in leopard frog populations is likely due to chytrid fungal infections.

Problems Affecting Habitats or Species

Ephemeral natural catchments were the aquatic key habitat that was most likely to be altered by cumulative factors in New Mexico (Chapter 4; Fig. 4-6). The other geographically isolated wetland types also had high cumulative factors that are likely to alter these habitats. Factors that adversely influence geographically isolated wetlands include: 1) habitat conversion (altered hydroperiod, sediment load), 2) abiotic resource use (oil/gas exploration and development, mining, dewatering), 3) pollution (toxic and solid waste), 4) consumptive biological use (improper grazing practices), and 5) modification of natural processes (drought and fire management). See Chapter 4 for a discussion of these factors. Additional factors that influence geographically isolated wetlands are detailed below.

Habitat Conversion
Any type of habitat conversion in geographically isolated wetlands (such as filling, dredging, draining, water discharges, etc.) that alters the hydroperiod of a given isolated catchment can result in the loss of ephemeral wetland abundance, a decrease in biotic diversity, reduced beneficial use by wildlife, and ecosystem dysfunction (New 1995, Belk 1998, Lang and Rogers 2002, Smith 2003).

For example, specific factors that influence the integrity of the New Mexico ramshorn snail include land-use practices that exacerbate arroyo entrenchment, sedimentation, and prolonged drought that could result in the extirpation of local populations. Similarly, populations of western chorus frog, lowland leopard frog, and the Arizona toad are influenced by fire management, invasion by non-native wildlife, and the spread of pathogens through increased recreational and commercial use (see Chapter 4).

Military Activities
Military maneuvers and related construction activities pose threats and loss of isolated populations of aquatic fauna that occur in ephemeral natural catchments on White Sands Missile Range (WSMR) and Holloman Air Force Bases (HAFB). The *Integrated Natural Resources Management Plans* for WSMR and HAFB, co-signed by the NMDGF and USFWS, attempt to mitigate potentially adverse affects of military maneuvers on significant natural resources.

Invasive Species

Invasive and non-native plants and animals have been identified as a concern in ephemeral natural catchments. The invasion of non-native species into such ecosystems can have adverse effects (Stohlgren *et al.* 1999). Invasive species have the ability to displace native plant and animal species, disrupt nutrient and fire cycles, and alter the character of the community by enhancing susceptibility to additional invasions (Cox 1999, Deloach *et al.* 2000, Zavaleta *et al.* 2001, Osborn *et al.* 2002). The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Legal Protection

Perhaps the most comprehensive factor affecting geographically isolated wetlands in the US is the loss of legal protection under the federal Clean Water Act (CWA). Protection was denied for "isolated, intrastate, non-navigable waters" of closed basins (such as ephemeral wetlands [catchments], streams, marsh/cienega, including perennial catchments and rivers). This followed the Supreme Court's ruling in the case of Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers (Corps) (Federal Register 2003). The protection of geographically isolated wetlands under the post-SWANCC wetlands regulatory regime emerges as a significant issue in New Mexico, where closed basins cover approximately 20% of the surface area of the state (NMDGF 2003). National policy directives issued by the Corps and Environmental Protection Agency in 2003 instructed field staff to begin withholding CWA protection to some 20 million ac (8 million ha) of wetlands nationwide (Sibbing 2004). In New Mexico, the Corps has already made decisions of non-jurisdiction regarding numerous isolated basins, including ephemeral and perennial waters in the Sacramento River and its tributaries in the Tularosa Basin (Tularosa River, its tributaries, Ysletano Canyon), the Mimbres River and tributaries, San Augustine Plains, Santa Clara Creek, Estancia Basin (Bachelor Draw), and Jornado del Muerto Basin (Sibbing 2004).

Pursuant to its statutory mandates, NMDGF actively manages 17 isolated wetlands (ponds, lakes) and five intermittent streams (Mimbres and Tularosa rivers, Running Water Draw, Three Rivers, and Tajique Creek) to provide fishing opportunities for anglers (NMDGF 2003). These cold and warm water fishery programs may be adversely affected by broad interpretations of the SWANCC decision.

Under the current post-SWANCC regulatory environment, New Mexico has no state-level wetlands permitting program to protect its most vulnerable waters. Moreover, the state's definition of "waters of the state" and surface water quality standards (NMAC 2000) are modeled after similar definitions and standards set forth under the CWA. Thus, "waters of the United States" in New Mexico that are no longer protected under the CWA may also lack state protection (NMDGF 2003, Sibbing 2004).

Information Gaps

Numerous information gaps regarding geographically isolated wetlands merit the attention of wetland scientists, policy-makers, and land/resource managers (Leibowitz and Nadeau 2003, NMDGF 2003, New Mexico Environment Department 2005).

- A clear definition of Clean Water Act language of “tributary”, “adjacency”, and “significant nexus” as they relate to federal and state wetland policies, regulations, and laws represents a significant information gap to refine jurisdictional authority over waters of the US and of the state.

- Explicit definitions are needed for geographically isolated wetland types in New Mexico.

- Comprehensive spatial data are lacking on the location, number, and total area of geographically isolated wetlands in New Mexico.

- Data are lacking on the biotic diversity of geographically isolated wetlands and waters of the state, especially for taxa that spend a significant part of their life history cycles in such habitats.

- Data are lacking on the types of wildlife that spend a significant part of their life cycles in waters of the US and the state, but also require isolated wetlands for their persistence across the landscape. Knowing the typical home ranges of these species would be useful to establish how far these organisms would be expected to travel between jurisdictional waters and geographically isolated wetlands.

- Fundamental information is lacking regarding the role of landscape scale interactions relative to the biotic and abiotic connectedness of geographically isolated wetlands and waters of the US and the state. How does geographic isolation and connectivity contribute to landscape function? Is isolation critical to the function of geographically isolated wetlands? How do isolated wetlands contribute to regional water quality?

- Studies are lacking that compare the diversity of geographically isolated wetlands relative to each other and to other aquatic and terrestrial ecosystems.

- The interrelationships of groundwater and surface waters of ephemeral natural catchments in the Tularosa Basin are poorly known. This lack of information raises concern for this habitat type regarding plans for water development projects (such as desalinization plants or water supply for Alamogordo) within the basin.

- The existing environmental conditions or thresholds that preclude populations of SGCN are unknown.

- Information is needed about the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN in Geographically Isolated Wetlands.

Research, Survey, and Monitoring Needs

Under the current post-SWANCC regulatory environment, the future condition of geographically isolated wetlands in New Mexico is contingent upon providing legal authorities and policymakers with sound scientific data to reform current interpretations of state and federal laws and policies that were originally developed to protect geographically isolated wetlands. Research or survey efforts required to make informed conservation decisions are detailed below (Semlitsch 2000, Leibowitz and Nadeau 2003, NMDGF 2003, and New Mexico Environment Department 2005).

- Comprehensive spatial data designating the location, number, total area, and functional classification of geographically isolated wetlands would provide the foundation for monitoring impacts, quantifying wetland loss/gain, and facilitating risk assessment for these waters.

- Empirical studies are needed to examine and quantify how geographically isolated wetlands, wetland complexes, and other potentially impacted waters contribute hydrologically, chemically, and biologically to waters.

- Further research is needed that describes how geographically isolated wetlands contribute to regional water quality, particularly with respect to groundwater aquifers and waters.

- Studies that use landscape-level concepts to classify geographically isolated wetland types and compare their function(s) relative to the "isolation-connectivity" continuum should be a research priority.

- Research should analyze the relationship of biodiversity of geographically isolated wetlands to size, spatial distribution, and connectedness, and how the loss of wetlands at varying spatial scales affects metapopulation processes.

- Field methods are needed for relatively inexpensive and rapid techniques (RAPIDs) to classify geographically isolated wetlands by employing abiotic and biotic functional criteria.

- Studies are needed to develop a state wetland ranking system, more protective water quality standards, and well-defined mitigation measures for wetland resources that are outside of federal, state, and tribal jurisdictions.

- Studies are needed to quantify and compare the diversity of geographically isolated wetlands relative to each other and to other ecosystems.

- GIS-based biotic surveys statewide would serve to map the distribution and areal extent of geographically isolated wetlands and their associated SGCN. These data will also serve to assess at-risk wetlands and will facilitate monitoring of wetland loss and gain.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are ephemeral wetlands obligates, those taxa that have obligate requirements of both wet and dry conditions, and those SGCN that primarily utilize jurisdictional wetlands but migrate to and from geographically isolated wetlands.

- Spatially explicit data are needed on physiochemical and hydrologic conditions of geographically isolated wetlands.

- Determine the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN and identify methods to minimize impacts from non-native species.

- Research is needed to determine environmental conditions or thresholds that preclude populations of SGCN.

Desired Future Outcomes

Desired future outcomes for geographically isolated wetlands include:

- Geographically isolated wetlands persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- There is no net loss of geographically isolated wetlands in New Mexico.

- An expanded database (such as maps, data, etc.) exists for the New Mexico Wetlands Inventory.

- Improved water quality standards and mitigation requirements for geographically isolated wetlands are established and implemented.

- Refined definitions of “wetlands” and “waters of the state” are developed.

- Clarification of the terms “tributary”, “adjacency”, and “significant nexus” relative to jurisdictional waters and wetlands of the US and New Mexico are developed.

- Proactive *ad hoc* committees comprised of federal, state, tribal, municipal, NGOs, and citizen-based watershed groups are established to facilitate the conservation of geographically isolated wetlands and to improve the use of existing data management systems (such as STORET, New Mexico Natural Heritage Program Wetlands/Riparian Assessment Database).

- Management practices are developed and implemented that protects the ecological integrity of geographically isolated wetlands.

- The identification and adoption of RAPID methods to classify, rank, and assess geographically isolated wetlands are established and implemented.

- Wetlands regulatory program is established that provides state government full regulatory authority over all wetland types in New Mexico, including geographically isolated wetlands.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to create public awareness and understanding afforded by geographically isolated wetlands.

2. Work with appropriate state and federal entities and potentially affected interests to strengthen or develop state laws and policies that will protect the biotic and abiotic resources of geographically isolated wetlands.

3. Collaborate with federal and state agencies and affected publics to achieve a state goal of no net loss of geographically isolated wetlands as set forth under federal policy directives for waters of the US.

4. Encourage collaboration among state, federal, tribal, NGO's, and private land stewards to form playa alliances or wetlands working groups that develop and implement management practices to protect geographically isolated wetlands. Similar ecosystem-based approaches and integrated management strategies have gained momentum, with some measure of proven success, for the conservation of migratory waterfowl in North America (such as Playa Lakes Joint Venture, Ducks Unlimited, Inc., and the Rainwater Basin Joint Venture).

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and geographically isolated wetlands outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

6. Work with federal, state, and private agencies and institutions to improve and increase the use of existing data management systems for tracking information pertinent to geographically isolated wetlands statewide.

7. Adopt standardized intergovernmental monitoring and survey methods to track gains and losses of geographically isolated wetlands statewide.

8. Encourage public participation in state and federal incentive-based programs to protect, enhance, and restore geographically isolated wetlands. Such incentive-based programs include: Swampbuster, Wetlands Reserve Program, Landowner Incentive Program, among others (McKinstry *et al.* 2004).

9. Provide information to the USFWS to update the New Mexico National Wetland Inventory.

10. Collaborate with the New Mexico Environment Department's Wetland Program to improve program efficiency to protect, restore, conserve, and create geographically isolated wetlands while tracking these achievements into the future.

11. Work with the Valles Caldera National Preserve to locate and protect populations of SGCN that occur in high-elevation ephemeral marsh/cienega habitats (such as vernal grassland pools) on the preserve.

12. Establish collaborative relations among state, federal, tribal, NGO's, universities, and private landowner to leverage funding at levels adequate to protect, enhance, and restore geographically isolated wetlands.

Ephemeral Man-Made Catchments

Habitat Condition

Ephemeral man-made catchments that serve as reservoirs for run-off provide aquatic habitat suitable for exploitation by wildlife and livestock. In practical terms, it is the joint beneficial use of ephemeral man-made catchments that affords rangeland wildlife and livestock the essential elements of habitat, food, water, and shelter to meet their needs. The hydrologic regime of these man-made habitats is similar to that of ephemeral natural catchments. These areas are very dynamic environments, subject to disturbance by flash flooding, drying, sedimentation, and routine maintenance.

Problems Affecting Habitats or Species

The primary factors that adversely affect man-made catchments and their ability to sustain SGCN include: 1) habitat conversion (altered hydroperiod, sediments), 2) abiotic resource use (oil/gas exploration/development, dewatering), 3) pollution (agricultural chemicals, solid waste, and toxic waste), and 4) drought. Detailed discussions of these factors are presented in Chapter 4. An additional discussion on habitat conversion factors is provided below.

Habitat Conversion
Habitat conversion that alters the hydroperiod of a catchment can result in a loss of abundance, a decrease in biotic diversity, and reduced beneficial use by wildlife (Lang and Rogers 2002).

Since there is no regulatory authority over man-made “wetlands” in New Mexico, this aquatic habitat type is subject to any form of disturbance or alteration, except where a federally listed species may occur or an alteration may adversely impact ground or surface waters.

Information Gaps

There are numerous information gaps regarding ephemeral man-made catchments that merit the attention of biologists, policy-makers, and land/resource managers. Information gaps that impair our ability to make informed conservation decisions are described below.

- Comprehensive spatial data are lacking on the number and total area of ephemeral man-made catchments in New Mexico.

- Data are lacking on the biotic diversity of ephemeral man-made catchments.

- Data are lacking on the types of wildlife that spend a significant part of its life cycle in ephemeral man-made catchments. Knowing the typical home ranges of these species would be useful to establish how far these organisms would be expected to travel between jurisdictional waters and human-created wetlands.

- Differences and similarities between the biotic diversity of ephemeral natural catchments and ephemeral man-made catchments are unknown.

- The existing environmental conditions or thresholds that preclude populations of SGCN are unknown.

Research, Survey, and Monitoring Needs

Research or survey efforts required to make informed conservation decisions for ephemeral man-made catchments are detailed below.

- Comprehensive spatial data designating the number and total area of ephemeral man-made catchments would provide the foundation for mapping this habitat type.

- Research is needed to analyze the relationship of ephemeral man-made catchment biodiversity to size, spatial distribution, and connectedness, and how man-made catchments may affect wildlife metapopulation processes.

- Studies focused on wildlife use of ephemeral man-made catchments would provide the foundation for understanding the function of such systems across the landscape.

- Studies are needed to quantify and compare the biotic diversity of ephemeral man-made catchments relative to each other and to other wetland ecosystems.

- Research is needed to assess the feasibility of creating man-made catchments as wetland mitigation banks that conform to state and federal objectives pertaining to no net loss of natural wetlands.

- GIS-based biotic surveys statewide would serve to map the distribution and areal extent of ephemeral man-made catchments and their associated SGCN. These data will also serve to assess at-risk populations of SGCN known to utilize this aquatic habitat.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are ephemeral wetlands obligates (aquatic macroinvertebrates), those taxa that have obligate requirements of both wet and dry conditions (amphibians), and those SGCN that primarily utilize jurisdictional wetlands but migrate to and from this habitat type (birds).

- Spatially explicit data are needed on physicochemical and hydrologic conditions of ephemeral man-made catchments.

- Research is needed to determine environmental conditions or thresholds that preclude populations of SGCN.

Desired Future Outcomes

Attaining the following desired future conditions will require collaboration among state, federal, tribal, NGOs, and private land stewards to foster a working environment that promotes conservation and management of this resource.

- Ephemeral man-made catchments persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource conflicts.

- A GIS-based database with spatial information on the distribution, water quality, and biotic diversity of ephemeral man-made catchments is available to state and federal agencies, NGOs, and private land stewards.

- Recommended management practices are established and implemented to protect the ecological integrity and function of ephemeral man-made catchments.

- Incentive-based programs are developed and implemented that encourage private landowners to construct, operate, and maintain catchments with assurances that protect property rights while also protecting the habitat of associated SGCN. The Safe Harbor Agreement for the Chiricahua leopard frog represents one such example (see Federal Register 2002, Malpai Borderland Group 2002).

Prioritized Conservation Actions

Ephemeral man-made catchments occur in a patchy network of government, tribal, and private ownerships across the landscape of New Mexico and will require collaborative efforts among these stakeholders. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of the functions and values afforded by ephemeral man-made catchments.

2. Encourage collaboration among state, federal, tribal, NGO, and private land stewards to form alliances or working groups to develop and implement management practices to protect, maintain, and enhance ephemeral man-made catchments to benefit both associated SGCN and stakeholders' land-use interests.

3. Promote efforts that take advantage of man-made catchments as a form of wetland mitigation to achieve a mutual goal of no net loss of wetlands in New Mexico. Guidance for such an initiative is detailed in vernal pool wetland conservation and management strategies in California (Witham 1998).

4. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and ephemeral man-made catchments outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

5. Collaborate with federal and state agencies and affected publics to improve and increase the use of existing data management systems for tracking information pertinent to ephemeral man-made catchments.

6. Work with federal and state agencies and affected publics to adopt standardized monitoring and iterative survey methods to track gains and losses of ephemeral man-made catchments statewide.

7. Encourage public participation in state and federal incentive-based programs with assurances to protect, enhance, and restore ephemeral man-made catchments. Such incentive-based programs may include federal programs such as Safe Harbor Agreement, Partners for Wildlife, Candidate Conservation Agreement, and state initiatives like the Landowner Incentive Program.

Perennial Tanks

Habitat Condition

Perennial tanks are uncommonly encountered in New Mexico partly due to the lack of natural springs of sufficient flow volume, and diversion and capping of natural springs for livestock operations. These tanks may vary from a few square feet of water surface to several acres and provide permanent refuge for numerous plants, invertebrates, and vertebrates. As with most riparian and wetland communities, perennial tanks continue to be rapidly destroyed by reductions of stream flows and lowered water tables (Minckley and Brown 1982).

Problems Affecting Habitats or Species

Literature review and assessment of factors that influence perennial tank habitats suggest that excessive grazing intensity, drought, pollution, and invasive plant species represent the primary factors that adversely affect them and their ability to sustain SGCN. Detailed discussions of these factors are presented in Chapter 4. An additional discussion on habitat conversion factors is provided below.

Habitat Conversion
Any habitat conversion (such as filling, dredging, draining, water discharges, etc.) that alters the hydroperiod of a perennial tank can result in a loss of abundance, a decrease in biotic diversity, and reduced beneficial use by wildlife (Lang and Rogers 2002). Since there is no regulatory authority over man-made wetlands in New Mexico, this aquatic habitat type is subject to any form of disturbance or alteration, except where a federally listed species may occur or an alteration may adversely impact ground or surface waters.

Information Gaps

There are numerous information gaps regarding perennial tanks that merit the attention of biologists, policy-makers, and land/resource managers. These information gaps are outlined below.

- Comprehensive spatial data are lacking on the number and total area of perennial tanks in New Mexico.
- Data are lacking on the biotic diversity of perennial tanks.
- Data are lacking on the types of wildlife that spend a significant part of its life cycle in perennial tanks. Knowing the typical home ranges of these species would be useful to establish how far these organisms would be expected to travel between jurisdictional waters and human-created wetlands.
- Studies are lacking that compare the biotic diversity of perennial tanks relative to that of ephemeral man-made catchments and natural catchments.

- The existing environmental conditions or thresholds that preclude populations of SGCN are unknown.

- Information is needed about the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN in perennial tanks.

Research, Survey, and Monitoring Needs

Research or survey efforts required to make informed conservation decisions for perennial tanks are described below.

- Comprehensive spatial data designating the number and total area of perennial tanks would provide the foundation for mapping this habitat type.

- Studies focused on wildlife use of perennial tanks would provide the foundation for understanding the function of such systems across the landscape.

- Studies are needed to quantify and compare the biotic diversity of perennial tanks relative to each other and to other wetland ecosystems.

- Research is needed to investigate the role of perennial tanks in the persistence of the chytrid fungus pathogen compared to other ephemeral wetlands.

- Research is needed to assess the feasibility of creating perennial tanks as wetland mitigation banks that conform to state and federal objectives pertaining to no net loss of natural wetlands.

- GIS-based biotic surveys statewide would serve to map the distribution and areal extent of perennial tanks and their associated SGCN. These data will also serve to assess at-risk populations of SGCN known to utilize this aquatic habitat.

- Field studies are needed that focus on habitat use patterns of SGCN associated with perennial tanks compared to ephemeral wetlands obligates (aquatic macroinvertebrates), those taxa that have obligate requirements of both wet and dry conditions (amphibians), and those SGCN that primarily use jurisdictional wetlands but migrate to and from this habitat type (birds).

- Spatially explicit data are needed on physiochemical and hydrologic conditions of perennial tanks.

- Determine the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN and identify methods to minimize impacts from non-native species.

- Research is needed to determine environmental conditions or thresholds that preclude populations of SGCN.

Desired Future Outcomes

Attaining the following desired future conditions for perennial tanks statewide will require collaboration among state, federal, tribal, NGOs, and private land stewards to foster a working environment that promotes conservation and management of this resource.

- Perennial tanks persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land management uses with reduced resource use conflicts.

- A GIS-based database with spatial information on the distribution, water quality, and biotic diversity of perennial tanks is available to state and federal agencies, NGOs, and private land stewards.

- Recommended management practices are developed and implemented to protect the ecological integrity and function of perennial tanks.

- Incentive-based programs are developed and implemented that encourage private landowners to construct, operate, and maintain perennial tanks with assurances that protect property rights while also protecting the habitat of SGCN. The Safe Harbor Agreement for the Chiricahua leopard frog represents one such example (see Federal Register 2002, Malpai Borderland Group 2002).

Prioritized Conservation Actions

Perennial tanks occur in a widely spaced network of government, tribal, and private ownerships across the landscape of New Mexico and will require collaborative efforts among these stakeholders. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of the functions and values afforded by perennial tanks.

2. Encourage collaboration among state, federal, tribal, NGO's, and private land stewards to form alliances or working groups that develop and implement management practices to protect, maintain, and enhance perennial tanks to the benefit of both wildlife resources and affected land-use interests.

3. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN

and perennial tanks outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

4. Promote efforts that take advantage of perennial tanks as a form of wetland mitigation to achieve a mutual goal of no net loss of wetlands in New Mexico. Guidance for such an initiative is detailed in vernal pool wetland conservation and management strategies in California (Witham 1998).

5. Collaborate with federal and state agencies and affected publics to improve and increase the use of existing data management systems for tracking information pertinent to perennial tanks.

6. Work with federal and state agencies and affected publics to adopt standardized monitoring and repetitive survey methods to track gains and losses of perennial tanks statewide.

7. Encourage public participation in state and federal incentive-based programs with assurances to protect, enhance, and restore perennial tanks. Such incentive-based programs may include federal programs such as Safe Harbor Agreement, Partners for Wildlife, Candidate Conservation Agreement and state initiatives such as Landowner Incentive Program.

CANADIAN WATERSHED

The Canadian Watershed encompasses about one-sixth the land area of the state or about 1.1 million ac (0.4 million ha) (New Mexico Water Quality Control Commission 2002). Canadian River tributaries flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado. As it traverses the Great Plains in a southerly and then easterly direction, several perennial tributaries, including the Vermejo, Cimarron, Mora, and Conchas Rivers join the South Canadian River before it exits New Mexico toward Texas near Logan. The Upper Canadian, Middle Canadian, Upper Beaver, and the Dry Cimarron are the only sub-basins that are perennial. Key habitats in the Canadian Watershed include perennial large reservoirs, perennial marsh/cienega/spring/seep, perennial 1st and 2nd order streams, and perennial 3rd and 4th order streams (Fig. 5-9).

Settlement and irrigation withdrawal along high mountain valleys in the Mora River dates back to the 1700s. Since the late 1800s, the area has been subject to logging, grazing, and mining. Eagle Nest dam was built on the Cimarron River in 1918. Numerous other small impoundments and diversions have been built throughout the upper watershed for irrigation and municipal water. Livestock grazing continues to be the primary land use activity throughout the Canadian Watershed. Logging activities are now limited to small tracts in the upper tributaries. Most coal mines were abandoned by the 1950s. Two large dams, Conchas River (constructed 1938) and Ute Dam on the Canadian River (constructed 1962), impound reservoirs and modify natural flows as the river approached the New Mexico-Texas border.

Species of Greatest Conservation Need

Overall, 36 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, occur in the Canadian Watershed (Table 5-11). Most species (n = 19 or 53%) were classified as nationally secure but state vulnerable, imperiled, or critically imperiled. Eleven species (31%) were classified as vulnerable, imperiled, or critically imperiled both statewide and nationally, and the remaining six species were secure both nationally and in the state. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. At present, the only fish SGCN that is known to occupy perennial spring, seep, marsh, or cienega habitats in the Canadian Watershed of New Mexico is the southern redbelly dace (*Phoxinus erythrogaster*). The distribution of southern redbelly dace in New Mexico is limited to the headwaters of the Mora River, particularly Coyote Creek, and tributaries to Black Lake (Sublette *et al*. 1990) where they are common in spring habitats, but are rare in stream habitats (Propst 1999, NMDGF 2004a). The southern redbelly dace was state listed as an endangered species (19 NMAC 33.1) in 1975. The species prefers spring-fed systems with dense aquatic vegetation and clear water (Pfleiger 1975).

Native crayfish of perennial reservoirs in the Canadian Watershed include the Conchas crayfish (*Orconectes deanae*) and the northern crayfish (*Orconectes virilis*). The former species is reported from Conchas Lake and riverine reaches (Conchas River and Canadian River) upstream (Lang and Mehlhop 1996), while the latter species occurs in Conchas Lake and Conchas Canal, where the non-native rusty crayfish (*Orconectes rusticus*) has been reported below Conchas Lake dam (Lang and Mehlhop 1996).

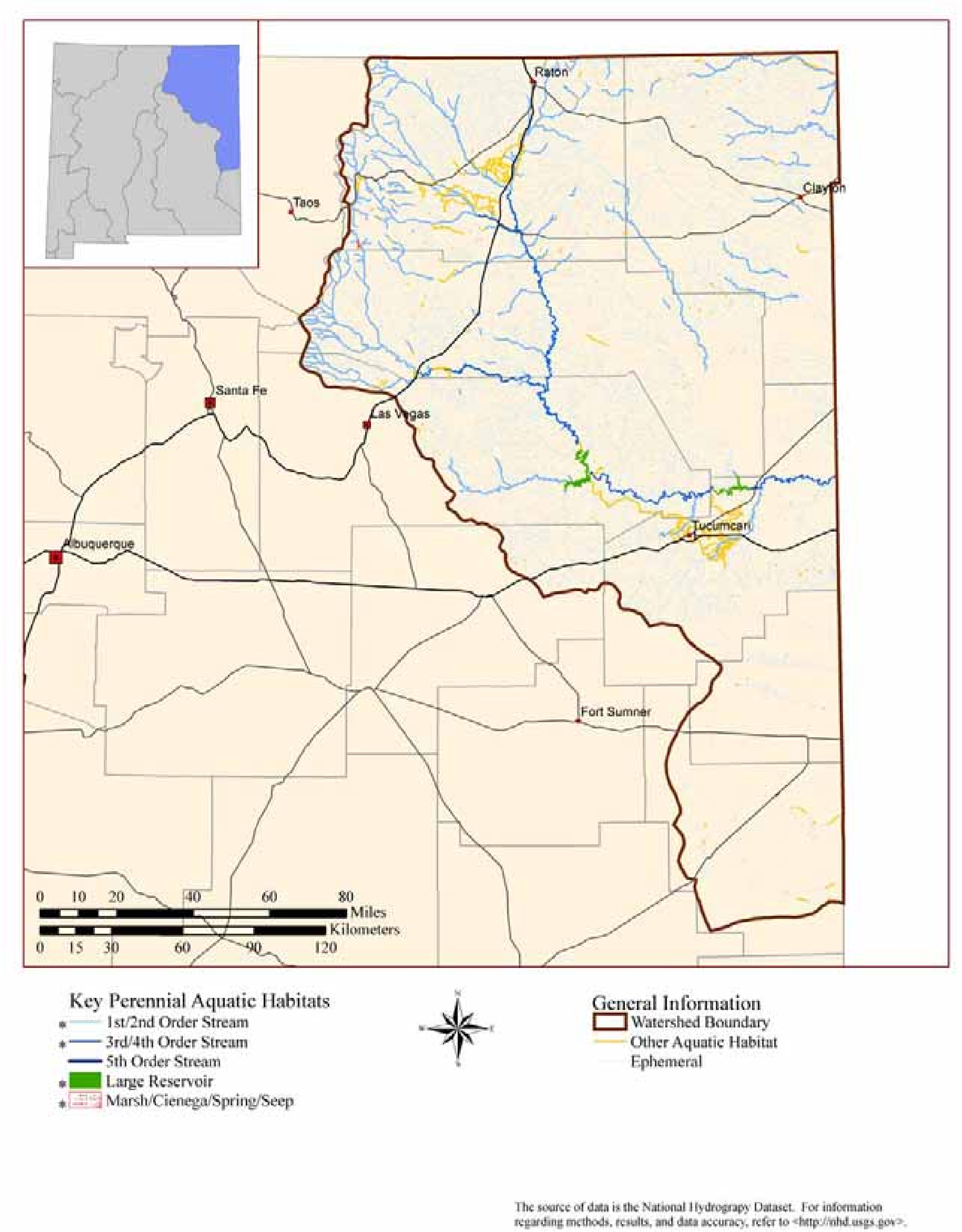


Figure 5-9. Key perennial aquatic habitats in the Canadian Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Taylor (1983) first reported the freshwater mussel, paper pondshell (*Utterbackia imbecillis*), in Conchas Lake. Lang and Mehlhop (1996) extended the range of this species eastward to Ute Reservoir. They speculated that the paper pondshell was introduced during bait fish release or game fish stocking from a fish bearing glochidia (larvae that has been dispersed from a female mussel). The giant floater (*Pyganodon grandis*) was introduced into Conchas Lake and Ute Reservoir in a similar manner. Lang and Mehlop (1996) considered native habitats for the paper pondshell as primarily riverine, and questioned the native status of the reservoir populations.

The fingernail clams (*Musculium* spp.) SGCN (Table 5-11) are known from the Upper Arkansas and Upper Dry Cimarron sub-basins in the northeastern part of the state (Taylor 1983, NMDGF 2004a), where little is known about their distribution and abundance. Lang and Mehlhop (1996) reported the freshwater limpit (*Ferrissia rivularis*) in the Conchas Canal. This species likely occurs in the Canadian River upstream of Conchas Lake to Mills Canyon.

Four fish SGCN occupy perennial 1st and 2nd order stream habitats of the Canadian Watershed in New Mexico: Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*), southern redbelly dace, suckermouth minnow (*Phenacobius mirabilis*), and central stoneroller (*Campostoma anomalum*) (Table 5-11). The Rio Grande cutthroat is confined to 11 populations in the headwaters of the South Canadian River and the Mora River (Sublette *et al*. 1990). It is protected as a game fish under state law (17-2-3 NMSA 1978). Southern redbelly dace is limited in distribution to the upper headwaters of the Mora River and Coyote Creek (Sublette *et al*. 1990) and listed as state endangered (19 NMAC 31.1). Suckermouth minnows are rare in the South Canadian River upstream of Conchas Reservoir and may be extirpated from the Dry Cimarron (NMDGF 2002). The suckermouth minnow is listed as state threatened (19 NMAC 31.1). The Central stoneroller occupies reaches of the South Canadian River above Conchas Reservoir and the Dry Cimarron River, and the fish is not protected by state or federal regulation.

Three fish SGCN occupy the perennial 3rd and 4th order stream habitats of the Canadian Watershed in New Mexico. They are suckermouth minnow, Arkansas River speckled chub (*Macrhybopsis tetranema*), and central stoneroller. Suckermouth minnows are rare in 3rd and 4th order stream habitats. Arkansas River speckled chub is restricted to the South Canadian River downstream of Ute Reservoir. Within this reach it was moderately common in the early 1990s, but no recent surveys have been conducted to accurately characterize its status in New Mexico. It is listed as threatened by the state (NMDGF 2004a).

Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

Table 5-11. Species of Greatest Conservation Need in the Canadian Watershed in New Mexico.

	Perennial			
Common Name	Large Reservoir	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream
Fish				
Rio Grande Cutthroat Trout			X	X
Central Stoneroller			X	X
Canadian Speckled Chub				X
Suckermouth Minnow				X
Southern Redbelly Dace		X	X	X
Birds[1]				
Eared Grebe	X	X		X
American Bittern		X		
White-Faced Ibis	X	X		
Northern Pintail	X	X		X
Osprey	X			X
Bald Eagle	X	X		X
Northern Harrier		X		
Common Black-Hawk		X	X	X
Peregrine Falcon	X	X		X
Sandhill Crane	X	X		
Snowy Plover	X			
Interior Least Tern	X			X
Southwestern Willow Flycatcher		X		X
Bank Swallow				X
Yellow Warbler		X	X	X
Mammals[1]				
American Beaver	X	X	X	X
Prairie Vole		X		
Amphibians[1]				
Tiger Salamander		X		
Western Chorus Frog		X	X	X
Plains Leopard Frog		X		X
Northern Leopard Frog	X	X	X	X
Reptile[1]				
Arid Land Ribbon Snake		X	X	X
Molluscs				
Swamp Fingernailclam				X
Long Fingernailclam				X
Lake Fingernailclam				X
Paper Pondshell Mussel	X			
Star Gyro Snail		X	X	X
Creeping Ancylid Snail				X

Table 5-11 Cont.

	Perennial			
Common Name	Large Reservoir	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream
Crustaceans				
Conchas Crayfish	X			X
Northern Crayfish (Canadian River)	X		X	X
Amphipod	X	X	X	X

[1] Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Perennial Large Reservoirs

Habitat Condition

The large reservoirs (Eagle Nest, Conchas, and Ute) in the Canadian Watershed have highly variable water levels depending on annual precipitation and irrigation needs. Habitat conditions can change dramatically with water levels. All three reservoirs have associated state parks that are popular recreation areas. There are several small perennial reservoirs within the Canadian Watershed. Some of these small reservoirs include Maxwell Lakes, Storrie Reservoir, McAllister Lake, and Clayton Lake. Like large reservoirs, most of the fish community consists of non-native fish species. There are no fish SGCN in large perennial reservoirs in the Canadian Watershed.

Problems Affecting Habitats or Species

Invasive Species
Non-native bivalves such as the Asian clam (*Corbicula fluminea*), the giant floater, and the invasive rusty crayfish have been introduced to the Canadian Watershed (Lang and Mehlhop 1996). Due to previous bait fish release and game fish stocking, it may be virtually impossible to discern the native species of the paper pondshell from Conchas Lake using genetic techniques, unless an extant population is located in perennial tributaries of the Canadian Watershed (R. Hoeh, unionid taxonomist, Kent State University, pers. comm.). Native crayfish populations of reservoirs are threatened by non-native crayfish. All stakeholders deriving beneficial use from Canadian River mainstem reservoirs are threatened by the potential introduction of zebra mussels (*Dreissena polymorpha*) and its sister species the quagga mussel (*Dreissena bugensis*).

Information Gaps

There are numerous information gaps regarding perennial large reservoirs that weaken our ability to make informed conservation decisions. Information gaps identified are outlined below.

- We lack information on reservoir meso-habitats used by native aquatic species.

- The existing environmental conditions or thresholds that preclude populations of SGCN are unknown.

- Information is needed about the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN in perennial large reservoirs.

Research, Survey, and Monitoring Needs

Research or survey efforts needed to make informed conservation decisions for perennial large reservoirs or SGCN are outlined below.

- Research is needed to investigate life history and ecology of the Conchas crayfish populations from all aquatic habitat types (perennial streams and reservoirs) in the Canadian Watershed.

- While Pittenger (2004) reported stable populations of the Conchas crayfish in the Canadian Watershed, routine inventory throughout the watershed is needed to monitor the population status of this species.

- Recreational use surveys are needed to assess intrastate and interstate boating activity of perennial reservoirs. These data are necessary for development and implementation of an effective statewide aquatic nuisance species plan.

Desired Future Outcomes

Desired future outcomes for perennial large reservoirs in the Canadian Watershed include:

- Perennial large reservoirs persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of SGCN while sustaining diverse and minimal resource use conflicts.

- Sport fish management is focused on species that are appropriate for biotic and abiotic conditions of each reservoir.

- Non-preferred sport fish species are controlled or eliminated.

- The emigration and subsequent impacts of non-native fishes from reservoirs into surrounding habitats is minimized.

- The spread of non-native and aquatic nuisance species within the Canadian River Watershed is eliminated or reduced.

Prioritized Conservation Actions

Although species management of large reservoirs is often focused on recreational species, stewardship of New Mexico's biodiversity will require adaptive conservation and management actions. Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with land managers to assure minimum conservation pools for reservoirs persist so as to provide year round recreational opportunities and maintain sport-fish populations.

2. Collaborate with federal and state agencies and affected publics to create awareness and understanding of large reservoirs functions, services, and values. Emphasis should be placed on educating the public of the risks posed by undesirable non-native fishes and aquatic nuisance species.

3. Work with public and private land managers to develop strategies to prevent escape of non-native species from large perennial reservoirs into surrounding areas.

4. Discourage the continued introduction of non-native crayfish and other invasive aquatic species through state regulations (such as, NMDGF bait dealer regulation 19-31-9, NMAC). An approach may include restricting the use of baitfish to only fathead minnows in perennial large reservoirs of the Canadian Watershed.

5. Work with law enforcement agencies to achieve compliance with regulations regarding illegal transport and release of undesired non-native fishes (including sport fishes) into perennial large reservoirs of the Canadian Watershed.

6. Collaborate with federal and state agencies and affected publics to enhance and improve Canadian Watershed large reservoir habitats used by native fishes.

7. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial large reservoirs outlined in the Research, Survey, and Monitoring Needs section.

8. Draft and implement an aquatic nuisance species plan for New Mexico that incorporates concerns in the Canadian Watershed.

9. Establish partnerships with federal, state, and local agencies (such as Interstate Stream Commission, New Mexico State Parks, New Mexico Environment Department, etc.) to monitor reservoir water quality relative to potential use by SGCN.

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Perennial springs and seeps occur through out the Canadian Watershed from high mountain elevations of the Sangre de Cristo Mountains to marsh areas in the lower Canadian Watershed. Upper elevation springs are dependent on snow pack while lower elevation springs/seeps are maintained by natural groundwater discharge from local aquifers or the surrounding water table. Factors affecting Canadian Watershed springs and seeps include grazing, logging, groundwater removal and invasion by non-native vegetation. Hudson Lake (Quay County) is an example of a low elevation spring/seep. Present condition of many of these habitats is unknown as most of them occur on private land and have not been inventoried. Some habitats, such as those on Vermejo Park Ranch are in relatively good condition due to changes in land use practices (reduced grazing intensity) in recent years. Other perennial marsh/cienega/spring/seep habitats in the Canadian Watershed continue to be influenced as landowners using historical land use practices struggle with economic stability.

Problems Affecting Habitats or Species

Urban Development/Dewatering
The town of Angel Fire and the Moreno Valley have experienced significant residential and recreational development in the past decade. The Angel Fire Resort and Ski Area and Eagle Nest Lake provide the focus for most of the development. All of the problems associated with human development, including groundwater depletion, sewage/septic contamination of water supplies, and drainage of wetlands have a high potential to affect SGCN in this locality. Excessive groundwater pumping and drought could lead to lower spring levels that would be detrimental to all species occupying these habitats.

Invasive Species
Predatory non-native fish species may also affect native fishes in these habitats by reducing their abundance in smaller habitats. Brown trout (*Salmo trutta*) have been established throughout the Mora River drainage, and rainbow trout (*Oncorhynchus mykiss*) are stocked for recreational angling in the drainage. The extent to which these non-native trout negatively affect populations of southern redbelly dace is unknown. Non-native aquatic species, such as crayfish and the New Zealand mudsnail (*Potamopyrgus antipodarum*), threaten the diversity of aquatic biota and functional integrity of this perennial habitat type.

Non-native vegetation is also adversely affecting perennial spring-fed habitats. Saltcedar (*Tamarix* spp.) occurs around some of the Canadian Watershed springs and seeps. This invasive plant has long taproots that allow it to intercept deep water tables and interfere with natural aquatic systems. This plant disrupts the structure and stability of native plant communities and degrades native wildlife habitat by out competing and replacing native plant species and over-exploiting limited sources of moisture. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Information Gaps

In addition to problems affecting perennial spring-fed habitats, there are several major information gaps that may weaken our ability to make informed conservation decisions. These are outlined below:

- Data are lacking on the distribution, abundance and natural history of SGCN, especially fish, associated with spring/seep/marsh/cienega habitats in the Canadian Watershed.
- Little is known about locations and condition of marsh/cienega/spring/seep habitats in the Canadian Watershed.
- Logging and grazing continue to be primary economic interests in the Canadian Watershed but the level and extent of effects from these activities on perennial marsh/cienega/spring/seep habitats is currently unknown.

Research, Survey, and Monitoring Needs

A survey of the distribution and conservation status of fishes of the South Canadian River Drainage is currently being conducted (Platania and Dudly 2003). The results of this survey will significantly increase our knowledge of the distribution of fishes. Additional research or survey efforts needed to make informed conservation decisions are detailed below.

- Additional surveys are needed that focus on the distribution of southern redbelly dace throughout the Mora River drainage.
- Research, surveys, and monitoring are greatly needed for SGCN occupying spring/seep/marsh/cienega habitats in the Canadian Watershed. Little is known of the extent of their distribution, their biology, or stability of their populations and microhabitats.
- Assess the potential for site-specific impacts from ongoing development in the Black Lake area where known populations of southern redbelly dace occur.
- A comprehensive survey is needed of aquatic macroinvertebrates in perennial marsh/cienega/spring/seep habitats in the Canadian Watershed.
- Investigate the extent to which land use activities (such as timing, intensity, and duration of livestock grazing, logging, human development and invasive or non-native species invasions) fragment and otherwise alter habitats in relation to size, edge effect, and use by wildlife. This information is important in understanding the effects of such disturbances upon SGCN in perennial marsh/cienega/spring/seep habitats.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep in the Canadian Watershed include:

- Perennial marsh/cienega/spring/seep habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.
- Marsh/cienega/spring/seep habitats persist at natural water levels with water quality adequate to support resident SGCN.
- Non-native predatory or competitive fish species are excluded from these habitats, such that the present distribution and abundance of self-sustaining populations of southern redbelly dace, and all other native species, are maintained or improved.
- Collaborative relations are established among state, federal, NGO's, universities, and landowners to secure, enhance, and restore perennial marsh/cienega/spring/seep habitats.
- Non-native vegetation around these habitats is eradicated or controlled to minimize impacts to SGCN.

Prioritized Conservation Actions

Much of the Canadian Watershed marsh/cienega/spring/seep habitat occurs on private land. Thus, conservation actions need to include private landowners input and support. Since the southern redbelly dace is listed as endangered by the state, some conservation actions are already in place. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies, private landowners, research institutions, and universities to establish a better understanding of the distribution and abundance of southern redbelly dace and the distribution and condition of marsh/cienega/spring/seep habitats in the Canadian Watershed (especially Black Lake, Coyote Creek and upper Mora River) through continued survey efforts.
2. Establish partnerships with other federal, state and local agencies (New Mexico Environment Department, US Geological Survey, New Mexico Office of the State Engineer, etc.) to encourage monitoring local aquifers for water quantity and quality as it relates to specific habitat locations and identifying potential threats to habitats important to the southern redbelly dace and other SGCN.

3. Work with appropriate state and federal government entities, NGOs, and private land owners to protect and secure habitats essential to the long-term survival of southern redbelly dace through partnerships with private landowners using existing federal conservation programs (LIP or other incentives), conservation easements and land acquisition.

4. Seek acceptance of "instream flow" water rights for wildlife conservation needs in New Mexico that will benefit perennial marsh/cienega/spring/seep habitats in the Canadian Watershed.

5. Discourage the continued introduction of predatory non-native fishes into Canadian Watershed habitats known to support southern redbelly dace or other SGCN.

6. Work with public and private land managers in the Canadian Watershed to develop sustainable livestock production practices on native rangelands around perennial marsh/cienega/spring/seep that would reduce spring degradation.

7. Provide outreach to private landowners, developers and other publics to encourage the protection, maintenance, and rehabilitation of Canadian Watershed habitats essential to the long-term survival of SGCN such as the southern redbelly dace.

8. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial marsh/cienega/spring/seep as outlined in the Problems or Research, Survey, and Monitoring Needs section.

9. Collaborate with public and private land managers in the Canadian Watershed to develop, adopt, and implement a program to eradicate and stop the spread of invasive plants. This program could be based on *the New Mexico Strategic Plan for Managing Noxious Weeds 2000-2001*; BLM, Partners Against Weeds Action Plan; US Forest Service, Stemming The Invasive Tide; National Interagency Strategy, Pulling Together and the National Invasive Species Management Plan.

Perennial 1st and 2nd Order Streams

Habitat Condition

Most of the tributaries of the Canadian Watershed begin in the high elevations of the Sangre de Cristo Mountains. The exception is Ute Creek, which is now ephemeral (Sublette *et al*. 1990). Most of the headwater streams of these tributaries are under the administration of the US Forest Service, but some lie within the boundaries of large, long-standing land grants. Habitats for most of the 1st and 2nd order streams are in relatively good condition, but grazing, logging, and roads continue to affect these small streams.

Problems Affecting Habitats or Species

Invasive Species

The primary threat to SGCN, such as the Rio Grande cutthroat trout, is the introduction of non-native salmonids that compete with, prey on and/or hybridize with them. Stressors specific to the southern redbelly dace include modification of spring systems and introduction of non-native predators. Brown trout have been established throughout the upper reaches of the watershed and compete with, or prey upon SGCN. Rainbow trout, which are stocked for recreational angling, also compete and prey upon SGCN and hybridize with Rio Grande cutthroat trout.

Diseases and Pathogens

The presence of whirling disease in rainbow trout was confirmed in New Mexico the spring of 1999. Since this confirmation, portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated in coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Habitat Alteration

Traditional land uses such as grazing, logging, and agriculture are the primary economic activities in this watershed. Sedimentation, desiccation, and other forms of habitat degradation to perennial 1st and 2nd order stream habitats are often attributed to improper grazing, logging, and water diversion for irrigation. Another potential factor that may alter these habitats is the lack of fire management.

Oil and Gas Exploration

Recent localized gas and oil exploration in the upper Canadian and Vermejo drainages has a potential for affecting these habitats. The degree to which these activities are affecting specific habitats on private land is not known. Where these habitats occur on public land, existing federal and state laws require consultation and mitigation to reduce negative effects. Desiccation of habitat or alteration of natural flows is a serious problem in aquatic ecosystems in New Mexico.

Information Gaps

Information gaps that limit our ability to make informed conservation decisions for perennial 1st and 2nd order stream habitats are outlined below:

- With exception of the Rio Grande cutthroat trout, data on the distribution and abundance of fish SGCN and the location and condition of 1st and 2nd order stream habitats is lacking.

- Information is lacking on the status of 1st order perennial stream habitat for the Rio Grande cutthroat trout in parts of the Canadian Watershed.

- The extent to which introduced predators negatively impact populations of SGCN, particularly the southern redbelly dace in this watershed, is unknown.

- The extent to which land use activities (such as timing, intensity, and duration of livestock grazing, human development, road-building, and oil and gas development) fragment and alter habitats in relation to size, edge effect, and use by wildlife is unknown. This information is important in understanding how these disturbances affect SGCN in perennial 1st and 2nd order streams.

- Limited information on the status of suckermouth minnow in New Mexico coupled with a lack of data on its life history make it difficult to determine what measures are needed to conserve the minnow in the Canadian Watershed and across the state.

- Data on the current distribution and status of the central stoneroller is also lacking and needs to be updated.

- The existing environmental conditions or thresholds that limit populations of SGCN in perennial 1st and 2nd order streams of the Canadian Watershed are unknown.

- The potential and risk for whirling disease to spread among salmonids of 1st and 2nd order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

Research, Survey, and Monitoring Needs

Although efforts for Rio Grande cutthroat trout in these habitats are conducted under ongoing Federal Aid Fisheries Grants (New Mexico Department of Game and Fish 2002) there are additional research and surveys needed to inform conservation managers.

- A better understanding of the distribution, abundance, and biology of SGCN is needed. Studies on the southern redbelly dace, suckermouth minnow, and central stoneroller in the Canadian Watershed are especially desirable.

- Further studies are needed to characterize habitat criteria and the biology of SGCN in the Canadian Watershed to guide further development of conservation actions and monitoring plans.

- Investigate the extent to which land use activities fragment and otherwise alter perennial 1st and 2nd order stream habitats in the Canadian Watershed.

- Research is needed to determine environmental conditions or thresholds that limit populations of SGCN in perennial 1st and 2nd order streams of the Canadian Watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order stream habitats include:

- Perennial 1st and 2nd order streams of the Canadian Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with minimal resource use conflicts.

- Factors that contribute to degraded habitat quality and quantity are eliminated or minimized in order to maintain or improve conditions that ensure the survival of self-sustaining populations of SGCN.

- Collaborative relations are established among state and federal agencies, NGO's, universities, and private landowner to protect, enhance, and restore perennial 1st and 2nd order streams habitats of the Canadian Watershed.

Prioritized Conservation Actions

Much of the 1st and 2nd order stream habitat in the Canadian Watershed occurs on private land. Thus, conservation activities need to include private landowner input and support. Existing conservation activities occur for the state endangered southern redbelly dace and the state threatened suckermouth minnow. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to establish a better understanding of the distribution and abundance and biology of southern redbelly dace, suckermouth minnow and central stoneroller in the Canadian Watershed. This information will further guide the development of conservation actions and monitoring plans for these species.

2. Collaborate with federal and state agencies and affected publics to continue to implement the long-range management plan for Rio Grande cutthroat (NMDGF 2002a).

3. Seek acceptance of "instream flow" water right for wildlife conservation needs in New Mexico that benefit 1st and 2nd order stream habitat in the Canadian Watershed.

4. Work with state, federal and private land managers to mitigate and reduce impacts from land and water use practices to perennial 1st and 2nd order streams in this watershed.

5. Discourage the continued introduction of predatory non-native fishes into Canadian Watershed habitats known to support southern redbelly dace, suckermouth minnow, and central stoneroller or other SGCN.

6. Work with appropriate state and federal government entities, NGOs, and private land owners to protect and secure habitats essential to the long-term survival of southern redbelly dace, suckermouth minnow, central stoneroller, and other SGCN through partnerships and using existing federal conservation programs (LIP or other incentives), conservation easements and/or land acquisition for protection.

7. Encourage private landowners to protect and maintain habitats essential to the long-term survival of SGCN such as the southern redbelly dace.

8. Establish partnerships with the New Mexico Environment Department, US Geological Survey, New Mexico Office of the State Engineer, and other local, state, and federal agencies to monitor surface and ground water quantity and quality as it relates to specific habitat needs of SGCN.

9. Work with federal and state agencies, private landowners, research institutions, NGOs, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order stream habitats of the Canadian Watershed outlined in the Problems or Research, Survey, and Monitoring Needs section.

10. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of perennial 1st and 2nd order stream habitat functions, services, and values in the Canadian Watershed.

Perennial 3rd and 4th Order Streams

Habitat Condition

Perennial 3rd and 4th order streams in the Canadian Watershed vary from high elevation cascades, to high sediment systems in low elevations with low gradients. Tributary streams meander across the low relief plains and often flow through narrow canyons. Flow is usually permanent in canyon-bound reaches but may be seasonally intermittent in less restricted reaches. In the upper reaches (3rd order), water is diverted to many small off-channel impoundments for irrigation, drinking water, and recreation. This results in many of the lower elevation systems becoming ephemeral prior to entering the main stem of the South Canadian River. Some portions of these 3rd order streams maintain sections of permanent flow from groundwater and spring discharge and maintain isolated populations of native and non-native fishes, generally in pool and marsh habitats. Habitats in both the main stem South Canadian River and its tributaries vary from deep pools formed around large boulders in canyon reaches to shallow, sand-bottomed runs.

Problems Affecting Habitats or Species

Habitat Alteration

The primary factors adversely affecting the suckermouth minnow, central stoneroller and other SGCN in perennial 3rd and 4th order stream habitats are excessive sedimentation of stream run habitats, habitat desiccation, and habitat fragmentation. Water diversion, groundwater pumping, and regulated reservoir releases are the primary stressors to the Arkansas River speckled chub. Habitat conversion caused by improper grazing, irrigation withdrawals, urbanization, and intensive stocking of non-native sport fish has also been implicated in population declines of freshwater limpit (Hovingh 2004).

Diseases and Pathogens

Portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps for perennial 3rd and 4th order stream habitats in the Canadian Watershed that impair our ability to make informed conservation decisions are outlined below.

- Information is lacking on the distribution and abundance of fish fauna, including the three fish SGCN, in the 3rd and 4th order stream habitats in the Canadian Watershed.

- Limited information on the status of resident SGCN and on the life history of some (e.g. suckermouth minnow) in New Mexico impedes determination of potentially effective conservation measures.

- It is unknown the extent to which habitat fragmentation in the watershed will affect the long-term viability and genetic diversity of species that were historically free to move about the watershed.

- Interactions among the various native fishes and introduced fishes in perennial 3rd and 4th order streams are unclear.

- It is unknown the extent to which land use activities (such as livestock grazing, human development, and agriculture) alter habitats in relation to connectivity, patch size, edge effect, and use by SGCN. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN in perennial 3rd and 4th order streams.

- The potential and risk for whirling disease to spread among salmonids of 3rd and 4th order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

Research, Survey, and Monitoring Needs

Research, Survey, and Monitoring needs for perennial 3rd and 4th order streams include:

- A better understanding of the distribution, abundance, and biology of SGCN in the Canadian Watershed is needed. Studies on the southern redbelly dace, suckermouth minnow, central stoneroller, freshwater limpit, fingernail clams, and other sphaeriid bivalves are especially desirable.

- Further studies are needed to characterize habitat needs and biology of these species in the Canadian Watershed to guide further development of conservation actions and monitoring plans.

- Investigate the extent to which land use activities fragment and alter perennial 3rd and 4th order stream habitats.

- Research is needed to determine environmental conditions or thresholds that limit populations of SGCN in this habitat.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order streams in the Canadian Watershed include:

- Perennial 3rd and 4th order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with minimal resource use conflicts.

- Factors that contribute to degraded habitat quality and quantity are eliminated or minimized in order to maintain or improve conditions that ensure the survival of self-sustaining populations of SGCN in the Canadian Watershed.

- Collaborative relations are established among state and federal agencies, NGO's, universities, and private landowner to protect, enhance, and restore perennial 3rd and 4th order stream habitats of the Canadian Watershed.

- Natural stream flow regimes are established and maintained with the absence of non-native predators.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement studies to establish a better understanding of the distribution, abundance, status, and biology of suckermouth minnow, Arkansas speckled chub, and central stoneroller in the Canadian Watershed.

2. Adopt and enforce strict regulations regarding the use of baitfish in the Canadian Watershed.

3. Establish partnerships with New Mexico State Engineer and the Bureau of Reclamation to establish and maintain permanent flows in South Canadian River downstream of Ute Dam. This flow should at least minimally mimic a natural hydrograph for the benefit of Arkansas speckled chub and other SGCN.

4. Seek acceptance of "instream flow" water rights for wildlife needs in New Mexico (such as below Conchas and Ute Reservoirs) benefit perennial 3^{rd} and 4^{th} order stream habitats in the Canadian Watershed.

5. Work with state, federal and private land managers to mitigate and reduce impacts from land and water use practices to perennial 3^{rd} and 4^{th} order streams in the Canadian Watershed.

6. Work with public and private land managers to develop sustainable land use practices on native rangelands around perennial 3^{rd} and 4^{th} order stream that would reduce stream degradation in the Canadian Watershed.

7. Collaborate with federal and state agencies and affected publics to continue control and eradication of non-native species and reestablish native fish communities where feasible in perennial 3^{rd} and 4^{th} order streams of the Canadian Watershed.

8. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 3^{rd} and 4^{th} order stream outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

GILA WATERSHED

Most of the Gila Watershed lies within Grant and Catron counties of southwestern New Mexico, but several headwater streams are in Sierra County. The lowermost reaches of the Gila River flow through Hidalgo County. The Gila River is the only un-dammed major river in New Mexico. Except for Silver City, which is outside the Gila Watershed, there is no town having more than 500 residents. The population of Grant County is 31,002 (US Census Bureau 2000), of which 10,545 live in Silver City. Catron and Hidalgo counties, in contrast, have substantially fewer residents. In 2000, 3,543 people resided in Catron County and 5,932 lived in Hidalgo County (more than half lived in Lordsburg, which lies outside of the Gila drainage). Reserve, the largest town in Catron County, has 387 residents. Sierra County, in the eastern portion of the watershed, has 13,270 residents, but few of these live within the watershed. Between 1990 and 2000, the population of Catron County grew 38%. Population of Grant County increased 12% and Hidalgo County declined less than 1%. Between 2000 and 2003, the population of all counties in watershed, including Sierra County, declined between 1% (Sierra) and 12% (Hidalgo). In 2000, the per capita income in Grant County was $18,507. Catron County was $13,095 and Hidalgo County was $15,940. Mining, construction, agriculture, and retail trade are among the largest economic activities in Grant County. Almost all economic activity in Catron County is related to agriculture, generating about $14.5 million in 2000. The economy of Hidalgo County was dominated by agriculture contributing $18.3 million in 2000.

Several small reservoirs including Snow, Roberts, Wall, and Bill Evans are present in the Gila Watershed. Snow and Roberts lakes are on US Forest Service lands. Bill Evans Lake is owned by NMDGF with water provided by the Phelps Dodge Corporation. Wall Lake is privately owned. Non-native rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*) live in Snow Lake. Rainbow trout and channel catfish (*Ictalurus punctatus*) are found in Lake Roberts, and rainbow trout and largemouth bass (*Micropterus salmoides salmoides*) are in Bill Evans Lake.

Native fishes, if present, are incidental. No native fish depends upon perennial reservoirs within the watershed and there are no Species of Greatest Conservation Need (SGCN) in these reservoirs. There is some potential to stock Gila trout (*Oncorhynchus gilae*) in Snow Lake, once the species has been downlisted from endangered to threatened.

The Gila Watershed in New Mexico is composed of two major streams, the Gila and San Francisco Rivers. Within these streams, perennial marsh/cienega/spring/seep, perennial 1st and 2nd order streams, perennial 3rd and 4th order streams, and perennial 5th order streams were identified as key habitats (Fig. 5-10). Headwaters of both major streams lie at high elevations in the Mogollon Mountains of southeastern Arizona and southwestern New Mexico.

Small, headwater canyon-bound streams are bordered by blue spruce (*Picea pungens*), Douglas-fir (*Pseudotsuga menziezii*), and aspen (*Populus tremuloide*) in high elevation headwaters. As the streams descend and coalesce, ponderosa pine (*Pinus ponderosa*), juniper (*Juniperus* spp.), and piñon (*Pinus* spp.) become the dominant conifers. Stands of willow (*Salix* spp.) are common in moderate gradient reaches. Headwater streams of the Gila join in the Mogollon Mountains to form the river's West, Middle, and East forks. From this junction, the Gila flows westerly and

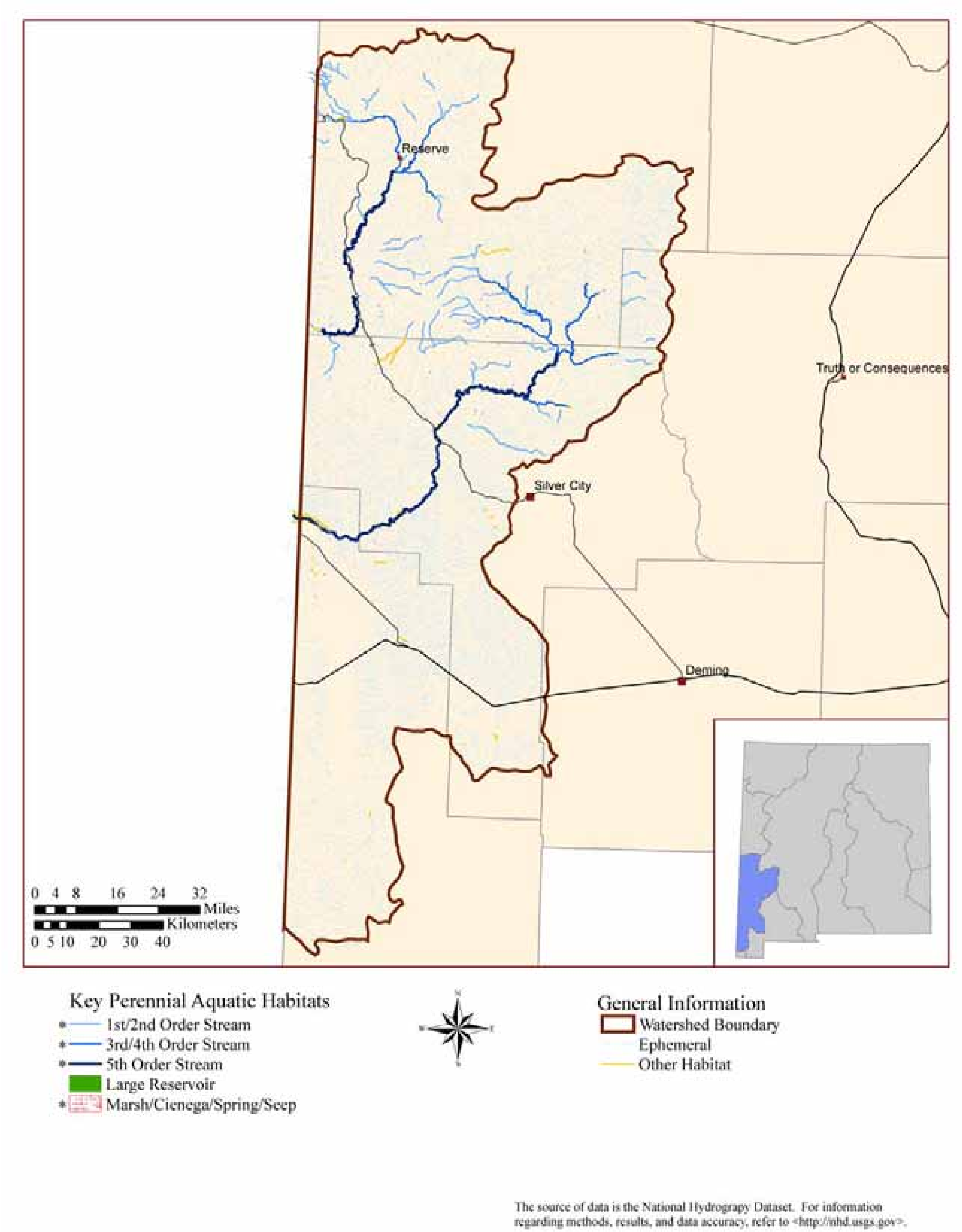


Figure 5-10. Key perennial aquatic habitats in the Gila Watershed in New Mexico. Key habitats are designated with an asterisk (*).

exits the Mogollon Mountains just east of the town of Gila. Along its mountain course, the river is bordered by ponderosa pine, piñon, juniper, cottonwood (*Populus deltoides*), Arizona sycamore (*Platanus wrightii*), boxelder (*Acer negundo*), and Arizona walnut (*Juglans major*). Mountainous portions of the Gila River are almost entirely within lands administered by US Forest Service and substantial portions flow within the Gila and Aldo Leopold wilderness areas. In high elevation streams, non-native brown trout (*Salmo trutta*), and rainbow trout are common.

After exiting the mountains, the Gila flows westerly through the Cliff-Gila Valley to the Arizona border near Virden. Portions of lower Gila River flow through lands administered by US Bureau of Land Management and US Forest Service but most lands are privately owned. The primary land uses along the river in this section is livestock grazing and irrigated cropland. Water is seasonally diverted from the river. An infiltration gallery diverts water to Bill Evans Lake. Rio Grande sucker (*Catostomus plebeius*) is common in Sapillo Creek, a mid-elevation tributary to Gila River. Several non-native fish, such as red shiner (*Cyprinella lutrensis*) and fathead minnow (*Pimephales promelas*) occupy the Cliff-Gila Valley, but none are common.

At the western end of the valley, the river is narrowly confined as it flows through the Middle Box. Non-native black bullhead (*Ameiurus melas*), smallmouth bass (*Micropterus dolomieui*), and channel catfish inhabit mid-elevation streams, and dominate fish assemblages in canyon reaches. Downstream, the Gila River flows across desert grasslands to another constriction, the Lower Box where it crosses desert shrub lands and exits New Mexico. Arizona sycamore, cottonwood, and mesquite (*Prosopis* spp.) are the primary woody vegetation in lower reaches. In this lower reach, channel catfish, flathead catfish (*Pylodictus olivaris*), and red shiner are common.

<u>Species of Greatest Conservation Need</u>

At least 49 SGCN, excluding arthropods other than crustaceans, occur in the Gila Watershed (Table 5-12). Historically, the watershed provided habitat for 11 and perhaps 13 fish species. Today only seven confirmed native species persist in the drainage. Most species (n = 28, 57%) are classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Fifteen SGCN are classified as nationally secure, but vulnerable, imperiled, or critically imperiled in the state. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) once occurred in the Gila River in Arizona as far upstream as Safford. Because there were no barriers to their movement upstream, it is presumed both species at least seasonally entered New Mexico. The Gila chub (*Gila intermedia*) formerly inhabited perennial marsh/cienega/spring/seep habitat in the Gila, but no extant perennial marsh/cienega/seep supports the species. Gila topminnows (*Poeciliopsis occidentalis occidentalis*) were noted in the Frisco Hot Springs in the past but were extirpated in the early 1950s (Sublette *et al.* 1990). The Gila trout has also been extirpated from 5^{th} order streams in this watershed.

Table 5-12. Species of Greatest Conservation Need in the Gila Watershed in New Mexico.

	Perennial			
Common Name	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Fish				
Colorado Pikeminnow				?
Desert Sucker		X	X	X
Gila Chub	X	X	X	
Gila Topminnow	E[1]	E	E	
Gila Trout		X	X	E
Headwater Chub			X	
Loach Minnow		X	X	X
Razorback Sucker				?
Roundtail Chub			E	E
Sonora Sucker	X	X	X	X
Spikedace			X	X
Birds[2]				
Eared Grebe	X		X	X
American Bittern	X			
White-Faced Ibis	X			
Northern Pintail	X		X	X
Osprey			X	X
Bald Eagle	X		X	X
Northern Harrier	X			
Common Black-Hawk	X	X	X	X
Peregrine Falcon	X		X	X
Sandhill Crane	X			X
Gila Woodpecker			X	X
Southwestern Willow Flycatcher	X		X	X
Bell's Vireo			X	X
Bank Swallow			X	X
Lucy's Warbler	X		X	X
Yellow Warbler	X	X	X	X
Abert's Towhee	X		X	X
Mammals[2]				
Arizona Shrew	X			
Western Red Bat	X			
Spotted Bat	X			
Allen's Big-Eared Bat	X			
Pocketed Free-Tailed Bat	X			
American Beaver	X	X	X	X
NM Meadow Jumping Mouse	X			
Desert Bighorn Sheep	X			
Amphibians[2]				
Tiger Salamander	X			
Arizona Toad	X	X	X	X
Western Chorus Frog	X	X	X	

Table 5-12 Cont.

Common Name	Perennial Marsh/ Cienega/ Spring/ Seep	Perennial 1st and 2nd Order Stream	Perennial 3rd and 4th Order Stream	Perennial 5th Order Stream
Amphibians Cont.				
Chiricahua Leopard Frog	X	X	X	X
Northern Leopard Frog	X	X	X	X
Lowland Leopard Frog	X	X		
Reptiles[2]				
Sonoran Mud Turtle	X	X	X	
Mexican Garter Snake	X	X	X	X
Narrowhead Garter Snake		X	X	X
Molluscs[2]				
Gila Pyrg Snail	X	X		
New Mexico Hotspring Pyrg Snail	X			
Blunt Ambersnail	X			
Crustacean[2]				
Sideswimmers / Scuds	X	X	X	X

1 Species is considered extirpated from habitat type.
2 Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Historically, extensive cienegas such as Mancos, Duck, and San Simon were present in the middle and lower reaches of the Gila River in New Mexico. Groundwater pumping, livestock grazing, and draining destroyed these habitats. Perennial springs like the East Fork Gila Springs, Alum Spring, and Middle Fork Gila Springs are scattered throughout the watershed. Some are developed and have lost all "natural" attributes while others retain most natural attributes. Many springs and seeps are geothermal. Gila chub formerly inhabited perennial marsh/cienega/ spring/seep habitats in the Gila Watershed, but no extant perennial marsh/cienega/seep now supports the species. Gila topminnows were extirpated in the early 1950s (Sublette *et al.* 1990).

Problems Affecting Habitats or Species

Water Withdrawal
Groundwater pumping and drainage have had significant adverse effects upon perennial marsh/cienega/spring/seep habitats. Drought and the persistence of these practices, will likely result in further loss of this habitat type in the Gila Watershed.

Grazing Practices
Improper grazing practices that reduce long-term plant and animal productivity (Wilson and MacLeod 1991), in combination with ground water pumping and drainage have, in the past, destroyed many Gila cienegas. Unmodified, these practices are likely to result in additional losses.

Non-Native/Invasive Species
Perennial marsh/cienega/spring/seep habitats continue to be vulnerable to modification by invasive plant species. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004). Native fish species in these habitats are most at risk from non-native species encroachment.

Information Gaps

There are numerous information gaps regarding perennial marsh/cienega/spring/seep habitats that impair our ability to make informed conservation decisions.

- There is little known about fish species in spring habitats of the Gila Watershed.
- The interactions between species that rely on this habitat type are largely unknown.
- Data are lacking on re-established topminnow population on Red Rock Wildlife Area.
- The existing environmental conditions or thresholds that limit SGCN populations are unknown.
- Information is lacking regarding the extent to which invasive and non-native species may alter perennial marsh/cienega/spring/seep habitats and limit populations of SGCN.

Research, Survey, and Monitoring Needs

Genetic studies and husbandry practices for Gila topminnow have been investigated in this habitat type (Meffe and Vrijenhoek 1988, Vrijenhoek *et al.* 1985). Additional research or survey needs that would enhance our knowledge of perennial marsh/cienega/spring/seep habitats or associated SGCN are detailed below.

- Research is needed on the biology and taxonomy of Gila chub.
- Current distribution of the Gila chub needs to be quantified.
- Investigate the extent to which land use activities such as livestock grazing timing, intensity, and duration, human development, off-road vehicle use, and invasive or non-native species intrusions that fragment and alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different

land use intensities and frequencies of disturbances affect SGCN in perennial marsh/cienega/spring/seep habitats.

- Investigate hydrologic relationships in perennial marsh/cienega/spring/seeps to provide a better understanding of the physicochemical and hydrologic processes that will allow for sustainable watershed conservation and management practices. This information will help evaluate the affects of extended drought on perennial marsh/cienega/spring/seep habitats and SGCN.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep habitats in the Gila Watershed include:

- Perennial marsh/cienega/spring/seep habitats in the Gila Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Native species are re-established in the Gila Watershed.

- There is no net loss of perennial marsh/cienega/spring/seep in the Gila Watershed.

- The final version of the *Gila Topminnow Recovery Plan* (USFWS 1994) is completed and implemented and garners wide public support.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to re-establish perennial cienega habitats along riparian corridors.

2. Work with federal, state, and private agencies and institutions to remove non-native species and restore Gila topminnow in appropriate perennial spring habitats.

3. Work with public and private land managers to develop sustainable livestock production practices on native rangelands around perennial marsh/cienega/spring/seep habitats to reduce spring degradation.

4. Collaborate with federal and state agencies and affected publics to create awareness and understanding of perennial marsh/cienega/spring/seep functions, services, and values.

5. Collaborate with federal and state agencies and affected publics to adopt standardized monitoring and survey methods to track gains and losses of perennial marsh/cienega/spring/seep in the Gila Watershed.

6. Work with federal and state agencies, landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and marsh/cienega/spring/seep habitats outlined in the Research, Survey, and Monitoring Needs section.

7. Collaborate with federal and state agencies and affected publics to implement the recovery plan for the Gila chub.

Perennial 1st and 2nd Order Stream

Habitat Condition

Although most 1st and 2nd order streams in the Gila Watershed are high elevation, several originate at lower elevations. High-elevation streams such as Iron, White, Rawmeat, Langstroth, and Whiskey cascade through narrow canyons and valleys. Cascade pools and cobbled riffles are the main habitat. Riparian vegetation shifts from aspen, spruce, and fir at high elevations to ponderosa, oak, piñon, and juniper at mid elevations. Low-elevation 1st order streams such as Mancos Creek typically begin at a spring source and are bordered by willow and cottonwood. Mancos Creek has continuous surface flows to the Gila River in most years. Flows of other low-elevation small perennial streams, such as Blue Creek, sink into the desert alluvium before reaching the Gila River.

Most high elevation 1st and 2nd order streams flow on lands administered by US Forest Service. From its origins near Aragon, the Tularosa River, a major San Francisco River tributary, is a 1st order stream, but rapidly becomes a 3rd and 4th order stream with the addition of tributaries such as Apache Creek. Most 1st and 2nd order streams in the San Francisco sub-drainage occur at higher elevations along the Mogollon Rim. These steep gradient headwater streams lie mostly within National Forests.

Few headwater streams have continuous surface flow throughout their entire course. Domestic livestock have been removed or precluded from grazing along most headwater streams within West Fork, Middle Fork, and East Fork Gila drainages. Wildfires have burned large portions of the West and Middle forks in recent years and resultant ash flows have diminished or eliminated fish from portions of the affected streams. There are few perennial low elevation, warm water 1st and 2nd order streams in the drainages. Habitat is mainly shallow, sand and gravel bottomed runs. Some are in comparatively good condition, but improper livestock grazing and ground water pumping have seriously modified others. Abandoned mines and associated tailings may affect water quality of some 1st and 2nd order streams.

Non-native rainbow and brown trout are common in mid to high-elevation 1st and 2nd order streams, and red shiner and western mosquitofish (*Gambusia affinis*) are common in low-elevation streams. Currently four native fishes occur in perennial 1st and 2nd order streams in the Gila River and five native fishes currently occur in the San Francisco River subdrainage. Gila trout occupy cold, high-elevation headwater streams of the Gila River subdrainage in the Mogollon and Black Mountain ranges. Speckled dace occupy some cold, headwater streams as well as warm, headwater streams. Longfin dace and desert and Sonora suckers occupy warm water 1st and 2nd order streams.

Problems Affecting Habitats or Species

Grazing Practices
Domestic livestock have been removed or precluded from grazing along most headwaters. However, some 1st and 2nd order streams have been, or continue to be, altered by historic effects of improper grazing practices that increased bank erosion and elevated sediment levels in streams.

Non-Native/Invasive Species
Mid to high-elevation 1st and 2nd order streams have become occupied by non-native rainbow and brown trout. Red shiner and western mosquitofish occur in low elevation streams.

Fire Management
Large portions of West and Middle fork drainages have been burned by wildfire in the past five years. Ash flows associated with these wildfires have diminished or eliminated fish from portions of affected streams.

Information Gaps

There are numerous information gaps that impair our ability to make informed conservation decisions regarding perennial 1st and 2nd order streams.

- Current distribution of the Gila chub in 1st and 2nd order streams is uncertain.
- Long-term effects of wildfire on stream biota, including Gila trout, are unknown.
- Little is known about the relative efficacy of mechanical versus piscicide removal of non-native species for Gila trout restoration.
- Effects of regulated angling on populations of Gila trout are largely unknown.
- Comprehensive spatial data designating the location and area of perennial 1st and 2nd order streams suitable for Gila trout and other SGCN would provide the foundation for monitoring impacts and facilitating risk assessment for species that occupy this habitat.
- Population dynamics and species interactions of mixed assemblages of Gila trout and native cyprinids and catostomids are unclear.

- The existing environmental conditions or thresholds that limit populations of SGCN are unknown.

- Information is lacking regarding the extent to which invasive and non-native species may alter perennial 1st and 2nd order streams and limit populations of SGCN.

Research, Survey, and Monitoring Needs

Currently small streams containing Gila trout are monitored on a regular basis. However, additional research, survey, and monitoring needs in perennial 1st and 2nd order streams are detailed below.

- Investigate the extent to which land use activities such as livestock grazing timing, intensity, and duration, road-building, and invasive or non-native species invasions fragment and alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different land use intensity and frequency of disturbance affects SGCN in perennial 1st and 2nd order streams.

- Investigate hydrologic relationships in perennial 1st and 2nd order streams to provide a better understanding of the physicochemical and hydrologic processes that will allow for sustainable watershed conservation and management practices. This information will help evaluate the effects of extended drought on streams and SGCN.

- Research is needed on the biology and taxonomy of the headwater, roundtail and Gila chubs.

- Research is needed to delineate the current distribution of Gila chub in 1st and 2nd order streams in the Gila Watershed.

- Studies are needed to characterize effects of piscicides on non-target aquatic organisms.

- The effect of regulated angling on populations of Gila trout needs to be characterized.

- Streams suitable for Gila trout restoration should be identified and prioritized.

- Research is needed to characterize population dynamics and species interactions of mixed assemblages of Gila trout and native cyprinids and catostomids.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order streams in the Gila Watershed include:

- Perennial 1st and 2nd order streams of the Gila Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Viable populations of native species are restored into 1st and 2nd order streams.
- Healthy watershed conditions exist that contribute to natural stream recovery.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with US Forest Service and other land managers to ensure that native species in perennial 1st and 2nd order streams are not adversely affected by fire management practices.

2. Collaborate with federal and state agencies and affected publics to control non-native species in perennial 1st and 2nd order stream habitats.

3. Collaborate with federal and state agencies and affected publics to implement the recovery plan for the Gila chub. Implementation of this plan is essential for perpetuation of the species in New Mexico.

4. Work with public and private land managers to develop sustainable livestock production practices on native rangelands around perennial 1st and 2nd order stream to reduce stream degradation.

5. Encourage collaboration among state, federal, NGO's, and private land stewards to assist with current Gila trout restoration.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order streams outlined in the Research, Survey, and Monitoring Needs section.

7. Collaborate with federal and state agencies and affected publics to create awareness, appreciation, and understanding of perennial 1st and 2nd order stream habitat functions, services, and values.

Perennial 3rd and 4th Order Streams

Habitat Condition

Collectively the West, Middle, and East forks of the Gila River are composed primarily of 3rd and 4th order streams. A few other main stem tributaries, such as Sapillo Creek are 3rd or 4th order streams. Riparian vegetation consists mainly of cottonwood, willow, and boxelder. Aquatic habitat consists of large boulder pools, long moderately deep runs, and short riffles. Fine sediment deposits, a consequence of wildfire induced ash flows, are common in the West and Middle forks of the Gila. Years of improper grazing have contributed to large sediment loads in the East Fork and subsequent armoring of cobble substrata. All native fishes extant in the Gila River occur in 3rd and 4th order streams. The occurrence of Gila trout is limited to the recently renovated upper West Fork of the Gila River.

Problems Affecting Habitats or Species

Transportation Infrastructure
Bridge maintenance and road construction result in channel modifications and disruption of normal streambed dynamics. Continued road maintenance activities have exacerbated problems rather than solved them.

Non-Native/Invasive Species
Invasive species are a concern throughout the drainage. Non-native smallmouth bass, black bullhead, yellow bullhead (*Ameiurus natalis*) are locally common in 3rd and 4th order streams. The most common species in Sapillo Creek is the non-native Rio Grande sucker.

Grazing Practices
The East Fork of the Gila River carries heavy sediment loads from improper grazing practices. This condition may be expected to continue or worsen if improper grazing practices continue without restoration.

Information Gaps

There are numerous information gaps regarding perennial 3rd and 4th order streams that impair our ability to make informed conservation decisions.

- Interactions are unclear between the various native fishes and introduced fishes in perennial 3rd and 4th order streams.
- The response of native and non-native fish to various flow regimes, including channel drying, needs to be known.
- The effects of wildfire induced ash flows on native fish assemblages are largely unknown.

- The response of native fish assemblages to the removal of non-native predators is unclear.

- Little is known on the status of rare fishes, including spikedace and loach minnows in perennial 3rd and 4th order streams.

- The distribution of the headwater, roundtail and Gila chub and their various habitat requirements is uncertain.

- Factors that limit the abundance of native fishes and other SGCN in the Gila River downstream of the Middle Box are unknown.

- The reasons for low density or absence of most native fish species from canyon-bound reaches are unclear.

- Little is known on the reasons for depressed native fish abundance throughout the Gila Watershed for the past 5 years.

- Information is lacking regarding the extent to which invasive and non-native species may alter perennial 3rd and 4th order streams and limit populations of SGCN.

Research, Survey, and Monitoring Needs

There are several research and survey projects that seek to address information gaps in perennial 3rd and 4th order streams. These projects are either underway or have recently been completed. They include: 1) annually monitoring fish assemblages at eight locations to assess species trends and characterize habitat associations, 2) restoration of Gila trout to the upper portion of the West Fork, 3) surveys to identify streams suitable for intensive management of native fishes, 4) evaluating the efficacy of mechanical removal of non-native fishes, 5) identification of potential sites for the construction of barriers to protect extant or restored native fish assemblages, 6) assessment of the effects of ash flows on native fishes, particularly Gila trout, and 7) a study to taxonomically differentiate the three species of chub that occupy the Gila River. Additional research, survey, and monitoring needs in perennial 3rd and 4th order streams are detailed below.

- Thorough surveys are needed to determine the current distribution of the headwater, roundtail and Gila chub.

- Evaluate the relative efficacy of mechanical versus piscicide removal of non-native species for Gila trout restoration.

- Studies are needed to characterize effects of piscicides on non-target aquatic organisms.

- The effects of regulated angling on populations of Gila trout need to be investigated and characterized.

- Streams and relevant renovation suitable for Gila trout should be identified.

- Research is needed to characterize population dynamics and species interactions of mixed assemblages of Gila trout and native cyprinids and catostomids.

- Systematic status surveys for native warm water fishes of the Gila Watershed are needed.

- Investigate the extent to which land use activities such as livestock grazing timing, intensity, and duration, human development, road-building, bridge maintenance, and road construction alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different land use intensity and frequency of disturbance affect SGCN in perennial 3^{rd} and 4^{th} order streams.

- Investigations are needed to characterize life history, biology, and habitat associations of native state and federal unlisted catostomids and cyprinids.

Desired Future Outcomes

Desired future outcomes for perennial 3^{rd} and 4^{th} order streams in the Gila Watershed include:

- Perennial 3^{rd} and 4^{th} order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Non-native species are controlled or eliminated.

- Natural flow regimes throughout the basin are maintained.

- Native riparian plant communities are restored and maintained.

- Viable native fish populations are maintained in perennial 3^{rd} and 4^{th} order streams.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to remove non-native species and restore native fish species in perennial 3^{rd} and 4^{th} order stream habitats.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 3rd and 4th order streams outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

3. Collaborate with federal and state agencies and affected publics to formulate conservation actions that gain public support for native fish management and conservation in perennial 3rd and 4th order streams. Actions may include creating public awareness, appreciation, and understanding of perennial 3rd and 4th order stream habitat functions, services, and values.

4. Work with public and private land managers to develop sustainable livestock production practices on native rangelands around perennial 3rd and 4th order streams to reduce stream degradation.

5. Work with federal and state agencies, private landowners, research institutions, and universities to continue fish assemblage monitoring and to identify suitable stream reaches for restoration of native fishes.

6. Work with US Forest Service to develop strategies to reduce the effects of wildfire induced ash flows on native fish assemblages.

7. Collaborate with federal and state agencies and affected publics to implement the recovery plan for the Gila chub. Implementation of this plan is essential for perpetuation of the species in New Mexico.

8. Encourage collaboration among state, federal, NGO's, and private land stewards to assist with current Gila trout restoration efforts.

Perennial 5th Order Streams

Habitat Condition

From the confluence of the East and West forks to the Arizona border, the Gila River is a 5th order stream. Flows are continuous, except during drought when irrigation withdrawals can diminish surface flow to a trickle in portions of the Cliff-Gila Valley. Gila River is the last main stem in New Mexico without a major water development. An infiltration gallery withdraws water from the river to maintain water levels in Bill Evans Reservoir. Livestock grazing is the major land use in the valley and resultant bank degradation is common.

The Nature Conservancy owns several parcels along the river. In the Cliff-Gila Valley, red shiner, channel catfish, and fathead minnow are rarely found. The lower valley is within the US Forest Service's Gila Bird Area. Non-native fish, especially channel catfish and flathead catfish, are common in the Middle and Lower boxes. Downstream of the Middle Box, non-native red shiner, fathead minnow, western mosquitofish, channel catfish, and flathead catfish dominate fish assemblages. The current native fish fauna of the main stem Gila River consists of few species. Speckled dace were historically rare and are currently absent. Roundtail chub were comparatively common in the past but are now apparently eliminated.

From its confluence with Tularosa River, the San Francisco River is a 5th order stream. For most of its course in New Mexico, the river flows through narrow canyons. In the vicinity of Reserve, Alma, and Pleasanton it flows through desert valleys. Water is diverted for agriculture in the valleys, but the river is seasonally dry only in Alma Valley. Two lowhead diversion dams, one in upper Alma Valley and the second in Pleasanton Valley, fragment riverine habitats. The downstream diversion dam likely contributes to precluding the establishment of non-native channel and flathead catfishes in upper reaches of the river. The US Forest Service administers most lands, but canyon bottoms and valleys are largely privately owned. Improper livestock grazing is the primary land use affecting watershed condition. In some reaches, grazing is quite intense along the river. With the exception of Gila trout, all extant native fishes of San Francisco River occur in the 5th order portion of the river

Problems Affecting Habitats or Species

Water Withdrawal
Water withdrawal for irrigation in the Cliff-Gila Valley, Redrock Valley, and Virden Valley depletes surface flows in the Gila River. In drought years, water withdrawals result in a complete drying of the river channel. Diversion dams in the San Francisco River cause some seasonal drying and habitat fragmentation. The Gila River development free status may be affected by the Arizona Water Settlements Act.

Grazing Practices
Livestock grazing is intense along some reaches of the Gila and San Francisco Rivers. As currently practiced, this exacerbates bank erosion in some areas and elevates sediment levels in streams.

Transportation Infrastructure
In the vicinity of highway bridges, gabion bank retention structures have altered river dynamics and increased problems associated with bank erosion and instability. Projects proposed to restore levees and harden stream banks, particularly in the vicinity of bridges, will cause considerable loss of aquatic habitats by channel incision and increase flood damage to surrounding floodplains and the probability of bridge failure. Removal of woody debris from river channel reduces habitat diversity to the detriment of native fishes.

Fire Management
Ash flows associated with upland wildfires also increase sediment loads in these perennial 5th order streams. Resultant deposition causes loss of interstitial spaces in riffle habitats and may adversely affect invertebrates and native fish assemblages in unknown ways.

Non-Native/Invasive Species
Non-native fish species, particularly centrarchids, ictalurids, and cyprinids have achieved numerical dominance in some reaches of the Gila River. Their potentially overwhelming presence poses serious threats to the persistence of several native fish species.

Information Gaps

There are numerous information gaps regarding perennial 5th order streams that impair our ability to make informed conservation decisions.

- The persistence of roundtail chub in the Gila Watershed in New Mexico is uncertain.
- The distribution of roundtail chub in perennial 5th order streams, and throughout New Mexico, is not fully understood.
- The current status of spikedace and loach minnow in the Gila Watershed is unknown.
- The effects of wildfire induced ash flows on native fish assemblages are poorly understood.
- Little is known about the effects of seasonal channel drying on native fish assemblages.
- The effects of abiotic factors, such as altered flow regime, on the reproductive success and recruitment of native fishes are unknown.
- Effects of range fragmentation on demographics and genetic integrity of native fishes are poorly understood.
- Effects of woody debris removal on occurrence of roundtail chub are unknown in the main stem Gila River.
- We know little about the effects of predation by non-native ictalurids on native fish assemblages.
- Information is lacking regarding the extent to which invasive and non-native species may alter perennial 5th order streams and potentially limit populations of SGCN.
- The reason(s) for the low density of native fish in canyon-bound reaches are unknown.

Research, Survey, and Monitoring Needs

Fish assemblages are annually monitored at eight stations in the Gila and San Francisco river drainages. Data from this effort are used to characterize habitat use, life history, and population trends of resident fishes. Additional research, survey, and monitoring needs in perennial 5th order streams are detailed below.

- Investigations are needed to characterize life history, biology, and habitat associations of native state and federal unlisted catostomids and cyprinids.
- Systematic status surveys of the basin’s native warm water fishes are needed.

- Investigate the extent to which land use activities such as livestock grazing timing, intensity, and duration, human development, road-building, bridge maintenance, and road construction alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and disturbance frequencies affect SGCN in perennial 5^{th} order streams.

- Research is needed to quantify the loss of habitat diversity due to the removal of woody debris from the river channel, and the affect on SGCN.

- Determine the efficacy of techniques for artificial propagation of rare fishes that occur in perennial 5^{th} order streams.

- Research is needed to characterize the life history, biology, and habitat needs of SGCN associated with perennial 5^{th} order streams, including the effects of non-native species on native assemblages.

- Conduct research to enhance currently incomplete information of the diverse vertebrate and invertebrate community structures, natural history, and ecological relationships in perennial 5^{th} order streams. Research should focus on factors that are limiting populations of native SGCN in canyon-bound reaches.

Desired Future Outcomes

Desired future outcomes for perennial 5^{th} order streams in the Gila Watershed include:

- Perennial 5^{th} order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Non-native species are controlled or eliminated.

- Natural flow regimes throughout the basin are maintained.

- Native riparian plant communities are restored and maintained.

- Viable populations of native fishes are maintained in perennial 5^{th} order streams.

- Cooperative efforts with other state and federal resource agencies and private entities are enhanced and promote the conservation of perennial 5^{th} order stream habitats and their associated SGCN.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to remove non-native species and restore native fish species in perennial 5th order stream habitats.

2. Implement and encourage compliance with strict baitfish regulations in 5th order stream habitats within the Gila Watershed so as to preclude introduction of non-native species.

3. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 5th order stream habitats outlined in the Information Gaps and Research, Survey, and Monitoring Needs section.

4. Work with public and private land managers to restore native fish populations that have been eliminated to 5th order stream habitats within the Gila Watershed.

5. Collaborate with federal and state agencies and affected publics to update and implement recommendations in the spikedace and loach minnow recovery plans.

6. Collaborate with federal and state agencies and affected publics to format conservation actions to gain public support for native fish management and conservation in perennial 5th order streams and in the Gila Watershed. Actions may include creating public awareness, appreciation, and understanding of perennial 5th order stream habitat functions, services, and values.

7. Work with public and private land managers to develop sustainable livestock production practices on native rangelands around perennial 5th order stream to reduce stream degradation.

8. Coordinate and cooperate with other state and federal resource agencies, conservation groups, and private land managers in developing and implementing measures to conserve native fish in 5th order stream habitats within the Gila Watershed.

9. Collaborate with federal and state agencies and affected publics to complete and implement the recovery plan for the roundtail chub.

MIMBRES WATERSHED

The Mimbres River occupies a small endorheic basin in southwest New Mexico. Its headwaters are on the west and south-facing slopes of the Black Range. It flows southward and dissipates onto the desert north of Deming. Much of the permanently watered portion of the river is in the Mimbres Valley, where the system was historically more swamp-like in character than river. For most of its perennial course, the Mimbres River flows within Grant County. The lower-most point with permanent water occurs in northern Luna County. Formerly small farms, orchards, and dispersed livestock grazing were the predominant land use in much of the Mimbres Valley. Upstream of the village of San Lorenzo, the valley becomes a checkerboard of small "ranchitos". The watershed uplands are mostly US Forest Service administered lands, but valley lands are largely privately owned. Although rural, the valley has been subdivided into numerous small tracts, many with dwellings that have private wells and septic systems. Here, the river channel is frequently mechanically realigned and woody riparian vegetation has been removed. The Nature Conservancy and the New Mexico Department of Game and Fish own several tracts along the river, which provide some protection to the aquatic habitat.

Bear Canyon Reservoir supports a non-native sport fishery including channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoidesi*), and rainbow trout (*Oncorhynchus mykiss*). Sediment accumulation in Bear Canyon Reservoir prompted recent draining and excavation to improve sportfish habitat. Though the rate of sediment deposition is expected to diminish as watershed conditions improve, excavation is likely to again be necessary.

Key habitats identified in the Mimbres Watershed include 1) perennial marsh/cienega/ spring/seep, 2) perennial 1^{st} and 2^{nd} order streams, and 3) perennial 3^{rd} and 4^{th} order streams (Fig. 5-11). Although historically the watershed contained many springs and seeps, these habitats are now limited to just Mimbres Spring.

Species of Greatest Conservation Need

Historically, three fish species were native to the Mimbres Watershed (Table 5-13). Some have suggested that trout may have naturally occurred in system, but there is no evidence to support this. A non-native population of federally and state listed Gila trout (*Oncorhynchus gilae*) occupies McKnight Creek, a 1^{st} and 2^{nd} order headwater tributary. Non-native rainbow and Gila trout inhabit several other headwater streams. The Rio Grande sucker (*Catostomus plebeius*) is the only native fish in 1^{st} or 2^{nd} order streams.

The Mimbres Watershed hosts a high diversity (37 species; excluding arthropods other than crustaceans) of Species of Greatest Conservation Need (SGCN) (Table 5-13). Eighteen species (49%) are classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. An additional 13 species are classified as vulnerable, imperiled, or critically imperiled in the state, but secure nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed within the appropriate Riparian Habitat, Ephemeral Habitats, and/or Terrestrial Habitat sections.

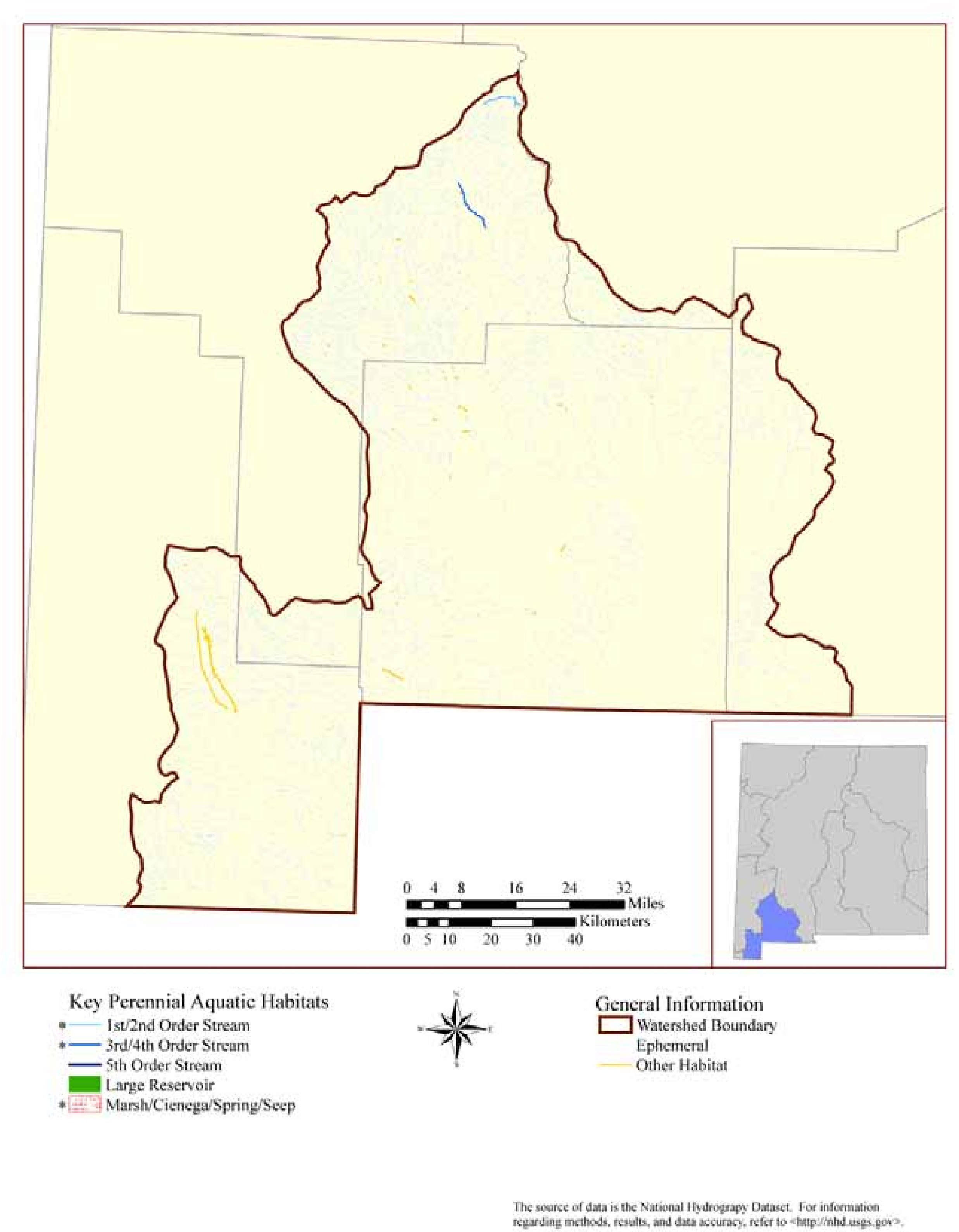


Figure 5-11. Key perennial aquatic habitats in the Mimbres Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Table 5-13. Species of Greatest Conservation Need in the Mimbres Watershed in New Mexico.

	Perennial		
Common Name	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream
Fish			
Gila Trout		X	
Chihuahua Chub	X		X
Rio Grande Sucker	X	X	X
Birds[1]			
Eared Grebe	X		X
American Bittern	X		
White-Faced Ibis	X		
Northern Pintail	X		X
Osprey			X
Bald Eagle	X		X
Northern Harrier	X		
Common Black-Hawk	X	X	X
Peregrine Falcon	X		X
Sandhill Crane	X		
Southwestern Willow Flycatcher	X		X
Bell's Vireo			X
Bank Swallow			X
Lucy's Warbler	X		X
Yellow Warbler	X	X	X
Mammals[1]			
Arizona Shrew	X		
Western Red Bat	X		
Spotted Bat	X		
Allen's Big-Eared Bat	X		
Pocketed Free-Tailed Bat	X		
American Beaver	X	X	X
New Mexico Meadow Jumping Mouse	X		
Amphibian[1]			
Tiger Salamander	X		
Arizona Toad	X	X	X
Western Chorus Frog	X	X	X
Plains Leopard Frog	X		X
Chiricahua Leopard Frog	X	X	X
Northern Leopard Frog	X	X	X
Lowland Leopard Frog	X	X	
Reptiles[1]			
Sonoran Mud Turtle		X	X
Mexican Garter Snake	X	X	X
Narrowhead Garter Snake		X	X

Table 5-13 Cont.

	Perennial		
Common Name	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream	3rd and 4th Order Stream
Molluscs[1]			
Pyrgulopsis spp. Snail	X		
Crustaceans[1]			
Sideswimmers / Scuds	X	X	X

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Historically, much of the Mimbres Valley was a complex system of spring, seep and cienega habitats. With European settlement, the system was modified and the river generally restricted to a well-defined single channel. Spring, seep, and cienega habitats were intentionally drained and largely eliminated. The drilling of numerous wells lowered the water table and further diminished these habitats. Currently, perennial spring, seep, marsh, and cienega habitats in the Mimbres Watershed are limited to Mimbres Spring.

Problems Affecting Habitats or Species

Water Withdrawal
Continued lowering of the water table is likely to adversely affect all spring, seep, and cienega habitats remaining in the Mimbres Valley. Surface water loss resulting from additional demands on the water supply will have significant adverse effects on the aquatic species associated with this habitat type. Extended drought conditions are compounding this problem.

Non-Native Species
Invasive and non-native plants and animals are a concern for the longevity of perennial spring-fed habitats. Non-native sportfish, particularly from Bear Canyon Reservoir, present a potential for predation and competition that may diminish native fauna. With increasing demand on limited sources of moisture, non-native plants may disrupt the structure and stability of native plant communities and degrade wildlife habitat.

Habitat Alteration
Livestock access to springs increases sedimentation, denudes banks of vegetation, and introduces fecal wastes. Most of the natural springs in the Mimbres have been modified for human use. The likelihood of disease and parasite outbreaks increases significantly where such modifications crowd fish populations into a much reduced habitat.

Information Gaps

There are numerous information gaps that impair our ability to make informed conservation decisions regarding perennial marsh/cienega/spring/seep habitats.

- Information is lacking on recharge or subsurface connectivity of springs to the Mimbres River.
- Demographics of fish populations are largely unknown in spring habitats.
- Interactions are largely unknown between various species that rely on perennial marsh/cienega/spring/seep habitats.
- The existing environmental conditions or thresholds are unknown that limit populations of SGCN.
- Factors causing parasite outbreaks in perennial marsh/cienega/spring/seep habitats are unclear.
- The long term effects of parasitic infections on resident fishes are unknown.
- Information is lacking as to the extent to which invasive and non-native species may alter perennial marsh/cienega/spring/seep habitats and limit populations of associated SGCN.

Research, Survey, and Monitoring Needs

Research or survey efforts needed to make informed conservation decisions for perennial marsh/cienega/spring/seep habitats or associated SGCN are detailed below.

- Research, surveys, and monitoring programs are greatly needed for SGCN associated with perennial marsh/cienega/spring/seep habitats. Little is currently known of the extent of their distribution, their biology, or the stability of their populations and microhabitats.
- Gather information to help understand the life history and control measures of various parasites, particularly the yellow grub (*Clinostomum marginatrum*). Parasites infect fish associated with perennial marsh/cienega/spring/seep habitats.
- Determine the movement of the Chihuahua chub (*Gila nigrescens*) from springs to the Mimbres River.
- Investigate the extent to which land use activities, such as livestock grazing timing, intensity, and duration, human development and invasive or non-native species invasions fragment and alter habitats in relation to size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN in perennial marsh/cienega/spring/seep habitats.

- Investigate hydrologic relationships in perennial marsh/cienega/spring/seeps to provide a better understanding of physiochemical and hydrologic processes that allow sustainable watershed conservation and management practices. This information will help evaluate the effects of extended drought periods on springs and associated SGCN.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep habitats in the Mimbres Watershed include:

- Perennial marsh/cienega/spring/seep habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- There is no net loss of perennial marsh/cienega/spring/seep habitat in the Mimbres River Watershed.

- Livestock use of perennial marsh/cienega/spring/seep habitats does not increase sedimentation, denude banks of vegetation, or introduce fecal wastes that affect water quality and associated SGCN.

- Perennial marsh/cienega/spring/seep habitats are free of non-native species that threaten the persistence of native species.

- Viable populations of Chihuahua chub are maintained in Mimbres Spring.

- A barrier to invasion of Mimbres Spring by non-native fish exists and is maintained in operating condition.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Continue to cooperate with private landowners and The Nature Conservancy to protect Mimbres Spring.

2. Work with public and private land managers to develop sustainable livestock practices on rangelands around perennial marsh/cienega/spring/seep habitats to reduce spring degradation.

3. Annually monitor the Chihuahua chub population in Mimbres Spring.

4. Use Chihuahua chub from Mimbres Spring to maintain stock at Dexter National Fish Hatchery & Technology Center.

5. Collaborate with federal and state agencies, research institutions, and universities to develop and implement methods to suppress yellow grub parasite in Mimbres Spring.

6. Work with federal, state, and private agencies and institutions to remove non-native species from Mimbres Spring.

7. Work with appropriate state and federal government entities, NGOs, and private landowners to construct barriers to prevent invasion by non-native fishes into Mimbres Spring.

8. Encourage partnerships between federal and state land managers and private landowners to protect and rehabilitate perennial marsh/cienega/spring/seep habitats.

9. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial marsh/cienega/spring/seep habitats outlined in the Problems or Research, Survey, and Monitoring Needs sections.

Perennial 1st and 2nd Order Stream

Habitat Condition

Most 1st and 2nd order perennial streams in the Mimbres Watershed, particularly those at high elevation, are on lands administered by US Forest Service. Improper livestock grazing contributed to bank erosion and loss of woody riparian vegetation. Modified grazing practices have resulted in some improvements. Aquatic habitats are generally in comparatively good condition. High intensity floods have incised stream channels in some areas but habitat quality has improved as riparian vegetation is restored. Wildfire and associated ash flow has diminished habitat quality in some stream reaches.

Problems Affecting Habitats or Species

Fire Management
The primary factor adversely affecting 1st and 2nd order stream habitats in the Mimbres Watershed is wildfire and associated ash flows. Until burned watersheds recover, ash flows and elevated sediment transport will continue to diminish habitat quality.

Non-Native/Invasive Species
Non-native rainbow and brown trout (*Salmo trutta*) inhabit 1st and 2nd order streams. Their continued presence is a threat to the Chihuahua chub that occurs in downstream reaches.

Information Gaps

There are numerous information gaps that impair our ability to make informed conservation decisions regarding perennial 1st and 2nd order streams.

- Interactions and habitat associations are unknown of sympatric Gila trout and Chihuahua chub in McKnight Creek.
- The presence and distribution is unclear of SGCN, especially fish species, in perennial 1st and 2nd order streams.
- Long-term effects of wildfire on stream biota are unknown.
- The location, area and quality of perennial 1st and 2nd order stream habitats for SGCN in the Mimbres Watershed are unknown.
- Suitability of habitats for restoration of native fishes, particularly Chihuahua chub is unknown.

Research, Survey, and Monitoring Needs

Research or survey efforts needed to make informed conservation decisions for perennial 1st and 2nd order streams and SGCN are detailed below.

- Develop comprehensive spatial data designating the location, area and quality of perennial 1st and 2nd order stream habitats to provide the foundation for monitoring impacts and facilitating risk assessment for SGCN that occupy this habitat type.
- Investigate the extent to which wildfire and associated ash flow has diminished habitat quality.
- Systematic inventories are needed of all perennial 1st and 2nd order streams.
- Research is needed to evaluate the potential for the persistence of mixed Gila trout and Chihuahua chub assemblages.
- Streams suitable for restoration of the Chihuahua chub need to be identified and prioritized.
- Available habitats throughout perennial 1st and 2nd order streams need to be quantified in the Mimbres Watershed.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order streams in the Mimbres Watershed include:

- Perennial 1st and 2nd order stream habitats in the Mimbres Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movements of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Non-native species in perennial 1st and 2nd order stream habitats are controlled or eliminated.

- Healthy populations of Chihuahua chub persist in McKnight Creek.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies to continue augmentation and monitoring of Chihuahua chub in the McKnight Creek.

2. Work with the US Forest Service to develop strategies to reduce the effects of wildfire induced ash flows on native fish assemblages.

3. Continue to monitor the Gila trout population in McKnight Creek.

4. Work with federal and state agencies, private landowners, research institutions, and universities to continue fish assemblage monitoring efforts. Identify suitable stream reaches for restoration of native fishes.

5. Collaborate with federal and state agencies and affected publics to develop and implement strategies to remove non-native species and restore native fish species in perennial 1st and 2nd order stream habitats.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order streams outlined in the Information Gaps and Research, Survey, and Monitoring Needs sections.

Perennial 3rd and 4th Order Stream

Habitat Condition

The upper 3rd and 4th order stream reaches in the Mimbres Watershed are within lands administered by US Forest Service. The lowermost reaches of several tributaries and main stem Mimbres River are 3rd and 4th order streams. NMDGF and The Nature Conservancy own short reaches of main stem Mimbres River. These streams are generally shaded and aquatic habitats in moderate to excellent condition.

Within the Mimbres Valley, land ownership is largely private and habitat quality is seriously compromised. Extensive reaches of the river are regularly bulldozed to straighten the channel and remove large woody debris. Pool habitat has been eliminated by such activities and the stream receives little shade. Diversion of water for agriculture seasonally diminishes flows in much of the river and it dries up downstream of San Lorenzo. Woody riparian vegetation has been removed from riverbanks on most private lands. Dispersed livestock grazing is the primary land use on upland portions of the watershed.

Problems Affecting Habitats or Species

Habitat Conversion
Extensive channel dewatering and straightening and the removal of woody debris are major activities adversely affecting perennial 3rd and 4th order stream habitats in the Mimbres Watershed. Resultant conditions diminish the capacity of these habitats to sustain associated SGCN.

Non-Native/Invasive Species
Introduced rainbow trout prey upon native fishes. Longfin dace (*Agosia chrysogaster*) compete with them for limited habitat. The specific effects of this predation and competition are perceived as problems affecting the persistence of native fishes.

Information Gaps

There are numerous information gaps that impair our ability to make informed conservation decisions regarding perennial 3rd and 4th order streams in the Mimbres Watershed.

- The status of the Chihuahua chub within the reaches of the Mimbres River that are bounded by private lands is largely unknown.

- The response of SGCN to various flow regimes, including channel drying, needs to be understood.

- Current trends and status of perennial 3rd and 4th order streams in the Mimbres Watershed are largely unknown.

- Information is lacking on the extent to which invasive or non-native species may alter perennial 3rd and 4th order streams and limit populations of SGCN.

Research, Survey, and Monitoring Needs

Research or survey efforts needed to make informed conservation decisions for perennial 3rd and 4th order streams or SGCN are detailed below.

- Annual monitoring of Mimbres River fish assemblages should continue.

- Movement and survival of stocked Chihuahua chub should be monitored and evaluated through use of implanted PIT tags.

- Research, surveys, and monitoring programs are greatly needed for SGCN associated with perennial 3rd and 4th order streams of the Mimbres Watershed. Little is currently known of the extent of their distribution, biology, or the stability of their populations and microhabitats.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order streams in the Mimbres Watershed include:

- Perennial 3rd and 4th order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Additional lands along the Mimbres River are managed for conservation of native fishes and other associated SGCN.

- Viable populations of the beautiful shiner (*Cyprinella formosa mearnsi*) have been restored in the Mimbres Watershed.

- The Chihuahua chub has expanded its range to include all warm water reaches of the Mimbres River and suitable tributary streams such as Gallinas Canyon.

- Public awareness and appreciation of perennial 3rd and 4th order stream resources is improved.

- Improved riparian corridor management exists through the development and adoption of management practices that protect the ecological integrity of stream habitats.

- Channel straightening and debris removal activities have ceased. Channel conditions are stabilized with appropriate streamside vegetation and substrates.

- Implementation and compliance with baitfish regulations that minimize introduction of non-native fish are realized.

- Impacts to native species communities by non-natives are eliminated.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Continue to work with landowners (public and private) to maintain and enhance riparian conditions along the Mimbres Watershed.

2. Identify and implement opportunities for further habitat conservation on private properties along the Mimbres River. Approaches may include enactment of conservation easements or other agreements and acquisition from willing sellers.

3. Encourage public participation in state and federal incentive-based programs to protect, enhance, and restore perennial 3rd and 4th order stream habitats. Such incentive-based programs may include: Wetlands Reserve Program, and the Landowner Incentive Program, among others.

4. Work with federal and state agencies and affected publics to establish minimum flows for fishes within important Chihuahua chub habitats in perennial 3rd and 4th order streams of the Mimbres Watershed.

5. Collaborate with federal and state agencies and affected publics to actively remove non-native predators from perennial 3rd and 4th order streams of the Mimbres Watershed.

6. Maintain the fish screen on Bear Canyon Reservoir outflow to prevent emigration of non-native fishes from the reservoir into the Mimbres River.

7. Continue to maintain the captive population of Chihuahua chub at Dexter National Fish Hatchery and Technology Center. This population is periodically augmented with wild fish. Similarly, continue to augment the wild population of Chihuahua chub with fish propagated at Dexter National Fish Hatchery and Technology Center.

8. Adopt and encourage compliance by anglers with baitfish regulations that will preclude introduction of non-native species.

9. Continue to manage properties owned by NMDGF and The Nature Conservancy to provide habitat for Chihuahua chub and other SGCN of the Mimbres River.

10. Evaluate the potential to successfully re-establish beautiful shiner in the Mimbres River.

11. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 3^{rd} and 4^{th} order stream habitats outlined in the Problems or Research, Survey, and Monitoring Needs sections.

12. Encourage partnerships with private, state, and federal land managers to protect, enhance, and rehabilitate perennial 3^{rd} and 4^{th} order stream habitat.

13. Educate local resource users about the measures necessary to conserve perennial 3^{rd} and 4^{th} order streams and associated SGCN in the Mimbres Watershed.

PECOS WATERSHED

The Pecos River arises in the Sangre de Cristo Mountains of Mora County, New Mexico. It runs south through San Miguel, Guadalupe, De Baca, Chaves, and Eddy counties in New Mexico before entering Texas. The Pecos Watershed encompasses 1.6 million ac (6,474,970 ha) in New Mexico (US Bureau of Reclamation 2002) and includes a variety of aquatic habitats. Key habitats in the Pecos Watershed include large reservoirs, perennial spring/seep/marsh/cienega, perennial 1^{st} and 2^{nd} order streams, and perennial 3^{rd} and 4^{th}, and perennial 5^{th} order streams (Fig. 5-12).

Land uses in this watershed consist mainly of rangeland, with some irrigated cropland and pastureland along the Pecos River. Roughly 10% of the industry in the lower Pecos Valley is agriculture (De Baca, Chavez, and Eddy Counties). Primary crops include small grains, alfalfa, and hay. Oil and gas development occurs within the lower Pecos River Valley. Soils range from shallow to moderately deep loams in all parts of the watershed. Along the Pecos River, soils are moderately deep to deep, with moderate to heavy texture.

Las Vegas, Santa Rosa, Fort Sumner, Roswell, Artesia, and Carlsbad are the principal cities within the watershed. The counties in the Pecos Watershed have experienced positive population growth from 1990 – 2000 (New Mexico Economic Development Department 2004), with only De Baca County showing slight declines (-0.5%). Lincoln County had the second highest growth rate in the state (59%) for this period.

Species of Greatest Conservation Need

Fifty-eight Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, occur in the Pecos Watershed (Table 5-14). Thirty-one of these SGCN (53%) are classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Only six SGCN (10%) were secure both statewide and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H.

Although large reservoirs are not native habitats, several native fish species use them as refuge when water diversions and low water conditions occur elsewhere in the river. For example, the blue sucker (*Cycleptus elongates*) and the gray redhorse (*Moxostoma congestum*) use the reservoirs near Carlsbad. A variety of SGCN, including five native fish species, use marsh/cienega/spring/seep habitats, primarily in the lower Pecos Watershed. Perennial 1^{st} and 2^{nd} and 3^{rd} and 4^{th} order streams within the watershed occur in several ecoregions, thus there are both cold and warm water SGCN in these habitat types. Diverse assemblages of SGCN, especially fish species, inhabit the main stem of the Pecos. The New Mexico Department of Game and Fish (NMDGF) have active projects for managing Pecos pupfish (*Cyprinodon pecosensis*) and Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*). Otherwise, there is little known about the distribution or variability of fish populations in these habitats. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the Statewide Distributed Ephemeral Habitats and Perennial Tanks section.

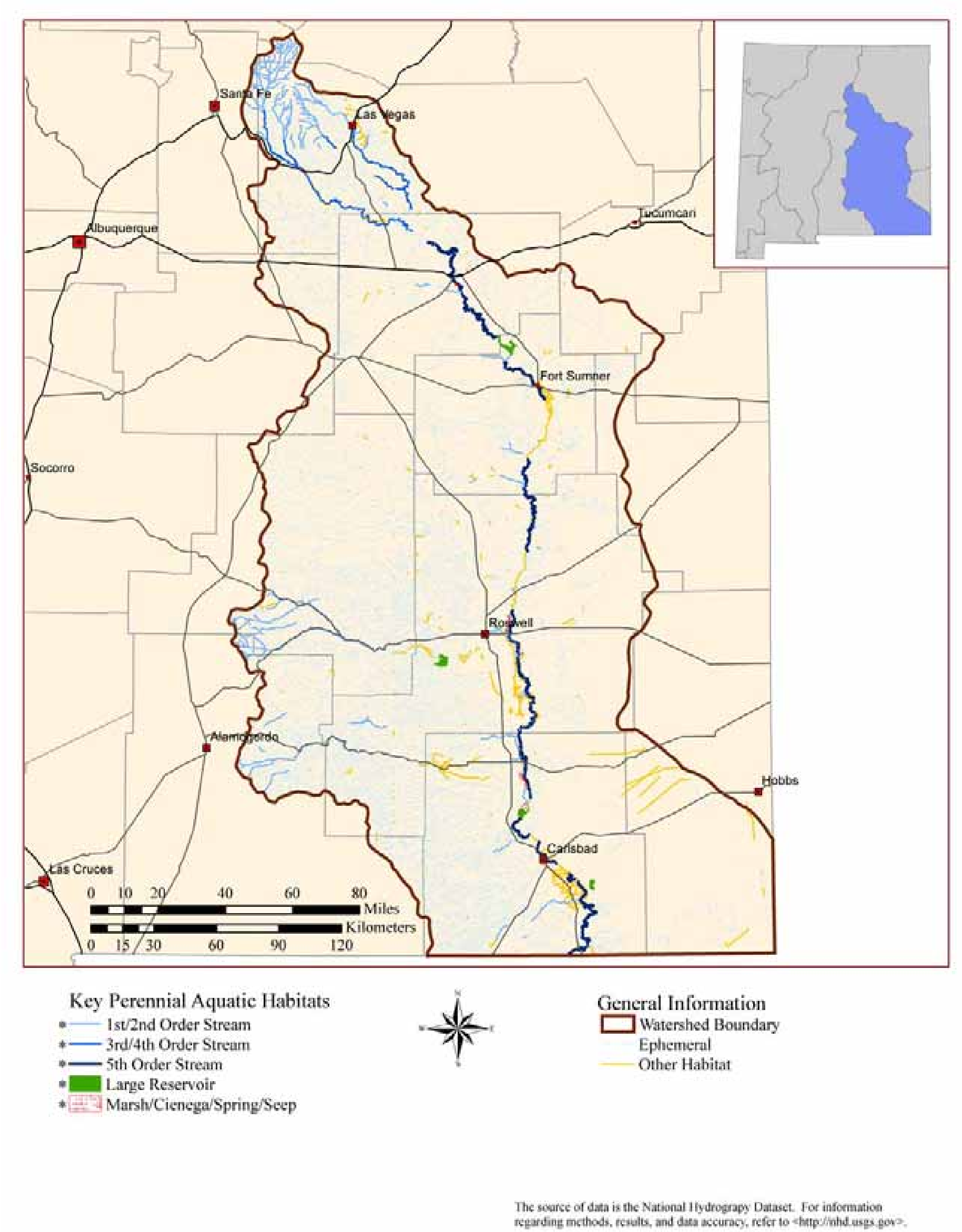


Figure 5-12. Key perennial aquatic habitats in the Pecos Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Table 5-14. Species of Greatest Conservation Need in the Pecos Watershed in New Mexico.

	Perennial				
Common Name	Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Fish					
Bigscale Logperch	X				X
Blue Catfish	X				X
Blue Sucker	X			X	X
Central Stoneroller			X	X	X
Gray Redhorse	X				X
Greenthroat Darter	X	X	X	X	X
Headwater Catfish				X	X
Mexican Tetra	X	X	X	X	
Pecos Bluntnose Shiner					X
Pecos Gambusia		X	X		
Pecos Pupfish		X	X	X	X
Rainwater Killifish		X	X	X	
Rio Grande Chub			X	X	
Rio Grande Cutthroat Trout			X	X	
Rio Grande Shiner					X
Rio Grande Silvery Minnow					E[1]
Smallmouth Buffalo	X				X
Speckled Chub					X
Birds[2]					
Eared Grebe	X	X		X	X
American Bittern		X			
White-Faced Ibis	X	X			
Northern Pintail	X	X		X	X
Osprey	X			X	X
Bald Eagle	X	X		X	X
Northern Harrier		X			
Common Black-Hawk		X	X	X	X
Peregrine Falcon	X	X		X	X
Sandhill Crane	X	X			X
Snowy Plover	X				X
Interior Least Tern	X			X	X
Southwestern Willow Flycatcher		X		X	X
Bell's Vireo				X	X
Bank Swallow				X	X
Yellow Warbler		X	X	X	X
Painted Bunting				X	X
Mammals[2]					
Pocketed Free-Tailed Bat		X			
American Beaver	X	X	X	X	X
NM Meadow Jumping Mouse		X			
Least Shrew		X			

Table 5-14 Cont.

Common Name	Perennial Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Amphibian[2]					
Tiger Salamander		X			
Western Chorus Frog		X	X	X	
Rio Grande Leopard Frog		X		X	X
Plains Leopard Frog		X		X	X
Northern Leopard Frog		X		X	X
Reptiles[2]					
Western River Cooter				X	X
Blotched Water Snake		X		X	X
Arid Land Ribbon Snake		X	X	X	X
Molluscs[2]					
Pecos Assiminea Snail		X			
Texas Liptooth Snail		X			
Blunt Ambersnail		X			
Ovate Vertigo Snail		X			
Blade Vertigo Snail		X			
Wrinkled Marshsnail		X			
Texas Hornshell				X	
Pecos Pyrg Snail		X	X		
Roswell Pyrg Snail		X	X		
Koster's Tryonia Snail		X	X		
Crustacean[2]					
Sideswimmers / Scuds		X	X	X	X

[1] Species is considered extirpated from habitat type.
[2] Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Perennial Large Reservoirs

Habitat Condition

Perennial large reservoirs in the Pecos Watershed are under diverse management regimes. The New Mexico State Parks Division administers three of the largest reservoirs in the drainage. Santa Rosa Reservoir is operated primarily for flood control, Sumner Reservoir is managed largely as an irrigation storage facility, and Brantley Reservoir is operated to store water for irrigation and for meeting interstate compact requirements. Water levels, therefore, vary greatly and independently of SGCN habitat needs. These reservoirs can be nearly drained in years of low run-off. Water levels in the smaller Avalon, Carlsbad Municipal, Six-Mile, and Ten-Mile reservoirs on the Pecos River generally fluctuate less than those of larger reservoirs. These perennial large reservoirs support non-native sport fish and other non-native fishes such as the common carp (*Cyprinus carpo*). Large reservoirs are also popular recreational sites for camping, boating, and angling.

Problems Affecting Habitats or Species

Reservoir Hydrology
Large reservoirs in the Pecos Watershed are operated to meet human needs. As a result, flood control management and irrigation requirements take precedence. Santa Rosa Reservoir is emptied when large inflows are anticipated. Sumner Reservoir water levels are determined by releases to meet irrigation requirements. Irrigation and interstate compact requirements determine Brantley Reservoir water levels. The extent and frequency of such water level fluctuations directly affect resident fish spawning, cover, and feeding habitats.

Water Quality
Water quality is a potential problem for SGCN, especially fishes, in large reservoirs in the Pecos Watershed. The New Mexico Environment Department monitors water quality and has identified mercury and petrochemicals as potential problems in reservoirs.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions with respect to perennial large reservoirs and associated SGCN are outlined below.

- Little information is known about the effects of reservoir management strategies on golden algae (*Chrysophyta*) outbreaks.

- The fate of Pecos bluntnose shiner (*Notropis simus pecosensis*) and other pelagic spawning fish displaced into Brantley Reservoir is unknown.

- Relative importance of run-of-river reservoirs (Carlsbad Municipal, Six-Mile and Ten-Mile) for the maintenance of populations of gray redhorse and blue sucker is unknown. This information would assist in conservation activities focused on large reservoirs.

- The relative importance of large reservoirs as sources of undesirable non-native fishes is poorly understood.

- The feasibility of water release modifications to benefit native river fishes, and the sequential affects on large reservoir SGCN, are unknown.

- Little is known about the reasons for the continued rarity of smallmouth buffalo (*Ictiobus bubalus*) in these large reservoirs.

- The existing environmental conditions or thresholds that limit populations of SGCN in large perennial reservoirs are unknown.

- It is unknown the extent to which invasive and non-native species may alter perennial large reservoirs and limit populations of SGCN.

- It is unknown the extent to which degraded water quality may limit SGCN in large reservoirs.

Research, Survey, and Monitoring Needs

NMDGF, New Mexico Environment Department, and New Mexico Department of Health conduct periodic testing for fish contaminants within large reservoirs. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions regarding large reservoirs and associated SGCN are outlined below.

- Annual sampling and life history studies of fish assemblages in run-of-river reservoirs are needed to provide information about SGCN.

- Determine the occurrence of small native fishes in large perennial reservoirs.

- Determine the relative importance of reservoirs as sources of undesirable non-native fishes, such as sheepshead minnow (*Cyprinodon variegatus*).

- Investigations of water withdrawal relationships in large reservoirs are needed to provide a better understanding of how fluctuating reservoir levels affect spawning fish and nursery habitats. This information will help in designing sustainable watershed conservation and management practices.

- Determine the extent to which invasive and non-native species alter perennial large reservoir habitats and limit populations of SGCN.

Desired Future Outcomes

Desired future outcomes for perennial large reservoirs in the Pecos Watershed include:

- Perennial large reservoirs persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of resident SGCN while sustaining land uses with reduced resource use conflicts.

- Recreational opportunities that do not pose significant threat to the persistence of SGCN are optimized at large reservoirs. This may include focusing sport fish management on species that are appropriate for the biotic and abiotic conditions specific to each reservoir.

- Large perennial reservoir operations do not pose significant threat to the persistence of native fish communities and associated SGCN.

- The emigration and impact of non-native fishes from reservoirs into surrounding habitats are minimized.

- SGCN within this habitat are not adversely affected by aquatic nuisance species or other non-native species.

Prioritized Conservation Actions

1. The conservation of New Mexico's biodiversity in perennial large reservoirs will require a variety of conservation actions focused on both native and non-native species and habitat requirements of SGCN. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

2. Collaborate with federal and state agencies and affected publics to implement the Draft State Aquatic Nuisance Species Management Plan (currently in development by NMDGF) in perennial large reservoirs of the Pecos Watershed.

3. Work with water management authorities to maintain minimum conservation pools in perennial large reservoirs sufficient to support established sport fisheries, SGCN, and year-round recreational opportunities.

4. Work with public and private land managers to develop strategies to prevent emigration of non-native fishes from reservoirs into surrounding areas and educate anglers on the importance of not relocating live fish to other areas.

5. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of large reservoirs functions, services, and values. Risks posed by undesirable non-native fishes to both sport and native fishes should be emphasized.

6. Collaborate with agencies and affected publics to adopt and encourage compliance with baitfish regulations that preclude introduction of non-native species into large perennial reservoirs.

7. Continue participating with other state and federal agencies in the Conservation Agreement for Pecos Pupfish and in completing development of The Pecos Pupfish Recovery Plan.

8. Establish partnerships with federal, state, and local agencies (Interstate Stream Commission, New Mexico State Parks, New Mexico Environment Department, etc.) to monitor reservoir water quality relative to SGCN.

9. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial large reservoirs outlined in the Research, Survey, and Monitoring Needs section.

Perennial Spring/Seep/Marsh/Cienega

Habitat Condition

The lower Pecos Watershed has an abundance of natural springs and associated lakes. Many of the springs and catchments and associated wetlands in the lower Pecos Watershed are now alkaline but originally supported unique species assemblages. Flood control, groundwater withdrawal, oil and gas development, erosion and invasion of non-native vegetation have adversely affected many of the natural wetlands springs in this watershed, including those of Bottomless Lakes State Park and Bitter Lakes National Wildlife Refuge (BLNWR).

Problems Affecting Habitats or Species

Non-Native/Invasive Species
Non-native centrarchids and gambusia have had the greatest impacts on SGCN, especially fish species, occupying perennial spring/seep/marsh/cienega habitats of the Pecos Watershed. Invasive New Zealand mudsnail (*Potamopyrgus antipodarum*), red-rim melania (*Melanoides tuberculatus*), and non-native crayfish are also potential problems.

Habitat Conversion
Alterations that drain, fill, channelize or impound wetlands compose habitat conversion processes that affect SGCN of marsh/cienega/spring/seep habitats. Capping of springhead sources may likewise permanently alter natural wetland characteristics. Human caused habitat conversion such as excessive groundwater pumping and physical alteration of artesian spring systems has resulted in extirpation of isolated populations of Noel's amphipod (*Gammarus desperatus*) and prosobranch gastropods (gill-breathing snails) in Chavez and Eddy counties.

Habitat essential to the persistence of these taxa in BLNWR burned during the March 2000 Sandhill Fire. Among the most salient fire impacts were the marked post-fire growth of the common reed (*Phragmites australis*), which may account for changes in hydrochemical conditions, stream flow patterns, and the riparian plant community of Bitter Creek (Lang 2005a).

All of the problems associated with human development have the potential to alter perennial marshes, cienegas, springs, and seeps, and thus affect associated SGCN. Excessive groundwater pumping, sewage/septic contamination of water supplies and drought could lead to lower spring levels (US Bureau of Reclamation 2002) that would be detrimental to species occurring in these habitats.

Information Gaps

- Information gaps that impair our ability to make informed conservation decisions for perennial marshes/cienegas/springs/seeps habitat in the Pecos Watershed are outlined below.

- The status, distribution, abundance and natural history of SGCN, especially Mexican tetra (*Astyanax mexicanus*), greenthroat darter (*Etheostoma lepidum*) and rainwater killifish (*Lucania parva*) are unknown.

- We do not have a current inventory of the species and habitats associated with Bottomless Lakes State Park.

- Little is known of the aquatic macroinvertebrates of perennial spring/seep/marsh/cienega habitats.

- Habitat requirements and life history data are lacking for most invertebrate SGCN of perennial spring/seep/marsh/cienega habitats.

- Little is known about the extent to which human related habitat conversion activities alter or potentially affect perennial spring/seep/marsh/cienega habitats in the Pecos Watershed.

Research, Survey, and Monitoring Needs

Current research and survey efforts in perennial spring/seep/marsh/cienega habitats in the Pecos Watershed include:

- The transport, fate, and effects of polychlorinated biphenyls (PCBs) in aquatic food webs within Hunter Marsh and Hunter Oxbow of BLNWR.

- The Interstate Stream Commission monitors flow levels from Lea Lake in the Bottomless Lakes State Park.

- The New Mexico Fishery Resources Office has conducted population monitoring on the Pecos River and BLNWR since the mid 1980s. These data provide population trend information on fish communities with emphasis on Pecos pupfish and Pecos gambusia (*Gambusia nobilis*).

- Surveys for gammarid amphipods and prosobranch snails of BLNWR have been conducted since 1995 under a state conservation and recovery plan (NMDGF 2005a).

- Research is ongoing on cryptic species of gammarid amphipods using molecular genetic techniques (Gervasio *et al*. 2004).

- NMDGF is collaborating with Dr. Robert Hershler of the Smithsonian Institution on a phylogenetic study of the Pecos assiminea (*Assiminea pecos*) snail species complex of New Mexico, Texas, and Mexico.

- Additional research, survey, and monitoring needs that would inform our conservation decisions regarding perennial marshes, cienegas, springs, and seeps, and associated SGCN are outlined below.

- Understand the distribution, biology, population stability, and microhabitat use of SGCN that rely on perennial spring/seep/marsh/cienega habitats.

- A comprehensive statewide survey of aquatic macroinvertebrates of perennial spring, seep, marsh, and cienega habitats is needed.

- Investigate the extent to which land use activities fragment and alter perennial spring/seep/marsh/cienega habitats. This information is important in understanding how different land use intensities and frequencies of disturbances affect associated SGCN.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep habitats and associated SGCN in the Pecos Watershed include:

- Perennial marsh/cienega/spring/seep habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Natural water levels in marsh, cienega, spring, and seep habitats are maintained sufficiently to sustain associated aquatic SGCN.

- The spread of aquatic non-native or invasive plant and animal species is controlled or minimized to a level that SGCN within this habitat are not adversely affected.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to implement the draft state aquatic nuisance species management plan in perennial marsh/cienega/spring/seep habitats in the Pecos Watershed.

2. Work with federal and state agencies and affected publics to take actions to prevent lowering of groundwater levels, including regulation of groundwater pumping.

3. Coordinate with state and federal land managers and private landowners to protect, restore, conserve, and create perennial marsh/cienega/spring/seep habitats and surrounding natural vegetation.

4. Collaborate with federal and state agencies and affected publics to adopt standardized monitoring and survey methods to track gains and losses of perennial marsh/cienega/ spring/seep habitats in the Pecos Watershed.

5. Seek partnerships that encourage the removal of harmful non-native species and the prevention of further introductions.

6. Establish partnerships with federal, state, and local agencies such as the Interstate Stream Commission, New Mexico State Parks Division, New Mexico Environment Department, to monitor and maintain water quality relative to SGCN.

7. Work with willing agencies, landowners, and NGO's to implement the conservation and recovery plan for the Pecos assiminea (snail), Noel's amphipod, Koster's springsnail (*Juturnia kosteri*), and Roswell springsnail (*Pyrgulopsis roswellensis*) (NMDGF 2005a).

8. Continue participating with other state and federal agencies in the Conservation Agreement for Pecos Pupfish, including updating the agreement, enforcing baitfish regulations, investigating the efficacy of legal protection for the species, and completing development of the state recovery plan for the Pecos pupfish.

9. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial large reservoirs outlined in the Research, Survey, and Monitoring Needs section.

Perennial 1st and 2nd Order Stream

Habitat Condition

Headwater streams occurring in the southern Sangre de Cristo Mountains, including the Pecos Wilderness, Capitan and Sacramento Mountains, are mainly under the administration of the US Forest Service and the Mescalero Apache Indian Reservation. These typically shaded streams range from meanders through high mountain meadows to cascading runs down steep canyons. Improper grazing, logging, and roads adversely affect small, high-elevation streams. Generally, habitat quality on publicly administered lands is fair to excellent. Lower elevation 1st and 2nd order streams in this drainage are mainly ephemeral, but several are perennial. Scattered cottonwood and willow typically border these streams and habitat conditions are diverse.

Problems Affecting Habitats or Species

Modification of Natural Processes
Improper livestock grazing, road building, improper timber harvest, and mineral extraction can diminish habitat quality. Groundwater pumping reduces surface flow in lower elevation 1st and 2nd order streams in the watershed (US Bureau of Reclamation 2002).

Non-Native/Invasive Species
Non-native fishes, particularly rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*), have been a major factor adversely affecting native Rio Grande cutthroat trout in perennial 1st and 2nd order streams of the Pecos Watershed.

Diseases and Pathogens
The presence of whirling disease in rainbow trout was confirmed in New Mexico the spring of 1999. Since this confirmation, portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

- Information gaps that limit our ability to make informed conservation decisions for perennial 1st and 2nd order stream habitats are outlined below.

- Little is known about perennial 1st and 2nd order streams habitats in lower elevations of the Pecos Watershed and the warm water fish species that occupy these habitats.

- There is little known about the movement of native fish, especially salmonids, between various tributary systems and how the metapopulation concept may apply to the management of these species.

- Data are lacking regarding the distribution and abundance of fish SGCN and the location and condition of perennial 1st and 2nd order stream habitats.

- It is unknown the extent to which land use activities such as livestock grazing intensity and duration, logging, human development, and road-building, fragment and alter habitats in relation to size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN in perennial 1st and 2nd order streams.

- Environmental conditions or thresholds that limit populations of SGCN in perennial 1st and 2nd order streams are unknown.

- It is unknown the extent to which non-native species are adversely affecting populations of SGCN in perennial 1st and 2nd order streams.

- The potential and risk for whirling disease to spread among salmonids of perennial 1st and 2nd order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

Research, Survey, and Monitoring Needs

NMDGF and the US Forest Service currently conduct surveys and monitoring of fish and habitats on forest service lands. These survey and monitoring efforts are valuable and need to continue. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions regarding perennial 1st and 2nd order streams and associated SGCN are outlined below.

- Determine SGCN distribution, abundance, and biology in lower elevation 1st and 2nd order streams.

- Ongoing research and survey for aquatic macroinvertebrates found in this habitat type is detailed under our consideration of perennial marsh/cienega/spring/seep habitats. Additional research needs to be conducted on distribution, habitat requirements, and life history for most invertebrate SGCN in perennial 1st and 2nd order streams habitats.

- Determine the extent to which land use activities fragment and alter perennial 1st and 2nd order stream habitats in the Pecos Watershed.

- Understand environmental conditions or thresholds that limit populations of SGCN in this habitat.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order stream habitats and associated SGCN of the Pecos Watershed include:

- Perennial 1st and 2nd order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Impacts to native species communities by non-natives are negligible and native species have been successfully re-established into previously occupied areas.

- Channel conditions are stabilized with appropriate streamside vegetation and substrates.

- The spread of aquatic nuisance species or other non-native or invasive plant and animal species is controlled or minimized in perennial 1^{st} and 2^{nd} order stream habitats to a level that SGCN within this habitat are not adversely affected.

- Natural flow regimes are present in perennial 1^{st} and 2^{nd} order stream habitats and sufficient to sustain SGCN.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to remove non-native species and to re-establish native fish communities in perennial 1^{st} and 2^{nd} order stream habitats.

2. Work with land management agencies, private land managers, and the agriculture industry to identify and promote grazing systems on rangelands near perennial 1^{st} and 2^{nd} order streams that ensure long-term ecological sustainability and integrity and are cost effective for livestock interests.

3. Collaborate with federal and state agencies to reduce the amount of stream degradation by logging and road building.

4. Coordinate with state and federal land managers and private landowners to protect, restore, conserve, and create perennial 1^{st} and 2^{nd} order streamside habitats, with consideration for natural vegetation.

5. Work with federal and state agencies and affected publics to develop techniques to maintain natural stream flows in perennial 1^{st} and 2^{nd} order stream habitats. Actions may include evaluating in-stream flow regulations for conservation of aquatic species.

6. Coordinate and cooperate with federal and state agencies and affected publics to implement the draft state aquatic nuisance species management plan (in development by NMDGF) in perennial 1^{st} and 2^{nd} order stream habitats in the Pecos Watershed.

7. Continue participating with other state and federal agencies in the Conservation Agreement for Pecos Pupfish, including updating the agreement, instituting baitfish regulations, investigating the efficacy of legal protection for the species, and completing development of the *Pecos Pupfish Recovery Plan*.

8. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order stream habitats outlined in the Information Gaps or Research, Survey, and Monitoring Needs sections.

Perennial 3rd and 4th Order Stream

Habitat Condition

Habitat conditions vary considerably among perennial 3rd and 4th order streams in the Pecos Watershed. Some streams retain considerable integrity while others have been greatly modified by human activities. There are many small impoundments and diversions along these systems used for irrigation, drinking water, and recreation. Many of the low-elevation systems are ephemeral prior to entering the main stem of the Pecos. The Black River provides habitat important to the survival of New Mexico's only remaining native freshwater mussel, the Texas hornshell (*Popenaias popeii*) (Lang 2004). Land use practices, such as excessive clearing of vegetation, improper grazing, and oil and gas development can exacerbate the effects of flooding and sedimentation, while contaminating surface waters. The Delaware River formerly supported several native fish species, including a population of headwater catfish (*Ictalurus lupus*). However, the diversion of all water from the river onto fallow fields has resulted in the loss of all resident stream fishes.

Problems Affecting Habitats or Species

Modification of Natural Processes
At higher elevations, almost all 3rd and 4th order streams have livestock grazing within their watersheds. Timber is harvested and roads constructed to provide access. These activities locally may increase bank erosion and sedimentation and remove riparian vegetation. In lower elevations, water diversion and groundwater pumping diminish surface flows and in some reaches have resulted in complete channel drying (US Bureau of Reclamation 2002). Dams regulate flows and disrupt natural flow regimes. In several places, these streams flow through urbanized areas and receive municipal runoff. Habitat modification caused by flooding and associated sedimentation is known to cause mortality of the Texas hornshell. Lang (2004) details threats to the Texas hornshell.

Non-Native/Invasive Species
Non-native fish species and bivalves such as the Asian clam (*Corbicula fluminea*) and giant floater (*Pyganodon grandis*) have been established in many of the 3rd and 4th order Pecos Watershed streams. The potential effects of their presence on associated SGCN are poorly understood.

Diseases and Pathogens
Portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated in coldwater streams and reservoirs. These waters may have been contaminated through inadvertent stocking of infected rainbow trout or by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps that limit our ability to make informed conservation decisions for perennial 3rd and 4th order stream habitats are outlined below.

- Current SGCN distribution and abundance are not well known. This is particularly true on private lands that contain a significant proportion of the perennial 3rd and 4th order stream habitats within the Pecos Watershed.

- Information is lacking regarding the extent to which invasive and non-native species may alter perennial 3rd and 4th order streams and limit populations of SGCN.

- The extent is unknown to which land use activities such as livestock grazing, logging, human development, and agriculture alter habitats in relation to connectivity, patch size, edge effect, and use by SGCN. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN in perennial 3rd and 4th order streams.

- The potential and risk for whirling disease to spread among salmonids of 3rd and 4th order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

Research, Survey, and Monitoring Needs

NMDGF and the US Forest Service currently conduct surveys and monitoring of fish and habitats on US Forest Service lands. Further, NMDGF is conducting capture-recapture studies to document survivorship of the Texas hornshell relative to variable flood regimes in the Black River. These survey and monitoring efforts are valuable and need to continue. Additional research and survey efforts of the Pecos Watershed that would assist conservation decisions regarding perennial 3rd and 4th order streams are outlined below.

- Determine the distribution, abundance, and biology of SGCN in perennial 3rd and 4th order streams. Studies on warm water 3rd and 4th order stream fishes are especially desirable to document their presence and status.

- Determine habitat use by juvenile mussels and glochidial (mussel larvae) host fish in situ.

- Refine captive aquaculture methods for the Texas hornshell and develop emergency response protocols to salvage mussels in the event of a human-caused or natural catastrophe that could threaten extant populations or population segments.

- Define the extent to which current land use activities fragment and alter perennial 3rd and 4th order stream habitats.

- Investigate environmental conditions or thresholds that limit populations of SGCN in perennial 3rd and 4th order stream habitats.

- A genetic study is needed comparing isolated populations of the Texas hornshell in New Mexico and Texas to make decisions regarding the federal listing status of this species.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order streams and associated SGCN in the Pecos Watershed include:

- Perennial 3rd and 4th order streams persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Impacts to native species communities by non-natives are negligible. Native species have been successfully re-established into previously occupied areas.

- Stream channel conditions are stabilized with appropriate streamside vegetation and substrates.

- The spread of aquatic nuisance species or other non-native or invasive plant and animal species are controlled or minimized in perennial 3rd and 4th order stream habitats to a level that SGCN within this habitat are not adversely affected.

- Natural flow regimes are present and maintained for the benefit of SGCN.

- A naturally reproducing population of the Texas hornshell persists in the Black River.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to remove non-native species and re-establish native fish communities in perennial 3rd and 4th order stream habitats.

2. Work with public and private land managers to develop sustainable livestock production practices on native rangelands around perennial 3rd and 4th order streams to reduce stream degradation.

3. Collaborate with federal and state agencies to reduce the degradation of perennial 3rd and 4th order stream habitats by logging and road building.

4. Coordinate with state and federal land managers and private landowners to protect, restore, conserve, and create perennial 3rd and 4th order streamside habitats, with consideration for natural vegetation.

5. Work with federal and state agencies and affected publics to develop techniques to maintain a natural stream flow in perennial 3rd and 4th order stream habitats. Actions may include evaluating the efficacy of in-stream flow regulations for conservation of SGCN.

6. Initiate a conservation and recovery plan for the Texas hornshell with the cooperation of federal and state agencies and affected publics.

7. Coordinate and cooperate with federal and state agencies and affected publics to implement the *Draft Aquatic Nuisance Species Management Plan*, which includes perennial 3rd and 4th order stream habitats in the Pecos Watershed, currently being prepared by NMDGF.

8. Continue participating with other state and federal agencies in the *Conservation Agreement for Pecos Pupfish*. This would include updating the agreement, instituting baitfish regulations, investigating the efficacy of legal protection for the species, and completing development of the state recovery plan for Pecos pupfish.

9. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 3rd and 4th order stream habitats outlined in the Information Gaps and Research, Survey, and Monitoring Needs sections.

Perennial 5th Order Stream

Habitat Condition

The main stem of the Pecos River comprises the 5th order stream of this watershed. Upstream of Roswell, it is a meandering, sand-bottomed river bordered by scattered cottonwoods and grasses. Pools occur around stream obstructions, making habitat diversity and quality comparatively high. Except for regulated flows from Sumner Reservoir, irrigation return near Taiban, and dispersed livestock grazing, the Pecos River in this reach is little modified by human activity. Downstream of Roswell to Brantley Reservoir, the river is more constrained and habitat less diverse. Run habitats tend to dominate. Downstream of Brantley Reservoir, four smaller dams impound the river. Between these impoundments, the river is bound by bedrock and habitat varies from large pools to short riffle and cascades. Downstream, dense stands of non-native saltcedar (*Tamarix* spp.) border the river.

Problems Affecting Habitat or Species

Impoundments
The Pecos River is impounded by several reservoirs starting at Santa Rosa. These main stem reservoirs and irrigation-water release patterns have altered the natural flow regime. Since Sumner Dam was closed in 1937, mean annual discharge of the Pecos River has decreased slightly and peak flows have diminished. During irrigation season, zero-flow days are common in reaches below diversions. Winter discharge from all Pecos River reservoirs is negligible. Spring input and aquifer recharge is presumably responsible for winter flows. In addition to altering flow regimes, reservoirs trap sediments depriving downstream reaches of depositional materials.

Channel Modification
Most of the lower Pecos Watershed is significantly affected by channel modification due to regulated flows from reservoirs and other diversions. From Sumner Dam to the Fort Sumner Irrigation Diversion the channel has become incised and armored with gravel and cobble (Hoagstrom 2003). From the Fort Sumner Irrigation Diversion to Brantley Reservoir, the Pecos River is shallow and braided, consisting primarily of sandy-bottomed runs and short riffles (Bestgen *et al.* 1989).

Groundwater Pumping
In the past, groundwater pumping near Roswell lowered the water table and thus diminished the wetted channel in the river (US Bureau of Reclamation 2002). With increased regulation of groundwater pumping, the water table has risen and maintenance of surface flows in the river has improved.

Pollution
Runoff from livestock feedlots and dairy operations introduces nutrients and numerous contaminants to the river. Petrochemical pollutants reach the river from various refinery operations in the vicinity of Artesia.

Non-Native/Invasive Species
The integrity of Pecos River habitats has been impacted by non-native and invasive species. Non-native fish have been established throughout the system. Salmonids in the upper Pecos River have tested positive for whirling disease. Golden algae (Chrysophyta) blooms have impacted the aquatic communities from Brantley Reservoir downstream into Texas. The non-native Asian clam and giant floater, a freshwater mussel, have been introduced to the Pecos Watershed. The former species occurs in the Pecos River from Santa Rosa downstream to the border with Texas, including 1st and 2nd order streams, while the latter species is reported from below Brantley Reservoir downstream to Carlsbad (Lang 2004).

Saltcedar is the dominant plant species in the riparian corridor in many areas. Saltcedar is an invasive plant with long taproots that allow it to intercept deep water tables and interfere with natural aquatic systems. This plant disrupts the structure and stability of native plant communities and degrades native wildlife habitat by out-competing native plant species and over-exploiting limited sources of moisture. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Information Gaps

Information gaps that limit our ability to make informed conservation decisions for Pecos River habitats and associated SGCN are outlined below.

- The effects are unknown of agricultural chemicals and petrochemicals on the native fish fauna.
- The current status of headwater catfish and the impacts of hybridization with channel catfish are uncertain.
- Life histories of SGCN, especially fishes, in the Pecos River have not been characterized.
- Long-term effects of periodic channel drying on fish assemblages are unknown.
- Impacts of non-native fishes, such as Arkansas River shiner (*Notropis girardi*) and plains minnow (*Hybognathus placitus*), on native fishes are unknown.
- Factors essential for survival of native large-bodied fishes, such as blue sucker and gray redhorse, in Pecos River are unknown.
- The taxonomic status of gray redhorse and blue sucker is unknown.
- The status of native crayfish (*Procambarus simulans simulans*) in the Pecos Watershed is uncertain.

Research, Survey, and Monitoring Needs

The US Fish and Wildlife Service, New Mexico Fishery Resources Office, and NMDGF conducted six population monitoring trips at 12 -13 sites on the main stem Pecos River between Fort Sumner Reservoir and Brantley Reservoir in 2004. The primary objective was to provide population trend data on Pecos bluntnose shiner, a federally protected species. Other ongoing research and survey efforts include an investigation on the effects of low and interrupted flow to the fish community of the middle Pecos River and a study on the ecology of the blue sucker and gray redhorse in the lower Pecos River. Additional research and survey efforts that would enhance our ability to make informed conservation decisions regarding the Pecos River and associated SGCN are outlined below.

- Characterize the life histories of rare fish in Pecos River.
- The main stem of the Pecos River between the village of Pecos and Santa Rosa Reservoir and downstream of Carlsbad needs to be systematically surveyed to determine distribution and status of SGCN.
- Develop effective methods to diminish or eliminate the sheepshead minnow.
- Determine the current status of the headwater catfish, including genetic surveys to increase our understanding of the impacts of hybridization with channel catfish.
- Identify environmental conditions that limit populations of SGCN in this habitat.
- Long-term effects of periodic channel drying on fish assemblages need to be quantified.
- Evaluate the impact of agricultural chemicals and petrochemicals on native fish fauna, especially SGCN.

Desired Future Condition

Desired future outcomes for the Pecos River and associated SGCN include:

- The Pecos River persists in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.
- Natural flow regimes are maintained throughout the main stem of the Pecos River.
- Water quality parameters in the Pecos River meet or exceed New Mexico water quality standards.
- The spread of aquatic nuisance species or other non-native or invasive plant and animal species are controlled or minimized in the Pecos River to a level that SGCN within this habitat are not adversely affected.

- Extirpated native fishes, such as Rio Grande silvery minnow (*Hybognathus amarus*), are restored and have viable populations in the Pecos River.

- Native crayfish populations persist in the lower Pecos River and its perennial tributaries.

Prioritized Conservation Actions

Prioritized conservation actions for the Pecos River are outlined in several biological assessments (see: http://www.usbr.gov/; USFWS *et al*. 2002) and the various recovery plans that are in place for fish species that occupy its main stem. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Seek acceptance of in-stream flow regulations for the conservation of aquatic species.

2. Work with federal, state, county, and city agencies and planners and affected publics to develop strategies for a no-net-increase in water development within the Pecos Valley.

3. Collaborate with federal and state agencies and affected publics to remove non-native species and to re-establish native fish communities in the Pecos River.

4. Coordinate with state and federal land managers and private landowners to protect, restore, and conserve Pecos Watershed habitats and streamside vegetation and to limit the degrading effects of anthropogenic activities.

5. Collaborate with federal and state agencies and affected publics to eradicate or control invasive plant species.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about Pecos Watershed habitats and associated SGCN outlined in the Problems or Research, Survey, and Monitoring Needs sections.

7. In cooperation with other state and federal agencies, continue participating in the *Conservation Agreement for Pecos Pupfish*. This would include updating the agreement, instituting baitfish regulations, investigating the efficacy of legal protection for the species, and completing development of the *Recovery Plan for Pecos Pupfish*.

8. Work with federal and state agencies and affected publics to develop and implement management plans for rare fishes, such as Rio Grande shiner (*Notropis jemezanus*), speckled chub (*Macrhybopsis aestivalis aestivalis*), blue sucker, and gray redhorse, greenthroat darter, and bigscale logperch (*Percina macrolepida*).

RIO GRANDE WATERSHED

The Rio Grande originates in the San Juan Mountains of southern Colorado and flows south through the entire length of New Mexico. The Rio Grande Watershed is approximately 1.9 million ac (0.8 million ha) in New Mexico (U. S. Geologic Service 1996). There are a number of streams that drain into the Rio Grande. These include: 1) the Rio Chama, which joins the Rio Grande in north central New Mexico and is the most significant tributary, 2) the Jemez River which joins the Rio Grande near Bernalillo, and 3) the San Jose/Rio Puerco Drainage which also joins the Rio Grande near Bernalillo. Smaller watersheds drain mountains in southern New Mexico. These drainages lack the diversity of those to the north, and many of them are ephemeral. Flow in the Rio Grande is affected by snowmelt and summer rains. The typical annual cycle is characterized by a low winter flow, a spring peak between early April and mid-May corresponding to snow melt, a low flow in June followed by smaller peaks associated with monsoon rains, and decreasing flow through the fall (Bullard and Wells, 1992). This flow regime has been greatly altered by irrigation diversions and agricultural reservoirs. Irrigation flows have increased the relative magnitude and duration of summer peaks and reduced peak flows associated with snowmelt.

Most lands within the Rio Grande Watershed are under federal and quasi-federal ownership. The main stem of the Rio Grande flows through large tracts of Bureau of Land Management, Middle Rio Grande Conservancy District, and Elephant Butte Irrigation District lands. About 7% of the watershed is occupied by cultivated cropland or orchards. Agriculture is particularly dense in the Española, Middle Rio Grande, and the Mesilla valleys. Other reaches flow through lands used for livestock grazing. Counties within the Rio Grande Watershed host 63% of New Mexico’s human population (US Census Bureau 2002). Bernalillo County alone has 31% of the state’s population. The estimated population growth within the watershed between 1990 and 2000 was 19%.

Aquatic habitats in the Rio Grande Watershed are diverse. Key habitats in this watershed include perennial large reservoirs, perennial marsh/ cienega/spring/seeps, perennial 1st and 2nd order streams, perennial 3rd and 4th order streams, and 5th order streams (Fig. 5-13).

Numerous species have been introduced into the Rio Grande Watershed. Common carp (*Cyprinus carpio*) are widespread and non-native salmonids, including rainbow trout (*Oncorhynchus mykiss*), cutthroat trout subspecies (*O. clarki*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*) are present in many of the 1st and 2nd order mountain streams within the drainage, as well as in the tailwaters of large reservoirs. Kokanee salmon (*Oncorhynchus nerka*), rainbow trout, and brown trout are present in reservoirs more than 6,234 ft (1,900 m) elevation. Warm/cool water fishes including largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieui*), walleye (*Sander vitrius*), northern pike (*Esox luciens*), white bass (*Morone chrysops*), crappie (*Pomoxis* spp.), and sunfishes (*Lepomis* spp.) are present in many of the waters below 6,234 ft (1,900 m) elevation. The Asian clam (*Corbicula fluminea*), first introduced to lower the Rio Grande (Metcalf, 1966), has since been observed in most reaches, including irrigation systems, upstream to Cochiti Reservoir. The non-native northern crayfish (*Orconectes virilis*) and red swamp crayfish (*Procambarus clarkii*) are also known to inhabit the Rio Grande Watershed.

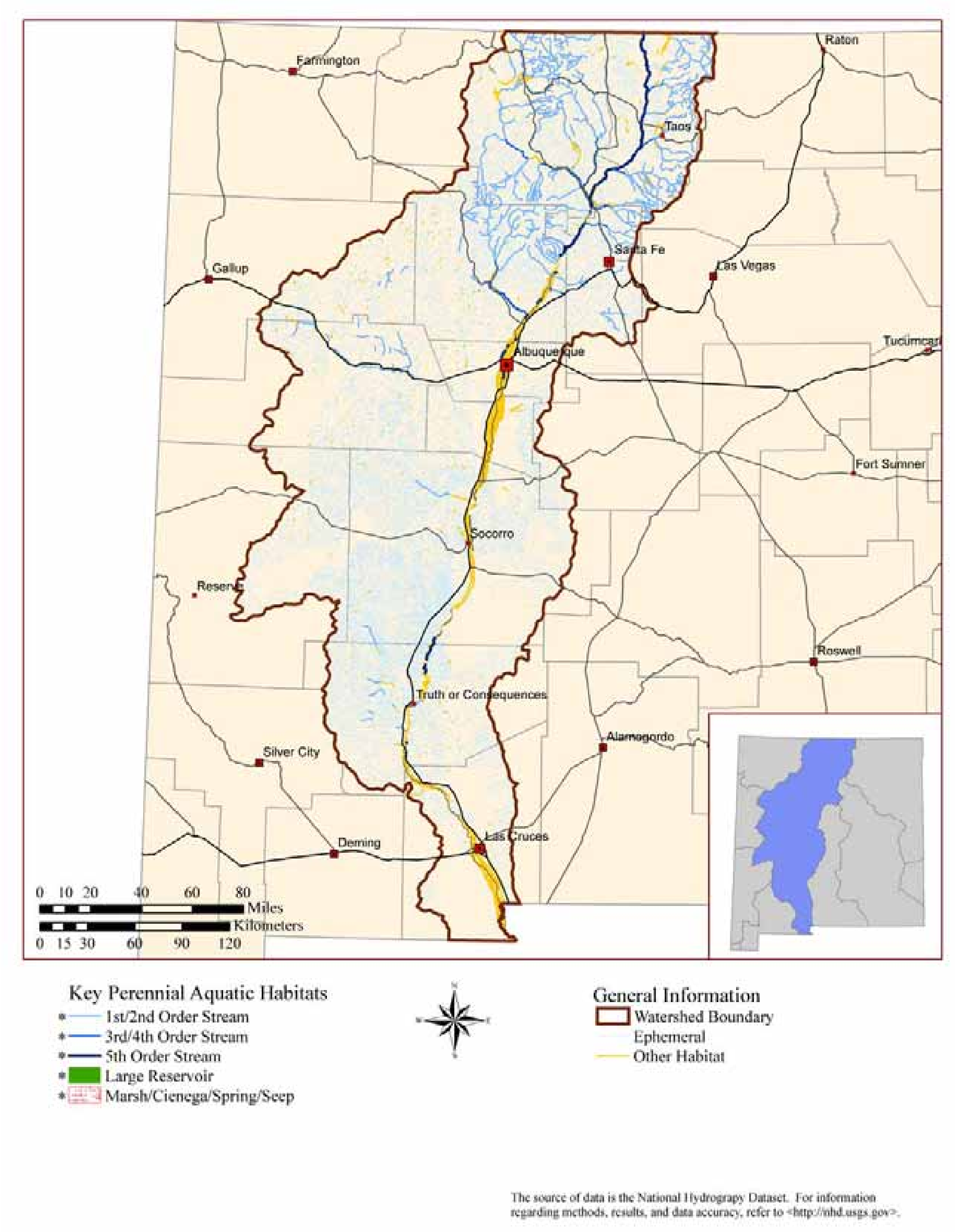


Figure 5-13. Key perennial aquatic habitats in the Rio Grande Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Species of Greatest Conservation Need

Fifty-three Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, have been identified in the Rio Grande Watershed (Table 5-15). Twenty-seven species (51%) are classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Eight SGCN are secure both nationally and in New Mexico. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. The Mexican tetra (*Astyanax mexicanus*), speckled chub (*Macrhybopsis aestivalis aestivalis*), Rio Grande shiner (*Notropis jemezanus*), blue sucker (*Cycleptus elongatus*), and gray redhorse (*Moxostoma congestum*) are considered extirpated from key habitats in the Rio Grande Watershed. Perennial springs scattered along the western flank of the Rio Grande Watershed provide habitat for several invertebrate SGCN known only from Socorro County. These endemic taxa include the Socorro isopod (*Thermosphaeroma thermophilum*), Alamosa springsnail (*Pseudotryonia alamosae*), Chupadera springsnail (*Pyrgulopsis chupaderae*), and Socorro springsnail (*Pyrgulopsis neomexicana*). Hyalellid amphipods occur in most of these spring-fed habitats. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

Table 5-15. Species of Greatest Conservation Need in the Rio Grande Watershed in New Mexico.

	Perennial				
Common Name	Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Fish					
Rio Grande Cutthroat Trout			X	X	
Mexican Tetra		E[1]	E		
Speckled Chub					E
Rio Grande Chub			X	X	X
Rio Grande Silvery Minnow		X			X
Rio Grande Shiner					E
Rio Grande Sucker			X	X	X
Blue Sucker					E
Smallmouth Buffalo	X				X
Gray Redhorse					E
Blue Catfish	X				X
Birds[2]					
Eared Grebe	X	X		X	X
American Bittern		X			
White-Faced Ibis	X	X			
Northern Pintail	X	X		X	X
Osprey	X			X	X
Bald Eagle	X	X		X	X
Northern Harrier		X			
Common Black-Hawk		X	X	X	X

Table 5-15 Cont.

Common Name	Perennial Large Reservoir	Marsh/Cienega/ Spring/Seep	1st and 2nd Order Stream	3rd and 4th Order Stream	5th Order Stream
Birds Cont.					
Peregrine Falcon	X	X		X	X
Sandhill Crane	X	X		X	
Snowy Plover	X			X	
Interior Least Tern	X			X	X
Southwestern Willow Flycatcher		X		X	X
Bell's Vireo				X	X
Bank Swallow				X	X
Lucy's Warbler		X		X	X
Yellow Warbler		X	X	X	X
Painted Bunting				X	X
Mammals[2]					
Western Red Bat		X			
Spotted Bat		X			
Allen's Big-Eared Bat		X			
American Beaver	X	X	X	X	X
NM Meadow Jumping Mouse		X			
Desert Bighorn Sheep		X			
Amphibians[2]					
Tiger Salamander		X			
Western Boreal Toad		X	X		
Western Chorus Frog		X	X	X	
Plains Leopard Frog		X		X	X
Chiricahua Leopard Frog		X	X	X	X
Northern Leopard Frog	X	X	X	X	X
Reptiles[2]					
Western Painted Turtle	X			X	X
Big Bend Slider	X				X
New Mexico Garter Snake		X	X	X	X
Molluscs[2]					
Chupadera Pyrg Snail		X			
Socorro Pyrg Snail		X			
Alamosa Springsnail		X	X		
Wrinkled Marshsnail			X		
Creeping Ancylid Snail				X	X
Ovate Vertigo Snail		X			
Blunt Ambersnail		X			
Crustaceans[2]					
Sideswimmers / Scuds		X	X	X	X
Socorro Isopod		X			

[1] Species is considered extirpated from habitat type.
[2] Additional concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Perennial Large Reservoir

Habitat Condition

The main stem of the Rio Grande and its major tributaries have been dammed to form five irrigation reservoirs. These include Heron, El Vado, Abiquiu, Bluewater, and Elephant Butte and three flood control lakes Cochiti, Jemez Canyon, and Caballo. Most of these reservoirs are in canyon topography where rocky substrate and decaying woody vegetation provide the majority of fish habitat. Hydrology is typically governed by irrigation demands. Typically water is stored through the winter and into spring runoff. Large drawdowns occur throughout the irrigation season, generally late April through September. Lowest reservoir water levels typically occur at the end of October, the highest levels generally occur in early April.

Problems Affecting Habitat or Species

Reservoir Hydrology
Reservoir hydrology can have major impacts on fish communities within them. Spawning and recruitment typically occurs coincident to irrigation season, thus fish populations can be greatly affected by lower reservoir levels. Reservoir releases may adversely affect riverine fishes through displacement, modified thermal regime, or habitat modification.

Non-Native/Invasive Species
The fish assemblages of perennial large reservoirs are composed almost entirely of non-native fishes. Non-native piscivores may affect native fish species within a reservoir via predation or competition. However, the abundance of non-native prey species within these reservoirs buffers species of conservation concern such as the smallmouth buffalo (*Ictiobus bubalus*) and blue catfish (*Ictalurus furcatus*) from predation impacts. Crayfish, non-native sunfish, catfish, and bullfrogs (*Rana catesbeiana*) are known to cause localized reductions in native ranid frogs. They may also exert a negative influence on native turtle populations by consuming hatchling turtles. Eurasian milfoil (*Myriophyllum spicatum*) has been collected in Cochiti and Elephant Butte Reservoirs indicating that despite their relative remoteness from contaminated waters, New Mexico systems may be vulnerable to aquatic nuisance species.

Commercial Harvest
Another potential factor affecting the population of smallmouth buffalo is commercial harvest, although commercial fishing in New Mexico reservoirs has decreased substantially in the last 20 years.

Information Gaps

Generally, the importance and effects of large reservoirs in the Rio Grande Watershed on SGCN are poorly understood. Information gaps that impair our ability to make informed conservation decisions are outlined below.

- Trophic dynamics within New Mexico reservoirs (especially within the Rio Grande Watershed) have not been thoroughly investigated.

- The role of introduced piscivores within the reservoir community is not well understood.

- Reservoirs provide the bulk of smallmouth buffalo habitat within New Mexico, but little recent information exists regarding population dynamics and biology of this species within these habitats.

- While reservoirs have been implicated as a source of non-native expansion and persistence in New Mexico watersheds, the role of reservoirs as refugia for SGCN has not been thoroughly investigated.

- Blue catfish have often been stocked within the basin. The genetic status of blue catfish within the basin has not been assessed to ascertain whether a native strain still exists within the Rio Grande watershed.

- The existing environmental conditions or thresholds that limit populations of SGCN are unknown.

- Information is lacking on the extent to which invasive and non-native species may alter perennial large reservoirs and limit populations of SGCN.

Research, Survey, and Monitoring Needs

The New Mexico Department of Game and Fish have conducted regular surveys of reservoir fisheries within the Rio Grande Watershed since 2001. Data gathered include population composition, size distribution, and species diversity. Resultant baseline information may be used to assess smallmouth buffalo populations. In addition, NMDGF has completed a pilot study of trophic dynamics in Elephant Butte Reservoir that will allow managers to design methods to adequately evaluate trophic relationships in Rio Grande reservoirs. Routine monitoring of sport and commercial fishing take by NMDGF also allows managers to assess the effects of consumptive use on fishery resources. NMDGF, New Mexico Environment Department, and New Mexico Department of Health periodically test for contaminants within fish inhabiting large reservoirs. Additional research and survey work that would enhance our understanding of large reservoirs and SGCN is outlined below.

- NMDGF needs to further understand the relationships between non-native piscivores and SGCN within and around large reservoirs in the Rio Grande Watershed.

- Investigate the extent to which invasive and non-native species alter perennial reservoir habitats and limit populations of SGCN.

- Investigate SGCN movements into and out of reservoirs and relationships between the reservoirs and the surrounding watershed.

- Targeted work on the status of smallmouth buffalo has not been conducted since the early 1970s and our knowledge and data need to be updated.

- A general status review of the SGCN within the Rio Grande Watershed is needed.

- Investigate water withdrawal schedules in large reservoirs to provide a better understanding of how reservoir levels potentially affect spawning fish and nursery habitats. This information will help in designing sustainable watershed conservation and management practices.

Desired Future Outcomes

Desired future outcomes that would maximize the contribution of large perennial reservoirs to SGCN conservation include:

- Perennial large reservoirs of the Rio Grande Watershed persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of resident SGCN while sustaining diverse land uses with reduced resource use conflicts.

- Water operations are conducted so as not to pose significant threats to the persistence of these SGCN communities.

- Sport and commercial harvest are managed in a manner that is consistent with best management practices.

- Adverse effects of non-native fishes emigrating from reservoirs into surrounding habitats are minimized.

- SGCN within this habitat are not adversely affected by the spread of aquatic nuisance species or other non-endemic species.

Prioritized Conservation Actions

The conservation of New Mexico's biodiversity in perennial large reservoirs will require a variety of conservation actions focused on both native and non-native species and habitat requirements of SGCN. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with water management agencies such as the US Bureau of Reclamation and US Army Corps of Engineers to continue to balance irrigation demands with the needs of fish communities within large reservoirs.

2. Assist efforts by conservancy districts and US Bureau of Reclamation to promote water conservation activities such as lining irrigation supply and return ditches.

3. Work with public and private land managers to develop strategies for preventing the movement of non-natives into surrounding areas and to educate anglers on the importance of not introducing fish into these habitats.

4. Collaborate with federal and state agencies and affected publics to create an understanding of the functions, services, and values of large reservoirs. Emphasize opportunities to educate anglers of the risk posed by undesirable non-native fishes to both sport and native fishes.

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial large reservoirs outlined in the Research, Survey, and Monitoring Needs section.

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Historically, over-bank flooding provided the majority of marsh/cienega habitat along the Rio Grande. Now greatly reduced through channelization and other water control activities, the most extensive marsh/cienega habitat occurs at the Low Flow Conveyance Channel (LFCC) in Sierra and Socorro counties where breaches in the dykes have flooded significant amounts of the bosque and created backwaters, oxbow lakes, and marshes. Smaller portions of this habitat type occur in the bosques at Albuquerque, Escondida, and Truth or Consequences.

Perennial spring-fed habitats (marshes, cienegas, seeps) occur sporadically throughout the Rio Grande Watershed as isolated wetlands that discharge surface water to localized aquatic systems. These localized systems eventually recharge shallow aquifers within the basin and contribute surface flows to perennial tributaries of the Rio Grande.

Problems Affecting Habitats or Species

Dewatering
Dewatering, channelization, and land conversion have greatly reduced these habitats through the middle Rio Grande Valley. Water tables have been lowered and areas that were formerly perennial cienegas and marshes have become ephemeral or no longer exist. This has caused a decline in a number of species including western painted turtles (*Chrysemys picta bellii*), leopard frogs (*Rana* spp.), and New Mexico garter snakes (*Thamnophis sirtalis dorsalis*). Plans to reconstruct the LFCC will significantly reduce flooding in that area and existing marsh habitat will be further reduced.

Habitat Conversion
Habitat conversion processes that most adversely affect SGCN of perennial marshes/cienegas/springs/seeps include alterations that drain, fill, channelize or impound wetlands. Capping spring sources may likewise permanently alter natural wetlands. Habitat desiccation resulted in the near extinction of the Socorro isopod (*Thermosphaeroma thermophilum*) in 1998 and

vandalism has further damaged this species' habitat (Lang *et al.* In Review). Proposed development of mineral resources within the Alamosa Creek drainage above the Monticello Box has the potential to adversely affect aquatic habitats for the Alamosa springsnail, ovate vertigo land snail (*Vertigo ovata*), and Chiricahua leopard frog (*R. chiricahuensis*).

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for perennial marshes/cienegas/springs/seeps in the Rio Grande Watershed are outlined below.

- Comprehensive data are incomplete on the distribution and abundance of fish, invertebrates, and amphibians and the location and condition of marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

- Extensive work has been conducted within the Middle Rio Grande Valley regarding riparian habitats and wetlands. Beyond this, from Angostura to San Marcial Diversion, information is lacking.

- Information is incomplete regarding the effects of chemical and physical removal of saltcedar (*Tamarix spp.*) on biological communities, particularly invertebrates and amphibians.

- Little is known about the extent to which habitat conversion alters or poses a threat to perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

Research, Survey, and Monitoring Needs

Federal agencies including the US Fish and Wildlife Service, US Army Corps of Engineers, US Bureau of Reclamation, and their contractors are conducting significant studies and restoration efforts directed towards the Rio Grande silvery minnow (*Hybognathus amarus*). Environmental impact statements have been and are being developed for Rio Grande water operation planning, reconstruction of the LFCC, bosque rehabilitation projects, and various irrigation related projects. Additional research and surveys that would enhance our understanding of perennial marsh/cienega/spring/seep habitats and SGCN of the Rio Grande Watershed are outlined below.

- Continued monitoring of perennial marsh/cienega/spring/seep habitats and their associated biotic communities is needed to intelligently assess potential threats to SGCN and their habitats.

- Increased mapping and population assessment activities should be conducted in disjunct spring/seep habitats within the watershed.

- Little is currently known of the SGCN that rely upon perennial marsh/cienega/ spring/seep habitats. Research is needed on their distribution, biology, population stability, and microhabitat use.

- A comprehensive survey is needed of aquatic macroinvertebrates of perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

- Investigations are needed on the extent to which land use activities fragment and alter perennial marsh/cienega/spring/seep habitats. This information is important in understanding how different land use intensities and frequencies of disturbances affect associated SGCN.

Desired Future Outcomes

Desired future outcomes for perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed include:

- Perennial marsh/cienega/spring/seep habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Perennial marsh/cienega/spring/seep communities are stable.

- There is no net loss of this habitat type in the watershed and, where possible, additional habitat is created.

- Dewatering and channelization no longer adversely affect the persistence of SGCN dependent on perennial marsh/cienega/spring/seep habitats.

- The spread of aquatic nuisance species or other non-native species is controlled or minimized to a level that SGCN within this habitat are not adversely affected.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with landowners within the watershed to protect marsh/cienega habitats along the Rio Grande. This work should include the review and contribution to National Environmental Policy Act (NEPA) documentation for repairs/reconstruction of the LFCC as well as continued participation in Rio Grande operations multi-agency planning efforts.

2. Continue to actively pursue the cooperation of private landowners in the protection and recovery of the Chupadera springsnail.

3. Coordinate and cooperate with federal and state agencies and affected publics to implement the draft aquatic nuisance species management plan for the state, which includes perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

4. Collaborate with federal and state agencies and affected publics to adopt standardized monitoring and survey methods to track gains and losses of perennial marsh/cienega/spring/seep habitats in the Rio Grande Watershed.

5. Collaborate with federal and state agencies, private landowners, research institutions, and universities to monitor perennial marsh/cienega/spring/seep communities to assess and eliminate potential adverse effects posed by introduced species.

6. Promote saltcedar management activities that do not adversely affect endemic communities and provide demonstrable positive effects on aquatic habitats.

7. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and the perennial marsh/cienega/spring/seep outlined in the Information Gaps or Research, Survey, and Monitoring Needs section.

Perennial 1st and 2nd Order Stream

Habitat Condition

The headwaters of the tributaries draining into the Rio Grande Watershed arise in the Sangre de Cristo, San Juan, Jemez, and Zuni mountains. Typically these waters are small 1st and 2nd order streams flowing through montane vegetation. Most of these streams are degrading with bedrock, cobble, and/or gravel substrate. Typically, these streams are the least impacted by human activity. There is some channelization and dewatering within these systems, but not to the degree noted lower in the watershed. Lower elevation 1st and 2nd order streams in the Rio Grande Watershed are generally ephemeral, unless directly associated with a spring.

Problems Affecting Habitat or Species

Sedimentation
Sedimentation resulting from improper grazing or logging and associated infrastructure presents the most serious potential adverse effect to the substrate of these small 1st and 2nd order streams.

Non-Native Species
Native species such as the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), Rio Grande sucker, and Rio Grande chub may also be adversely affected by the presence of non-native salmonids through hybridization, competition, or predation. The eastern most distribution of the Chiricahua leopard frog is in these streams. Populations of frogs are known to be declining as a result of the chytrid fungus (*Batrachochytrium dendrobatidis*).

Diseases and Pathogens
The presence of whirling disease in rainbow trout was confirmed in New Mexico the spring of 1999. Since this confirmation, portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated in coldwater streams and reservoirs. These waters may have been contaminated through inadvertent stocking of infected rainbow trout or by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 1st and 2nd order stream habitats in the Rio Grande Watershed are outlined below.

- It is unknown how long-term fragmentation of the watershed has affected the viability and genetic diversity of Rio Grande cutthroat trout.

- The potential and risk for whirling disease to spread among salmonids of 1st and 2nd order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

- Population information is incomplete for non-game species such as the Rio Grande sucker in perennial 1st and 2nd order stream habitats.

- There is little information available about invertebrates in perennial 1st and 2nd order stream habitats of the Rio Grande Watershed.

- We lack information about SGCN life history and habitat use in perennial 1st and 2nd order stream habitats. This information is needed for sound comprehensive habitat management.

- Little is known about the intensity, scale, and extent of different land use activities that degrade 1st and 2nd order stream habitats and their effects on populations of SGCN.

Research, Survey, and Monitoring Needs

NMDGF has developed and implemented a long-range management plan for Rio Grande cutthroat trout. Efforts are currently focused on assessing population status and genetic composition, increasing the current range of the species, and securing current populations from introgression. NMDGF also conducts periodic surveys of 1st and 2nd order streams to assess sport fish populations and gather data on native species including Rio Grande chub and Rio Grande sucker. Additional research and surveys that would enhance our ability to make informed conservation decisions are outlined below.

- Research and survey work is needed to obtain comprehensive population data for Rio Grande sucker and Rio Grande chub in 1st and 2nd order streams of the watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

- Genetic inventory studies of Rio Grande cutthroat trout are needed to evaluate the effects of population fragmentation as well as potential threats of introgression in perennial 1st and 2nd order streams.

- A recovery plan is nearing completion for the Chiricahua leopard frog. Recovery efforts that need research or survey work include further cataloging of the distribution of the species, identifying methods for minimizing impacts from non-native fish species, and determining how to reduce the spread of chytrid fungus within the range of the species.

- An assessment is needed of the current stocking of non-native fish species and means to minimize potential conflicts with SGCN.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are perennial 1st and 2nd order stream obligates.

- Research, surveys, and monitoring are needed for SGCN, especially invertebrate species. Little is currently known of the extent of their distribution, their biology, or stability of their populations and microhabitats in 1st and 2nd order streams of the watershed.

- Research is needed to characterize population dynamics and species interactions in perennial 1st and 2nd order stream habitats.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order stream habitats in the Rio Grande Watershed include:

- Perennial 1st and 2nd order stream habitats in the watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Threats are eliminated to Rio Grande cutthroat trout due to competition, disease, and or introgression with non-native salmonids.

- Threats are eliminated to the Chiricahua leopard frog due to chytrid fungus and competition or predation by non-native species.

- The stability of SGCN, such as the Rio Grande sucker and Rio Grande chub, is assured and sub-populations have connectivity that allows some degree of gene flow and long-term physical security.

- Non-native species that threaten the persistence of SGCN in perennial 1st and 2nd order stream habitats have been removed or populations reduced to minimize effects to SGCN.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies, private landowners, research institutions, and universities to complete an inventory of the distribution of the whirling disease parasite (*M. cerebralis*) within the watershed.

2. Include non-game species in NMDGF fish survey analysis to improve baseline information regarding distribution and status of SGCN within the watershed.

3. Work with federal and state agencies, tribes, NGOs, and affected publics to increase connectivity of Rio Grande cutthroat trout populations within this habitat type by incorporating a "metapopulation" strategy into restoration efforts. The metapopulation theory assumes that an environment consists of discrete patches of suitable habitat surrounded by unsuitable habitat, interconnected through patterns of gene flow, extinction, and re-colonization (Lande and Barrowclough 1987, Hanski 1999). Increasing connectivity for trout should also benefit other SGCN within this habitat type, as well as maintaining their populations through these efforts is a focus of restoration activities, such as saving founder populations during stream treatments.

4. Work with land managers to develop methods that reduce the adverse effects of non-native aquatic species on native SGCN in the watershed.

5. Work with US Fish and Wildlife Service and other federal agencies to implement the *Chiricahua Leopard Frog Recovery Plan* and develop and implement strategies to reduce the spread of chytrid fungus.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order stream habitats outlined in the Information Gaps or Research, Survey, and Monitoring Needs section.

Perennial 3rd and 4th Order Stream

Habitat Condition

The Rio Chama, Rio San Jose/Rio Puerco, and Jemez River systems are the major 3rd and 4th order stream habitats in the Rio Grande Watershed. Historically these channels were degrading with complex morphology greatly influenced by seasonal hydrology and sediment motion. As the streams increased in size, meanders, over-bank flooding, and braiding provided habitat for numerous native species. Substrates typically consist of cobble, gravel, and sand with decreasing particle size associated with decreased stream gradient near the confluence with the main stem of the Rio Grande. Human influence is greater upon these streams than it is for the higher elevation 1st and 2nd order streams and irrigation diversion and excessive sedimentation have affected all of these river systems. Formerly complex habitats have been simplified and Rio Grande silvery minnow and western painted turtle no longer occupy the Chama and Jemez Rivers.

Problems Affecting Habitat or Species

Modification of Natural Processes
Sedimentation has had significant effects on perennial 3rd and 4th order stream habitats in the Rio Grande Watershed. Erosion from surrounding land use and changes in sediment transport in rivers due to damming have altered channel morphology. Diversion and damming of rivers have affected temperature and flow regimes and fragmented fish populations due to physical barriers and reduced availability of suitable habitat.

Diseases and Pathogens
Portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors. Very little is known regarding whether the disease exists in Rio Grande cutthroat trout. However, it is likely that if *M. cerebralis* were to spread to Core Conservation Areas for Rio Grande cutthroat trout, the species would be at risk of infection.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 3rd and 4th order stream habitats in the Rio Grande Watershed are outlined below.

- Perennial 3rd and 4th order streams formerly provided connectivity to Rio Grande cutthroat trout populations. It is unknown how long-term fragmentation of the watershed has affected the viability and genetic diversity of Rio Grande cutthroat trout and other native species.

- The potential and risk for whirling disease to spread among salmonids of 3rd and 4th order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

- Population information is incomplete for non-game species such as the Rio Grande sucker.

- SGCN life history and habitat use information needed for comprehensive habitat management.

- Little is known about the intensity, scale, and extent of different land use activities that degrade habitats and their effects on populations of SGCN.

Research, Survey, and Monitoring Needs

NMDGF has developed and implemented a long-range management plan for Rio Grande cutthroat trout. Efforts are currently focused on assessing the status and genetic composition of populations, increasing the current range of the species, and securing current populations from introgression. NMDGF conducts periodic surveys of perennial 3rd and 4th order streams to assess sport fish populations and gather data on native species, including the Rio Grande chub and the Rio Grande sucker. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions are outlined below.

- Research is needed to obtain comprehensive population data for Rio Grande sucker and Rio Grande chub in perennial 3rd and 4th order streams of the Rio Grande Watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

- Genetic inventory studies of Rio Grande cutthroat trout are needed to evaluate the effects of population fragmentation as well as potential threats of introgression in perennial 3rd and 4th order streams.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are perennial 3rd and 4th order stream obligates.

- Research is needed to characterize population dynamics and species interactions in these perennial 3rd and 4th order stream habitats.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order stream habitats in the Rio Grande Watershed include:

- Perennial 3rd and 4th order stream habitats in the Rio Grande Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.

- Potential adverse effects upon Rio Grande cutthroat trout due to competition, disease, and or introgression with non-native salmonids are eliminated.

- The stability of SGCN, such as the Rio Grande sucker and Rio Grande chub, are assured.

- The risk of habitat fragmentation and dewatering is eliminated or minimized by employing water operations that retains adequate water in perennial 3rd and 4th order stream habitats for SGCN.

- Land uses in and around stream habitats increase stream diversity.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies, private landowners, research institutions, and universities to complete inventory of the distribution of the whirling disease parasite *M. cerebralis* within the Rio Grande watershed to mitigate threats to Rio Grande cutthroat trout.

2. Include non-game species in NMDGF fish survey analysis to improve baseline information regarding distribution and status of SGCN within the watershed.

3. Work with federal and state agencies, tribes, NGOs, and affected publics to increase connectivity of Rio Grande cutthroat trout populations within this habitat type by incorporating a "metapopulation" strategy into restoration efforts. The metapopulation theory assumes that an environment consists of discrete patches of suitable habitat surrounded by unsuitable habitat, interconnected through patterns of gene flow, extinction, and re-colonization (Lande and Barrowclough 1987, Hanski 1999). Increasing connectivity for trout should also benefit other SGCN within this habitat type,

as long as maintaining their populations through these efforts is a focus of restoration activities such as saving founder populations during stream treatments.

4. Collaborate with federal and state agencies, private landowners, research institutions, and universities to investigate habitat modification strategies and work with land managers and private landowners to implement modifications when appropriate.

5. Work with water management agencies to minimize impacts of water management in the watershed to avoid dewatered conditions.

6. Assist efforts to reduce sedimentation and promote water conservation activities such as lining irrigation supply and return ditches.

7. Encourage land uses that increase stream diversity within this habitat type.

8. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about perennial 3rd and 4th order stream habitats and associated SGCN outlined in the Information Gaps or Research, Survey, and Monitoring Needs sections.

Perennial 5th Order Stream

Habitat Condition

The main stem of the Rio Grande is a 5th order stream as it enters New Mexico. It flows through a narrow, deeply incised canyon with a very narrow floodplain, approximately 50 ft (15 m), until it nears the confluence with the Rio Chama (Sublette *et al.* 1990). The Rio Chama also flows through a deeply incised canyon for much of its length. Piñon-juniper parkland is the dominant vegetation community found along these reaches.

Downstream of the confluence of the Rio Chama, the Rio Grande again enters a deeply incised canyon until it reaches a broad valley of low relief near Cochiti Lake. The remainder of its course flows with decreasing gradient until it reaches the New Mexico border near El Paso. Here the historic floodplain was wide and diverse. It included numerous meanders and oxbows (Crawford *et al.* 1993) and the reach was agrading. However dams on the river have altered this regime to degrading immediately below the dam and agrading elsewhere. Degrading streambeds of the Rio Grande are typically boulder, cobble, or gravel. Agrading portions typically have sandy substrate with increasing silt influence and decreasing stream gradient.

Before channelization, channel morphology was complex with meanders, oxbows, and braiding. The floodplain also experienced frequent over-bank flows generating off-river ponds and marshes. Vegetation around the Rio Grande varies from piñon/juniper parklands at the upper end through various Chihuahuan desert shrub communities in the southern portion of the state.

Problems Affecting Habitat or Species

Modification of Natural Processes
The Rio Grande has been greatly affected by anthropogenic activity as previously noted immediately above and within perennial large reservoirs. Diversion and dewatering may pose the greatest adverse affect to fish occupying this habitat, but other habitat stressors exist. Diversions and dams effectively fragment 5th order stream habitat by blocking the passage of fish. Agricultural return flows alter water chemistry and sediment load. Large dams alter water quality in tail waters. Channelization has reduced channel diversity and eliminated over-bank flow for significant stretches in the southern half of the system.

A number of species of conservation concern such as the bluntnose shiner, gray redhorse, blue sucker, and Rio Grande shiner have been extirpated from the watershed, primarily through habitat alteration. Non-native predators and disease likely caused the extirpation of the northern leopard frog. Big Bend sliders are now mostly confined to perennial reservoirs due to water diversion and alteration of the river channel.

Information Gaps

Information gaps that impair our ability to make informed conservation decisions for 5th order stream habitats in the Rio Grande Watershed are outlined below.

- Underlying causes of the decline of Rio Grande silvery minnow are not clearly understood, particularly as related to habitat changes within the drainage. Current management for the species has subsequently consisted of temporary and reactive measures.

- Long-term effects of habitat fragmentation on population viability and genetic diversity of native species within 5th order streams are not clearly understood.

- While reservoirs have been implicated as a source for non-native species expansion and persistence in New Mexico watersheds, the role of reservoirs as refugia for SGCN has not been thoroughly investigated.

- Effects of habitat modification on potential expansion of aquatic nuisance species have not been documented.

- Information is not complete regarding the effects of chemical and physical saltcedar removal on biological communities, particularly invertebrates and amphibians, along the middle Rio Grande.

Research, Survey, and Monitoring Needs

Federal agencies including the USFWS, US Army Corps of Engineers, and US Bureau of Reclamation (BOR), are conducting significant studies and restoration efforts for the Rio Grande silvery minnow. BOR has experimented with channel modification to improve minnow recruitment. Environmental impact statements have been and are being developed for Rio Grande water operation planning, reconstruction of the LFCC, bosque rehabilitation projects, and various irrigation related projects. Additional research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions are outlined below.

- Investigate the underlying causes of the decline of Rio Grande silvery minnow related to habitat changes within the drainage.
- Research is needed on the effects of habitat fragmentation on the population viability and genetic diversity of SGCN in 5^{th} order stream habitats of the watershed.
- Explore the role of reservoirs as refugia for SGCN, and the biological connectivity of large reservoirs to 5^{th} order stream habitats.
- Research is warranted on the effects of habitat fragmentation and modification in terms of reduced gene flow and the potential expansion of aquatic nuisance species.
- The effects of saltcedar removal on biological communities (particularly invertebrates and amphibians) along the Rio Grande through chemical and physical means needs to be investigated.

Desired Future Outcomes

Desired future outcomes for the Rio Grande include:

- The Rio Grande persists in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land uses with reduced resource use conflicts.
- Threats to the Rio Grande silvery minnow are eliminated and the minnow is downlisted.
- Effects of habitat fragmentation are reduced and gene flow for SGCN is unrestricted through most of the Rio Grande.
- Riverine habitats increase in diversity and host stable native fish communities.
- Land and river management practices that threaten SGCN are minimized.
- Water operations are modified such that species formerly inhabiting the Rio Grande may be restored to the system.
- Non-native species that threaten native species in the Rio Grande have been removed or their populations reduced so as to minimize effects to native species.

Prioritized Conservation Actions

The Rio Grande extends from the north to the south across the entire state. It hosts a variety of economic, recreational, and environmental uses and concerns and supports a significant amount of New Mexico's biodiversity. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below. Additional conservation actions related to the Rio Grande are located in the Riparian Habitat section.

1. Continue work on identifying recruitment limitations for the Rio Grande silvery minnow.

2. Assist agencies responsible for Rio Grande silvery minnow recovery whenever possible.

3. Work with federal and state agencies, private landowners, research institutions, and universities to investigate the role of irrigation supply and return ditches as refugia for SGCN and the biological connectivity of large reservoirs to 5^{th} order stream habitats.

4. In cooperation with other agencies, develop and implement an aquatic nuisance species prevention/abatement program.

5. Collaborate with federal and state agencies and NGOs to monitor Rio Grande plant and animal communities to assess problems posed by introduced species, and to eliminate threats where possible. Promote saltcedar management activities that pose the least harm to endemic communities.

6. Collaborate with federal and state agencies, private landowners, research institutions, and universities to investigate habitat modification strategies and work with land managers and private landowners to implement them when appropriate.

7. Work with water management agencies to minimize impacts of water management in the Rio Grande Watershed and avoid dewatered conditions.

8. Assist efforts to reduce sedimentation and promote water conservation activities such as lining irrigation supply and return ditches.

9. Work with federal and state agencies, landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 5^{th} order stream habitats outlined in the Research, Survey, and Monitoring Needs sections.

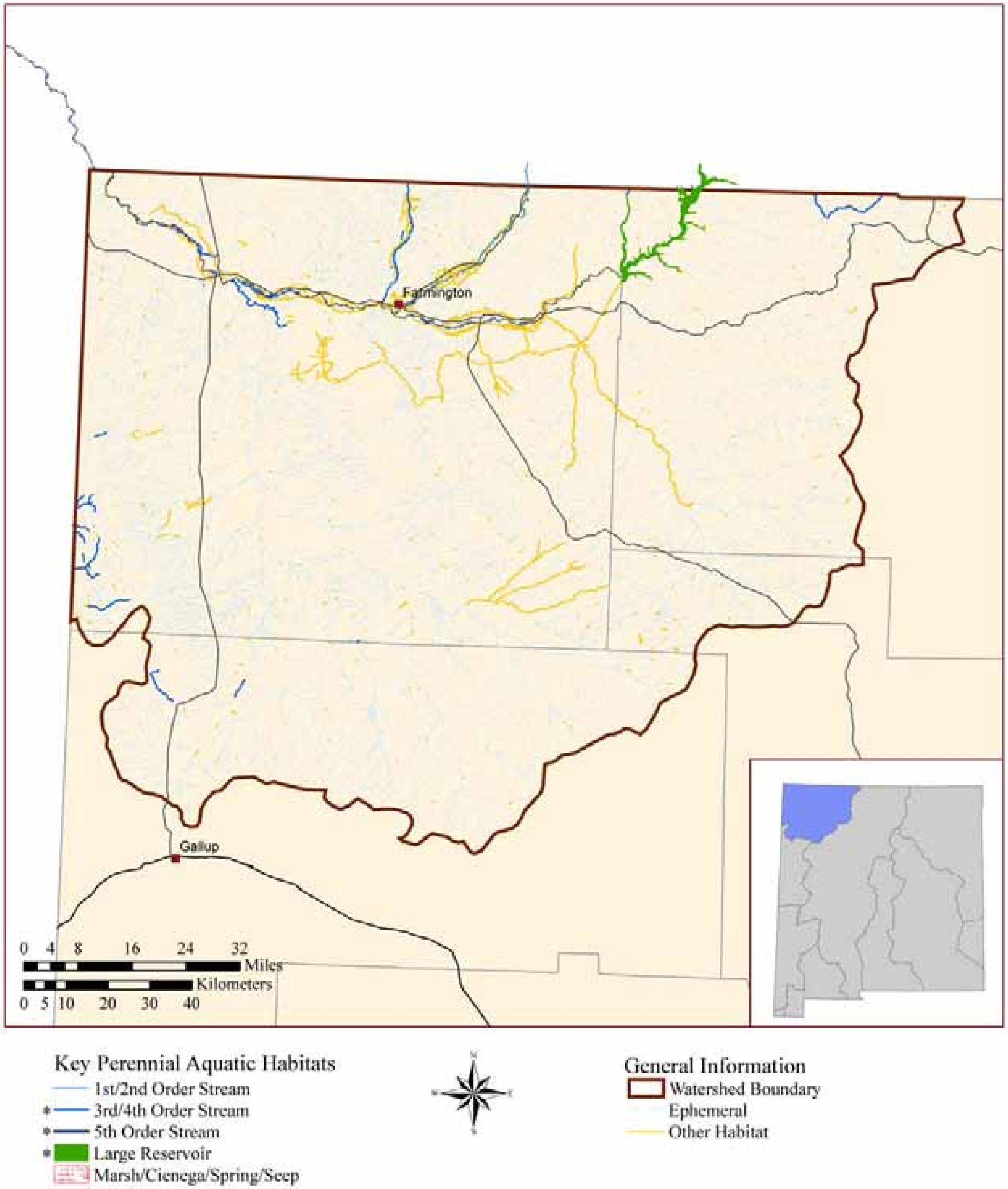
SAN JUAN WATERSHED

The San Juan River originates in the San Juan Mountains of southwestern Colorado. It enters New Mexico northeast of Farmington and flows westward for about 93 mi (150 km) to exit the state near "Four Corners." Upstream of Four Corners, the river drains about 6,918,372 ac (2,799,780 ha), including portions within Colorado. Associated key perennial aquatic habitats are a large reservoir, 3rd and 4th order streams, and 5th order stream (San Juan River) (Fig. 5-14).

Navajo Dam impounds the upper 19 mi (30 km) of the river in New Mexico. From Navajo Dam downstream to Farmington, the river is restricted to a single, moderately incised channel and habitats are mainly cobbled riffles, moderately deep runs, and large pools. As the river progresses downstream from Farmington to Shiprock, gradient diminishes, but flow remains mainly in a single channel. Downstream of Shiprock, the river is frequently divided among two, three, or four channels and habitat diversity increases with channel complexity. In addition to habitats common in upstream reaches, backwaters, embayments, shoals, and secondary channels (having their own mix of habitats) are present. Navajo Dam controls flows in the river and its tailwaters support a nationally recognized trout fishery. Several low-head diversion dams seasonally diminish discharge. The San Juan River, within New Mexico, is permanently watered, but permanently flowing tributaries are currently limited to the Navajo, Animas, and Mancos rivers. The US Bureau of Land Management administers much of the watershed upstream of Farmington and large portions are on Navajo and Jicarilla Apache lands.

The population of San Juan County grew 24% from 1990 to 2000 and slightly less than half the 113,801 residents of San Juan County live in the municipalities of Aztec (6,378), Bloomfield (6,417), and Farmington (37,844) (US Census Bureau 2002). Mining, construction, and utilities are the most important economic activities in the county. In addition to regulated flows, aquatic habitats of the San Juan River are influenced by channelization in some sections, water diversion, runoff from municipalities and rowcrop agricultural lands, and petroleum-extraction activities. Currently, Navajo Reservoir operates to mimic a natural hydrograph in compliance with the conditions of a Biological Opinion issued to the US Bureau of Reclamation by the US Fish and Wildlife Service, under authority of Section 7 of the Endangered Species Act. Considerable data on water quality and habitats of the main stem San Juan River are available in various reports produced by the San Juan River Basin Recovery Implementation Program (USFWS 2004; http://www.fws.gov/southwest/sjrip/).

A number of non-native fish species have been captured or reported from the San Juan River, but only red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus* carpio), fathead minnow, (*Pimephales promelas*), plains killifish (*Fundulus zebrinus*), white sucker (*Catostomus commersoni*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and channel catfish (*Ictalurus punctatus*) are regularly found and comparatively common. Navajo Reservoir supports populations of non-native smallmouth bass (*Micropterus dolomieui*), largemouth bass, (*M. salmoides*), rainbow trout, and kokanee salmon (*O. nerka*). Considerable data on native and non-native fishes are available in various reports produced by the San Juan River Basin Recovery Implementation Program (USFWS 2004; http://www.fws.gov/southwest/sjrip/) and New Mexico Department of Game and Fish (NMDGF) federal aid reports.



The source of data is the National Hydrograpy Dataset. For information regarding methods, results, and data accuracy, refer to <http://nhd.usgs.gov>.

Figure 5-14. Key perennial aquatic habitats in the San Juan Watershed in New Mexico. Key habitats are designated with an asterisk (*)

Species of Greatest Conservation Need

The New Mexico Department of Game and Fish identified 22 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, in the San Juan Watershed (Table 5-16). Twelve species (55%) are classified as vulnerable, imperiled, or critically imperiled in New Mexico, but secure nationally. Six species are classified as vulnerable, imperiled, or critically imperiled in New Mexico and nationally. Four species are considered secure both in the state and nationally. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H.

Table 5-16. Species of Greatest Conservation Need in the San Juan Watershed.

	Perennial		
Common Name	Large Reservoir	3rd and 4th Order Stream	5th Order Stream
Fish			
Roundtail Chub	X	X	X
Colorado Pikeminnow			X
Razorback Sucker			X
Mottled Sculpin		X	X
Birds[1]			
Eared Grebe	X	X	X
American Bittern			
White-Faced Ibis	X		
Northern Pintail	X	X	X
Osprey	X	X	X
Bald Eagle	X	X	X
Northern Harrier			
Peregrine Falcon	X	X	X
Sandhill Crane	X		X
Wilson's Phalarope	X		
Southwestern Willow Flycatcher		X	X
Bank Swallow		X	X
Yellow Warbler		X	X
Mammal[1]			
American Beaver	X	X	X
Amphibians[1]			
Western Chorus Frog		X	
Northern Leopard Frog		X	X
Reptile[1]			
Western Painted Turtle	X	X	X
Crustacean[1]			
Amphipod	X	X	X

[1] Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

The native fish fauna of San Juan Watershed historically consisted of at least eight or nine species. Bonytail chub (*Gila elegans*) occupied San Juan River downstream in Utah but was not documented in upstream portions of the river. Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) were likely found in coldwater tributaries of the San Juan but there are no extant populations of the subspecies known in New Mexico. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

<u>Perennial Large Reservoir</u>

Habitat Condition

Navajo Reservoir is the large perennial reservoir in the San Juan Watershed. It has permanent surface water and is primarily inhabited by non-native sport fishes such channel catfish, kokanee salmon, smallmouth bass, and yellow perch (*Perca flavescens*). Roundtail chub (*Gila robusta*) and flannelmouth sucker (*Catostomus latipinnis*) are the only native species documented in Navajo Reservoir and neither is common. Navajo Reservoir provides only incidental habitat for native fishes in San Juan Watershed.

Problems Affecting Habitats or Species

Water Withdrawals
Changes in water volume in large reservoirs directly affect the amount and quality of habitats available for fishes. Water withdrawals during the irrigation season lower reservoir levels, potentially affecting fish spawning and nursery habitats. Though detrimental to non-native sport fishes, such changes may be indirectly beneficial to resident native fishes. Reservoir releases to meet agricultural and municipal needs may adversely affect native riverine fishes through displacement, modified thermal regime, or habitat modification.

Non-Native Species
The fish assemblages of Navajo Reservoir are composed almost entirely of non-native sport fishes. While desirable for recreational purposes, these non-native fishes preclude occupancy of the reservoir by native fishes via predation or competition. It also provides a source of non-native fishes that move into up-stream reaches of the San Juan River.

Information Gaps

Electrofishing surveys for centrarchids and passive net surveys for all species are annually conducted on Navajo Reservoir. Data collected in these efforts are useful in tracking overall status and trends of resident fishes. There are, however, numerous information gaps regarding perennial large reservoirs that weaken our ability to make informed conservation decisions.

- Little information is available on predator-prey relationships among perennial large reservoir fishes and the emigration of reservoir fishes to other waters up stream.

- The effects of water level fluctuations on spawning and recruitment in perennial large reservoirs are poorly understood.

- We lack information on mesohabitats used by native fishes in reservoirs.

- We do not have good estimates of the occurrence and abundance of small-bodied fishes such as fathead minnow and red shiner in perennial large reservoirs.

- The existing environmental conditions or thresholds that limit populations of SGCN in perennial large reservoirs are unknown.

- Information is lacking regarding the extent to which invasive and non-native species may alter perennial large reservoirs and limit populations of SGCN.

Research, Survey, and Monitoring Needs

Surveys conducted on perennial large reservoirs by NMDGF primarily focus on game species though data are collected on all incidentally captured non-game species as well. Data from these surveys can be used to characterize assemblage dynamics, effects of water-level manipulations on species abundances and recruitment success, and growth and longevity of common species. Additional research, survey, and monitoring needs are described below.

- Document the occurrence and abundance of small-bodied fish species such as fathead minnows in Navajo Reservoir.

- Determine how water withdrawal and subsequent lower reservoir levels potentially affect spawning fish and nursery habitats. This information will help in designing sustainable watershed conservation and management practices.

- Determine habitat use by native fishes in large reservoirs.

- Determine seasonal movements of native fishes into and out of Navajo Reservoir.

- Quantify the extent to which invasive and non-native species alter perennial reservoir habitats and limit populations of SGCN.

Desired Future Outcomes

Desired future outcomes for the perennial large reservoir in the San Juan Watershed include:

- Perennial large reservoir habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Sport fish management is focused on species that are appropriate for biotic and abiotic conditions.

- The non-preferred sport fish species are controlled or eliminated.

- The emigration and impact of non-native fishes from Navajo Reservoir into surrounding habitats is minimized.

Prioritized Conservation Actions

Although species management of large reservoirs is often focused on those of high recreational interests, conservation of New Mexico's biodiversity will require multiple conservation actions. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with land managers to assure minimum conservation pools in reservoirs persist to provide year-round recreational opportunities and maintain sport fish populations.

2. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of large reservoir functions, services, and values. Emphasize educating anglers about the risks posed by undesirable non-native fishes to both sport and native fishes.

3. Work with public and private land managers to develop strategies to prevent emigration of non-native species into surrounding areas.

4. Restrict baitfish use to fathead minnows.

5. Work with law enforcement agencies to increase compliance with regulations regarding transport and release of undesired non-native fishes (including sport fishes).

6. Collaborate with federal and state agencies and affected publics to enhance and improve large perennial reservoir habitats for use by native fishes.

7. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about perennial large reservoir habitats and associated SGCN outlined in the Research, Survey, and Monitoring Needs sections.

Perennial 3rd and 4th Order Streams

Habitat Condition

The Navajo, Animas, and Mancos tributaries to the San Juan River are perennial 3rd or 4th order streams. Although the La Plata River does not have continuous discharge in its lower reaches, it does have permanent surface water in vicinity of the Colorado/New Mexico border. These perennial 3rd or 4th order stream habitats range from large boulder and debris pools, to cobbled riffles, and backwaters. Habitats in the La Plata River consist mainly of pools and shallow runs. Water diversion for agriculture seasonally reduces flow in all. Non-native fish occur in each tributary. Of these, rainbow and brown trout, white sucker, and common carp are the most common. Perennial 3rd and 4th order streams currently support four native fish SGCN. The Navajo River, within New Mexico, flows largely within the Jicarilla Apache Reservation.

Problems Affecting Habitats or Species

Water Withdrawal
Water development projects in the San Juan drainage include Navajo Reservoir, the San Juan-Chama Diversion, the pending Animas/La Plata Project, the proposed Gallup-Navajo Project, and miscellaneous irrigation diversions. Water removal as a result of these developments may have direct and indirect effects on native fishes in 3rd and 4th order streams. Some mortality to native fishes may occur through entrainment by water withdrawal structures.

Non-Native/Invasive Species
Non-native fish species have become established throughout the system. The water development projects noted above may facilitate the transport of non-native species among associated 3rd and 4th order streams.

Diseases and Pathogens
The presence of whirling disease in rainbow trout was confirmed in New Mexico the spring of 1999. Since this confirmation, portions of the San Juan, Rio Grande, Canadian, and Pecos Watersheds in New Mexico have tested positive for *Myxobolus cerebralis* (whirling disease causal agent) (Hansen 2002). Routine testing and remediation procedures have begun in New Mexico's hatcheries and a testing program has been initiated coldwater streams and reservoirs that may have been inadvertently stocked with rainbow trout carrying the disease or infested through transmission by natural or anthropogenic vectors.

Information Gaps

Information gaps that limit our ability to make informed conservation decisions for perennial 3rd and 4th order streams of the San Juan Watershed are outlined below.

- It is unknown the extent to which habitat fragmentation in the watershed will affect the long-term viability and genetic diversity of species that were historically free to move about the drainage.

- Interactions are unclear among the various native fishes and introduced fishes in perennial 3rd and 4th order streams of the San Juan Watershed.

- Current data is inadequate on species distributions in many of these 3rd and 4th order tributaries.

- Information is lacking regarding the current distribution, life history, habitat use, and genetics of the mottled sculpin (*Cottus bairdi*) and the roundtail chub in the San Juan Watershed.

- The potential and risk for whirling disease to spread among salmonids of 3rd and 4th order stream habitats is uncertain until investigations into the extent of *M. cerebralis* distribution within the watershed has been completed.

Research, Survey, and Monitoring Needs

The US Department of the Interior, Bureau of Reclamation (BOR) and the Southern Ute Indian Tribe are cooperating in conducting surveys on the Animas River in New Mexico and Colorado. The intent is to set up baseline information prior to the implementation of the proposed Animas/La Plata water diversion project south of Durango, Colorado. This project is described in an Environmental Impact Statement issued by the BOR in 2000. The Colorado Division of Wildlife is making efforts to protect and restore native fishes to the Mancos and La Plata rivers. Additional research, survey, and monitoring needs that would enhance our collective conservation efforts are outlined below.

- Determine the current distribution of SGCN in perennial 3rd and 4th order stream habitats.

- Investigate the effects of water withdrawals on the distribution and abundance of aquatic SGCN in perennial 3rd and 4th order streams of the San Juan Watershed.

- Determine the current distribution, life history, habitat use, and genetics of the mottled sculpin (*Cottus bairdi*) and the roundtail chub in perennial 3rd and 4th order streams of the San Juan Watershed.

- There is a need to complete the ongoing investigation into the distribution of *M. cerebralis* to determine the risk of whirling disease to Rio Grande cutthroat trout by this parasite.

Desired Future Outcomes

Desired future outcomes for perennial 3rd and 4th order streams in the San Juan Watershed include:

- Perennial 3rd and 4th order stream habitats persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- Diversion structures and water withdrawals on 3rd and 4th order streams do not impair SGCN.
- Impacts to native species by non-natives are eliminated or significantly reduced.
- Extirpated native fishes are successfully restored to many previously occupied areas.
- Channel conditions are stabilized with appropriate streamside vegetation and substrates.
- Natural flow regimes are maintained.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with federal and state agencies and affected publics to minimize the effect of diversion structures and water withdrawals on native fishes. This may include timing of withdrawals, removal of barriers or impediments to fish movement, physical movement of fish over barriers, fish ladders, and enhancement of native habitat to provide refuge during low-flow periods.

2. Encourage collaboration and coordination among state and federal agencies, NGO's, and private land stewards in designing and implementing irrigation water withdrawal structures that minimize entrainment of native fishes.

3. Work with federal and state agencies and affected publics to control non-native fishes by physical means or habitat manipulation.

4. Adopt and encourage compliance with strict baitfish regulations.

5. Continue collaboration with federal and state agencies and affected publics to support the Three Species Conservation Agreement to protect, manage, and preserve bluehead sucker (*Catostomus discobolus*), flannelmouth sucker, and roundtail chub throughout their range. Continued participation in the agreement, including drafting and implementation of state management plans, is essential to the conservation of these species. NMDGF is currently completing a recovery plan for roundtail chub.

6. Collaborate with federal and state agencies and publics to develop conservation activities that gain public support for native fish management and conservation. Actions may include promoting public awareness and understanding of stream functions and values.

7. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about perennial 3rd and 4th order stream habitats and associated SGCN outlined in the Information Gaps and Research, Survey, and Monitoring Needs sections.

Perennial 5th Order Stream

Habitat Condition

From Navajo Dam to its exit from New Mexico near Four Corners, the San Juan River is a perennial 5th order stream. Upstream of Shiprock, suburban and urban development is common along the river. Irrigated rowcrop and pasture agriculture is also common where the land is not under residential development. Downstream of Shiprock, the primary land use shifts from irrigated cropland to dispersed livestock grazing. The riparian area of the lower San Juan was once dominated by cottonwood bosque. Except where development impinges, non-native Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix* spp.) border the river. Several low head diversion dams seasonally divert water from the river. Non-native fishes (especially common carp, channel catfish, red shiner, and fathead minnow) are common, particularly downstream of Shiprock. Habitats consist mainly of moderately deep runs, but cobbled riffles, shoals, backwaters, debris pools, and secondary channels are common. The San Juan River downstream of Navajo Dam supports seven native fishes. Problems affecting of 5th order streams and associated SGCN are similar to those for species in 3rd and 4th order habitats.

Problems Affecting Habitats or Species

Modification of Natural Processes
Impoundment of the San Juan River behind Navajo Dam inundated river habitats occupied by several native fishes, particularly Colorado pikeminnow (*Ptychocheilus lucius*), roundtail chub, and razorback sucker (*Xyrauchen texanus*). Habitat loss and physical and thermal regime modification of the river downstream of the dam have precluded these lower reach habitats from use by most native fish species. The reservoir also traps sediment and thus disrupts or alters the sediment budgets of downstream reaches. Such decreases in sediment inputs alter the natural dynamics of mesohabitat creation and maintenance. Dams also fragment species ranges, preventing upstream and downstream movement of fishes. Navajo Dam regulates flows of the San Juan and loss of a natural flow regime is the over-arching problem for native fish assemblages in the main stem. Under the San Juan River Basin Recovery Implementation Program (USFWS 2004; http://www.fws.gov/southwest/sjrip/), water is released from Navajo Reservoir to mimic a natural flow regime.

Pollution
Irrigation water returns are common in the river reach upstream of Cudei. Agricultural and municipal runoff has affected habitat quality.

Non-Native/Invasive Species
Non-native fish species have severe impacts on the native-fish fauna of the San Juan through competition for resources and predation. In addition, injury to native fish from the spines of non-native channel catfish has been documented.

Information Gaps

Several information gaps limit our ability to make informed conservation decisions regarding the San Juan River and associated SGCN:

- Current distribution, life history, habitat use, and genetic information on roundtail chub in the San Juan River are needed to adequately protect and manage this species.

- The reasons are largely unknown for the near elimination of roundtail chub from San Juan River habitats.

- Information is needed on the effects of non-native fishes on the trophic dynamics of San Juan River mesohabitats.

- Information is needed on the extent and effects of hybridization of flannelmouth and bluehead suckers with non-native white sucker and the extent of detrimental competitive interactions among white, bluehead, and flannelmouth suckers.

- Little is known about trophic dynamics within 5th order streams and other aquatic habitats in the San Juan Watershed.

- Information is lacking regarding the growth and survival of common native fishes in the 5th order stream habitats of the San Juan Watershed.

- The efficacy and opportunities for using non-native fishes as forage for native piscivores are unknown.

- The effects of interrupting natural flow regime in the Animas River on native and non-native fish assemblage are poorly understood.

- Information is needed regarding factors affecting over-winter survival of rare fishes in the San Juan River.

- Although water release from Navajo Reservoir is conducted to mimic a natural flow regime, little is known about the effectiveness of this strategy in maintaining essential 5th order stream habitats.

Research and Survey Efforts

Most research and monitoring on fishes in San Juan River are accomplished under the auspices of San Juan River Basin Recovery Implementation Program (USFWS 2004; http://www.fws.gov/southwest/sjrip/). In addition, US Bureau of Reclamation and the Southern Ute Indian Tribe have conducted fisheries investigations on the Animas River. This information is compiled in a GIS database at the University of New Mexico and in annual reports by participating agencies and groups (http://www.fws.gov/southwest/sjrip/annualrpts.html).

Current research and survey efforts with this program include: 1) long term monitoring of channel morphology, 2) habitat mapping, 3) water quality and temperature monitoring, 3) movement of fish through the hogback fish ladder, 4) trophic relationships among Colorado pikeminnow and its prey in the San Juan River, 5) evaluation of Colorado pikeminnow and razorback sucker augmentation programs, 6) non-native species removal, 7) yearly monitoring of large and small-bodied fishes, and 8) evaluation of the current level of fish entrapment in irrigation canals associated with the San Juan River. Additional research and survey efforts that would enhance our ability to make informed conservation decisions are outlined below.

- Quantify the current distribution of roundtail chub in the San Juan River.

- Determine the factors that make secondary channels important habitat for non-native fishes.

- Determine the extent to which land use activities such as urban development, irrigated rowcrop and pasture agriculture, and livestock production alter habitats in relation to size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and frequencies of disturbance affect SGCN in perennial 5^{th} order stream habitats in the San Juan Watershed.

- Characterize the life history, biology, and habitat associations of SGCN associated with perennial 5^{th} order stream habitat in the San Juan Watershed, including the effects of non-native species on native assemblages.

- Investigate the effectiveness of current endeavors to mimic natural flow regimes from the Navajo Reservoir in maintaining 5^{th} order stream habitats.

Desired Future Outcomes

Desired future outcomes for perennial 5^{th} order streams in the San Juan Watershed include:

- The perennial 5^{th} order stream habitats of the San Juan River persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN and host a variety of land uses with reduced resource use conflicts.

- San Juan River management and conservation activities are directed towards effective restoration or mimicry of natural flow regimes.

- Non-native fishes are eliminated from perennial 5th order stream habitats, and self-sustaining populations of historically occurring native fishes are present.

- Stocking of non-native sport fishes, except in limited areas such as the Navajo Dam Special Trout Waters, where potential interactions with native fishes are minimal, are eliminated.

- Baitfish use regulations that preclude introduction of non-native species garner wide public support and compliance.

- Native fish management and conservation of perennial 5th order stream habitats in the San Juan Watershed are widely supported by the public.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Continue research and management activities under the auspices of the San Juan River Basin Recovery Implementation Program (USFWS 2004) to benefit the federally protected Colorado pikeminnow and razorback sucker. These activities also benefit other native species.

2. Collaborate with federal and state agencies and affected publics to continue efforts to remove fish ladders and non-native fishes, particularly channel catfish and common carp, around diversion dams on the San Juan River.

3. Collaborate with ongoing research investigating energy pathways and effects of non-native fishes on carrying capacity of the San Juan River.

4. Encourage water release endeavors that are designed to mimic natural flow regimes below Navajo Reservoir.

5. Continue NMDGF current policy of not stocking non-native warm water sport fishes in lotic habitats of the San Juan Watershed.

6. Collaborate with the Colorado Division of Wildlife in propagating and rearing captive roundtail chub.

7. Continue participating with involved western states in the recently initiated "Three Species Conservation Agreement" to conserve flannelmouth sucker, bluehead sucker, and roundtail chub throughout their historical ranges in the San Juan Watershed.

8. Complete development and implementation of the Roundtail Chub Recovery Plan.

9. Collaborate with federal and state agencies and affected publics to create public awareness and understanding of perennial 5th order stream ecosystem functions, services, and values to SGCN.

10. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide the information about perennial 5th order stream habitats and associated SGCN outlined in the Information Gaps and Research, Survey, and Monitoring Needs sections.

11. Compile, analyze, and synthesize the considerable demographic data collected for bluehead and flannelmouth suckers and speckled dace and develop appropriate management plans for each species.

TULAROSA WATERSHED

The Tularosa Watershed covers approximately 3.2 million ac (0.1 million ha) in south central New Mexico in the northern Chihuahuan Desert and includes parts of Santa Fe, Torrance, Socorro, Lincoln, Otero, and Dona Ana counties and the municipalities of Alamogordo, Carrizozo, and Mountainair. It is a closed basin with no inlet or outlet. All of the water in the watershed remains within the basin. Much of the Tularosa Watershed is federal government property (White Sands Missile Range (WSMR), Holloman Air Force Base, White Sands National Monument, and the Lincoln National Forest). Further, the Mescalero Apache Indian also has ownership and jurisdiction of significant portions of the Tularosa Watershed. As such, there has been limited development and currently there are no man-made barriers (dams or reservoirs) or other alterations to the natural flow regime. Between 1990 and 2000, population growth within the watershed varied from a 65% increase in Torrance Country to a 20% increase in Otero County. According to the *2003 State Water Plan* (Office of the State Engineer/Interstate Stream Commission 2003), both water levels and water quality are declining in the Tularosa Watershed.

Key aquatic habitats in the Tularosa Basin include perennial marsh/cienega/spring/seep, and perennial 1st and 2nd order stream (Fig. 5-15). These habitats are primarily restricted to the Salt River drainage on White Sands Missile Range. Perennial 1st and 2nd order streams, such as Indian Creek, are found in the higher elevation mountains.

Non-native species occur sporadically throughout the watershed. They include largemouth bass (*Micropterus salmoides*), goldfish (*Carassius auratus*), western mosquitofish (*Gambusia affinis*), and crayfish (*Procambarus clarkia*). Prior to 1994 a large population of feral horses on WSMR caused a severe reduction in vegetative cover and subsequent channelization and cutting of waterways. Since 1995 nearly all of the horses have been removed and rapid re-vegetation has been observed. Oryx (*Oryx beisa*), a non-native African antelope introduced onto WSMR in the 1960s to provide hunting opportunities, are currently abundant.

Species of Greatest Conservation Need

Within the Tularosa Watershed low-elevation perennial springs provide habitat for several endemic Species of Greatest Conservation Need (SGCN), such as the White Sands pupfish (*Cyprinodon Tularosa*), Tularosa springsnail (*Juternia tularosae*), an un-described gammarid amphipod and hyalellid amphipods (Table 5-17). Higher elevation marsh habitat associated with the Tularosa River supports an isolated population of blunt ambersnails (*Oxyloma retusum*), land snails of restricted occurrence in New Mexico. Fossil specimens of blade vertigo snails (*Vertigo milium*) and ovate vertigo snails (*Vertigo ovata*) are also known from Pleistocene and Holocene deposits within the basin (Metcalf and Smartt 1997). Only two SGCN are found in 1st and 2nd order stream habitats in the Tularosa Watershed, Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*), in mountain streams, and White Sands pupfish, in low desert streams.

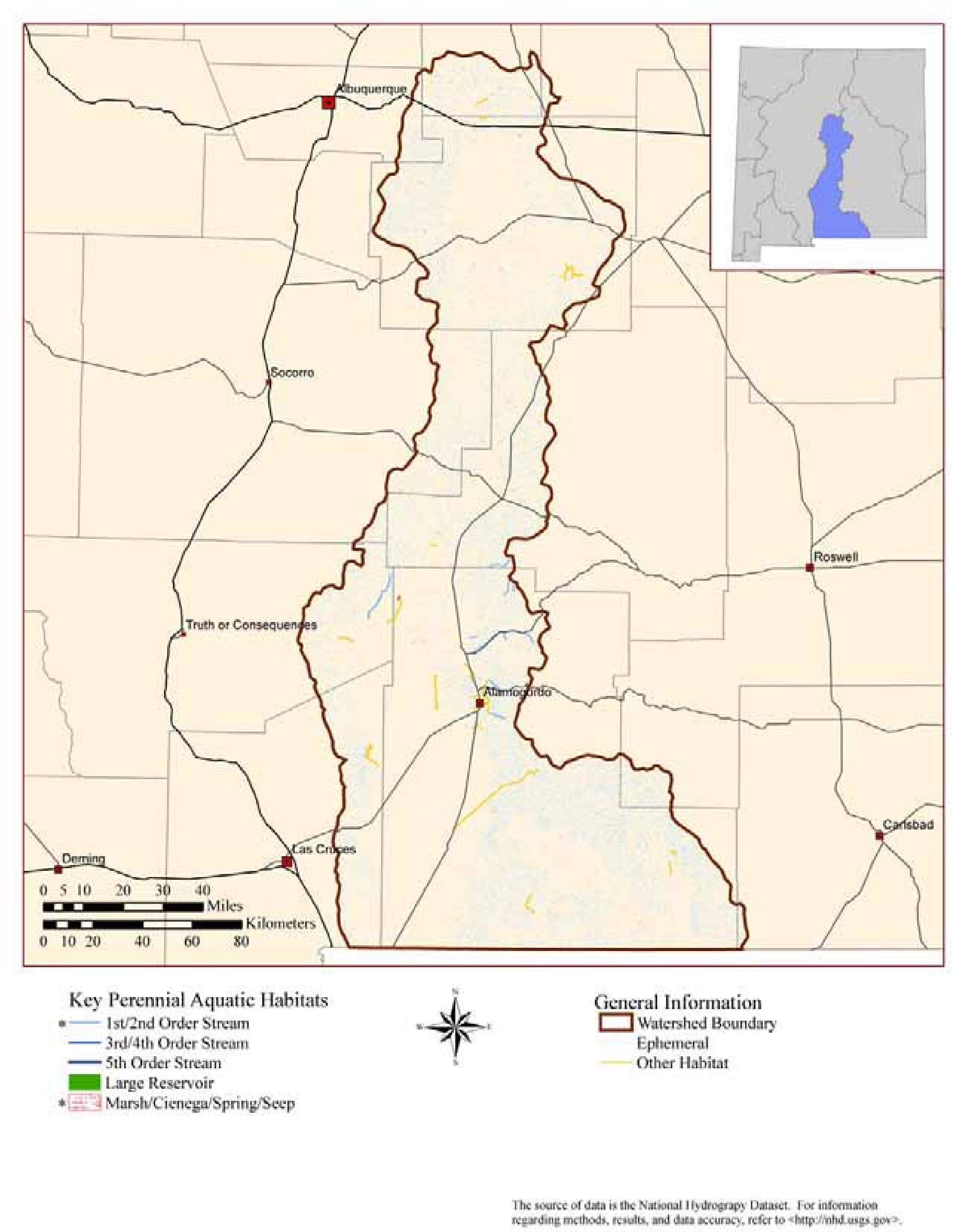


Figure 5-15. Key perennial aquatic habitats in the Tularosa Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Table 5-17. Species of Greatest Conservation Need in the Tularosa Watershed in New Mexico.

	Perennial	
Common Name or Scientific Name[1]	Marsh/ Cienega/ Spring/ Seep	1st and 2nd Order Stream
Fish		
White Sands Pupfish	X	X
Rio Grande Cutthroat Trout		X
Birds[2]		
Eared Grebe	X	
American Bittern	X	
White-Faced Ibis	X	
Northern Pintail	X	
Bald Eagle	X	
Northern Harrier	X	
Peregrine Falcon	X	
Sandhill Crane	X	
Southwestern Willow Flycatcher	X	
Yellow Warbler	X	X
Mammals[2]		
Western Red Bat	X	
Spotted Bat	X	
New Mexico Meadow Jumping Mouse	X	
Desert Bighorn Sheep	X	
Amphibian[2]		
Tiger Salamander	X	
Plains Leopard Frog	X	
Northern Leopard Frog	X	X
Molluscs[2]		
Tularosa Springsnail	X	
Blunt Ambersnail	X	
Ovate Vertigo Snail	X	
Blade Vertigo Snail	X	
Crustaceans[2]		
Hyalella spp.	X	X
Gammarus spp.	X	

1 Scientific names are provided where common names for the species does not exist.

2 Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

Twenty-five SGCN, excluding arthropods other than crustaceans, occur in the Tularosa Watershed (Table 5-17). Ten species (40%) were classified as vulnerable, imperiled, or critically imperiled both statewide and nationally. Thirteen species (52%) were considered nationally secure, but vulnerable, imperiled, or critically imperiled in New Mexico. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the Riparian Habitat and/or Terrestrial Habitat section.

Perennial Marsh/Cienega/Spring/Seep

Habitat Condition

Perennial spring-fed habitats (marshes, cienegas, springs, seeps) occur sporadically throughout the Tularosa Watershed as isolated wetlands that discharge surface water to localized aquatic systems that eventually recharge shallow aquifers. Other springs may contribute surface flows to perennial streams found throughout the basin. Thompson *et al.* (2002) developed a rapid assessment procedure for springs and seeps in the Tularosa Basin. Springs and seeps were rated on the basis of riparian vegetation, surface water, and evidence of recent human activity. Of the 276 springs and seeps evaluated, 84 springs retained typical riparian vegetation and perennial surface water. Of these, 73 springs had evidence of human activity that may alter these habitats. Overall, 6% of the historic springs were dry and had no typical riparian vegetation. Much of the vegetation (grasses and sedges) in and around marsh/cienega/spring/seep habitats in the Tularosa Basin has been rejuvenated following the removal of feral horses from WSMR.

Problems Affecting Habitats or Species

Water Withdrawal
Several proposals and plans exist for desalination plants for research and development and to provide drinking water to Alamogordo. The surface water loss resulting from the water withdrawal and dewatering necessary to support these projects, exacerbated by recent drought conditions, will have significant adverse effects upon marsh/cienega/spring/seep habitats and associated SGCN of the Tularosa Basin.

Military Activities
Habitat loss or contamination and species extermination from military activities are serious factors that adversely influence aquatic perennial spring-fed habitats in the Tularosa Basin. The *Integrated Natural Resources Management Plans* for White Sands Missile Range and Holloman Air Force Base, to which both the New Mexico Department of Game and Fish (NMDGF) and US Fish and Wildlife Service (USFWS) are signatories, consider and propose to mitigate adverse military mission effects on natural resources (Holloman Air Force Base 2000, WSMR 2001). Additional efforts have been made on WSMR to protect SGCN and associated habitats, particularly the White Sands pupfish. A *Cooperative Agreement for the Protection and Maintenance of White Sands Pupfish* was signed in 1994 (NMDGF 1994b), but the potential to update and continue implementation of the agreement on WSMR is tenuous. Military activities may increase the risk of fire in areas with sufficient fine fuels. White Sands Missile Range has recently completed a fire management plan outlining specific responses.

Invasive Species
Currently, perennial marsh/cienega/spring/seep habitats in the Tularosa Basin have only native aquatic animal species. However, non-native crayfish and western mosquitofish occupy waters in nearby areas, and may impose a future factor of concern. The possibility of introductions into these key habitats exists and would be a significant detriment to native species including the White Sands pupfish. Saltcedar (*Tamarix* spp.) occurs around many of the springs in the Tularosa Basin. This invasive plant has long taproots that allow it to intercept deep water tables and interfere with natural aquatic systems. Saltcedar disrupts the structure and stability of native plant communities and degrades native wildlife habitat by successfully competing with and replacing native plant species and consuming limited sources of moisture. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Legal Protection
Current interpretation of state and federal regulatory authority (Clean Water Act) over non-navigable waters of the United States and the state poses concern for protection of perennial wetlands (such as, marsh/cienega/spring/seep, 1st and 2nd order streams, ponds, lakes) and ephemeral wetlands (natural catchments, marsh/cienega/spring/seep, 1st and 2nd order streams) within the Tularosa Watershed. See Statewide Distributed Ephemeral Habitats and Perennial Tanks section for details.

Information Gaps

There are several major information gaps regarding perennial marsh/cienega/spring/seep habitats in the Tularosa Basin and associated SGCN that impair our ability to make informed conservation decisions. These are outlined below.

- Little is known about the natural history and ecological needs of invertebrate SGCN, such as the Tularosa springsnail, in perennial marsh/cienega/spring/seep habitats.

- Our capacity to implement actions to conserve the White Sands pupfish, despite an existing cooperative agreement, is currently unknown because of funding cuts for natural resource protection in the Department of Defense.

- Uncertainty exists regarding the potential effects of recent changes in the Clean Water Act apparently removing protections for closed basins such as the Tularosa.

- Current condition, trend, and status of perennial marsh/cienega/spring/seep habitats in the Tularosa Basin are largely unknown. Thompson *et al.* (2002) provides a baseline to obtain this information.

Research, Survey, and Monitoring Needs

Research and surveys needed to make informed conservation decisions for the perennial marsh/cienega/spring/seep habitats of the Tularosa Watershed and associated SGCN are outlined below.

- Research, surveys, and monitoring projects are needed regarding the distribution, biology, and stability of invertebrate SGCN and their microhabitats.

- Detailed surveys and monitoring of perennial marsh/cienega/spring/seep habitats are needed to adequately protect these habitats and SGCN. Surveys, following guidelines of Thompson *et al.* (2002), would provide trend data to evaluate the longevity and potential amount of net loss that has occurred in springs and seeps over the last 10 years.

- GIS-based biotic surveys basin wide would serve to map the distribution and extent of perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed, including their associated SGCN. These data will also serve to assess at-risk wetlands and will facilitate monitoring of wetland loss or gain.

Desired Future Outcomes

The following broad future outcomes are consistent with the *Cooperative Agreement for the Protection and Maintenance of White Sands Pupfish* and the *Integrated Natural Resources Management Plans for White Sands Missile Range and Holloman Air Force Bases*.

- Perennial marsh/cienega/spring/seep habitats in the Tularosa Basin persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land management uses with reduced resource use conflicts.

- Perennial marsh/cienega/spring/seep habitats are free of non-native species that that may adversely affect SGCN or their habitats.

- There is a no net-loss of perennial spring-fed habitats throughout the Tularosa Watershed.

- Collaborative relations are established among state and federal agencies, NGO's, universities, and private landowners to secure adequate funding to conserve, enhance, and restore perennial marsh/cienega/spring/seep habitats of the Tularosa Watershed.

- Citizen-based "watershed watch groups" or "wetland alliances" are established to facilitate the conservation of perennial marsh/cienega/spring/seep habitats of the Tularosa Watershed.

- Management practices are developed and adopted by land managers to protect the ecological integrity of perennial spring-fed habitats.

- Viable populations of the White Sands pupfish are distributed throughout their historic range in the perennial marsh/cienega/spring/seep habitats of the Tularosa Watershed.

- The *Cooperative Agreement for Protection and Maintenance of White Sands Pupfish* and the *Integrated Natural Resources Management Plans* for White Sands Missile Range and Holloman Air Force Bases are fully implemented.

Prioritized Conservation Actions

Conservation actions necessary to conserve the perennial marsh/cienega/spring/seep habitats of the Tularosa Basin are also outlined in the *Cooperative Agreement for Protection and Maintenance of White Sands Pupfish* and the *Integrated Natural Resources Management Plans* for White Sands Missile Range and Holloman Air Force Base (NMDGF 1994b, Holloman Air Force Base 2000, WSMR 2001). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Collaborate with involved government agencies to attain implementation of the Integrated Natural Resources Management Plans for White Sands Missile Range and Holloman Air Force Bases.

2. Work with the USFWS and the Department of Defense to re-authorize the *Cooperative Agreement for Protection and Maintenance of White Sands Pupfish*.

3. Work with state and federal land managers, and research institutions to investigate the current status of SGCN associated with perennial marsh/cienega/spring/seep habitats of the Tularosa Basin and factors limiting their populations.

4. Work with appropriate state and federal government entities and potentially affected interests to identify and pursue alternatives to the Clean Water Act for restoring protection to perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed.

5. Work with federal, state, and tribal governments, NGOs, and universities to improve and increase the use of existing data management systems for tracking information pertinent to perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed.

6. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial marsh/cienega/spring/seep habitats specified in the Problems or Research, Survey, and Monitoring Needs sections, with emphasis on the White Sands pupfish and Tularosa springsnail.

7. Work with public and private land managers to remove non-native aquatic and riparian species from the Tularosa Basin and to prevent further introductions.

8. Encourage partnerships between federal and state land managers and private landowners to protect and rehabilitate perennial marsh/cienega/spring/seep habitat.

9. Collaborate with federal, state, local, and tribal governments and affected publics to adopt and implement standardized monitoring and survey methods by which to track gains and losses of perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed.

10. Work with local, state, federal, and tribal governments, NGOs, and private landowners to establish "watershed alliances" or "wetland working groups" that monitor, protect, and restore perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed.

11. Encourage public participation in state and federal incentive-based programs, such as Swampbuster, Wetlands Reserve Program, and the Landowner Incentive Program, to protect, enhance, and restore perennial marsh/cienega/spring/seep habitats.

12. Collaborate with WSMR and Holloman Air Force base to provide information concerning perennial marsh/cienega/spring/seep habitats to the USFWS for updating the New Mexico National Wetland Inventory.

13. Collaborate with the New Mexico Environment Department's Wetland Program to more efficiently protect, restore, conserve, and create perennial marsh/cienega/spring/seep habitats and to monitor and evaluate progress.

14. Teach local resource users about measures that conserve perennial marsh/cienega/spring/seep habitats and associated SGCN in the Tularosa Basin.

15. Collaborate with federal and state agencies, tribal governments, NGOS, and affected publics to create an awareness and understanding of ecosystem functions, services, and values afforded by perennial marsh/cienega/spring/seep habitats in the Tularosa Watershed.

Perennial 1st and 2nd Order Streams

Habitat Condition

There are several perennial 1st and 2nd order streams in the closed Tularosa Basin including Salt Creek, Lost River, Three Rivers, and Indian Creek. The watershed as a whole has experienced few adverse effects from urban or rural development and there are currently few impediments to natural flows of 1st and 2nd order streams in the Tularosa Basin. Although 1st and 2nd order streams are for the most part uncorrupted, they have been subject to drying associated with the recent drought and often are wetted only near spring heads.

Problems Affecting Habitats or Species

Water Withdrawal
Several proposals and plans exist for desalination plants to provide drinking water to the city of Alamogordo. The surface water loss resulting from water withdrawal and dewatering necessary to support these projects, exacerbated by recent drought conditions, will have significant adverse effects upon perennial 1st and 2nd order stream habitat and associated SGCN.

Military Activities
Habitat loss or contamination and species extirpation from military activities are potentially serious factors that may adversely influence perennial 1st and 2nd order streams in the Tularosa Basin. The *Integrated Natural Resources Management Plans* for WSMR and Holloman Air Force Base, to which both NMDGF) and USFWS are signatories, propose to mitigate adverse military mission effects on natural resources (Holloman Air Force Base 2000, WSMR 2001). Additional efforts have been made on WSMR to protect SGCN and associated habitats, particularly the White Sands pupfish. A *Cooperative Agreement for the Protection and Maintenance of White Sands Pupfish* was signed in 1994 (NMDGF 1994b), but the potential to update and continue implementation of the agreement on WSMR is tenuous.

Habitat Conversion
Land uses, such as urban development, improper grazing, logging, road building, and fire management, alter perennial 1st and 2nd order streams in the Tularosa Watershed. Wildfires and increased urban development have the potential to adversely affect streams such as Indian Creek where Rio Grande cutthroat trout and other SGCN are present.

Invasive Species
Invasive and non-native plants and animals are a concern in the perennial 1st and 2nd order streams in the Tularosa Basin. The introduction of crayfish and western mosquitofish from nearby waters into these key habitats would significantly impact native species including the White Sands pupfish. Non-native trout are present and adversely affect Rio Grande cutthroat trout. Saltcedar occurs around many perennial 1st and 2nd order streams in the Tularosa Basin. This invasive plant has long taproots that allow it to intercept deep water tables and interfere with natural aquatic systems. Saltcedar disrupts the structure and stability of native plant communities and degrades native wildlife habitat by successfully competing with and replacing native plant species and consuming limited sources of moisture. The State Forest and Watershed Health Plan devotes significant planning to the management of non-native invasive phreatophytes (New Mexico Energy, Minerals, and Natural Resources Department 2004).

Legal Protection
Current interpretation of state and federal regulatory authority (Clean Water Act) over non-navigable waters of the United States and the state poses concern for protection of perennial wetlands. These include marsh/cienega/spring/seep, 1st and 2nd order, ponds, lakes and ephemeral wetlands such as natural catchments, marsh/cienega/spring/seep, 1st and 2nd order streams within the Tularosa Watershed. See Statewide Distributed Ephemeral Habitats and Perennial Tanks section for details.

Information Gaps

- There are several major information gaps regarding perennial 1st and 2nd order streams and associated SGCN that impair our ability to make informed conservation decisions.

- The extent is unknown to which the timing, intensity, and duration of livestock grazing, anthropogenic development, road-building, off-road vehicle use, and non-native species invasions fragment and alter habitats in relation to patch size, edge effect, and use by wildlife. This information is important in understanding how different land use intensities and frequencies of disturbances affect SGCN in perennial 1st and 2nd order streams.

- Little is known about the invertebrate SGCN in perennial 1st and 2nd order streams in the Tularosa Watershed.

- Our capacity to implement actions to conserve the White Sands pupfish, despite an existing cooperative agreement, is currently unknown because of undetermined effects of natural resource funding reductions by the US Department of Defense.

- The effects of chemical treatment for saltcedar on pupfish are unknown.

Research, Survey, and Monitoring Needs

Much of the land upon which perennial 1st and 2nd order streams occur in the Tularosa Basin is under the ownership and jurisdiction of the US Department of Defense, the Lincoln National Forest, and the Mescalero Apache Tribe. The conduct of meaningful and productive research, survey, and monitoring work will require that NMDGF collaborate closely with these entities. Research and surveys needed to make informed conservation decisions for perennial 1st and 2nd order streams in the Tularosa Watershed include:

- Research, surveys, and monitoring projects are needed regarding the distribution, biology, and stability of invertebrate SGCN and their microhabitats.

- Research is needed to characterize population dynamics and species interactions in perennial 1st and 2nd order streams.

- More detailed habitat surveys are needed of perennial 1st and 2nd order streams and associated SGCN.

- Research is needed to investigate the effects of chemical treatment for saltcedar around perennial 1st and 2nd order streams on pupfish.

Desired Future Outcomes

Desired future outcomes for perennial 1st and 2nd order streams in the Tularosa Watershed include:

- Perennial 1st and 2nd order streams in the Tularosa Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land management uses with reduced resource use conflicts.

- The NMDGF, the Lincoln National Forest, The US Department of Defense, and the Mescalero Apache Tribe are engaged in collaborative and complementary research, survey, monitoring, and resource management activities in the Tularosa Basin.

- Native riparian plant communities associated with perennial 1st and 2nd order streams in the Tularosa Watershed are restored and maintained.

- The perennial 1st and 2nd order streams in the Tularosa Watershed are free of non-native species that may adversely affect SGCN or their habitats.

Prioritized Conservation Actions

Conservation actions necessary to secure the perennial 1st and 2nd order streams of the Tularosa Basin are also outlined in the Cooperative Agreement for Protection and Maintenance of White Sands Pupfish and the Integrated Natural Resources Management Plans for White Sands Missile Range and Holloman Air Force Base (NMDGF 1994b, Holloman Air Force Base 2000, WSMR 2001). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with the USFWS and the US Department of Defense to re-authorize the *Cooperative Agreement for Protection and Maintenance of White Sands Pupfish*.

2. Work with federal and state agencies, the Mescalero Apache Tribe, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1st and 2nd order streams outlined in the Problems or Research, Survey, and Monitoring Needs section. Studies on the White Sands pupfish and invertebrates are especially desirable.

3. Collaborate with involved government agencies to implement the *Integrated Natural Resources Management Plans* for White Sands Missile Range and Holloman Air Force Bases

4. Work with the US Forest Service to implement the watershed goals of the Lincoln National Forest Plan.

5. Promote cooperation and partnerships among federal, state, and tribal governments, NGOs, and private landowners to conserve perennial 1^{st} and 2^{nd} order streams in the Tularosa Watershed.

6. Work with public, tribal, and private land managers to remove non-native aquatic and riparian species from the Tularosa Basin and prevent further introductions.

7. Work with state, federal, and tribal governments and potentially affected interests to identify and pursue alternatives to the Clean Water Act for restoring protection to perennial 1^{st} and 2^{nd} order streams in the Tularosa Watershed.

8. Teach local resource users about measures that conserve perennial 1^{st} and 2^{nd} order streams and associated SGCN in the Tularosa Watershed.

ZUNI WATERSHED

The Zuni River drains about 840,155 ac (340,000 ha) as it flows from its headwaters in west-central New Mexico to the Little Colorado River in Arizona. Key aquatic perennial habitats in the Zuni Watershed include 1st and 2nd order streams and 3rd and 4th order streams (Fig. 5-16). Continuous surface flow generally occurs in the Zuni River only during heavy spring run-off. Many stream reaches are dry except near perennial springs. Headwaters of the Zuni Watershed include 1st and 2nd order streams such as Rio Nutria and Tampico Draw. Lower areas of the watershed include the main stem of the Zuni River, a 3rd and 4th order system, and associated impoundments, such as Black Rock Reservoir.

In New Mexico, the Zuni Watershed includes parts of San Juan, McKinley, Valencia, and Catron Counties and the municipalities of Gallup, Zuni, Quemado, and Ramah. Population in this area of the state grew from 8% (Cibola) to 46% (Valencia) between 1990 and 2000, with an average of 23%. Land in the upper watershed is primarily owned privately and by the US Forest Service. The lower areas of the watershed are under the jurisdiction of the sovereign Zuni Pueblo.

Post-European settlement changes to the landscape and subsequent effects on the Zuni Watershed are well documented (see *Zuni River Watershed Plan*; Natural Resources Conservation Service 1998). The watershed was severely degraded by extensive logging and overgrazing in the late 1800s and early-to-mid 1900s. Effects of subsequent vegetative cover loss included increased surface erosion, gullying, headcutting, wide discharge fluctuations, and loss of water in the system. Impacts were so severe that the Zuni Pueblo brought litigation against the United States government in the early 1970s. The settlement called the "Zuni Watershed Act of 1990" (Public Law 102-388), seeks to restore tribal lands damaged because of upstream misuse of resources. In addition, the "Zuni Land Conservation Act of 1990" (Public Law 101-486) provided funds for the Zuni Pueblo to take corrective measures within the Zuni Indian Reservation in response to damage of lands as a result of federal improprieties.

After being subjected to early twentieth century land use practices, the Zuni River was dammed for flood control, irrigation storage, and recreational fishing. In addition, water withdrawals for irrigation and human consumption reduced surface discharge in the system. Limited water quality monitoring at the Zuni River above Black Rock Reservoir (US Geological Survey 1996) indicates water is fairly hard, with a mean total dissolved solids concentration of 38.5 oz/gal (537 mg/l), but with heavy metals well below allowable standards. Overall water quality is unknown. The *Zuni River Watershed Plan* (Natural Resources Conservation Service 1998) was completed in 1998. It details current conditions of the watershed; makes recommendations for protection and rehabilitation of the area; establishes management guidelines for maintaining and improving resources; establishes a system for monitoring conditions; and provides proposals for voluntary cooperative programs among partner agencies. Specific tasks for implementing this plan include establishing a regular monitoring program to examine effects of management on hydrology and erosion, agriculture and cropland, rangeland, forestry, wildlife, archeology, cultural values, and social and economic values in the Zuni Watershed.

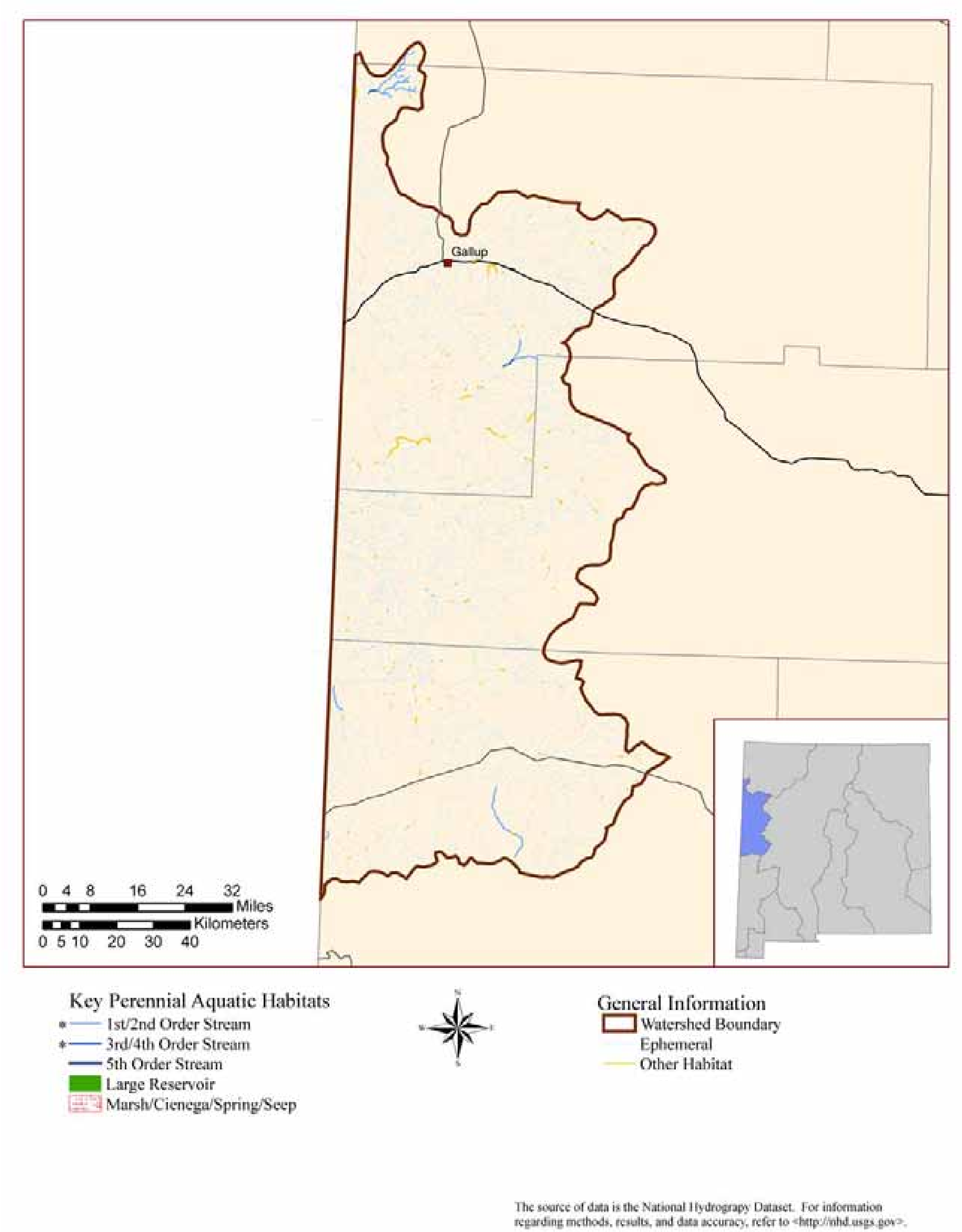


Figure 5-16. Key perennial aquatic habitats in the Zuni Watershed in New Mexico. Key habitats are designated with an asterisk (*).

Several non-native species reside in the watershed. Eight non-native fish species have been reported from the Zuni River drainage (Hanson 1980, Propst and Hobbes 1996), but only green sunfish (*Lepomis cyanellus*), fathead minnow (*Pimephales promelas*), and plains killifish, (Fundulus zebrinus), are comparatively common and widespread. Several species have been introduced as sport fish, including northern pike (*Esox lucius*), rainbow trout (*Oncorhynchus mykiss*), and channel catfish (*Ictalurus punctatus*). Crayfish (*Orconectes virilis*) have also been introduced into the basin and are spreading.

Species of Greatest Conservation Need

Only 14 Species of Greatest Conservation Need (SGCN), excluding arthropods other than crustaceans, occurred in the Zuni Watershed (Table 5-18). Eight species (57%) were classified as vulnerable, imperiled, or critically imperiled in New Mexico, and secure nationally. Three species (21%) are vulnerable, imperiled, or critically imperiled in New Mexico and nationally, and three species are secure both nationally and in the state. Conservation status codes (abundance estimates) for each SGCN are provided in Appendix H. Zuni bluehead sucker

Table 5-18. Species of Greatest Conservation Need in the Zuni Watershed in New Mexico.

	Perennial	
Common Name or Scientific Name[1]	1st and 2nd Order Stream	3rd and 4th Order Stream
Fish		
Roundtail Chub		E[2]
Zuni Bluehead Sucker	X	X
Birds[3]		
Eared Grebe		X
Northern Pintail		X
Osprey		X
Bald Eagle		X
Peregrine Falcon		X
Southwestern Willow Flycatcher		X
Bank Swallow		X
Yellow Warbler	X	X
Mammals[3]		
American Beaver	X	X
Amphibians[3]		
Western Chorus Frog	X	X
Northern Leopard Frog	X	X
Crustaceans[3]		
Hyalella spp.	X	X

1 Scientific names are provided where common names for the species does not exist.
2 Species is considered extirpated from habitat type.
3 Additional conservation concerns for these taxa are addressed in the Statewide Distributed Riparian Habitats, Statewide Distributed Ephemeral Habitats and Perennial Tanks and/or Ecoregion and terrestrial habitat sections.

(*Catostomus discobolus yarrowi*) was listed as endangered in New Mexico in 1975 because habitat modification and predation by non-native fishes jeopardized its ability to persist and reproduce within the state (Propst 1999). As directed by the Wildlife Conservation Act amendments of 1995, New Mexico Department of Game and Fish (NMDGF), along with an advisory committee with representatives from federal, state, local, and tribal agencies, conservation organizations, and private landowners, completed a recovery plan for the species (NMDGF 2005b). The *Zuni Bluehead Sucker Recovery Plan* provides detailed information on the biology, threats to populations and habitats, and strategies for recovering the species. The roundtail chub (*Gila robusta*) was collected from the Zuni River (Baird and Girard 1853), but the species has not been collected there in more than 100 years. Lack of continuous flow, habitat degradation, and the introduction of non-native fishes may have led to the extirpation of roundtail chub from the Zuni River in New Mexico. Conservation concerns for birds, mammals, amphibians, and reptiles are primarily addressed in the statewide distributed riparian habitats section and/or the discussion of terrestrial habitats in each ecoregion. Additional concerns for molluscs and crustaceans are addressed in the statewide distributed ephemeral habitats and perennial tanks section.

Perennial 1st and 2nd Order Streams and Perennial 3rd and 4th Order Streams

Perennial 1st and 2nd order streams and perennial 3rd and 4th order streams in the Zuni Watershed have similar problems, information gaps, research, survey, and monitoring needs, desired future outcomes, and conservation actions. Thus, we present information on these two key habitat types collectively.

Habitat Condition

Perennial 1st and 2nd order stream habitats in the Zuni River system include the Rio Nutria, Tampico Draw, and Agua Remora. These tributaries are varied and flow through mountain meadows and narrow canyons where habitats are mainly bedrock-bottomed pools in canyon-bound reaches, and runs and cobbled riffles in meadows. Many of the 1st and 2nd order streams are spring fed and only permanently wet near the spring source. The main stem of the Zuni River (perennial 3rd and 4th order stream habitat) is intermittent, slow and meandering, and interrupted by several reservoirs (Propst and Hobbes 1996). Habitats are deep runs and pools over sand and silt substrates. Gradient decreases as the river flows through fluvial floodplain. Surface flow is generally continuous only during heavy spring run-off and near perennial springs. Small reservoirs such as Ramah, Black Rock, and McGaffey, once intended for water storage and recreational fishing opportunities, are often shallow and silty or completely dry, and impede the natural flow of water and species dispersal. Past grazing and logging excesses have caused surface erosion, gullying, headcutting, wide discharge fluctuations, and loss of water.

Damming for flood control, irrigation storage, and recreational fishing have inundated and fragmented Zuni bluehead sucker habitats and reduced the species to about 9 mi (15 km) or 10% of its historical range (see *Zuni Bluehead Sucker Recovery Plan* (NMDGF 2005b) for a summary). Populations of non-native aquatic vertebrates and invertebrates have become established in reservoirs and perennial 1st - 4th order streams of the Zuni Watershed.

Problems Affecting Habitats or Species

Modification of Natural Processes
The combination of drought, groundwater depletion, water withdrawal, and impoundments has resulted in the absence of perennial water necessary to sustain the functionality stream ecosystems of the Zuni Watershed. It is anticipated that increased urban/residential development and associated infrastructure (roads, utility corridors) may exacerbate this condition. Ash flows associated with wildfires have the potential to diminish or eliminate SGCN from portions of affected streams.

Invasive Species
Introduced largemouth bass (*Micropterus salmoides*), green sunfish, and crayfish occupy Zuni Watershed reservoirs and streams where they compete with and prey upon native species. They are responsible for the state-endangered status of the Zuni bluehead sucker.

Information Gaps

Numerous information gaps concerning perennial streams constrain our ability to make informed conservation decisions in the Zuni Watershed. They include:

- There is little information available on invertebrates of the Zuni Watershed.
- Little is known about water quality in the Zuni Watershed and its affects upon associated SGCN.
- The specific effects of fluctuating flows on the life history of all SGCN are unknown.
- The life history of most of the SGCN and their use of this habitat type are unknown.
- The extent to which non-native species may alter perennial stream habitats and limit populations of SGCN is unknown.
- The intensity, scale, and extent of different human-caused habitat degradation factors, and their effects on populations of SGCN are unknown.

Research, Survey, and Monitoring Needs

Ownership and management of perennial streams and the surrounding landscape in the Zuni Watershed are divided between private, federal, and tribal interests. These land managers have conservation efforts underway and plans to research, monitor, and rehabilitate areas of the watershed and conserve or restore associated wildlife. New Mexico Department of Game and Fish is actively involved in implementation of the *Zuni Bluehead Sucker Recovery Plan*, including establishment of an annual monitoring program and funding of genetic and morphometric research on the species. The Natural Resources Conservation Service (NRCS) has survey and monitoring programs in place and the New Mexico Environment Department

(NMED) recently completed a watershed survey of the Zuni River, including physiochemical water quality monitoring, invertebrate and fish surveys, and limited habitat assessments.

The Cibola National Forest, Mount Taylor Ranger District, manages much of the upper watershed where most of the perennial 1st and 2nd order stream habitat is located and has a variety of research and monitoring programs ongoing including monitoring of grazing conditions to ensure compliance with habitat requirements for Mexican spotted owl (*Strix occidentalis*). The Zuni Department of Natural Resources has ongoing and planned monitoring, survey, and research projects.

Additional research or survey initiatives needed to inform conservation decisions are outlined below. In conducting research it is important that tribal sovereignty is recognized. Tribes, agencies and institutions must collaborate to gather information needed to protect and conserve resources of mutual interest.

- Conduct thorough surveys of current and potential Zuni Bluehead sucker habitat to locate extant populations per the *Zuni Bluehead Sucker Recovery Plan*.

- Research is needed to develop a hydrological model and monitoring protocol for the Zuni Watershed per the *Zuni Bluehead Sucker Recovery Plan*.

- Field studies are recommended that focus on habitat use patterns of all SGCN that are perennial stream obligates.

- Research, surveys, and monitoring programs are needed for invertebrate SGCN. Little is currently known about the extent of their distribution, biology, or stability and microhabitats.

- Research is needed to characterize population dynamics and species interactions in these key habitats.

Desired Future Outcomes

Mutually held and complementary expectations have been expressed in the collaboratively developed *Zuni Bluehead Sucker Recovery Plan* and the *Zuni River Watershed Plan* (Natural Resource Conservation Service 1998, NMDGF 2005b). The plans have indicated the following desired future outcomes for perennial streams:

- Perennial 1st - 4th order stream habitats in the Zuni Watershed persist in the condition, connectivity, and quantity necessary to sustain viable and resilient populations of resident SGCN, facilitate uninterrupted movement patterns of native aquatic and terrestrial SGCN, and host a variety of land management uses with reduced resource use conflicts.

- Secure, self-sustaining sub-populations of Zuni bluehead sucker are distributed throughout their historic range in the Zuni Watershed.

- Land and resource management initiatives are coordinated among jurisdictional entities in the Zuni Watershed and are resulting in complementary and effective conservation actions.

- Healthy watershed conditions have been restored and natural stream recovery is progressing.

- Native riparian plant communities of the Zuni Watershed are restored and maintained.

- Non-native species that adversely affect SGCN have been removed from key stream habitats.

Prioritized Conservation Actions

Conservation actions necessary to secure the perennial headwater habitat and species of the Zuni River are largely outlined in the *Zuni River Watershed Plan* and *Zuni Bluehead Sucker Recovery Plan* (Natural Resource Conservation Service 1998, NMDGF 2005b). The implementation of these plans is foremost for conservation of the habitat and species of the Zuni Watershed. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Establish better communication, coordination, and collaboration between state, federal, private, and tribes to jointly protect and conserve Zuni Watershed habitats and wildlife of mutual interest.

2. Increase habitat protection through government, NGO, and landowner cooperation and partnerships.

3. Implement a Zuni Bluehead Sucker Conservation Agreement with interested parties to formalize partnerships and coordinate implementation of the *Zuni Bluehead Sucker Recovery Plan* (NMDGF 2005b) across jurisdictional boundaries.

4. Work with state and federal land managers and research institutions to investigate the current status of the Zuni bluehead sucker and identify factors limiting its populations.

5. Work with land managers and affected interests to remove non-native aquatic species from key watershed habitats and to restore SGCN and other native species to the Zuni Watershed.

6. Organize a management oversight group to collaboratively implement the *Zuni River Watershed Plan* (Natural Resource Conservation Service 1998).

7. Work with federal and state agencies, Zuni Pueblo, private landowners, research institutions, and universities to design and implement projects that will provide information about SGCN and perennial 1^{st} - 4^{th} order stream habitats outlined in the Information Gaps and/or Research, Survey, and Monitoring Needs sections. Studies on watershed modeling and hydrologic rehabilitation are especially desirable.

8. Collaborate with federal and state agencies, the Zuni Pueblo, NGOs, and affected publics to create an awareness and understanding of watershed functions, services, and values afforded by perennial 1^{st} - 4^{th} order stream habitats.

9. Construct a hydrological model and monitoring protocol to rehabilitate the Zuni Watershed per the *Zuni Bluehead Sucker Recovery Plan*.

ADDITIONAL SPECIES OF GREATEST CONSERVATION NEED

As noted in the Approach chapter, association with key habitats was employed to identify Species of Greatest Conservation Need (SGCN). However, there were eight additional species of birds, mammals, amphibians and molluscs that lack an association with key habitats. These species have been designated as SGCN for reasons noted below. Although limited information precluded our use of the habitat association criterion for the arthropod taxonomic group, we have identified 154 of them as SGCN.

Bird, Mammal, Amphibian, and Mollusc SGCN

The tenuous status and limited New Mexico distribution and abundance of these eight indicative species (Table 5-19) warrant their designation as SGCN. We have therefore included them as SGCN and provide the requisite information on their distribution and abundance, identify relevant problems, information gaps, research, survey, and monitoring needs, desired outcomes, and conservation actions.

Table 5-19. Additional bird, mammal, amphibian, and mollusc SGCN in New Mexico.

Taxa Group	Common Name	State Status
Bird	Boreal Owl	Threatened
Mammal	Organ Mountains Colorado Chipmunk	Threatened
Mammal	Oscura Mountains Colorado Chipmunk	Threatened
Amphibian	Eastern Barking Frog	Not listed
Mollusc	Hacheta Grande Woodlandsnail	Threatened
Mollusc	Lilljeborg's Peaclam	Threatened
Mollusc	Peloncillo Mountains Talussnail	Species of Concern
Mollusc	Sangre de Cristo Peaclam	Threatened

Boreal Owl

Distribution and Abundance

Boreal owls (*Aegolius funereus*) occur in the boreal forests of both the Old and New Worlds. In Alaska and Canada, boreal owls inhabit forests of spruce (*Picea* spp.), aspen (*Populus tremuloides*), birch (*Betula* spp.), and balsam-fir (*Abies balsamea*). In the Rocky Mountains, they are found in forests of sub-alpine fir (*Abies* spp.) and Englemann spruce (*Picea englemanni*). In Colorado, boreal owls are found at 9,200 – 10,500 ft (2,800-3,200 m), with highest densities above 9,850 ft (3000 m), where mature spruce-fir forests are interspersed with sub-alpine meadows (Palmer 1986). SWReGAP associates boreal owls with Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland, Rocky Mountain Sub-alpine Dry-Mesic Spruce-Fir Forest and Woodland, and Rocky Mountain Sub-alpine Mesic Spruce-fir Forest and Woodland.

The species reaches its southernmost limits in the mountains of northern New Mexico, where it was first detected in 1987 (Stahlecker and Rawinski 1990). Here the boreal owl has been documented as resident at 10 specific sites in eight general locales in the San Juan, Sangre de Cristo, and Jemez mountains. All were found on public lands in the Carson and Santa Fe National Forests located in Rio Arriba, Taos, Santa Fe, Mora, and San Miguel counties (Stahlecker and Duncan 1996, NMDGF 2004a). The average elevation where boreal owls are found in New Mexico is 10,345 ft (3,154 m), with only one locale below 10,000 ft (3,000 m).

The species is an obligate cavity nester, typically selecting old woodpecker holes in large trees, although natural cavities are also used. In the northern Rocky Mountains, nest sites are largely restricted to the older, multi-layered forest stands preferred by this owl. The diet of boreal owls is predominantly small mammals. Preferred foraging habitats are mature or older spruce-fir stands where prey populations are highest and an open lower story facilitates hunting. For roosting, this owl selects dense conifer stands with high canopy cover and high tree density (Hayward and Hayward 1993).

Abundance data are meager for boreal owls in New Mexico where numbers are believed to be small. Surveys conducted from 1987 through 1993 located only 23 individuals in the three northern mountain ranges and none in similar habitats farther south (Stahlecker and Duncan 1996). Conservation status codes (abundance estimates) for boreal owls are provided in Appendix H.

Problems Affecting Habitats or Species

Timber Harvest
New Mexico's small and highly fragmented boreal owl populations are vulnerable and would be adversely affected by losses to their specialized and limited sub-alpine habitats. In particular, timber harvest in such areas would eliminate nesting cavities, reduce prey populations, and remove forest structure necessary for nesting, foraging and roosting. The slowness of forest succession in high elevation stands suggests that disturbed habitats would remain unsuitable for one to two centuries (Hayward and Hayward 1993, Hayward and Verner 1994, Hayward 1997, NMDGF 2004a). Once lost, New Mexico's small, isolated populations are unlikely to be quickly replenished by birds dispersing down from the north.

Information Gaps

Information gaps that limit our ability to make informed conservation decisions regarding the boreal owl are outlined below.

- Abundance, distribution and trend data are absent or sparse for boreal owls in New Mexico.

- The location, timing, duration, frequency and intensity of factors influencing boreal owl habitats are unknown.

Research, Survey, and Monitoring Needs

Research and surveys that would enhance our ability to make informed conservation decisions are outlined below.

- Research is needed to estimate boreal owl demographic parameters.
- The effects of natural and human-caused habitat fragmentation on boreal owls need to be determined.

Desired Future Outcomes

Desired future outcomes for boreal owls and their habitats include:

- Boreal owl habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.
- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Prioritized conservation of the boreal owl in New Mexico depends on protection of high-elevation stands of mature spruce-fir forests in the San Juan, Sangre de Cristo, and Jemez Mountains. Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with the US Forest Service and affected publics to develop strategies for the protection of suitable boreal owl habitat. Actions should include the identification and setting aside areas of known occupancy.
2. Collaborate with state and federal agencies and private landowners to develop timber management practices that focus on maintaining the distribution and abundance of suitable boreal owl habitats in their natural states.
3. Work with the US Forest Service, timber companies, and affected publics to reduce and eliminate even-aged timber management on a broad scale in suitable boreal owl habitat.
4. Work with government and private land managers to eliminate or reduce forest management practices that are based simply on snag retention in clear cut areas, as the slowness of forest succession in high-elevation stands limits the utility of this management practice (Hayward and Hayward 1993, Hayward *et al.* 1993, Hayward and Verner 1994, Hayward 1997).

5. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about boreal owls, their habitats, and limiting factors as outlined in the Research, Survey, and Monitoring Needs section.

Organ Mountains Colorado Chipmunk

Distribution and Abundance

The Organ Mountains Colorado chipmunk (*Neotamias quadrivittatus australis*) is confined to the Organ Mountains in Doña Ana County where it occurs on both the east and west slopes of the range. White Sands Missile Range, Fort Bliss Military Reservation, and the US Bureau of Land Management administer portions of the mountain range (Sullivan 1998). The distribution of this chipmunk is generally centered in the Aguirre Springs basin. This is an area bounded by Baylor, Baldy, and Sugarloaf peaks (Patterson 1979, 1980). All of its known range is included in a 4,480 ac (1,813 ha) area (Sullivan 1998).

This chipmunk is most abundant in the broad, dissected basin around Aguirre Springs on the north aspect of the Organ Mountains. They are associated with ponderosa pine (*Pinus ponderosa*) and deciduous oaks (*Quercu*s spp.) (Patterson 1979, 1980). However, they also occur locally in adjacent areas characterized by dominant stands of oak (*Quercus* spp.), juniper (*Juniperus* spp.), apache plume (*Fallugia paradoxa*) and sumac (*Rhus* spp.). More than 69 species of plants, most commonly mountain mahogany (*Cerocarpus montanus*), gray oak (*Q. grisea*), wavyleaf oak (*Q. undulata*), and unidentified oaks (*Quercus* sp.) are associated with the presence of this chipmunk (R. Sullivan, pers. comm.).

The chipmunk occupies the Upper Sonoran Zone or the oak-mountain mahogany community (R. Sullivan, pers. comm.) of the Organ Mountains. Specimens have been collected from 6,050-7,300 ft (1,845-2,225 m) (Patterson 1980). SWReGAP land cover types identified for this subspecies include Rocky Mountain Cliff and Canyon (S006), Inter-mountain Basins Cliff and Canyon Complex (S009), Rocky Mountain Piñon-Juniper Woodland (S038), and Mogollon Chaparral (S057).

There are no recent data on the abundance of this chipmunk. Patterson (1980) estimated that the Organ Mountains Colorado chipmunk numbered 1,000 to 2,000 individuals. Populations may be subject to wide fluctuations and the species is not abundant (Patterson 1979). Conservation status codes (abundance estimates) for the Organ Mountains Colorado chipmunk are provided in Appendix H.

Problems Affecting Habitats or Species

Habitat Conversion
Public access to the Organ Mountains is limited due to an absence of roads, although road development and facility construction associated with White Sands Missile Range (WSMR) on the east side of the mountains could cause habitat degradation and fragmentation. Particularly

susceptible components of chipmunk habitat include: 1) areas of mesic piñon-juniper-oak woodland in limestone or igneous rock outcrops or cliff habitats along north and east-facing escarpments, 2) old-growth piñon-juniper woodland associated with calcareous or igneous bedrock, red-granites or rhyolitic talus with interstices of igneous talus filled with soil and leaf litter, 3) ecotones between woodland, arroyo, and scrub vegetation in drainages and talus accumulations, and 4) slopes and bajadas with extensive, large boulders, fallen yucca stems, and woody bases of sotol (*Dasylirion wheeleri*) (R. Sullivan, pers. comm.).

Fire Management
Fire may provide both a benefit and a detriment to this mammal. Prescribed fire in woodland habitats may serve to increase primary productivity and reduce the risk of catastrophic wildfire in the future (Rivieccio *et al.* 2003). Alternatively, catastrophic fires or full fire suppression may have adverse effects on habitats through fragmenting, simplifying or destroying habitats, or greatly modifying disturbance regimes.

Information Gaps

There is little information on the ecology of this species. Accordingly, information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution of this species is poorly understood.

- The abundance and habitat use of this species is unclear.

- Environmental conditions that limit chipmunk populations are unknown.

- The intensity, scale, and extent of man-caused habitat fragmentation are unknown.

Research, Survey, and Monitoring Needs

Rivieccio (2000) and Rivieccio *et al.* (2003) developed survey methodologies involving GIS modeling and observational field surveys of this population. Visual/audible surveys may prove to be more effective than trapping surveys (Rivieccio *et al.* 2003). Research and surveys that would enhance our ability to make informed conservation decisions for this species are outlined below.

- Additional distribution and biological surveys should continue to document the population size, habitat requirements, and distribution of Organ Mountains Colorado chipmunk. Future surveys and development of a species management plan should be a multi-agency effort.

- Habitats considered essential for these chipmunks should be surveyed and evaluated prior to activities that may potentially fragment or disturb them.

- Monitoring of environmental factors associated with construction and testing activities and should include a component of environmental/habitat restoration as needed to assure functional ecosystems in the Organ Mountains.

- A formalized survey and monitoring methodology needs to be developed, possibly incorporating aspects of GIS habitat data and observational and/or trapping surveys. This effort should include coordination between NMDGF, US Bureau of Land Management, Fort Bliss Military Reservation, WSMR, and other entities with land management responsibilities in the Organ Mountains.

Desired Future Outcomes

Desired future outcomes for the Organ Mountains Colorado chipmunk and their habitats include:

- Organ Mountains Colorado chipmunk habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.

- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with WSMR and Fort Bliss Military Reservation to develop and implement a survey protocol for systematically detecting Organ Mountains Colorado chipmunk and tracking its population trends.

2. Work with WSMR and Fort Bliss Military Reservation to develop and implement a habitat assessment and monitoring plan to determine changes in chipmunk habitat in the Organ Mountains.

3. Develop a cooperative agreement among entities with resource management responsibilities in the Organ Mountains to ensure that important habitat for this species is identified and maintained.

4. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information about the Organ Mountains Colorado chipmunk, its habitats and limiting factors as outlined in the Research, Survey, and Monitoring Needs section.

Oscura Mountains Colorado Chipmunk

Distribution and Abundance

The Oscura Mountains Colorado chipmunk (*Neotamias quadrivittatus oscuraensis*) is known only from the Oscura Mountains in Socorro and Lincoln counties. The chipmunk has been found from approximately 0.6 mi (1 km) north of North Oscura Peak to 3.7 mi (6 km) south of Oscura Peak (Sullivan 1996). The entire Oscura Mountains and its surrounding area are contained within WSMR. No information on abundance is available for this sub-species (Sullivan 1998). Conservation status codes (abundance estimates) for the Oscura Mountains Colorado chipmunk are provided in Appendix H.

The Oscura Mountains, located at the northern edge of the Tularosa Basin, are arid and characterized by steep and broken mountainous terrain with large outcrops of limestone, particularly along the west-facing escarpment. Areas of dense stands of mature piñon-juniper are present and interspersed with poorly vegetated areas of limestone bedrock (Sullivan 1996). Dominant trees are piñon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*). Characteristic shrub species include mountain mahogany (*Cerocarpus montanus*), antelope brush (*Purshia tridentata*), four-wing salt bush (*Atriplex canescens*), and oaks (*Quercus* sp.). Open areas are variously covered with side-oats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), blue grama (*B. gracilis*), Chihuahuan love-grass (*Eragrostis erosa*), and soaptree yucca (*Yucca elata*) (Sullivan 1996).

Chipmunks in the Oscura Mountains have been observed on steep, northwest-facing slopes where extensive limestone cliffs and ledges are present. Most have been found within 20 ft (6 m) of mixed stands of piñon, one-seed juniper, and Gambel oak (*Quercus gambelii*). Accumulations of leaf litter are usually present. Other woody plants in these areas are barberry (*Berberis* spp.), mountain mahogany, beargrass (*Nolina* spp.), mockorange (*Philadelphus* spp.), currants (*Ribes* spp.), rose (*Rosa* spp.), and snowberry (*Symphoricarpos* spp.) (Sullivan 1996). SWReGAP land cover types associated with this subspecies include: Rocky Mountain Cliff and Canyon (S006), Inter-mountain Basins Cliff and Canyon Complex (S009), Rocky Mountain Piñon-Juniper Woodland (S038), and Mogollon Chaparral (S057).

Problems Affecting Habitats or Species

Habitat Conversion
As noted above, the geographic range of this subspecies is entirely contained within WSMR and is not accessible to the public. Road development and facility construction associated with the mission of WSMR poses the greatest potential threat to this species and could cause habitat degradation and fragmentation. Isolation of these patchy habitats may exceed distance thresholds beyond which these chipmunks are capable of searching for seasonally available foods and increase their vulnerability to starvation, exposure, and predation (Sullivan 1996). Species characterized in patchy distributions or those that use a variety of microhabitats are vulnerable to extinction in fragmented landscapes.

Fire Management
Fire may provide both a benefit and a detriment to this mammal. Prescribed fire in woodland habitats may serve to increase primary productivity and reduce the risk of catastrophic wildfire in the future (Rivieccio *et al.* 2003). Conversely, catastrophic fires or full fire suppression may have adverse effects on habitats through fragmenting, simplifying or destroying habitats, or greatly modifying disturbance regimes.

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution of this species is poorly understood.
- The abundance and habitat use of this species are unclear.
- Environmental conditions that limit chipmunk populations are unknown.
- The intensity, scale, and extent of man-caused habitat fragmentation are unknown.

Research, Survey, and Monitoring Needs

Rivieccio (2000) and Rivieccio *et al.* (2003) developed survey methodologies involving GIS modeling and observational field surveys of this population. Visual and audible surveys may prove to be more effective than trapping surveys (Rivieccio *et al.* 2003). Research and surveys that would enhance our ability to make informed conservation decisions for this species are outlined below.

- Additional distribution and biological surveys should continue in order to document population size, habitat requirements, and distribution of the Oscura Mountains Colorado chipmunk. Future surveys and development of a species management plan will be a multi-agency effort.
- Habitats considered essential for these chipmunks should be surveyed and evaluated prior to activities that potentially further fragment or disturb them.
- Monitoring of environmental factors associated with construction and testing activities and should include a component of environmental/habitat restoration as needed to assure functional ecosystems in the Oscura Mountains.
- A formalized survey and monitoring methodology, possibly incorporating aspects of GIS habitat data and observational and/or trapping surveys, needs to be developed. This effort should include coordination between NMDGF and WSMR.

Desired Future Outcomes

Desired future outcomes for the Oscura Mountains Colorado chipmunk and its habitat includes:

- Habitat persists in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.

- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with WSMR to develop and implement a survey protocol for systematically detecting this chipmunk that will allow comparison among survey periods to determine population trends.

2. Work with WSMR to develop and implement a habitat assessment and monitoring plan to determine changes in chipmunk habitat in the Oscura Mountains.

3. Develop a cooperative agreement between NMDGF and WSMR to ensure that important habitat for this species is identified and maintained.

4. Work with WSMR to preserve habitat patches in their natural states where this recently described subspecies occurs. If habitat modifications are inevitable in the Oscura Mountains, Sullivan (1996) has suggested two approaches: 1) restrict future development to previously disturbed sites, or 2) restrict development in the mature piñon-juniper woodlands east of the escarpment. This would have fewer impacts than altering the piñon-juniper-oak woodlands and limestone ledges essential to this chipmunk.

5. Work with WSMR, research institutions, and universities to design and implement projects that will provide information about the Oscura Mountains Colorado chipmunk, its habitats, and limiting factors as outlined in the Research, Survey, and Monitoring Needs section.

Eastern Barking Frog

Distribution and Abundance

In New Mexico, the eastern barking frog (*Eleutherodactylus augusti latrans*) occurs only at scattered localities in specific habitats in Chaves, Eddy, and Otero counties. They are found from 2,950-3,950 ft (900-1,200 m) in elevation. Suitable habitats include barren creosote bush (*Larrea tridentata*) flats with numerous and extensive rodent burrows on gypsum soils in and near limestone and gypsum outcrops. SWReGAP land cover types associated with the barking frog include the Chihuahuan Mixed Desert and Thorn Scrub.

The species is uncommon within its limited range in New Mexico. During a 5-year intensive study of barking frogs, only 33 individuals were observed at Bitter Lakes Wildlife Refuge where a "dense population" is known to exist (Radke 2001). At other sites known to harbor populations of barking frogs, it is unusual to locate more than 2-3 frogs per night during optimal weather conditions (C.W. Painter, pers. observ.). Abundance is therefore difficult to determine. The recent specimen reported from near Aguirre Springs (Murray and Painter 2003) represents a disjunct and questionable record. Conservation status codes (abundance estimates) for the barking frog are provided in Appendix H.

Problems Affecting Habitats or Species

Habitat Conversion
Factors that adversely affect barking frogs include herbicide control of creosote bush, shrub land conversion to agriculture, and soft-rock mining. Little is known about the intensity, scale, and extent of the effects on barking frog populations.

Collecting
Commercial exploitation is also a concern for the barking frog. Little is known about the extent of this market or its effects on barking frog populations.

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- Information is lacking on population density, distribution, abundance, habitat use, activity periods, and reproduction.

- The natural history of this species in New Mexico is little known.

- Little is known about the intensity, scale, and extent of the effects of chemical creosote bush control on barking frog populations, shrub land conversion to agriculture, soft-rock mining, or commercial exploitation.

Research, Survey, and Monitoring Needs

Currently there are isolated reports and anecdotal observations on the natural history of eastern barking frogs in New Mexico. Research and surveys that would enhance our ability to make informed conservation decisions for this species are outlined below.

- Research is needed to determine the distribution, abundance, and habitat use of eastern barking frogs.
- Research or survey work is needed to determine the extent and effects of commercial exploitation.
- Research is needed to identify and evaluate factors limiting eastern barking frog populations.
- Research is needed to quantify the intensity, scale, extent, and effects of man-caused habitat conversion on eastern barking frog populations.

Desired Future Outcomes

Desired future outcomes for the eastern barking frog and its habitats include:

- Eastern barking frog habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.
- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on eastern barking frog distribution and habitat use in New Mexico.
2. Work with federal and state agencies and affected publics to protect limestone and gypsum outcroppings within the range of the species.

3. Work with federal and state agencies and affected publics to develop strategies to reduce or eliminate incidental take of the species.

4. Collaborate with interested agencies and publics to develop a research and monitoring plan for this species.

Hacheta Grande Woodlandsnail

Distribution and Abundance

The endemic Hacheta Grande woodlandsnail (*Ashmunella hebardi*) is narrowly restricted to the south wall of Chaney Canyon on the west-central flank of the Big Hatchet Mountains. The canyon is west of Big Hatchet Peak in Hidalgo County (Metcalf and Smartt 1997, Lang 2005a). They are found at elevations of 6,600-7,300 ft (2,000-2,200 m). The Hacheta Grande woodlandsnail occupies densely forested habitats at the base of limestone outcrops, living beneath large rock fragments and in rubble piles where soil mold collects (Lang 2005a). No information is available regarding the abundance of this species. Conservation status codes (abundance estimates) for the Hacheta Grande woodlandsnail are provided in Appendix H.

Problems Affecting Habitats or Species

Biotic/Abiotic Resource Use
Any form of soil disturbance (mineral mining) or vegetative removal (logging, fire, or grazing) in areas where this species is known to occur could result in adverse affects upon edaphic conditions and cause direct habitat loss.

Fire Management
The prospects of a 2005 prescribed burn in the north-central range of the Big Hatchet Mountains could adversely affect the persistence of this woodlandsnail in Chaney Canyon.

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution and abundance of this species is poorly understood.

- The short and long-term effects of fire on forest ecosystem dynamics are poorly understood, especially with respect to mollusc recovery periods (Lang 2005a).

Research, Survey, and Monitoring Needs

Distribution surveys for this species have been conducted from the early 1970s to 2004 (Metcalf and Smartt 1997, Lang 2001, 2005a). Based on morphologic and genetic studies, Lang (2005a) recommended that the currently accepted taxonomy of *Ashmunellas* in the Big Hatchet

Mountains (Metcalf and Smartt 1997) recognize two species, *A. mearnsii* and *A. hebardi*, and their hybrids (*A. mearnsii* x *A. hebardi*).

The Department has worked closely with the BLM Las Cruces Field Resources Office to consider alternative prescribed fire strategies to prevent the burning of forested habitat. This habitat is currently occupied by Hacheta Grande woodlandsnail, and five additional species of land snails endemic to the Big Hatchet Mountains and outlying ranges. Pre and post-fire studies are ongoing. Additional research and survey work that would enhance our ability to make informed conservation decisions are outlined below.

- Investigate alternative prescribed fire strategies to prevent burning of forested habitat currently occupied by woodlandsnail populations.

- Research is needed to further define habitat use, abundance, and distribution of woodlandsnails.

- Investigate environmental conditions that limit woodlandsnail populations.

- Research the effects of man-caused habitat alteration and degradation factors on woodlandsnails.

Desired Future Outcomes

Desired future outcomes for the woodlandsnail and its habitats include:

- Woodlandsnail habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.

- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

This species is listed as state threatened (NMDGF 2004a) and as a federal species of concern (Federal Register 1994). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with state and federal agencies charged with protection of Hacheta Grande woodlandsnail to develop a plan to conserve this species.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on the woodlandsnail and its habitat that is outlined in the Problems Affecting Species and Habitats, and Research, Survey, and Monitoring Needs sections.

3. Work with federal land managers to adopt and implement fire management strategies that avoid destruction of woodlandsnail habitats.

Lilljeborg's Peaclam

Distribution and Abundance

This circum-boreal species occurs in lakes and rivers from the Arctic south across the northern United States (Herrington 1962, Burch 1975). In the western United States, Lilljeborg's peaclam (*Pisidium lilljeborgi*) is found in high-elevation lakes of California (Trinity Alps), Utah (Uinta Mountains), and New Mexico (Sangre de Cristo Mountains) (Taylor 1983). In New Mexico, Lilljeborg's peaclam is known only from Nambe Lake, a remote glacial cirque located in the Santa Fe National Forest. Nambe Lake has been modified to serve as a water supply for the city of Santa Fe. This population represents the most southern and highest known elevation occurrence in either North America or Eurasia (Taylor 1983, NMDGF 2004a). Lilljeborg's peaclam is not abundant in New Mexico where it is listed as a state threatened species (NMDGF 2004a). Conservation status codes (abundance estimates) for the Lilljeborg's peaclam are provided in Appendix H.

Problems Affecting Habitats or Species

Pollution and Modification of Natural Processes
Due to its restricted distribution, the Nambe Lake population of Lilljeborg's peaclam is vulnerable to contaminants from fire suppressant chemicals and natural stochastic events such as fire, sedimentation, and drought (Taylor 1983, NMDGF 2004a, McDonald and Hamilton 1995).

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution and abundance of this species is poorly understood.

- Environmental conditions that limit the species populations are unknown.

- The intensity, scale, and extent of man-caused habitat degradation are unknown.

Research, Survey, and Monitoring Needs

Research, survey, and monitoring needs that would enhance our ability to make informed conservation decisions are outlined below.

- The Department should continue surveys of high-elevation aquatic habitats to determine the statewide distribution and abundance of this species.
- Investigate environmental conditions that limit Lilljeborg's peaclam populations.
- Research is needed on the effects of human-caused habitat alteration and degradation factors.

Desired Future Outcomes

Desired future outcomes for Lilljeborg's peaclam and its habitat includes:

- Lilljeborg's peaclam habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.
- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on the statewide distribution and abundance for this species, including information regarding basic biology and habitat requirements.
2. Work with interested agencies and publics to develop a conservation and recovery plan for the Lilljegborg's peaclam.

Peloncillo Mountains Talussnail

Distribution and Abundance

Pilsbry and Ferris (1915) described the Peloncillo Mountains talussnail (*S. h. peloncillensis*) from a single collection in Skull Canyon, Peloncillo Mountains, in Hidalgo County. It occurred in igneous talus sprawls at higher elevations. A single living specimen and several fresh shells of this talussnail were collected from Skull Canyon in March 2004 (Lang 2005a). This talussnail is considered a species of concern by the NMDGF (NMDGF 2005c) and in a habitat conservation plan for the Peloncillo Mountains of New Mexico and Texas (Lehman 2003). This species is included on the Interagency Interstate Sensitive Species List adopted by the US Bureau of Land Management, US Fish and Wildlife Service, US Forest Service, NMDGF, and Arizona Game and Fish. Little is known of its abundance. Conservation status codes (abundance estimates) for the Peloncillo Mountains talussnail are provided in Appendix H.

Problems Affecting Habitats or Species

Biotic/Abiotic Resource Use
Any form of soil disturbance (mineral mining) or vegetative removal (logging, fire, or grazing) in areas where this species is known to occur could result in adverse effects upon edaphic conditions and cause direct habitat loss.

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution and abundance of this species is poorly understood.
- Factors that limit species populations are unknown.
- The intensity, scale, and extent of man-caused habitat degradation are unknown.

Research, Survey, and Monitoring Needs

Research and survey work that would enhance our ability to make informed conservation decisions regarding this species are outlined below.

- Surveys should be conducted in the Peloncillo and Guadalupe Mountains of New Mexico to further define the abundance, habitat use, and distribution of the Peloncillo Mountains talussnails.
- Research is needed on the effects of man-caused habitat alteration and degradation factors.

Desired Future Outcomes

Desired future outcomes for the Peloncillo Mountains talussnail and its habitats include:

- Peloncillo Mountains talussnail habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.

- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on the statewide distribution and abundance for this species, including information regarding basic biology and habitat requirements.

2. Work with interested agencies and publics to develop a conservation plan for the Peloncillo Mountains talussnail.

<u>Sangre de Cristo Peaclam</u>

Distribution and Abundance

The narrowly distributed Sangre de Cristo peaclam (*Pisidium sanguinichristi*) is endemic to Middle Fork Lake. This lake is found in a single, high-elevation glacial cirque at 10,485 ft (3,195 m.) elevation at the base of Wheeler Peak, Taos County. The peaclam colonizes muddy shallows along the lake perimeter and a narrow stretch of the lake outflow (Taylor 1983, 1987; NMDGF 2004a). This peaclam can be considered the most narrowly restricted of all known North American, and perhaps worldwide, Pisidia (Lang 2002). Little is known of its abundance and it is listed as a state threatened species (NMDGF 2004a) and a federal species of concern (Federal Register 1994). Conservation status codes (abundance estimates) for the Sangre de Cristo peaclam are provided in Appendix H.

Problems Affecting Habitats or Species

Recreational Use
The remoteness and management of Middle Fork Lake within the Carson National Forest affords some measure of protection. However, this site experiences intense periods of recreational use (USFS 1996). Associated problems include shoreline destabilization, erosion, and sedimentation due to foot and vehicular traffic (Taylor 1983, NMDGF 2004a, McDonald and Hamilton 1995, USFS 1996).

Pollution and Modification of Natural Processes
Middle Fork Lake receives contamination from forest fire suppressants, placer mining runoff, and natural stochastic events such as fire, drought (Taylor 1983, NMDGF 2004a, McDonald and Hamilton 1995, USFS 1996).

Non-Native/Invasive Species
In the western United States, passive dispersal of non-native molluscs commonly occurs by human activities, such as contaminated fishing equipment, aquatic sampling gear, and aquatic shipments (Western Regional Panel on Aquatic Nuisance Species 2001).

In 2004, the non-native New Zealand mudsnail (*Potamopyrgus antipodarum*) was reported from a stream in the Rocky Mountains of Colorado. Potential adverse effects posed by non-native molluscs may include direct or indirect competition with native species for food and space, alteration of species composition and structure of primary producers, and disruption of energy transfer from macroinvertebrates to fish (Shannon *et al.* 2004). Aquatic conditions of Middle Fork Lake could possibly support an introduced population of the New Zealand mudsnail. This potential is particularly germane considering recreational use of Middle Fork Lake.

Information Gaps

There is little information on the ecology of this species. Information gaps that limit our ability to make informed conservation decisions are outlined below.

- The distribution and abundance of this species is poorly understood.
- Environmental conditions that limit species populations are unknown.
- The intensity, scale, and extent of man-caused habitat degradation are unknown.

Research, Survey, and Monitoring Needs

Annual population monitoring of Sangre de Cristo peaclam began in July 1995 under a multi-agency conservation effort initiated by the US Forest Service (US Forest Service 1996). Only six specimens collected from Middle Fork Lake (1995-1999) remotely resembled paratype (*P. sanguinchristi*) specimens (Lang 1996). No *Pisidia* collected from any other statewide surveys (1995-2005) are referable to Sangre de Cristo peaclam. A mitochondrial DNA study comparing the nominal species with Held's peaclam (*Pisidium milium*) yielded inconclusive results since the biochemical analysis was restricted to a comparison of DNA extracted from shell proteins (Wilson *et al.* 1998). Although a study comparing shell characteristics of these species may help resolve outstanding taxonomic questions, significant ecophenotypic variation in valve morphology and hinge dentition of sphaeriid clams, as manifested by local environmental influences, could prove inconclusive (Herrington 1962). Additional research, survey, and monitoring needs that would enhance our understanding of this species and inform conservation decisions are outlined below.

- Conduct a taxonomic assessment of Sangre de Cristo peaclam to confirm this as a valid species. The taxonomic status of this species merits further study prior to adopting a conservation strategy (Lang 2004).

- Additional surveys should be conducted in New Mexico to further define the abundance, habitat use, and distribution of Sangre de Cristo peaclam.

- Research is needed on the effects upon Sangre de Cristo peaclam of man-caused habitat alteration and degradation factors.

Desired Future Outcomes

Desired future outcomes for the Sangre de Cristo peaclam and its habitats include:

- Sangre de Cristo peaclam habitats persist in the condition, connectivity, and quantity necessary to maintain viable and resilient populations of this species while sustaining diverse land uses with minimal resource use conflicts.

- Abundance, distribution, and population trend information and understanding of limiting factors are sufficient to make informed conservation decisions for this species.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with interested agencies and effected publics to continue sphaeriid clam surveys in high-elevation, wetland habitats throughout the Sangre de Cristo Mountains. Expand this effort to include the Jemez Mountains. In the event live peaclams referable to *P. sanguinichrisiti* are located, genetic studies comparing *P. sanguinichristi* with *P. milium* would be in order.

2. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on the statewide distribution and abundance for this species. These studies should gather information regarding basic biology and habitat requirements.

Arthropod (Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha) SGCN

An extensive inventory of New Mexico arthropods (other than crustaceans) has not been completed and our current list of arthropod SGCN (Appendix H) is biased toward those taxonomic groups for which we have some information. We anticipate future discoveries of undescribed arthropod taxa in New Mexico. We also anticipate new geographic distribution and ecological information for those already described arthropods. We therefore present only summary information about the 154 arthropod SGCN in the classes of Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha.

Distribution and Abundance

Little is known about arthropod distribution and abundance in New Mexico. Federal and state conservation status ranks are only known for about half of the arthropod SGCN. Of those, 85% of the species are not ranked in New Mexico, and 25% of the species are not federally ranked. Only four species are known to be critically imperiled at the state level, while 25 are known to be imperiled or critically imperiled at the national level. Conservation status codes (abundance estimates) for arthropod SGCN in the classes of Insecta, Arachnida, Chilopoda, Diplopoda, and Entognatha are provided in Appendix H.

Information on the distribution of arthropods in New Mexico is even more scant, and is limited to general observations about habitats or ecoregions. Habitats for arthropods in New Mexico appear to be quite diverse. They are known to inhabit desert grasslands and shrublands, mountain ranges, riparian habitats, rocky canyons, ponderosa pine and juniper savannas, gypsum sand dunes, caves, aquatic habitats, and sub-terrestrial habitats. The Chihuahuan Desert and the Arizona-New Mexico Mountains Ecoregions appear to host the majority of arthropod SGCN. However, there is uncertainly associated with the extent of these distributions (Appendix Q).

Problems Affecting Habitats or Species

Problems affecting the persistence of arthropod SGCN include improper grazing practices, forest and fire management, and over-collecting. However, the most prevalent threat to arthropods is the lack of good information on the problems that may affect species or their habitats (Appendix I). Many SGCN species are local endemics about which there is only little information regarding problems that may influence their habitats or populations.

Information Gaps

Information gaps that limit our ability to make informed conservation decisions regarding arthropods are outlined below.

- Arthropod species in New Mexico are relatively poorly known. We are aware of close to 50 undescribed arthropods, most of which are narrow endemics that have been recently discovered in New Mexico as a result of local biological inventory studies and collecting by taxonomic researchers.

- There is little information about arthropod abundance, distribution, or factors that limit or pose problems for species populations.

- Basic ecological data on arthropod species is lacking.

- The actual extent of undescribed arthropod taxa is unknown.

Research, Survey, and Monitoring Needs

Research and survey work that would inform conservation decisions applicable to arthropods are outlined below.

- An extensive inventory of arthropods is needed before NMDGF can address arthropod taxa with confidence.

- Basic research is needed to determine arthropod abundance, distribution, habitat requirements, and factors that limit or pose problems for species populations.

Prioritized Conservation Actions

Approaches for conserving New Mexico's biological diversity at the species or site-specific level are inadequate for long-term conservation of SGCN. Conservation strategies should be ecosystem-based and include public input and support (Galeano-Popp 1996). Monitoring of species and habitat will be employed to evaluate the effectiveness of the conservation actions described below. Those found to be ineffective will be modified in accordance with the principles of adaptive management. Conservation actions, in order of priority, which assist in achieving desired future outcomes, are outlined below.

1. Work with federal and state agencies, private landowners, research institutions, and universities to design and implement projects that will provide information on the statewide distribution and abundance of arthropod SGCN, including information regarding basic biology and habitat requirements that will inform future conservation decisions.

Chapter 6
MONITORING STATUS AND TRENDS

This chapter describes proposed strategic plans for monitoring Species of Greatest Conservation Need (SGCN), their habitats, and the effectiveness of proposed actions and for adapting actions to respond appropriately to new information or changing conditions (**Element 5**). It describes how New Mexico Department of Game and Fish (NMDGF) will collaborate with other entities to monitor the effectiveness of proposed conservation actions and lists the performance indicators that will likely be employed to facilitate evaluations leading to adaptive management. The narrative discusses the scales at which monitoring will be conducted, why selected umbrella or keystone species will be used as monitoring surrogates, and our intent to build upon existing monitoring and survey systems. Additional insights into how monitoring and adaptive management will be integrated into the Comprehensive Wildlife Conservation Strategy (CWCS) implementation, review, and revision phases are provided in Chapter 7.

WHY MONITORING IS IMPORTANT

The following discussion on the importance of monitoring is provided for CWCS readers to emphasize that a commitment to monitoring is necessary for effective wildlife and habitat management and conservation. This discussion is adapted primarily from Gibbs *et al.* (1999), unless otherwise noted.

In general (and in particular with regard to CWCS monitoring efforts), the ultimate goal of monitoring is to develop a scientifically defensible prediction of the status and trends of SGCN and their key habitats, to evaluate management practices and inform necessary modification. Successful monitoring programs provide the foundation for effective wildlife management and conservation. Monitoring establishes a method for evaluating the success of meeting desired management and conservation outcomes, detecting shifts in distribution or changes in habitat, and documenting regulatory compliance. Elzinga *et al*. (1998) defines monitoring as "…the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective…" which "…promotes a problem-oriented approach to monitoring and greatly enhances its rigor, effectiveness, and utility." Monitoring plays a key role in the adaptive management process by its ability to direct future management and potentially change objectives, based on the response of monitored resources to management actions or environmental changes (Holling 1978 and Ringold *et al.* 1996).

> The goal of monitoring is to develop a scientifically defensible prediction of the status and trends of SGCN and their key habitats, thereby informing a determination as to whether management practices are effective or in need of modification.

Monitoring is most effective if explicitly linked to well-defined management goals and objectives. To effectively conserve biological diversity, changes in wildlife and habitats must be evaluated, and appropriate management decisions must be made in response to those detected changes. Therefore, successful wildlife management and monitoring must be closely linked by defining specific objectives for evaluation at the site- or regional-level. Objectives should be measurable, realistic and easily repeatable and include the following components: 1) what is to be monitored; 2) the geographical area where the monitoring will occur; 3) precise identification of the specific metric(s) of the indicator(s) that will be measured; 4) the expected response of the indicators to management or change (to increase, decrease, or remain stable); 5) the magnitude of response or change expected; and (6) the time frame during which the response to management is expected to occur (Elzinga *et al.* 1998). NMDGF will develop project-specific monitoring objectives during the operational planning phase prior to CWCS implementation (See Chapter 7).

Before monitoring programs can perceive and evaluate changes in wildlife populations, baseline conditions must be determined. Field monitoring to detect changes in wildlife populations must have sufficient sampling effort to allow precise enough population or density estimates to have a reasonable chance to detect an important change (Thompson *et al.* 1998). Some of the inherent problems associated with designing and implementing an effective monitoring program include 1) the complexity and quantitative nature of monitoring multiple biological indicators across space and time; 2) determining the necessary sampling effort to adequately generate precise and reliable estimates of change of monitored resources; 3) complete baseline conditions may not be known (or may be unknowable) to allow comparison with perceived changes; 4) management objectives or goals may not be explicitly defined to allow accurate measurement of success, making it difficult to adaptively manage for future success; and 5) data collected must be comparable across monitored sites and time, analyzed correctly, archived effectively, and communicated appropriately to policy makers.

> NMDGF will develop project-specific monitoring objectives during the operational planning phase prior to CWCS implementation.

CURRENT MONITORING EFFORTS

Species Monitoring

NMDGF gathers information used for monitoring SGCN and key habitats through many approaches including:

- Surveys and inventories conducted by staff biologists;
- Surveys and inventories conducted by private biological contractors;
- Collaboration with federal land management and natural resource agencies such as the US Fish and Wildlife Service, US Forest Service, US Bureau of Land Management, US Bureau of Reclamation, US Geological Survey, and tribal entities;
- Collaboration with academic researchers through consultation, academic and graduate research programs, peer review of scientific publications, scientific collection permitting and reporting requirements;
- Collaboration with citizen science-led efforts such as annual Breeding Bird and Christmas Count Surveys;
- Systematic environmental review and assessment of 1) project proposals that may impact wildlife and habitats; and 2) biological information provided by project proponents; and
- Review of scientific peer-reviewed and gray literature publications.

All federally listed species and all but five state-listed bird species are SGCN. The five state-listed bird species that are not SGCN include: 1) whooping crane (natural occurrence of the species in New Mexico is unproven), 2) white-eared hummingbird (limited distribution in New Mexico and their conservation concerns covered by other species), 3) brown pelican (rare vagrant), 4) buff-collared nightjar (limited distribution in New Mexico, possibly extirpated), and 5) piping plover (very rare migrant to New Mexico). NMDGF monitoring efforts have been focused on state and federally listed species, as indicated by Tables 6-1. Current monitoring efforts for state and federally listed species are primarily systematic efforts, but also include information collected opportunistically. Systematic monitoring efforts generally involve repeated sampling at pre-determined intervals within specific areas. SGCN status and trend information is thereby acquired through annual or periodic surveys, inventories and research efforts conducted by NMDGF personnel, contractors, and other (primarily) federal natural resource and/or land management biologists (Table 6-1). Opportunistically acquired monitoring information tends to be provided through networks of citizen scientists that submit reports and observations to NMDGF taxonomic specialists. This information is usually documented with specimens, recordings and/or photographs for establishing presence/absence, range extension, mortality and habitat information.

Table 6-1. Current monitoring efforts for terrestrial and aquatic SGCN that identify ongoing status, population trend, presence/absence, reproduction, demographic and other monitoring efforts for state- and federally-listed species and other SGCN. This list does not identify all species with monitoring efforts, nor all monitoring efforts for each species.

Lead Agency/ Organization	Monitoring Efforts Underway	Cooperators	Time Frame
Terrestrial SGCN			
NMDGF	Jemez Mountain Salamander	USFWS, USFS, USGS	Annual
NMDGF	Sacramento Mountain Salamander	USFWS, USFS, USGS	Annual
NMDGF	Lowland Leopard Frog	USFWS, USFS	Annual
NMDGF	Chiricahua Leopard Frog	USFWS, USFS	Annual
NMDGF	Colorado River Toad	Private citizen	Annual
NMDGF	Boreal Toad	USFS	Periodic
NMDGF	Sand Dune Lizard	USFWS, BLM, Texas A&M, State Land Office, Natural Heritage New Mexico	Annual
NMDGF	River Cooter	Contractors (2005-2006 Share With Wildlife Project	Periodic
NMDGF	Plainbelly Water Snake	Contractors (2005-2006 Share With Wildlife Project	Periodic
NMDGF	NM Ridgenose Rattlesnake	USFS, Private landowners, University of Arizona	Annual
NMDGF	Gray-banded Kingsnake	NPS	Annual
NMDGF	Black Bear	Legal harvest quota system, Dept. research, pelt tag database for relocation efforts and mortalities	Annual
NMDGF	Mule Deer	Annual Dept. surveys, USFS, BLM	Annual
NMDGF	Rocky Mountain Bighorn Sheep	Frequent Dept. surveys, FNAWS, USFS	Annual
NMDGF	Desert Bighorn Sheep	Frequent Dept. surveys, FNAWS, USFS, BLM, Private landowners	Annual
NMDGF	Mexican Wolf	USFS, Wildlife Services, Arizona Game and Fish, Tribes	Annual
NMDGF	Mexican Long-nosed Bat	USGS, USFS, BLM, Private landowners	Periodic
NMDGF	Lesser Long-nosed Bat	USGS, USFS, BLM, Private landowners	Periodic
NMDGF	White-sided Jackrabbit	Private landowners	Periodic
NMDGF	Least Shrew	USFWS, State Forestry	2004-05
NMDGF	New Mexico Jumping Mouse	USFS, USFWS	2004-05
NMDGF	Arizona Montane Vole	USFS	2004-05
NMDGF	Oscura Mountains Colorado Chipmunk	White Sands Missile Range	Developing
NMDGF	American Pine Marten	USFS	Periodic
NMDGF	Swift Fox	University of New Mexico	Annual
NMDGF	Black-tailed Prairie Dog	APHIS, USFWS, BLM, White Sands Missile Range, Cannon Air Force Base, Turner Foundation, Private landowners	Periodic

Table 6-1. Cont

Lead Agency/ Organization	Monitoring Efforts Underway	Cooperators	Time Frame
Terrestrial SGCN Cont.			
NMDGF	Gunnison's Prairie Dog	APHIS, USFWS, USFS, BLM, Pueblos and Tribes, Cities of Albuquerque and Santa Fe, State Land Office, volunteer groups, Kirtland AFB	Periodic
NMDGF	Southern Pocket Gopher	BLM, private lands	Periodic
NMDGF	Southwestern Willow Flycatcher	USFWS, BOR, USFS, Pueblos,	Annual
NMDGF	Mexican Spotted Owl	USFS, Tribes and Pueblos, Contractors	Annual
NMDGF	Northern Goshawk	USFS, contractors	Annual
NMDGF	Peregrine Falcon	USFS, BLM, contractors	Annual
NMDGF	Bald Eagle	USFS, Tribes and Pueblos, Contractors	Annual
NMDGF	Aplomado Falcon	BLM	Annual
NMDGF	Osprey	Contractors	Annual
NMDGF	Gray Vireo	BLM	Periodic
NMDGF	Lesser Prairie Chicken	BLM, State Land Office, Natural Heritage New Mexico, landowners	Annual
NMDGF	Interior Least Tern	USFWS	Annual
NMDGF	Mourning Dove	Annual Dept. surveys, USFWS	Annual
NMDGF	Northern Pintail Duck	Annual Dept. waterfowl surveys	Annual
NMDGF	Shortneck Snaggletooth	USFWS, landowners	Periodic
NMDGF	Animas Peak Woodlandsnail	USFWS, landowners	Periodic
NMDGF	Animas Talussnail	USFWS, landowners	Periodic
NMDGF	Animas Holospira	USFWS, landowners	Periodic
NMDGF	Apache Snaggletooth	USFWS, landowners	Periodic
NMDGF	Mineral Creek Mountainsnail	USFS, USFWS	Periodic
NMDGF	Fringed Mountainsnail		Periodic
NMDGF	Hatcheta Mountainsnail	BLM, USFWS	Periodic
NMDGF	Cook's Peak Woodlandsnail	BLM, USFWS	Periodic
NMDGF	Big Hatchet Woodlandsnail	BLM, USFWS	Periodic
NMDGF	Hacheta Grande Woodlandsnail	BLM, USFWS	Periodic
NMDGF	Dona Ana Talussnail	BLM, USFWS	Periodic
NMDGF	Big Hatchet Mountain Talussnail	BLM, USFWS	Periodic
Aquatic SGCN			
NMDGF	Gila Chub, Chihuahua Chub, Roundtail Chub, Headwater Chub, Spikedace, Loach Minnow, Desert Sucker, Sonora Sucker monitoring in Gila and Mimbres River	USFS	Annual
NMDGF	Pecos Bluntnose Shiner in Pecos River	USFWS	Spring/ Summer/ Fall
NMDGF	Greenthroat Darter, Pecos Pupfish, Pecos Gambusia	USFWS, State Parks	Annual
NMDGF	Gila Trout	USFWS, USFS	Annual

Table 6-1. Cont

Lead Agency/ Organization	Monitoring Efforts Underway	Cooperators	Time Frame
Aquatic SGCN Cont.			
NMDGF	Colorado Pikeminnow, Razorback Sucker, Roundtail Chub; part of San Juan monitoring program	USFWS, Utah DOW, Navajo Game and Fish, Jicarilla Apache	Annual
NMDGF	Blue Sucker, Gray Redhorse		Periodic
NMDGF	White Sands Pupfish	USFWS, Hollaman AFB, White Sands Missile Range, White Sands National Monument	Spring/ Fall
NMDGF	Rio Grande Cutthroat Trout	USFS	Annual
USFWS	Rio Grande Silvery Minnow	NMDGF, UNM, BOR, Interstate Stream Commission	Annual
NMDGF	Zuni Bluehead Sucker	USFWS, USFS, Zuni Pueblo, The Nature Conservancy	Annual
NMDGF	Prosobranch snails (8 species; Hydrobiidae, Assimineidae)	USFWS, White Sands Missile Range	Biannually
NMDGF	Pulmonate snails (state-listed)		Periodic
NMDGF	Texas Hornshell (mussel)	USFWS, Miami University, private landowners	Seasonally (May-Oct.)
NMDGF	Sangre de Cristo Peaclam	USFS	Triennially
NMDGF	Sphaeriid bivalves (state-listed)		Periodic
NMDGF	Socorro Isopod	USFWS, private landowners	Monthly
NMDGF	Gammarid amphipods	USFWS, USFS, White Sands Missile Range, Miami Univ.	Biannual
NMDGF	Decapods		Periodic
NMDGF	Large branchiopods	USFS, BLM	Periodic

Much baseline information on the distribution, status, habitat affinities and natural history of SGCN is being housed in the Biota Information System of New Mexico (BISON-M) database, which contains species accounts for all New Mexico vertebrates and selected invertebrates. BISON-M has received an average of over 1,300 user inquiries per month since January 2004. BISON-M species accounts are constantly being updated and the database is currently being converted to a more user-friendly web-based format. However, the volume of information regarding the status, population trends and habitat preferences of SGCN is constantly growing; thus, at this time no single source contains or has the capability of containing all of this information (see further discussion of BISON-M capabilities in the New Mexico monitoring plans discussion below). Therefore, we provide general information describing some ongoing monitoring efforts, but actual baseline data identifying SGCN status, population trend and habitat information is contained primarily in many individual publications, reports and databases. Status, distribution and population trend studies (some intensive) have, or will soon be, conducted for state-listed and SGCN such as:

- Great Plains Narrowmouth Toad (1992),
- Gila Monster (study completed recently at NMDGF's Red Rock facility),
- Gray-checkered Whiptail (1980s),
- Bunch Grass Lizard (1980s),

- Giant Spotted Whiptail (1980s),
- Mountain Skink (1980s),
- Green Rat Snake (1980s),
- Narrowhead Garter Snake (planned for 2006-07),
- Arizona Shrew (2003),
- Penasco Least Chipmunk (anticipated for 2005-06), and
- Spotted Bat (anticipated for 2005-06).

Recovery Plans

Recovery plans for state and federally listed species also provide information on current and recommended future conservation actions and monitoring efforts needed to recover these species. The status of these recovery plans for both federal and state listed species in New Mexico is provided in Table 6-2.

Other federal recovery plans for SGCN not state-listed include the razorback sucker, Mexican spotted owl, and the Chiricahua leopard frog (nearing completion). The Wildlife Conservation Act (N.M. Stat. Ann. §§ 17-2-37-46 (1995)) states that, to the extent practicable, recovery plans shall be developed for species listed by the state as threatened or endangered. NMDGF is actively developing recovery plans for such state-listed species that are also SGCN. These plans describe current species status and trend information, ongoing monitoring efforts and to some degree identify future monitoring needs. Recovery plans for state-listed species under the New Mexico Wildlife Conservation Act include the:

- *Gray-banded Kingsnake Conservation Recovery Plan*
- *Zuni Bluehead Sucker Conservation and Recovery Plan*
- *Chavez County Invertebrates Recovery Plan*
- *Roundtail, Gila and Headwater Chubs Recovery Plan* (Draft)
- *Boreal Toad Recovery Plan* (Draft)

Other state-listed species that are SGCN that are prioritized for recovery plan development or finalization include the sand dune lizard, New Mexico ridgenosed rattlesnake (joint federal and state plan), blue sucker, Chihuahua chub, southern redbelly dace, Gila topminnow, Pecos pupfish, White Sands pupfish, Chupadera springsnail, wrinkled marshsnail, Gila springsnail, Pecos springsnail, New Mexico hot springsnail, and Texas hornshell.

NMDGF is also a party to interstate and interagency conservation agreements for state-listed species that are also SGCN, generally in lieu of federal listing. Conservation agreements that the NMDGF is signatory to include the Sangre de Cristo Peaclam Conservation Agreement, Pecos Pupfish Conservation Agreement, White Sands Pupfish Conservation Agreement, Jemez Mountains Salamander Conservation Agreement, Jaguar Conservation Agreement, Swift Fox Conservation Team, Black-tailed and Gunnison's Prairie Dog Conservation Strategy, and Townsend's Big-eared Bat Conservation Strategy. Additional NMDGF conservation and management plans for state listed species include the Sand Dune Lizard Conservation Plan, and the NMDGF Desert Bighorn Sheep Management and Recovery Plan. NMDGF is committed to non-signatory conservation agreements such as the Lesser Prairie-chicken Conservation Strategy

Table 6-2. Federal Recovery Plans for New Mexico State-listed and SGCN Wildlife.

Species	Year (most recent version)
Socorro Isopod	1982
Socorro/Alamosa Springsnails	1994
Gila Trout	1983, revision in progress
Chihuahua Chub	1986
Spikedace	1991
Loach Minnow	1991
Colorado Pikeminnow	1991
Pecos Gambusia	1990
Rio Grande Silvery Minnow	1999
Gila Topminnow	1984
Pecos Bluntnose Shiner	1992
New Mexico Ridgenose Rattlesnake	1985
Southwestern Bald Eagle	1982
Northern Aplomado Falcon	1989
Whooping Crane	1994
Interior Least Tern	1990
Southwestern Willow Flycatcher	2002
Brown Pelican (Eastern)	1980
Piping Plover (Great Lakes, N. Great Plains)	1988
Mexican Gray Wolf	1982
Mexican Long-nosed Bat	1994
Lesser Long-nosed Bat	1994

and the Boreal Toad Conservation Agreement. Other recovery or conservation plans in progress include a federal plan for the Arkansas River shiner and a plan for the Organ Mountains Colorado chipmunk, being developed by a contractor for White Sands Missile Range.

NMDGF personnel also are active members of Federal Recovery Teams for federally listed species, such as the Mexican spotted owl, Southwestern willow flycatcher, Mexican wolf, Chiricahua leopard frog, Boreal toad, Gila trout, Chihuahua chub, Rio Grande fishes and Rio Grande silvery minnow recovery teams. NMDGF endangered species biologists are also key members of the Middle Rio Grande Endangered Species Collaborative Program, Spikedace and Loachminnow Working Group, Central Arizona Project Fishes Mitigation Program, San Juan River Recovery Implementation Program, Pecos Pupfish Conservation Team, White Sands Pupfish Conservation Team, Roundtail Chub, Flannelmouth Sucker, and Zuni Bluehead Sucker Conservation Team, Aplomado Falcon Working Group, New Mexico Bat Working Group, Endemic Salamander Team, and New Mexico and Southwest Section Carnivore Working Groups. Membership to these teams requires that individual participants "monitor" or otherwise stay abreast of the most current information and research regarding species conservation status and population trends, habitat parameters, and survey and monitoring data.

NMDGF is required by the New Mexico's Wildlife Conservation Act to conduct a biennial review of all species of wildlife named on the Wildlife Conservation Act Threatened and Endangered Species List. In addition to status information, the 2004 Threatened and Endangered Species of New Mexico Biennial Review also provides information on conservation actions and survey and monitoring efforts needed for state-listed species, all but five of which are SGCN.

NMDGF also is involved with regional and national level conservation and monitoring efforts, such as the national and international (Mexico) Breeding Bird Surveys, Christmas Bird Counts, and Playa Lakes Joint Venture. Coordinated survey/monitoring efforts at a regional scale, such as the annual Breeding Bird Surveys, allow the long-term evaluation of migratory and year-round resident bird populations at a much larger national and even international scale. Bird monitoring efforts conducted by NMDGF and cooperators in New Mexico contribute to regional, national and international conservation efforts, such as the North American Waterbird Conservation Plan (Kushlan *et al.* 2002), United States Shorebird Conservation Plan (Brown *et al.* 2001), and North American Landbird Conservation Plan. NMDGF also gathers species status, distribution, natural history and habitat information for species of concern from our Share with Wildlife (SwW) program as participant researchers are required to submit reports of their findings.

Natural Heritage New Mexico (NHNM), formerly the New Mexico Natural Heritage Program, investigates the biological richness of New Mexico, monitors changes of natural systems, stores and retrieves data, and maps the distribution of plants and animals of New Mexico. NMDGF coordinates certain activities, such as the BISON-M database update and the Comprehensive Wildlife Conservation Strategy development effort with NHNM.

Each of the National Wildlife Refuges (NWR) in New Mexico, which includes Bosque del Apache NWR, Bitter Lakes NWR, Las Vegas NWR, Maxwell NWR, Grulla NWR, and San Andres NWR, conduct their own wildlife monitoring efforts and provide important information to NMDGF. For example, Bitter Lakes NWR provides important least shrew information through its small mammal trapping surveys and shorebird surveys, which provide information on the status and trends of nesting species like Interior least terns, a federal and state endangered species, and a SGCN. Bosque del Apache NWR conducts important wintering waterfowl surveys that NMDGF uses to compare diversity and abundance with our annual winter aerial waterfowl surveys. San Andres NWR routinely monitors desert bighorn sheep herds in the San Andres Mountain, one of the most important populations of this state endangered mammal, and a SGCN. Many more research projects of species status, trend, distribution, natural history, ecology and evolution are being conducted by academic and private researchers around the state. An exhaustive discussion of these is beyond the scope of this chapter.

Habitat Monitoring

Aquatic species monitoring for state and federally listed fishes and aquatic invertebrates generally includes systematic water quality parameter sampling in conjunction with population monitoring activities. Parameters sampled and monitored for these species generally include water temperature, dissolved oxygen, pH, turbidity and flow rates. These measurements may be conducted at the microhabitat level for species such as springsnails, which may occur only in very small springhead systems, or for large riverine systems. Flow rates for New Mexico's larger streams and rivers and lake capacities are measured and documented by the Bureau of Reclamation and US Army Corps of Engineers, generally on a daily basis. Water quality and chemistry are routinely monitored throughout the state by the New Mexico Environment Department.

Aquatic, riparian and wetland habitats are some of the most important habitats in the state, due to the aridity of the desert Southwest and the reliance of so many wildlife species on these habitats during some portion (or all) of their life cycles. Because of the importance of these habitats for New Mexico SGCN, this portion of the following habitat monitoring discussion will focus on these habitats, rather than attempting to include additional discussion for other key terrestrial habitats beyond what was already addressed in Assessments and Strategies for SGCN and Key Habitats (Chapter 5). Many riparian monitoring projects are underway, following monitoring plans and programs designed specifically for New Mexico. This following discussion includes only a sampling of ongoing riparian habitat restoration and monitoring efforts in the state. NMDGF stays abreast of these aquatic/riparian monitoring efforts by participating in cooperative programs for the management of these sites, and by review of reports and publications documenting these efforts.

- The *Conceptual Restoration Plan, Active Floodplain of the Rio Grande, San Acacia to San Marcial, New Mexico* (TetraTech 2004), presents a Monitoring and Adaptive Management Strategy for the River/Riparian Restoration Plan. This monitoring strategy is one of the most thoroughly researched and carefully designed monitoring efforts in New Mexico. It is the product of several years of compilation of baseline data, analysis of existing conditions, modeling of potential outcomes of various restoration scenarios, and coordination of a broad array of stakeholders. It should serve as a model for riparian restoration and monitoring efforts elsewhere along the Rio Grande, and in the state where large river floodplain restoration is taking place or being considered.

- The Bosque Ecosystem Monitoring Program conducts ongoing ecological monitoring in the floodplain of the Rio Grande. The program has produced a guidebook for monitoring and three monitoring reports that provide specific protocols for floodplain monitoring.

- The Sevilleta Long Term Ecological Research Project, located in and around the Sevilleta NWR, is part of the National Science Foundation's Long Term Ecological Research Network and is managed by the Department of Biology, University of New Mexico. The Sevilleta LTER conducts ongoing research, including research on riparian systems that includes long-term monitoring.

- The Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA) Program is a NSF-funded research effort aimed at developing an integrated, multidisciplinary understanding of the hydrology of semi-arid regions, and building partnerships with a broad spectrum of stakeholders (both public agencies and private organizations) so that this understanding is effectively applied to the management of water resources and to the rational implementation of public policy. Functioning of riparian ecosystems is one of SAHRA's primary focus areas, which includes monitoring elements.

- Bosque del Apache NWR conducts monitoring of saltcedar (*Tamarix sp.*) removal projects, plus other floodplain functions. Bosque del Apache NWR is recognized nationally as a leader in implementing successful removal of tamarisk and Rio Grande cottonwood and willow riparian restoration efforts.

- The Middle Rio Grande Endangered Species Act Collaborative Program funds and oversees riparian monitoring projects.

- The Taos Field Office of the BLM initiated a riparian vegetation-monitoring program, in cooperation with Natural Heritage New Mexico, for its lands along the lower Santa Fe River just west of La Cienega, New Mexico. The intent of this program was to detect long-term trends in riparian plant communities within a two-mile reach of the river that has been recently excluded from livestock grazing. Milford *et al.* (2004) present the results of 2002 and 2003 monitoring. The sampling system used was designed to allow the detection of changes in species composition and abundance, major shifts in vegetation zones, and the restructuring of the floodplain. This report presents a riparian monitoring protocol useful in northern New Mexico.

- The Roswell Field Office of the BLM initiated a riparian monitoring program for its grazing allotments within the floodplain corridor of the Pecos River in southeast New Mexico (Milford *et al.* 2001). The intent of this program is to detect long-term trends in riparian plant communities in relation to grazing management practices and vegetation manipulation projects. In addition, the monitoring program is intended to help managers and ranchers effectively implement adaptive management techniques in response to trends indicated by the monitoring data.

- Beginning in 1999 and continuing through 2000, the New Mexico Natural Heritage Program (NMNHP) established a set of high-resolution monitoring plots and reconnaissance surveys to collect the necessary baseline data for the 15 BLM allotments that are directly adjacent to the river. This baseline survey provides the foundation for future monitoring and also details current vegetation information for use in the development or revision of allotment management plans.

Additional terrestrial and aquatic habitat monitoring by the NMDGF include efforts associated with our Technical Guidance and Endangered Species Sections project reviews of all types of statewide projects that may impact wildlife populations or habitats. All of these efforts necessarily include the review and assessment of species and habitat information. For example, by Presidential Executive Order, wetland loss must be mitigated by replacement; therefore in reviewing NEPA documentation for proposed New Mexico Department of Transportation projects, NMDGF is able to monitor impacts of highway projects to state wetlands. From 1 July 2004 to 30 June 2005, Department's Technical Guidance Section received 725 project notifications and generated 555 responses, many of which included recommendations for wildlife and habitat recommendations. Unfortunately, Technical Guidance staff is not currently sufficiently manned or funded to follow up on project recommendations to see if mitigation has been implemented.

NMDGF monitors existing hard rock, coal and uranium mining operations and their effects on habitats in New Mexico by having considerable involvement in the implementation of the New Mexico Mining Act of 1993. NMDGF and the Mining and Minerals Division, through hard rock mine permit fees, jointly fund a full-time Mining Habitat Specialist, who reviews and provides recommendations on biological reports, permit applications, closeout and reclamation plans for all of these mines in New Mexico. NMDGF is therefore involved in developing reclamation and monitoring plans for a substantial number of mines throughout the state, many of which will become wildlife habitat after mine closure. The NMDGF also reviews and comments on US Fish and Wildlife Service Comprehensive National Wildlife Refuge Plans for New Mexico's National Wildlife Refuges, which include Bosque del Apache NWR, Bitter Lakes NWR, Las Vegas NWR, Maxwell NWR, Grulla NWR, and San Andres NWR.

In an effort to further our knowledge of on-the-ground habitat conservation actions to benefit federally listed species in New Mexico, NMDGF has been seeking enhanced opportunities to be advised of implementation of Endangered Species Act conservation tools for federal agencies and private landowners in New Mexico, such as Habitat Conservation Plans, Safe Harbor Agreements, and Candidate Conservation Agreements. For example, the NMDGF has participated in meetings of the Malpais Borderlands Group (MBG) Habitat Conservation Plan (HCP) Working Group, prepared draft summaries, and reviewed existing documents to support development of a HCP to address both federal and state listed species in the MBG area of southwestern New Mexico. These efforts will allow the NMDGF to monitor ongoing habitat conservation actions directed toward federally listed species that are also state listed and SGCN.

The NMDGF is a voting member of the State Forest Stewardship Committee and Forest Legacy Program Subcommittee. The Forest Stewardship Committee administers Farm Bill conservation program grants (such as EQUIP) for forest and woodland habitat improvement projects that directly benefit wildlife. The Forest Legacy Program is a cost-share conservation easement program provided by the US Forest Service. The Forest Legacy Subcommittee evaluates, prioritizes and selects proposals by private landowners to protect valuable forest and woodland habitats with conservation easements, thereby protecting these properties from development for perpetuity. The NMDGF stays abreast of habitat improvement projects and conservation easements on privately-owned forests and woodlands in New Mexico, whose owners participate in these programs.

The NMDGF is also developing enhanced working relationships with private landowners who wish to implement wildlife habitat improvements on their private lands with State Wildlife Grants and Landowner Incentive Program Grants offered through the State and Tribal Wildlife Grants Program. Monitoring of the success of conservation actions instituted through these grants is an important component of this program.

In summary, these efforts allow NMDGF biologists to monitor important habitats in a secondary, non-systematic method. Other than the efforts of the USGS Southwest Regional Gap Analysis Project (SWReGAP) to map vegetation and wildlife species distribution of the southwestern United States, to our knowledge, no formal, systematic, standardized monitoring of key habitats (e.g. Madrean Encinal) at a landscape level within ecoregions is occurring in New Mexico.

Monitoring Needs

SGCN and habitat monitoring needs are addressed individually for key habitats within the *Information Gaps* and *Research, Survey, and Monitoring Needs* sections of Chapter 5. For example, the first bullet under *Research, Survey, and Monitoring Needs* in the *Statewide Distributed Ephemeral Habitats and Perennial Tanks* section states:

> "Comprehensive spatial data designating the location, number, total area, and functional classification of geographically isolated wetlands would provide the foundation for monitoring impacts, quantifying wetland loss/gain, and facilitating risk assessment for these waters."

Therefore, this discussion will not attempt to recapture those recommendations more specific to key habitat types, but focus on a larger scale monitoring needs and challenges.

The NMDGF has not had a sufficient dedicated source of funds or the personnel necessary to conduct monitoring activities for all wildlife species, particularly the non-game species. Many state listed species (all but five of which are SGCN) currently do not have systematic, ongoing survey, sampling and monitoring efforts to determine population trends, nor have protocols been developed to conduct monitoring. Basic life history information, status, distribution and habitat affinities still need to be determined for many SGCN. In general, money has not been available to conduct the research needed on these species until they become federally or state listed, with most efforts being directed toward federally listed species. Even once a species is federally or state listed, oftentimes not enough money and personnel are available to conduct this work.

Other difficulties associated with implementing field monitoring efforts, in addition to those stated above regarding monitoring plan design and goals, include differences in the ability to sample certain groups of organisms. For example, bats species are difficult to sample in the field without roost location information, as they are nocturnal, often occur at very low densities across the landscape, and are difficult to capture. However, individual states associated with the Western Bat Working Group are developing sampling protocols for bat species. Colorado, Arizona, Texas and Utah have all adopted bat survey and monitoring protocols. The NMDGF is a participant in the New Mexico Bat Working Group, which is considering developing a bat conservation plan, likely using similar protocols as surrounding states. Existing resources that will likely be used include the North American Bat Conservation Partnership State Planning Guide for Bats (see http://www.batcon.org/nabcp/newsite/index.html).

As stated above, recovery and conservation plans and agreements are good sources of population status and trend information, and usually identify needed conservation actions monitoring efforts. State listed wildlife with no type of recovery plan, conservation plan, or conservation agreement are provided in Table 6-3.

Table 6-3. State listed wildlife without a recovery plan, conservation plan, or conservation agreement.

Common Name	Scientific Name
Fish	
Gila Chub	*Gila intermedia*
Roundtail Chub	*Gila robusta*
Southern Redbelly Dace	*Phoxinus erythrogaster*
Colorado Pikeminnow	*Ptychocheilus lucius*
Blue Sucker	*Cycleptus elongates*
Mexican Tetra	*Astyanax mexicanus*
Arkansas River Speckled Chub	*Macrhybopsis tetranema*
Suckermouth Minnow	*Phenacobius mirabilis*
Gray Redhorse	*Scartomyzon congestum*
Greenthroat Darter	*Etheostoma lepidum*
Bigscale Logperch	*Percina macrolepida*
Birds	
White-Tailed Ptarmigan	*Lagopus leucurus*
Common Ground-Dove	*Columbina passerina*
Buff-Collared Nightjar	*Caprimulgus ridgwayi*
Elegant Trogon	*Trogon elegans*
Northern Beardless-Tryannulet	*Camptostoma imberbe*
Thick-Billed Kingbird	*Tyrannus crassirostris*
Neotropic Cormorant	*Phalacrocorax brasilianus*
Common Black-Hawk	*Buteogallus anthracinus*
Peregrine Falcon	*Falco peregrinus*
(Previously Had Federal Recovery Plan)	
Whiskered Screech-Owl	*Otus trichopsis*
Boreal Owl	*Aegolius funereus*
Broad-Billed Hummingbird	*Cynanthus latirostris*
White-Eared Hummingbird	*Hylocharis leucotis*
Violet-Crowned Hummingbird	*Amazilia violiceps*
Lucifer Hummingbird	*Calothorax lucifer*
Costa's Hummingbird	*Calypte costae*
Gila Woodpecker	*Melanerpes uropygialis*
Bell's Vireo	*Vireo bellii*
Gray Vireo	*Vireo vicinior*
Abert's Towhee	*Pipilo aberti*
(Arizona) Grasshopper Sparrow	*Ammodramus savannarum ammolegus*
Baird's Sparrow	*Ammodramus bairdii*
Yellow-Eyed Junco	*Junco phaeonotus*
Varied Bunting	*Passerina versicolor*
Mammals	
Arizona Shrew	*Sorex arizonae*
(Penasco) Least Chipmunk	*Tamias minimus atristriatus*
(Arizona) Montane Vole	*Microtus montanus arizonensis*
Least Shrew	*Cryptotis parva*
Spotted Bat	*Euderma maculatum*
Western Yellow Bat	*Lasiurus xanthinus*
White-Sided Jackrabbit	*Lepus callotis*
Southern Pocket Gopher	*Thomomys umbrinus*
Meadow Jumping Mouse	*Zapus hudsonius*
American Marten	*Martes americana*

Table 6-3 Cont.

Common Name	Scientific Name
Amphibians	
Lowland Leopard Frog	*Rana yavapaiensis*
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*
Sacramento Mountain Salamander	*Aneides hardii*
Colorado River Toad	*Bufo alvarius*
Reptiles	
Gila Monster	*Heloderma suspectum*
Gray-Checkered Whiptail	*Cnemidophorus dixoni*
Mexican Garter Snake	*Thamnophis eques*
Plainbelly Water Snake	*Nerodia erythrogaster*
Western River Cooter	*Pseudemys gorzugi*
Bunch Grass Lizard	*Sceloporus scalaris*
Giant Spotted Whiptail	*Cnemidophorus burti*
Mountain Skink	*Eumeces tetragrammus*
Green Rat Snake	*Senticolis triaspis*
Narrowhead Garter Snake	*Thamnophis rufipunctatus*
Western Ribbon Snake	*Thamnophis proximus*
(Mottled) Rock Rattlesnake	*Crotalus lepidus lepidus*
Invertebrates	
Papershell Pondshell Mussel	*Utterbackia imbecillis*
Texas Hornshell	*Popenaias popeii*
Chupadera Pyrg	*Pyrgulopsis chupaderae*
Ovate Vertigo	*Vertigo ovata*
Wrinkled Marshsnail	*Stagnicola caperata*
Shortneck Snaggletooth	*Gastrocopta dalliana dalliana*
Florida Mountain Snail	*Oreohelix florida*
Lake Fingernailclam	*Musculium lacustre*
Swamp Fingernailclam	*Musculium partumeium*
Long Fingernailclam	*Musculium transversum*
Lilljeborg Peaclam	*Pisidium lilljeborgi*
Sangre De Cristo Peaclam	*Pisidium sanguinichristi*
Gila Pyrg	*Pyrgulopsis gilae*
Pecos Pyrg	*Pyrgulopsis pecosensis*
New Mexico Hot Spring Pyrg	*Pyrgulopsis thermalis*
Star Gyro	*Gyraulus crista*
Hacheta Grande Woodlandsnail	*Ashmunella hebardi*
Cooke's Peak Woodlandsnail	*Ashmunella macromphala*
Mineral Creek Mountainsnail	*Oreohelix pilsbryi*
Doña Ana Talussnail	*Sonorella todseni*

Unless addressed in Table 6-1, most of the state listed and SGCN species do not have systematic population trend monitoring efforts in place. Exceptions to that are the avian SGCN, which have the potential to be generally surveyed at least once annually during citizen survey efforts such as the Breeding Bird Surveys and Christmas Counts. However, limitations of these surveys include the limited coverage of routes surveyed throughout the state, and they are primarily presence/absence surveys, although distribution, density and long-term trend information can be inferred.

National and regional level organizations such as Partners in Amphibian and Reptile Conservation (PARC) have, or are developing, regional guidelines (e.g. Southwest United States) for habitat management for groups of organisms such as reptiles and amphibians. These efforts will assist NMDGF in developing similar guidelines for future management and conservation actions.

To our knowledge, no systematic, standardized monitoring of introduced, non-native plant and animal species is occurring. Introduced non-native species are a primary cause of the decline of native biological diversity globally, and should be addressed at a state, regional and national level, in part by instituting monitoring programs at these different scales. Monitoring and efforts to identify new invasions (both deliberate and accidental) are technically feasible, but lack sufficient funding and coordination (Simberloff *et al.* 2005). This information should be incorporated into a dynamic statewide Geographical Information System (GIS) database to allow tracking of these trends.

A more efficient monitoring program needs to be developed to track the effectiveness of conservation actions such as riparian and terrestrial habitat restoration programs at a statewide level. This information should be incorporated into a dynamic statewide GIS database to allow the tracking and assessment of project performance at a landscape level.

As stated above, other than the efforts of the USGS Southwest Regional Gap Analysis Project (SWReGAP) to map vegetation and wildlife species distribution of the southwestern United States, to our knowledge, no formal, systematic, standardized monitoring of key habitats (e.g. Madrean Encinal) at a landscape level within ecoregions is occurring in New Mexico. Development of the capacity to detect habitat changes and compare them directly with SGCN monitoring results is essential to evaluating the effectiveness of our conservation actions.

NEW MEXICO'S MONITORING PLANS

Our strategic approach to monitoring the status and trends of SGCN and their habitats and the effectiveness of our conservation actions will include adopting a focused approach, enhancing cooperation and coordination, establishing a fish and wildlife habitat monitoring group, monitoring habitat connectivity, establishing a centralized database and clearinghouse, and integrating citizen science. Operational considerations for monitoring plan design, data management, quality control, and reporting are also provided as are suggested performance indicators.

Adopt a Focused Approach to Monitoring

Because 452 SGCN and 19 key habitats have been selected for the CWCS for New Mexico, it is *not reasonable* to assume that NMDGF and our cooperators will be able to effectively monitor all SGCN and their habitats, particularly SGCN for which NMDGF currently lacks legal authority, such as insects. Nor can NMDGF directly affect or monitor habitats over which it lacks jurisdiction. However, we believe that expanding our monitoring capabilities to include all state and federally listed species, and selected SGCN "umbrella", "indicator" or "keystone" species, and/or guilds or functional groups of SGCN associated with key habitats will greatly assist us and our cooperators to meet our primary conservation goals and the intent of the State and Tribal Wildlife Grants Program. This expansion of monitoring capacity will necessarily require an associated ability to monitor the effectiveness of conservation actions, as well as provide adaptive response capability to modify future management decisions and objectives based on conservation action outcomes.

With regard to developing individual state habitat monitoring programs to meet the intent of the State and Tribal Wildlife Grants Program, Schoonmaker and Luscombe (2005) state:

> "To the extent species are monitored in the context of habitat, it is more efficient to select a few easily sampled indicator species that are strongly associated with priority habitats, and that act as "umbrella species" for other taxa of interest. Indicators are functionally linked to other species and habitats (but aren't necessarily keystone species), whereas umbrella species may or may not be functionally linked, but rather are used as conservation tools owing to their widespread distribution compared to the species and habitats they are used to protect. In any case, it is not possible nor especially informative to attempt to monitor all species, or even all species of greatest conservation need, so the list of species to be monitored is more likely to be useful if it is short and strategically developed."

In further support of this monitoring strategy, Gibbs *et al*. (1999) state:

> "Indicators that represent broad changes in the resources of concern [wildlife diversity and habitats] are useful. Good candidates are umbrella species (those species whose habitat hosts many other, associated species) or keystone species (those species whose strong interactive effects with other species generate effects that are large relative to the keystone species' abundance)."

Given these observations, our strategic approach to acquiring information of SGCN status and trends will be to monitor unique indicator guilds or functional groups of SGCN, other suites of SGCN that are indicators of the health of key habitats, umbrella species whose persistence in a key habitat is likely to ensure the persistence of other species that occur in those habitats, and keystone species, whose conservation within a key habitat is important for the persistence of many other species in that habitat type. As a broad example, birds have been shown to be effective indicators of biological integrity in wetland and riparian ecosystems (Adamus and Brandt 1990, Croonquist and Brooks 1991), and they have been considered good indicators of environmental change (Verner 1984). Several metrics for the bird community (e.g., bird abundance, diet and foraging guilds, and disturbance tolerance) are generally well correlated with degree of degradation of forest riparian systems in the northeastern US as a result of several types of anthropogenic activities (Moors 1993). A bird biological integrity index tested by Bryce *et al.* (2002) was shown to be a useful management and monitoring tool for assessing riparian integrity.

Because the Comprehensive Wildlife Conservation Strategy for New Mexico is a strategic planning document, NMDGF and its cooperators will develop monitoring details to meet the intent of the State and Tribal Wildlife Grants Program during the operational planning process described in Chapter 7. However, the NMDGF and federal land management and private landowner cooperators are already moving in the direction of the concepts identified above, by recognizing the importance of monitoring of the status and trends of the lesser prairie chicken, sand dune lizard, and black-tailed prairie dog, three very important indicator and keystone SGCN, to assess the status of key habitats within the Southern Shortgrass Prairie Ecosystem.

Enhance Cooperation and Coordination

The greatest challenge that the NMDGF and cooperator's will likely face in implementing Comprehensive Wildlife Conservation Strategy for New Mexico will be the effective monitoring of key habitats, habitat changes and evaluating outcomes of conservation actions, as required by Element 5. Schoonmaker and Luscombe (2005) adequately identify some of the inherent difficulties of effectively monitoring habitats. They state:

> "Ownership and jurisdictional boundaries add at least four more challenges to the already complex question of how to monitor habitats. First, ownership and jurisdictional boundaries sometimes coincide with habitat boundaries, but often they do not. Second, not only are the goals of federal, state, local and private land owners different, but conservation goals within each of these categories can vary widely. Third, ownership changes over time, with these changes being moderately linked to (either caused by, or causing) changes in habitat condition. And finally, the motivations for habitat monitoring and the resulting habitat monitoring programs (if any) vary widely in terms of approach, proprietary versus public information, and data compatibility."

In consideration of these observations our strategic approach to monitoring will include a dedicated effort to enhance cooperation and coordination with state and federal land management and natural resource agencies, Native American tribes, non-governmental organizations such as land conservation trusts and agricultural organizations, and private landowners. For example, irreplaceably important monitoring efforts of SGCN and key habitats are carried out by federal land management agencies, primarily the USFS and BLM. Their efforts are essential to informing wildlife management and conservation initiatives. Likewise, 22 sovereign tribes manage wildlife and habitat on 9% of the land surface within New Mexico's borders. It therefore behooves us to maintain and improve effective communication and information and technology transfer among these entities.

Private lands encompass approximately 45% of New Mexico's land base. About 54% of New Mexico consists of rangeland, croplands, or pasture important to supporting our agricultural industry. Long-term conservation of many species (e.g., lesser prairie-chicken, black-tailed and Gunnison's prairie dogs) will be impossible without substantial buy-in and support from a significant proportion of landowners and agricultural interests in key habitats. The development and implementation of monitoring programs for habitat improvement projects (conservation actions) for SGCN on private lands will be an important component of meeting our desired conservation outcomes. The State Wildlife Grants and Landowner Incentive Programs have allowed the NMDGF to begin developing relationships that will lead to the necessary cooperation and coordination.

We have recently begun working with land conservation trusts such as the New Mexico Land Conservancy, Trust for Public Land and The Nature Conservancy to enact conservation easements on important private lands whose willing owners wish to protect them from future development. The 2005 New Mexico state legislature provided the NMDGF and State Game Commission with $4 million dollars to assist in purchasing important private lands from willing sellers for wildlife, agriculture and open space conservation. As a result, the NMDGF anticipates building enhanced cooperation and coordination with landowners and land conservation trusts. The NMDGF will also collaborate with land conservation trust organizations to evaluate important wildlife habitats on private lands of willing sellers.

NMDGF will seek to further cooperation and coordination with the State Land Office to facilitate the effective monitoring of SGCN and key habitats on the significant portion of New Mexico's land base managed by that entity for the purpose of financially supporting the state's schools. NMDGF will seek closer cooperation and coordination with the State Forestry Division, to facilitate coordination and cooperation in monitoring New Mexico's privately-owned forests and woodlands, whose owners participate in federal and state wildlife and habitat conservation programs.

Establish a Fish and Wildlife Habitat Monitoring Group

Our strategic approach to monitoring will include pursuing the establishment of a Fish and Wildlife Habitat Monitoring Group. Schoonmaker and Luscombe (2005) state:

> "In order to develop and implement a monitoring program, each state may consider establishing a fish and wildlife habitat monitoring group, to facilitate cooperative monitoring, assessment, and reporting activities. The monitoring group could be a collaborative partnership among federal, state, and local agencies, as well as landowners, conservation organizations and other interest groups. Members could also be drawn from

> various geographic regions within the state to ensure broad biological and policy knowledge within the group…Collaborative initiatives, such as…establishing multi-stakeholder monitoring groups are fundamental to developing a fish and wildlife monitoring program that has credibility within and beyond the stakeholder group."

Our strategic approach will follow Schoonmaker and Luscombe's (2005) recommended framework for establishing a habitat monitoring program for state comprehensive wildlife conservation strategies. In doing so we will:

1. Identify the decision-makers, partners, and resources needed for a fish and wildlife habitat monitoring group to track conservation actions, adaptive management hypotheses, and longer-term changes in habitat distribution, condition, and conservation status.

2. Work with partners to identify available information sources, determine whether existing data are adequate to establish a meaningful baseline, and secure and/or enhance GIS layers. Data can include statewide registry of conservation actions, present and historic land use/land cover map, aquatic resources map, existing conservation network areas, priority habitats identified in the CWCS, and existing conservation projects.

3. Determine what elements of the strategy are suitable for monitoring by agencies, organizations and citizens. Set up systems to train field naturalists and citizen volunteers to collect data, using consistent protocols.

4. Evaluate the impacts of conservation actions periodically and make adjustments as necessary within an adaptive management framework.

5. Update the land use and land cover data every five to ten years to track habitat changes.

6. Develop an efficient and effective communication system for reporting and disseminating information to decision-makers and other stakeholders, including the public.

To address the development of a fish and wildlife habitat monitoring group, the NMDGF anticipates organizing a conference consisting of two phases. Phase one would be conducted to develop a habitat monitoring group and otherwise meet guidelines 1, 2, 3, and 6 above. The second phase would entail summit meetings with surrounding state wildlife agencies (Arizona, Colorado, and Texas to develop interstate habitat connectivity priorities and facilitate information and technology transfer between states. This effort is necessary to better coordinate SGCN and habitat conservation and monitoring across state and ecoregional boundaries.

Challenges to coordinating effective wildlife and habitat conservation and monitoring across state and land ownership boundaries include the facts that states have different species assemblages, habitat types, economic and political pressures, land use regulations, development priorities, stakeholders and conservation opportunities (Schoonmaker and Luscombe 2005). However, because habitat loss, fragmentation and degradation are the leading causes of species decline globally, there is a great need for communication and cooperation across state and land ownership lines, and a necessity for compatibility in monitoring data collection efforts. Therefore, we believe that this regional coordination effort is necessary.

Monitor Habitat Connectivity

Because habitat loss, fragmentation and degradation are the leading causes of species decline globally, monitoring the connectivity or "linkages" of major habitat in New Mexico and across state boundaries is essential. A promising opportunity lies in cooperating and coordinating with the New Mexico Department of Transportation and Federal Highways Administration to identify important wildlife habitat linkages and wildlife movement corridors that have been fragmented by highways, roadways and other human travel corridors. Important work in this regard has been ongoing in New Mexico and surrounding states (Arizona and Colorado), but efforts to address opportunities to reconnect important habitats are just beginning.

For example, in June of 2003, the New Mexico Carnivore Working Group, in conjunction with NMDGF, USFWS and USFS, conducted the "Critical Mass" workshop to educate participants in ongoing efforts to reconnect habitats across highways in Europe, Canada and (more recently) the United States and to prioritize important wildlife habitat linkages across highway barriers in New Mexico to assist agencies to direct mitigation solutions. Over 100 federal and state wildlife and land management agency personnel, New Mexico Department of Transportation personnel, private highway consultants, conservationists and interested members of the public attended this two-day workshop. Through a consensus-building process, 30 high-priority highway/transportation corridor sections were identified based on three criteria: 1) potential for wildlife/vehicle collisions based on large game animal/vehicle collision accident report data; 2) connectivity of major tracts of public lands; and 3) threatened, endangered and sensitive species concerns. Spatial depictions of these prioritized highway segments are provided in Figure 6-1.

The Critical Mass workshop essentially initiated important work that is ongoing at two identified high-priority habitat linkages, Tijeras Canyon and Abo Canyon, which connect central cordillera mountain chains and allow habitat connectivity between southern and northern New Mexico. Each project is slated for wildlife passage enhancements and protections across Interstate 40 in Tijeras Canyon and a major railway line in Abo Canyon. The importance of these two locations as wildlife travel corridors are indicated by monitoring results indicating a high mortality of mule deer, black bear and Rocky Mountain bighorn sheep (all SGCN) from collisions with vehicles and trains. Continued monitoring of future wildlife mortality from vehicles and trains and wildlife use of constructed and enhanced wildlife passages below the interstate and railroad line will allow the evaluation of the effectiveness of these projects at maintaining and improving habitat connectivity.

As further priority habitat linkages and wildlife travel corridors are identified and enhanced in New Mexico, monitoring of wildlife roadkill mortality data and wildlife passage indicator data (e.g., track monitoring, camera detection) will allow a determination of habitat connectivity capabilities at important sites. Monitoring the "connectivity" of important wildlife linkages is essential to determining the ability of key habitats to support SGCN.

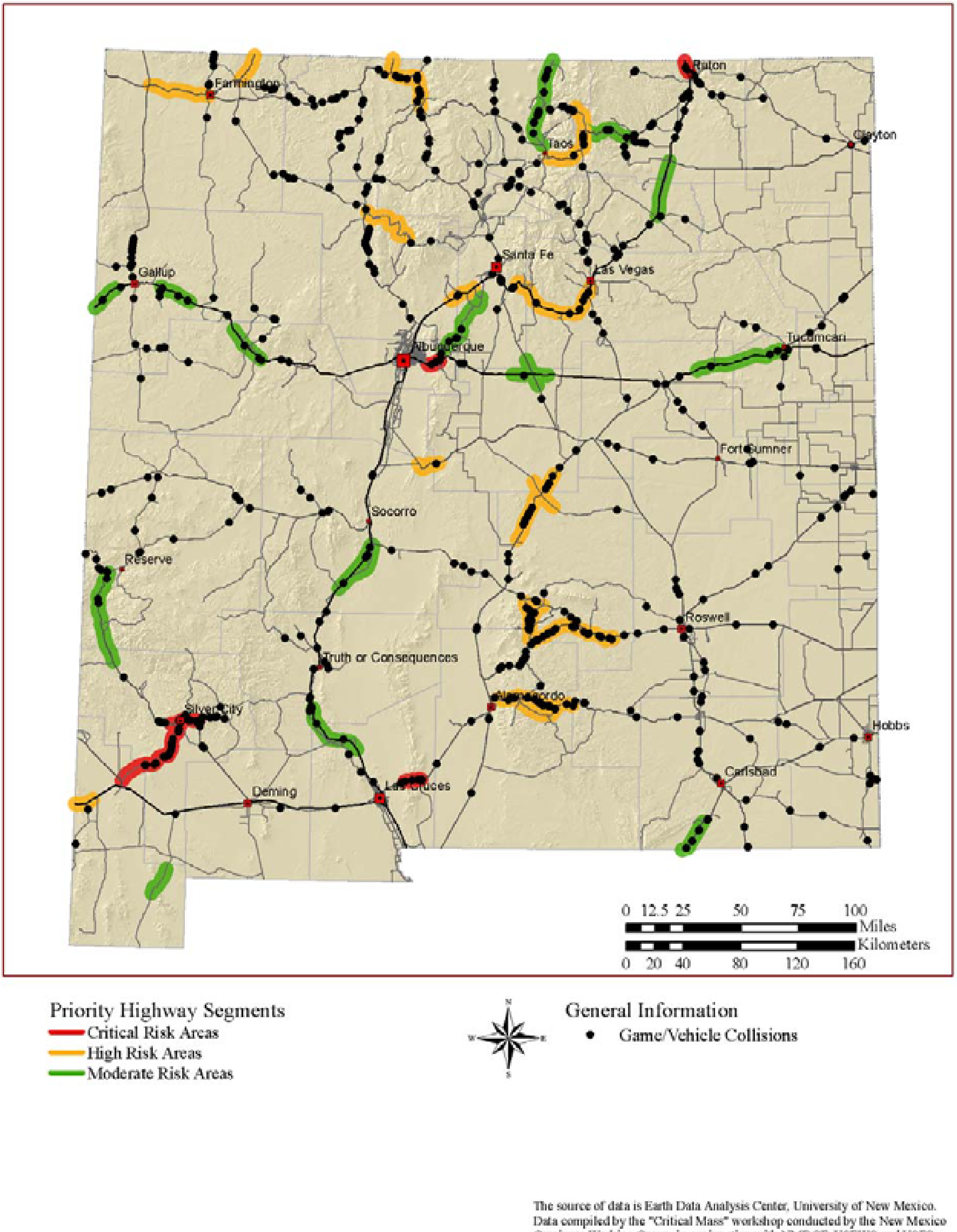


Figure 6-1. Spatial depictions of these priority highway segments identified during the 2003 "Critical Mass" workshop sponsored by the New Mexico Carnivore Working Group, NMDGF, USFWS and USFS.

Subsequent to the Critical Mass workshop, similar habitat linkage identification workshops have occurred in Arizona and Colorado, and interstate coordination efforts are ongoing. The recent signing by the President of the 2005 Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFTEA-LU), in addition to providing additional funding opportunities for "…reduce[ing] vehicle-caused wildlife mortality while maintaining habitat connectivity," requires that state departments of transportation consult with state wildlife management agencies in the development of 20-year long-range plans, and provides funding for joint positions between the state wildlife agencies and DOTs to enhance collaboration and consultation. To increase the ability of NMDGF and cooperators to implement wildlife passage enhancements and monitor important wildlife habitat linkages across human transportation corridors, the NMDGF will consider the feasibility of creating a cooperative joint position with NMDOT.

Establish a Centralized Monitoring Database and Clearinghouse

Establishing effective collaborative monitoring efforts requires the development of standardized data collection methods and a centralized data collection system to act as a clearinghouse for housing, managing, analyzing and distributing data collected from monitoring. NMDGF is therefore committed to collaborating with other state and federal agency and non-governmental organization cooperators to develop a dynamic database to collect, store, and manage monitoring data at a scale appropriate to that of our performance measures and targets so as to facilitate communication and utility across agency and organization information systems.

The NMDGF's Biota Information System of New Mexico (BISON-M), which contains species accounts of status, distribution, habitat preferences and other natural history information on all New Mexico vertebrates and many invertebrates, is planned for expansion to store spatially-explicit geographic information, and after consideration and analysis, may be the most appropriate platform to serve as the clearinghouse for the integrated geographical information system (GIS)/biological database monitoring system. However, as noted below, a number of other entities have the capacities and data to substantially enhance this effort.

Landscape scale satellite imagery and vegetation analysis is also available through the Southwest Regional Gap Analysis Project (SWReGAP). SWReGAP is an update of the Gap Analysis Program's mapping and assessment of biodiversity for the five-state region encompassing Arizona, Colorado, Nevada, New Mexico, and Utah. It is a multi-institutional cooperative effort coordinated by the US Geological Survey Gap Analysis Program. The primary objective of the update is to use a coordinated mapping approach to create detailed, seamless GIS maps of land cover, all native terrestrial vertebrate species, land stewardship, and management status, and to analyze this information to identify those biotic elements that are under-represented (considered "gaps") on lands managed for their long term conservation. SWReGAP provides baseline information to guide monitoring efforts. If institutionalized, the products of this effort can provide current information regarding state habitats and detection of habitat change. Data provided by SWReGAP can help identify SGCN areas for monitoring, research, or conservation. When monitoring for a specific species is necessary, the use of habitat models to limit the sampling frame for the monitoring effort can provide efficiency.

Changes in ownership or in management intent over time are another important aspect of monitoring. SWReGAP stewardship is designed to provide the baseline for this effort and to place context to conservation actions and provide areas to focus these actions. Institutionalizing this effort can provide states with current information. Currently SWReGAP is not funded to pursue these types of endeavors. Data from SWReGAP provides a common baseline to use in regionalization of conservation efforts within Arizona, Colorado, Nevada, New Mexico, and Utah. This seamless dataset of land cover, terrestrial species, and stewardship can be used to synthesize conservation efforts across the region.

Natural Heritage New Mexico (formerly the New Mexico Natural Heritage Program) also has GIS capabilities and maintains a database of species of concern records and conducts research and monitoring and the US Bureau of Land Management maintains the most comprehensive geospatial database of land ownership in the state. To meet CWCS monitoring needs and the intent of the State and Tribal Wildlife Grants Program it may be necessary to employ all of these existing resources to develop a workable central clearinghouse dynamic monitoring database.

Integrate Citizen Science into CWCS Monitoring

NMDGF already promotes citizen science to collect habitat data, primarily for watersheds. The Watershed Watch Program, a component of the Aquatic Resources Education Program, is active in approximately twenty high schools around New Mexico. Each school adopts a watershed (or portion of a watershed) and collects water quality and aquatic macroinvertebrate abundance and diversity data. Water parameter data such as temperature, pH, turbidity, nitrates and phosphates are collected. NMDGF contracts a facilitator to conduct training workshops and develop standardized protocols to implement these programs among schools and watersheds.

For terrestrial habitats and species monitoring, opportunistic monitoring efforts occur with the Natural History Workshops sponsored by NMDGF through our Conservation Education Program. Teachers from schools around the state have participated in these workshops to document biological information (primarily presence/absence data) on butterflies, birds, bats, and reptiles and amphibians. These observations and data are usually provided to the appropriate wildlife specialists, but a central clearinghouse is needed to act as a repository and center of distribution for this data.

NMDGF is in the process of planning "BioBlitzes", similar in nature to rapid ecological assessments, except that they are directed at the public primarily for educational value. However, these programs do provide opportunistic monitoring value of wildlife and plant species diversity and abundance. The similar "Discovery Days" program operated by New Mexico State Parks has documented new species occurrence records for the state and individual counties.

These programs have a great potential to expand in New Mexico, as there are many more schools, teachers and members of the public who interested in science, natural history and conservation. NMDGF is committed to expanding the use of citizen science through the Watershed Watch, Natural History Workshop and BioBlitz programs, and to exploring other training and protocol development options, to gather wildlife and habitat data in New Mexico to assist us in meeting our CWCS monitoring needs.

Citizens are becoming more active statewide in monitoring wildlife/vehicle collisions on local highways, documenting wildlife corridors across highways and proposing that habitat connectivity be reestablished using technologies similar to those being implemented for Tijeras and Abo Canyons. The formation of local groups of citizens that identify the need for projects at the local level, work with local NMDOT planners and engineers, and conduct monitoring of the effectiveness of these solutions will be an important component of implementing these types of projects statewide. This process has already begun in several locations around the state.

Considerations for Monitoring Plan Design

The following information is included to provide guidance in the future when working with cooperators to implement conservation actions and habitat monitoring programs. This knowledge was gained from monitoring efforts of successful and unsuccessful riparian habitat restoration projects, but is applicable to all types of habitat improvement projects. Because of the importance of riparian habitats to New Mexico's SGCN, this discussion should be particularly useful to future monitoring plan design efforts.

Restoration projects are often developed with little consideration for understanding their effects on wildlife. Block *et al.* (2001) contend that monitoring treatment effects on wildlife should be an integral component of the design and execution of any management activity, including restoration. Block *et al.* (2001) provide a conceptual framework for the design and implementation of monitoring studies to understand the effects of restoration on wildlife. Their underlying premise is that effective monitoring hinges on an appropriate study design for unbiased and precise estimates of the response variables. They advocate using measures of population dynamics for response variables given that these indicators provide the most direct measures of wildlife status and trends. The species to be monitored should be those constituting an assemblage of umbrella species that represent the range of spatial and functional requirements of wildlife in a restored ecological system. Selection of umbrella species should be based on strong empirical evidence that justifies their usage. They also advocate that monitoring be designed as true experiments or quasi-experiments rather than as observational studies to allow for stronger inferences regarding the effects of restoration on wildlife. Their framework is applicable to riparian ecosystems.

An important aspect of riparian monitoring is adaptive management of ongoing operations. This entails monitoring of operations or practices, measuring the outcomes against standards or desired outcomes, learning from outcomes of existing operations or practices, adjusting operations or practices to improve the outcomes, and monitoring again as an iterative process. Good adaptive management produces information on what works and what does not. This information can be disseminated through various means, from published articles or agency reports to presentations at workshops and training sessions.

Reid (2001) conducted an informal sample of 30 riparian monitoring projects and discovered that 70% had design problems, and 50% had procedural problems. Monitoring projects implemented by land-management agencies tended to have a higher proportion of procedural problems than did university-based programs (generally graduate student research), while the frequency of design problems was similar between agencies and universities. The most common problems were poorly trained or unmotivated field crews (37% of projects, a procedural problem), a sampling plan that was not capable of measuring what was needed to meet project objectives (30%, design), delays in analyzing data (27%, procedure), inadequate monitoring durations (27%, design), and absence of the collateral information needed to interpret results (20%, procedure). Most of the problems could have been avoided by submission of the study design to thorough technical and statistical review, active participation of the principal investigators in field data collection, and analysis of at least some of the data as soon as information was collected so that problems could be recognized early enough to be corrected.

Data Management, Quality Control, and Reporting Considerations

The following discussion by Gibbs *et al*. (1999) provides valuable technical guidance for data management, quality control and reporting for monitoring efforts, and should be considered as those efforts occur. Therefore, we include this discussion for future reference.

> "Even modest monitoring efforts can generate substantial amounts of information to proof, digitize, analyze, and interpret (Elzinga *et al.* 1998). Issues of data management are best dealt with early in the planning of a monitoring program. Streamlining and troubleshooting data collection are therefore two key themes to focus upon early in developing a monitoring program."
>
> "Even after a dataset is compiled, issues of reporting, sharing and archiving data also are critical. The value of monitoring data increases substantially as it ages. Properly organizing and archiving today's monitoring data can permit that opportunity for future wildlife biologists."
>
> "Explicit documentation of sampling protocols must be made so that new personnel can repeat measurements exactly. Proven and standardized methods should be implemented that are not susceptible to the vagaries of technology change or changing observer ability (Ringold *et al.* 1996). Use of such protocols also increases the comparability of monitoring data among different sites and programs and thereby generates a valuable spatial component as well as true replication on a large scale."
>
> "An effective communication strategy is necessary to ensure that the results of the monitoring program reach the broadest number of individuals involved in management processes."

Performance Indicators

Schoonmaker and Luscombe (2005) state "A monitoring program begins with clearly defined goals that are linked directly to the state wildlife strategies. Goals should generate action, performance indicators and targets, which can then be used to assess if goals were met and whether they need to be adapted to changing conditions." Table 6-4 provides potential conservation actions and performance indicators.

Table 6-4. Potential conservation actions and performance indicators for the CWCS in New Mexico.

Action Category	Performance Indicators
Technical Guidance and Endangered Species Sections Environmental Review	Number of responses generated as compared to the number of project request notifications received; number of site visits; number of projects with NMDGF recommendations implemented; number of new habitat guideline papers developed; number of consultations with project proponents
Surveys, research	Number of new SGCN or key habitat research projects funded and/or initiated; number of new survey sites and/or acreage surveyed, sampled or inventoried; development of revised comprehensive SGCN species accounts; number of conservation action affects detected on SGCN and or/key habitats; number of publications in scientific peer-reviewed journals generated on SGCN, key habitats
Monitoring	Number of new species or suites of species to receive recovery plans, monitoring programs, and/or monitoring protocols developed; number of population recovery targets achieved; number of species for which trend information can be assessed, number of adaptive management decisions made based on outcomes of conservation actions; number of database users; volume of new information input into database; database user evaluation comments
Conservation Actions (Terrestrial)	Number of conservation actions implemented; acreage of successful habitat improvement/restoration projects successfully implemented; number of state- and/or federally-listed species populations replicated; acreage of habitat in key habitat areas protected; number of improved measures of terrestrial species abundance/diversity indices documented
Conservation Actions (Aquatic)	Number of stream/river miles restored; number of improved measures of water flow regimes and/or aquatic species abundance/diversity/indices measured
Program coordination, cooperation	Number of new partners enjoined in CWCS efforts; number of new sources of non-federal match funding dedicated to SWG and LIP programs; number of contacts/information changes documented
Education/outreach efforts	Number of media/outreach products developed; number of publications generated; members of the public reached; number of teachers/students/and/or other members of the public to attend "Citizen Scientist" educational efforts; number of presentations given; number of outreach/educational programs offered; number of positive comments generated; number of successful public survey results obtained

Chapter 7
IMPLEMENTATION, REVIEW, AND REVISION

Element 6 requires that the CWCS describe periodic review procedures at intervals not to exceed ten years. **Element 7** requires plans for coordinating CWCS development, implementation, review and revision with federal, state, and local agencies and Indian tribes that manage significant land and water areas or administer programs that affect the conservation of SGCN or their habitats. **Element 8** affirms that broad public participation is an essential element of developing and implementing the CWCS. This chapter addresses future compliance with these requirements. We also describe herein our planned strategic approach to integrating monitoring and adaptive management into our implementation, review and revision processes (**Element 5**).

IMPLEMENTATION

The CWCS development process has provided a strategic level of planning that has identified numerous prioritized conservation actions and many research, survey, and monitoring needs (See Chapters 4,5, and 6). To facilitate implementation, this broad array of strategic intentions will be further narrowed through an executive staff process to comprise a wildlife action plan focused upon near-term conservation priorities.

> The operational planning process will include appropriate coordination with local, state, and federal government agencies, tribes and NGOs. These entities will be given opportunities to influence and participate in project design and implementation.

NMDGF will next employ an operational planning process by which to propose, select, schedule, design, staff, and budget the site or area-specific projects through which these strategic conservation priorities will be implemented (Fig. 7-1). A standardized project proposal format will be employed such that all projects will include performance measures and targets pertaining to SGCN, their habitats, or desired new information (in the case of research, survey, or monitoring projects) as well as mechanisms by which to monitor progress and evaluate project effectiveness. Project implementation, reporting, and evaluation will occur in accordance with a prescribed schedule and, where found necessary, component actions will be modified to improve their effectiveness. The operational planning process will include appropriate coordination with local, state, and federal government agencies and tribes and afford these entities, NGOs and interested publics opportunities to influence and participate in project design and implementation. NMDGF will encourage partnering and cost sharing with these interests and, where necessary, engage and oversee contractors to implement some projects. We will strive to integrate, to the extent practical, with action planning associated with Forest Management Plans of the USFS, Resource Management Plans of the BLM, Integrated Natural Resource Management Plans of the DoD, and land use allocation by the State Land Office; a collective endeavor that addresses habitat and wildlife resources on about 46% of New Mexico's land surface. Formal agency and tribal coordination and public involvement approaches for implementation will follow the processes described below under Review and Revision. We will keep all interests aware of implementation progress through periodic announcements and events, including an annual CWCS for New Mexico Progress Report.

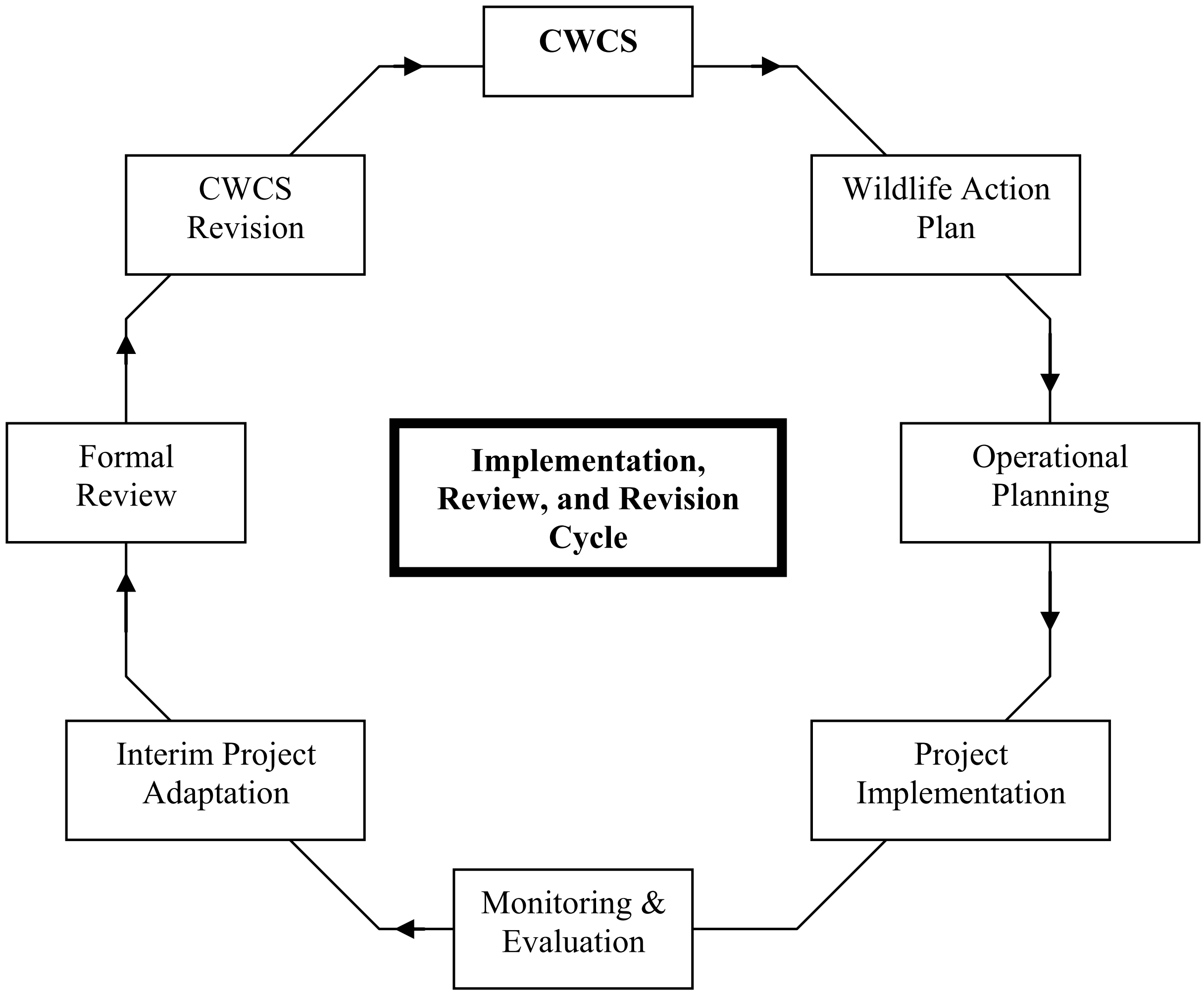


Figure 7-1. New Mexico's CWCS Implementation, Review, and Revision Cycle.

REVIEW AND REVISION

The CWCS is intended to be responsive to changing conditions and new information and will occasionally and appropriately be amended in accordance with the principles of adaptive management and in collaboration with partners and interested publics. Implementation projects containing actions that have been found to be ineffective will be similarly modified on an as-needed basis. In addition to such interim amendments, NMDGF will conduct a formal review and revision process during year seven of the first CWCS implementation cycle and year five in cycles thereafter (Fig. 7-1), to openly and collaboratively:

- Assess progress toward desired outcomes.
- Evaluate effectiveness of conservation actions.

- Assess CWCS currency with respect to new information or changing circumstances.
- Identify needs for revision in next CWCS iteration.
- Revise the CWCS.

Agency Coordination and Public Involvement

NMDGF directly controls only 166,000 acres of the 55% of New Mexico's land area under federal, state, and tribal jurisdiction. The ability to substantially affect a significant proportion of key habitats and associated SGCN will therefore depend upon close collaboration with federal, state, and tribal governments. To facilitate future coordination, review, and revision of the CWCS, NMDGF will request that each federal, state, or local agency identify a designated contact person who can help plan and facilitate communication with appropriate agency program personnel at multiple staff levels within each agency. This effort will be the joint responsibility of the Planner in the Director's office and the Chief of the Public Information and Outreach Division. For tribal coordination, NMDGF will follow the Governor's established protocol (Executive Order No. 2005-004) for government-to-government relationships between the tribes and the state that recognizes both the sovereignty of tribal governments and the state citizenship of tribal members. Accordingly, tribal leaders will be notified in writing of opportunities for participation in the implementation, review or revision of the CWCS and invited to designate appropriate persons to represent them in consultation and collaboration. Through this process NMDGF will coordinate with federal, state, local and tribal governments (Appendix R) to review and revise the CWCS as well as design, implement, and fund monitoring, survey, research, and other projects that are consistent with our respective conservation interests.

Approximately 45% of New Mexico lands are under private management and many private entities also have economic and recreational interests in the use of state and federal lands. The inter-related challenges of maintaining a healthy economy, accommodating growth, and conserving the state's biodiversity can only be overcome through the awareness and support of a broad spectrum of decision makers and publics. NMDGF will therefore broadly publicize its intent to review and revise the CWCS early in the decision-making process so that interested and affected parties may be well aware of the consideration, express their views, exchange information, and otherwise influence decisions (Appendix R).

Effective agency coordination or public participation and the avoidance of conflict require that all parties possess a clear understanding of the sequence and timing of the decision-making process and make relevant contributions at appropriate stages. Therefore, in planning both agency coordination and public involvement NMDGF will:

1. Establish a clear decision-making process for the CWCS implementation, review or revision event under consideration.
2. Designate stages within the decision-making process warranting inter-agency coordination or public involvement.

3. For each stage so designated, specify the objectives for involving agencies or publics and identify the information exchange required to attain coordination or involvement objectives.

4. Identify agencies and publics that are affected by or who might otherwise inform or collaborate in the decision-making process.

5. Identify special considerations that may influence the process through which the information exchange might best be accomplished and design and implement appropriate techniques or events.

MONITORING AND ADAPTIVE MANAGEMENT IN IMPLEMENTATION, REVIEW AND REVISION PROCESSES

To support and inform its implementation, review and revision processes, as well as interim decision making, the Department will adopt a philosophy of adaptive management in which monitoring and evaluation are employed to measure progress toward stated biological outcomes, to become aware of and adapt to changing information or conditions, and to inform necessary revisions of any conservation actions shown to be ineffective. To facilitate this process of managing for results (IAFWA, 2003) we will:

- Adopt a glossary of managing for results terminology (inputs, outcomes, performance measures, targets, etc.) consistent with that of New Mexico's performance based budgeting system.

- Establish performance measures and targets appropriate to the geographic scale upon which our conservation actions and selected projects are based and against which progress with respect to conserving SGCN and key habitats and the effectiveness of conservation actions can be evaluated.

- Include within all projects, mechanisms to monitor short-term results of component actions and evaluate progress toward intended project outcomes in terms of the status of SGCN and the condition of key habitats. Where appropriate, such evaluation mechanisms will make use of monitoring initiatives already in place and opportunities for mutually beneficial partnering.

- Include within all projects an implementation, evaluation, and semi-annual reporting schedule to prevent organizational drift due to attrition or preoccupation with current issues and to assure that timely adaptive management decisions are made.

- Appoint a team of program supervisors to annually review project implementation and evaluation reports, determine whether implementation schedules and performance targets are being met, and consider any new project-relevant information regarding the status and trends of SGCN and key habitats.

- Adapt conservation actions as necessary to overcome ineffectiveness, accommodate new information or changing conditions, and attain performance targets.

- Build upon potentially relevant monitoring activities currently conducted by federal, state, or local agencies, tribes, universities, non-government organizations, or individuals by partnering in a collaborative interagency monitoring project to track trends in the status of SGCN and the condition of their habitats. The project will inventory ongoing monitoring initiatives, build compatible, consistent, and coordinated monitoring protocols that will be useful at a range of scales and for multiple purposes, and develop and conduct joint complementary monitoring operations. Examples of potentially relevant monitoring initiatives and protocols are provided in Chapter 6.

- Partner with the Center for Applied Spatial Ecology, New Mexico Cooperative Fish and Wildlife Research Unit, NMSU, to maintain a dynamic database to collect, store, manage, and report monitoring data at a scale appropriate to that of our performance measures and targets and to facilitate communication across other agencies' information systems. The database will link project performance targets to conservation actions and key habitats to facilitate reporting and evaluation in an appropriate spatial context.

- Integrate, where possible, with existing internal or external data management efforts to facilitate local, regional, and national assessments and seek opportunities for partnerships and cost sharing in database development and maintenance.

- Establish the CWCS-specific infrastructure, oversight, roles, and responsibilities necessary to coordinate implementation, monitoring, review and revision processes internally and externally.

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APPENDICES

Appendix A. Glossary of terms used in the CWCS for New Mexico.

Abiotic resource use- The use of non-living natural resources. Example: Hard-rock mining.

Adaptive management- A natural resources management process under which planning, implementation, monitoring, research, evaluation and incorporation of new information are combined into a management approach that is: 1) based on scientific findings and the needs of society, 2) treats management actions as experiments, 3) acknowledges the complexity of these systems and scientific uncertainty, 4) uses the resulting new information to modify future management methods and policy.

Aestivate- The condition of dormancy or torpidity.

Agrading- Increasing the surface substrate level.

Alien species- Species that are not native to the ecosystem.

Amphibians- An animal, such as a frog, which lives both on land and in water but must lay its eggs in water.

Animal herbivory- The utilization of forage by domestic or wild animals.

Anostracans- An order of crustaceans, known as fairy shrimps or brine shrimps. These organisms range up to about 4 in (100 mm) long, but usually are much smaller.

Anthropogenically induced- Human-caused impacts to natural resources.

Apache Highlands Ecoregion- The Apache Highlands Ecoregion extends from central to southeastern Arizona into southwestern New Mexico, the western tip of Texas, and northern Mexico. This ecoregion contains 30 million acres and is known as the Sky Islands Mountain Archipelago.

Area-sensitive species- Those species whose life history needs are influenced by spatial requirements.

Argillic soil horizon- A subsurface soil layer with an accumulation of silicate clays.

Arizona-New Mexico Mountains Ecoregion- The Arizona-New Mexico Mountains Ecoregion encompasses the highlands of eastern Arizona and central and western New Mexico covering 29 million acres of land.

Arthropod- Any of numerous invertebrate animals of the phylum Arthropoda, including insects, crustaceans and arachnids that are characterized by a chitinous exoskeleton and a segmented body to which jointed appendages are articulated in pairs.

Astatic- Without orientation or directional characteristics. Having no tendency to change position.

ATV- All-terrain vehicle.

Avifauna- The birds of a specific region or period.

Avulsion- Any sudden cutting off or separation of land or abrupt change in the course of a stream, generally by breaking through the stream banks during a flood, including the formation of a cutoff meander.

Bajadas- A geologic term for alluvial sediment at the base of a mountain that extends outward from the base onto the floodplain. A bajada can be relatively narrow, made up of two or three fans, or a broad, extensive, continuous alluvial slope consisting of many fans. The upper boundary of a bajada is commonly merged with a pediment slope.

Bioaccumulation- The accumulation of toxic substances, such as a chemicals or metals, found in tissues of a living organism.

Biodiversity- The number and variety of organisms found within a specified region.

Biomass- The total mass of living material within a given unit of area.

Biological soil crusts- The community of organisms living at the surface of desert soils. Major components are cyanobacteria, green algae, microfungi, mosses, liverworts and lichens.

BISON-M database- A natural history database containing information on 1,166 species in New Mexico and some species in Arizona and Colorado.

Bivalves- A mollusc (such as a clam) that has a shell consisting of two hinged sides.

Boolean overlay- An analysis procedure in GIS where overlaying spatial data from two or more map layers are used to create new features and attributes from the input layers. Spatial data layers are queried using Boolean logic and may be added, subtracted, or multiplied together.

Boreal forest- Post-pliocene conifer forests consisting of pines and fir trees.

Bosque- The forested area on either side of a watercourse, typically in the Southwest.

Brackish- Water having less salt than seawater, but still undrinkable.

Branchiopods- Any of various aquatic crustaceans of the subclass Branchiopoda, such as the fairy shrimp and water fleas, characterized by a segmented body and flattened, leaf-like thoracic appendages.

Calcic soil horizon- A mineral soil horizon with evidence of calcium carbonate deposition.

Caliche- A layer of hard alkaline clay typically used for road building.

Canadian Watershed- The Canadian River tributaries flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado. The watershed encompasses about one-sixth the land area of the state or about 44,000 km^2.

Carrying capacity- Maximum number of individuals that a given environment can support without detrimental effects.

Catostomids- The sucker family that includes approximately 61 species in the order.

Cypriniformes- They are the most abundant fishes in North America.

Centrarchids- The sunfish family that includes 30 species in the order Perciformes. The bass and crappie are included, and all are native only to North America.

Channel morphology- The shape and structure of streambeds.

Channelization- Mechanical redirecting of a streambed in more or less a straight line.

Chaparral- A vegetation type consisting of mostly evergreen shrubs.

Charismatic species-Larger high-profile animals that receive a lot of public attention.

Chihuahuan Desert Ecoregion- The Chihuahuan Desert Ecoregion encompasses approximately 70 million hectares from San Luis Potosi, Mexico north to southwestern Texas and southern New Mexico.

Chihuahuan Mesquite Upland Scrub- An upland shrubland that is concentrated in the grassland-shrubland transition in foothills and piedmont slopes in the Chihuahuan Desert.

Chihuahuan Semi-Desert Grasslands- A broadly defined desert grassland, mixed shrub-succulent or xeromorphic tree savanna that is typical of the Borderlands of Arizona, New Mexico and northern Mexico.

Cienega- A swampy or typically wet area supported by a spring or other water source. Also called a wetland, marsh, or swamp.

Closed basins- A geographic area where all surface waters drain into a basin with no outlet.

Colorado Plateau Ecoregion- The Colorado Plateau Ecoregion encompasses the four corners region of Arizona, Colorado, New Mexico, and Utah. The ecoregion contains 48.5 million acres.

Consumptive biological use- The removal of biological natural resources such as hunting, fishing and logging.

Coppicing- To cut back or burn woody plants to produce shoots from stumps or roots.

CRP-Conservation Reserve Program- A federal program that pays landowners not to produce agricultural products or graze livestock on a piece of land.

Crustaceans- Predominantly aquatic arthropods of the class Crustacea, including lobsters, crabs, shrimps, and barnacles, characteristically having a segmented body, a chitinous exoskeleton, and paired, jointed limbs.

CWCS- Comprehensive Wildlife Conservation Strategy.

Cyprinidae- The minnow and carp family, which makes up the largest fish family with more than 2000 species in the order Cypriniformes.

Cyst- An encapsulated minute organism that is going into a resting or spore-like stage.

Degrading- Lower the surface substrate level.

Disjunct habitats- Habitats that are not adjacent, separated.

Delisting- Removing a species from either the federal or state Endangered Species list.

Desertification- The transformation of arable or habitable land to desert, by a change in climate or destructive land use.

Desiccation- Permanent decrease or disappearance of water caused by a variety of factors.

Diapausing- Periods of physiologically enforced dormancy between periods of activity.

Disjunctive- Serving to separate or divide.

Disturbance forests- An event that causes change in structure and composition of the forest such as fire, flood, wind, or earthquake or mortality caused by insect, disease outbreaks, Forest disturbance can also be human caused such as timber harvest.

Dog-hair thickets-Very dense stands of same-age woody vegetation. Optimum growth by individual plants is inhibited by the environmental conditions.

Ecological sustainability- A human system of natural resource use that can be maintained into the future. The long-term maintenance of ecosystem functions, processes and services over time.

Ecosystem- A plant and animal community together with its environment, functioning as a unit.

Ecosystem integrity- Incorporates the concept of functioning and resilience. Five goals of ecosystem integrity were defined by Grumbine (1994) including 1) maintaining viable populations 2) ecosystem representation 3) maintaining ecological processes 4) protecting evolutionary potential and 5) accommodating human uses.

Edaphic conditions- Relating to soil, especially as it affects living organisms.

Embayment- A bay or bay like shape.

Endangered species- Species present in such small numbers that they are at risk of extinction.

Endemic- Native to or confined to a certain region.

Endorheic basin- A drainage pattern of a basin or region in which little or none of the surface drainage leaves the basin.

Ephemeral- Channel or basin which carries water only during and immediately after periods of rainfall or snowmelt.

Ephemeral natural catchments- A natural water collecting feature that accumulates water temporarily after rainfall events.

Episodic fires- Fires that occur at relatively predictable intervals.

Equilibrium- A condition in which all influences are canceled by others, resulting in a stable, balanced, or unchanging system.

Exotic species- Species that are not native to the ecosystem, introduced from elsewhere.

Extant populations- Still existing, not destroyed, lost, or extinct.

Extinct- No longer existing or living.

Extirpated- Locally destroyed or exterminated.

Exurbia- A residential area outside of a city and beyond suburbia.

Fauna- The animals of a particular region or period, considered as a group.

Fellfields- The environment of a slope, usually alpine or tundra, where the dynamics of freeze and thaw cycles and wind give rise to characteristic plant forms.

Flora- Plants considered as a group, especially the plants of a particular country, region, or time.

Flow regime- The flow of a moving body of water, i.e. river or stream, over time and space.

Founder population- Typically the original, small population that occurs when a species invades a new area. The concept of a founder population is usually used in a context of subsequent population growth.

Gastropods- Any of various molluscs of the class Gastropoda, such as the snail, slug, cowrie, or limpet, characteristically having a single, usually coiled shell or no shell at all, a ventral muscular foot for locomotion, and eyes and feelers located on a distinct head.

Geographically Isolated Wetlands- Wetlands that are completely surrounded by upland at the local scale. For this document, we've included large endorheic basins, complexes of wetlands within a single basin, and individual isolated wetlands.

Gila Watershed- The watershed lies within southwest New Mexico and is comprised of two major streams, the Gila and San Francisco rivers.

GIS- Geographic Information Systems.

Graminaceous plants- Herbaceous plants with hollow jointed stems and narrow long-bladed leaves commonly known as grasses.

Habitat- The area or environment where an organism or ecological community normally lives or occurs.

Habitat conversion- The alteration or change of a habitat by anthropogenic or natural means.

Headcutting- The early stage of an erosional process that creates arroyos.

Hectare- A metric unit of area equal to 2.471 acres.

Herbaceous plants- Soft, green plant containing little woody tissue.

Herbivorous animals- Plant-eating animals.

Herpetofauna- The reptiles and amphibians of a specific region or period.

Hibernacula roosts- The winter shelter of a hibernating bat colony.

Hybridization- The act of mixing different species or varieties of animals or plants and to produce hybrids.

Hydrologic regimes- The movement of water, including atmospheric, ground and surface water over time, distance and space.

Hydroperiods- The period during which a soil is waterlogged.

Ictaluridae- The North American catfish family in the order Siluriformes containing approx. 45 species. They are scaleless fish and usually dark in color.

Improper grazing practices- Practices that reduce long-term plant and animal productivity, and include both domestic livestock and wildlife.

Incised channel- A land surface that had been deeply down-cut by flowing water forming a narrow channel with steep sides.

Indicative species- Species indicative of New Mexico's diverse life zones, habitats, and natural heritage.

Instream flow-A legal term for allowing water to remain in aquatic habitats to maintain aquatic wildlife.

Intermountain Basins Big Sagebrush Shrubland- Cold desert located in the northwestern to north central part of New Mexico, typically occurring in broad basins between mountain ranges, plains and foothills.

Inundation- Flooding, by the rise and spread of water, of a land surface that is not normally submerged.

Introgression- Backcrossing of hybrids of two plant populations to introduce new genes into wild populations.

Invasive species- An alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Invertebrates- Animals that have no spinal column.

Island Mountains-Mountain ranges isolated by broad valleys in which other ecosystems are located. As a result, the mountain ecosystems are isolated from each other, and species can develop in parallel.

Jurisdictional waters- Waters that fall under the jurisdiction of the Clean Water Act which strives to preserve and protect water quality and quantity. Not all wetlands or waters of the state are considered Jurisdictional Waters.

Keystone species- Species that have a large overall effect on ecosystem structure or function. This effect is disproportionately large relative to species abundance. Examples include prairie dogs, beaver and bison.

Ladder fuels- Plants of varying heights that allows a ground fire to reach the lower branches of trees and spread to the canopy.

Lotic habitats- Habitat in moving water.

Lowhead diversion dam- Diversion dam is a structure placed across a stream to divert water into another waterway. In a lowhead dam, the water above is not high above the turbines, if present.

Macroinvertebrates- Larger-than-microscopic invertebrate animals. Freshwater macroinvertebrates include aquatic insects, worms, clams, snails, and crustaceans.

Madrean Archipelago Region- A biogeographic region that includes south east Arizona, southwest New Mexico, and Northern Mexico and contains floral and faunal influences from the Sierra Madre Mountains of Mexico.

Madrean Encinal- An oak dominated woodland and savanna within the Madrean Archipelago/Sky Island Region.

Madrean Pine-Oak Conifer-Oak Forest and Woodland- A pine/oak forest or woodland, and mixed conifer/oak forest or woodland within the Madrean Archipelago/Sky Island Region.

Marsh- A type of wetland, featuring grasses, rushes, reeds, typhas, sedges, and other herbaceous plants in a context of shallow water.

Mesic riparians- A moist vegetative habitat on the banks of rivers, streams and seeps.

Mesohabitats- Localized physiographic (streams, seeps, cliffs) or physiognomic (forests) features.

Metapopulation- A theory that assumes an environment consists of discrete patches of suitable habitat surrounded by unsuitable habitat, interconnected through patterns of gene flow, extinction, and recolonization.

Mimbres Watershed- The Mimbres River occupies a small basin in southwest within Grant County, New Mexico. It headwaters on west and south-facing slopes of the Black Range, flows southward, and dissipates onto the desert.

Modification of Natural Processes- Drought is a process that influences all habitats in the southwest. Most of forested systems have low resistance to drought. Riparian areas have high likelihood of being altered by extended drought periods.

Molluscanfaunal- The molluscs of a specific region or period.

Molluscs- Aquatic invertebrates, including shellfish and snails, typically having a soft unsegmented body, a mantle, and a protective calcareous shell.

Monsoonal rain events- Weather system that influences large climatic regions. In the Southwest it is typically characterized by heavy summer rainfall and thunderstorms.

Montane- Of, growing in, or inhabiting mountain areas.

Morphology- The form and structure of an organism or one of its parts.

Native species- Originating and adapted in a certain place or region, indigenous.

Natural hydrograph- The physical conditions, boundaries, flow, and related characteristics of surface waters unaffected my man.

Neotropical migrant- Bird species wintering in the tropical regions of the New World that migrate to the temperate regions of North America to breed.

NGOs-Non-government organizations

NMDGF-New Mexico Department of Game and Fish.

Non-consumptive biological use- Recreational enjoyment of biological natural resources such as bird watching, catch-and-release fishing and wildlife photography.

Non-native species- Species that are not native to the ecosystem, introduced from elsewhere.

Noxious weeds-Plant species harmful to living things; injurious to health of other plants or animals.

Obligate- Plants or animals able to exist or survive only in a particular environment or by assuming a particular role.

Palustrine marshes- All nontidal wetlands dominated by trees, shrubs, peristent emergents, emergent mosses or lichen.

PCA- Prairie-chicken Area, owned by the State Game Commission for protection of prairie chicken habitat.

Pecos Watershed- The Pecos River originates in North Central New Mexico. Flowing southward it encompasses 50,022 km^2 within the state.

Perennial- Body of water, which contains water at all times except during extreme drought.

Perennial 1st and 2nd order stream- First and second order perennial streams are typically small headwater streams in New Mexico. First order streams have no other tributaries; they are the start of the river system. Second order streams are formed when at least two first order streams join.

Perennial 3rd and 4th order stream- Third and fourth order streams in New Mexico are typically mid-sized streams, formed when at least two second order streams join, then when at least two third order streams join.

Perennial 5th order stream- Fifth order streams are the largest rivers in New Mexico, including the San Juan, Pecos and Rio Grande. The joining of at least two fourth order streams forms fifth order streams.

Perennial graminoids- Grasses and grass-like plants such as sedges and rushes that grow from the same rootstock every year.

Perennial large reservoir- Perennial large reservoirs in New Mexico are natural or man-made impoundments. They include the lower Pecos River reservoirs and Elephant Butte Reservoir.

Perennial spring/seep/marsh/cienega- Variety of wetted, slow or not flowing habitats. These can vary from deep spring pools to wide, shallow marshes.

Phytophagous insect species- Insects that feed on plants or plant matter.

Piscivores-Habitually feeding on fish; fish-eating.

PIT tags-Passive Infrared Transponder. Tiny identification chips which are harmlessly injected into an animal for permanent identification.

Plant species with C_3 and C_4 photosynthetic pathways- C_3 plants are typically shrubs and trees, while C_4 plants are predominantly grasses. They respond differently to changes in atmospheric gases, temperature and soil moisture.

Playa- A nearly level, generally dry surface in the lowest part of an arid basin with internal drainage. When its surface is covered by shallow water, it is called a playa lake.

Population energetics- The estimated daily energy expenditure that animals need for survival; including energy from food and reserves

Prairie chicken leks- A mating and ritualistic display area for prairie chickens.

Prescribed burning- Planned burning by land management agencies under specific weather conditions to remove excess plant material and replicate natural fire regimes.

Pulmonate- Possessing lungs or lung-like organs.

Ranid frog- Member of a large family of frogs characterized by slightly dilated transverse sacral processes.

Recruitment- Renew or restore the health or vitality of a species with new members.

Reproductive phenology- Periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions.

Reptile- Any of various cold-blooded, usually egg-laying vertebrates such as snakes, lizards or turtles, having an external covering of scales or horny plates and breathing by means of lungs.

Rio Grande Watershed- The state's largest watershed originates in the San Juan Mountains of southern Colorado and flows south through central New Mexico for the entire length of the State.

Riparian habitat- Vegetative habitat on the banks of rivers, streams and seeps.

Riverine- Located on or inhabiting the banks of a river.

Rocky Mountain Alpine-Montane Wet Meadow- High-elevation communities found throughout the Rocky Mountains and intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows.

Rocky Mountain Montane Mixed Conifer Forest and Woodland- Highly variable habitat of the montane zone of the Rocky Mountains. These are mixed-conifer forests occurring at elevations ranging from 1200 to 3300 m.

Salterns- A large, shallow basin where brackish water is evaporated by solar heat, leaving salt deposits.

San Juan Watershed- The San Juan River watershed is almost entirely within San Juan County, New Mexico. The river originates in the San Juan Mountains of southwestern Colorado, enters New Mexico northeast of Farmington, flows westward to exit the state near Four Corners.

Sangre de Cristo cordillera-The Sangre de Cristo mountain range.

Savannas- Grassland habitats broken intermittently by trees or shrubs.

Seep- A generally small area where water percolates slowly to the surface.

Seral stages- A transitory plant community that develops during ecological succession from bare ground to the climax stage.

SGCN- Species of Greatest Conservation Need.

Shin-oak motts-Growing clumps or hedges of shinnery oak.

Solifluction- A type of permanently frozen earthflow often found in Periglacial environments. During warm seasonal periods, the surface layer melts and literally slides across the frozen under layer slowly moving downslope.

Southern Rocky Mountains Ecoregion- The Southern Rocky Mountains Ecoregion encompasses nearly 40 million acres across portions of southern Wyoming, central Colorado, and northern New Mexico.

Southern Shortgrass Prairie Ecoregion- This area is dominated by immense expanses of grasses including blue grama (*Bouteloua gracilis*) and buffalo grass (Buchloe dactyloides).

Species Related Threats- Included threats are commercial trade, indiscriminate harvest, disease, hybridization, competition with native species, pet trade, and fluctuations in prey base.

Sphaeriid- Minute bog beetles, a small family of coleopteran insects in the suborder Myxophaga.

Spring- The location where an underground source of water emerges from the ground.

Stand replacing crown fires- Intense wildfires fires that reach the crowns of trees and kill entire stands; often resulting in a habitat conversion to grasslands or shrublands.

Steppe- A vast semiarid grass-covered plain, as found in southeast Europe, Siberia, and central North America.

Stochastic events- Events occurring at random or variable intervals.

Subalpine- Relating to, inhabiting, or growing in mountainous regions just below the timberline.

SWANCC Supreme Court decision- A Supreme Court decision that limited the U. S. Army Corps of Engineers Clean Water Act authority over a man-made water feature.

SWReGAP- Southwest Regional Gap Analysis Project, a mapping assessment of land cover, habitats, (floral and faunal) biodiversity, and land management status for the five-state region of AZ, CA, NV, NM, and UT. (http://fws-nmcfwru.nmsu.edu/swregap/).

Sympatric- Occurring in the same area.

Talus slopes- Sloping mass of broken rock debris at the base of a cliff.

Tank- Man-made structure designed to hold water from a runoff event or pump.

Taxa- A taxonomic category or group, such as a phylum, order, family, genus, or species

Threatened species- Species of plants or animals of concern that have the potential of becoming endangered.

Tobosa swales- A species of grass that occurs primarily in shallow draws.

Trophic dynamics- Interactions of organisms at different levels of biological organizations within food webs.

Tularosa Watershed- The closed basin covers approximately 13,000 km^2 in south central New Mexico in the northern Chihuahuan Desert.

Ungulates- Animals belonging to the orders Perissodactyla and Artiodactyla composed of the hoofed mammals such as horses, cattle, deer, elk, and pigs.

Uplisting- Elevating a species from threatened to endangered under either the federal or state endangered species list.

Ustic soils- A soil moisture regime where moisture is limited but present at times suitable for plant growth. Ustic soils are moist for more than 180 cumulative days per years or for 90 or more consecutive days.

Vertebrates- Animals that have a spinal column.

Voracious- Having a huge appetite.

Watershed- Region draining into a river, river system, or other body of water.

Western Great Plains Sand Sagebrush- Found mostly in southeastern areas of New Mexico. The climate is semi-arid to arid. Soils are well-drained, deep and sandy. They are associated with dune systems and ancient floodplains.

Western Great Plains Shortgrass Prairie- Found primarily in the eastern third of New Mexico and occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sand to clay.

Wildland urban interface- Zone of contact between human development and undeveloped forested habitats.

Xeric habitat- Habitats found in arid regions.

Xeric riparian areas- Dry vegetative habitat on the banks of rivers, streams and seeps.

Zuni Watershed- Drains about 3,400 km^2 as it flows from its headwaters in west-central New Mexico to the Little Colorado River in Arizona. Continuous flow is absent from the headwaters downstream to the Arizona/New Mexico border. Surface flow is only continuous during heavy spring run-off.

Appendix B. Taxa specific criteria developed by the New Mexico Department of Game and Fish to determine the vulnerability of species for placement onto the SGCN list.

Fish Criteria– A list of all native and nonnative species of fish known to occur (historically and currently) in New Mexico was compiled from Sublette *et al*. (1990), NMDGF files, and the Bison-M database and excluded all non-native fish species, including those introduced as sport fish. Next, all native species extirpated from the State were excluded. The status of remaining species was determined from published sources. Species widespread and common in their native range, including New Mexico, were excluded. Exceptions to these general selection criteria were Pleistocene relicts and species whose natural distributional limits occurred within the political boundaries of New Mexico. The status (distribution and numeric) of the remaining species was evaluated. Additional species were removed if they: 1) had comparatively broad environmental tolerances, 2) were widespread and common where present, and 3) had no known or documented threats to their persistence.

Bird Criteria– The bird team used several available sources in evaluating which of New Mexico's 506 bird species should be included in the state's SGCN list. The bird team included all State and Federal threatened and endangered species, providing those species were regular and viable components of the State's avifauna. Thus, the team excluded the brown pelican (*Pelecanus occidentalis*) (accidental vagrant), whooping crane (*Grus americana*) (experimental population extirpated), and piping plover (*Charadrius melodus*) (accidental vagrant), buff-collared nightjar (*Caprimulgus ridgwayi*) (possibly extirpated) and white-eared hummingbird (*Hylocharis leucotis*) (breeding status uncertain in New Mexico). The team also considered all priority, responsibility, and representative species for each habitat type as identified in the New Mexico Partners in Flight Bird Conservation Plan (2000). In addition, all species of conservation concern were included for each Bird Conservation Region in New Mexico (U.S. Fish and Wildlife Service 2002). Bird lists compiled by the New Mexico Partners in Flight and the U.S. Fish and Wildlife Service were developed from breeding bird surveys and expert opinion. They include all species considered sensitive, vulnerable, declining, or otherwise of concern. Finally, the bird team included several game species and species with high recreation value that had documented population declines or threats to their persistence.

Mammal Criteria– The mammal team employed several criteria for the inclusion of species. First, the team included species listed as State or Federal threatened or endangered. These species were listed because of habitat loss or vulnerability, endemism, and documented population declines. Second, the team selected several small mammal species that are either endemic to New Mexico or have extremely restricted ranges within the State. A few keystone species were included that are disproportionately beneficial to other wildlife species and the maintenance of community integrity. Finally, several species were included due to declining, vulnerable populations and/or unknown population status.

Amphibians and Reptiles Criteria– The amphibian and reptile team consulted numerous scientific publications and employed expert opinions to determine which species should be included as candidate SGCN. Several criteria were employed. First, the team included State or Federal threatened or endangered species. These species were listed because of habitat loss or vulnerability, endemism, and documented population declines. Second, the team selected several amphibian and reptile species that are either endemic to New Mexico or have extremely restricted ranges in New Mexico. Third, commercially exploited species were included. Finally, several species were included due to declining, vulnerable populations and/or unknown population status.

Molluscs and Crustaceans Criteria– The molluscs and crustacean technical group consulted scientific publications and employed expert opinion to identify a comprehensive set of molluscs and crustaceans considered representative of New Mexico's diverse life zones, habitats, and natural heritage. These species included all State and Federally listed threatened or endangered species, Federal candidate and species of concern, and other species of conservation interest (e.g. endemic or vulnerable). For aquatic molluscs, this list consists of a diversity of taxa from bivalves (clams, mussels) to gastropods (aquatic and land snails). Species that were narrowly restricted endemics were included. More common or widespread species were also included if they were considered indicators of ecosystem health and integrity (due to their trophic roles as primary consumers or filter feeders and acute sensitivity to environmental conditions). In New Mexico, approximately 53% (62 of 117 native species and subspecies) of land snail fauna is endemic to the State. This pattern of endemism in the genera Ashmunella, Oreohelix, and Sonorella is responsible for the relatively large number of land snail species among the invertebrate SGCN. Crustaceans likewise play significant functional roles in aquatic ecosystems. Their persistence across the landscape of New Mexico is considered essential to sustain native fish, amphibian, and reptile communities, and populations of resident and migratory birds.

Appendix C. List of species that are indicative of the diversity and health of New Mexico's wildlife (Indicative Species). Selection criteria and total score values are given. Abbreviations for selection criteria precede species list.

Selection Criteria
- D - Declining
- V - Vulnerable
- E - Endemic, Disjunct or Keystone
- W - Wide-ranging
- R - Recreational, Economic, or Charismatic
- T - Total Score is the Sum of the Above Criteria

Common Name	Scientific Name	Selection Criteria					
		D	V	E	W	R	T
Fish							
Smallmouth Buffalo	*Ictiobus bubalus*	1					1
Blue Catfish	*Ictalurus furcatus*	1	1			1	3
Headwater Catfish	*Ictalurus lupus*	1	1	1		1	4
Chihuahua Chub	*Gila nigrescens*	1		1			2
Gila Chub	*Gila intermedia*	1		1			2
Headwater Chub	*Gila nigra*	1	1	1			3
Rio Grande Chub	*Gila pandora*	1					1
Roundtail Chub	*Gila robusta*	1	1	1			3
Speckled Chub	*Macrhybopsis aestivalis aestivalis*	1	1	1			3
Canadian Speckled Chub	*Macrhybopsis aestivalis tetranemus*	1	1	1			3
Southern Redbelly Dace	*Phoxinus erythrogaster*	1	1	1			3
Greenthroat Darter	*Etheostoma lepidum*	1	1	1			3
Pecos Gambusia	*Gambusia nobilis*	1	1	1			3
Rainwater Killifish	*Lucania parva*	1	1				2
Bigscale Logperch (Native pop.)	*Percina macrolepida*	1	1	1			3
Loach Minnow	*Rhinichthys cobitis*	1	1	1			3
Rio Grande Silvery Minnow	*Hybognathus amarus*	1	1	1			3
Suckermouth Minnow	*Phenacobius mirabilis*	1	1				2
Colorado Pikeminnow	*Ptychocheilus lucius*	1	1		1	1	4
Pecos Pupfish	*Cyprinodon pecosensis*	1	1	1		1	4
White Sands Pupfish	*Cyprinodon tularosa*	1	1	1		1	4
Gray Redhorse	*Moxostoma congestum*	1	1	1			3
Mottled Sculpin	*Cottus bairdi*	1	1	1			3
Pecos Bluntnose Shiner	*Notropis simus pecosensis*	1	1	1			3
Rio Grande Shiner	*Notropis jemezanus*	1	1	1			3
Spikedace	*Meda fulgida*	1	1	1			3
Central Stoneroller	*Campostoma anomalum*		1				1
Blue Sucker	*Cycleptus elongatus*	1	1	1			3
Zuni Bluehead Sucker	*Catostomus discobolus yarrowi*	1	1	1			3
Desert Sucker	*Catostomus clarki*	1					1
Razorback Sucker	*Xyrauchen texanus*	1	1		1		3
Rio Grande Sucker	*Catostomus plebeius*	1					1
Sonora Sucker	*Catostomus insignis*	1					1

Appendix C Cont.

Common Name	Scientific Name	Selection Criteria D	V	E	W	R	T
Mexican Tetra	*Astyanax mexicanus*		1				1
Gila Topminnow	*Poeciliopsis occidentalis occidentalis*	1	1				2
Rio Grande Cutthroat Trout	*Oncorhynchus clarki virginalis*	1		1		1	3
Gila Trout	*Oncorhynchus gilae*	1		1		1	3
Birds							
American Bittern	*Botaurus lentiginosus*	1	1	1	1	1	5
Common Black-Hawk	*Buteogallus anthracinus*	1	1	1	1	1	5
Painted Bunting	*Passerina ciris*		1	1	1	1	4
Varied Bunting	*Passerina versicolor*	1	1	1	1	1	5
Neotropic Cormorant	*Phalacrocorax brasilianus*	1	1	1	1		4
Sandhill Crane	*Grus canadensis*	1	1	1	1	1	5
Yellow-Billed Cuckoo	*Coccyzus americanus*	1	1	1	1	1	5
Long-Billed Curlew	*Numenius americanus*	1	1	1	1	1	5
Mourning Dove	*Zenaida macroura*	1	1	1	1	1	5
Northern Pintail	*Anas acuta*	1	1	1	1	1	5
Bald Eagle	*Haliaeetus leucocephalus*		1	1	1	1	4
Golden Eagle	*Aquila chrysaetos*	1	1	1	1	1	5
Aplomado Falcon	*Falco femoralis*	1	1	1	1	1	5
Peregrine Falcon	*Falco peregrinus*		1	1	1	1	4
Olive-Sided Flycatcher	*Contopus cooperi*	1	1		1	1	4
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	1	1	1	1	1	5
Northern Goshawk	*Accipiter gentilis*	1	1	1	1	1	5
Eared Grebe	*Podiceps nigricollis*	1	1	1	1	1	5
Common Ground-Dove	*Columbina passerina*	1	1	1	1	1	5
Blue Grouse	*Dendragapus obscurus*	1	1	1		1	4
Northern Harrier	*Circus cyaneus*	1	1	1	1	1	5
Ferruginous Hawk	*Buteo regalis*	1	1	1	1	1	5
Broad-Billed Hummingbird	*Cynanthus latirostris*	1	1	1	1	1	5
Costa's Hummingbird	*Calypte costae*	1	1	1	1	1	5
Lucifer Hummingbird	*Calothorax lucifer*	1	1	1	1	1	5
Violet-Crowned Hummingbird	*Amazilia violiceps*	1	1	1	1	1	5
White-Faced Ibis	*Plegadis chihi*		1	1	1	1	4
Pinyon Jay	*Gymnorhinus cyanocephalus*	1	1	1	1	1	5
Yellow-Eyed Junco	*Junco phaeonotus*	1	1	1	1	1	5
Thick-Billed Kingbird	*Tyrannus crassirostris*	1	1	1	1	1	5
Hooded Oriole	*Icterus cucullatus*	1	1	1	1	1	5
Osprey	*Pandion haliaetus*		1	1	1	1	4
Boreal Owl	*Aegolius funereus*	1	1	1		1	4
Burrowing Owl	*Athene cunicularia*	1	1	1	1	1	5
Elf Owl	*Micrathene whitneyi*		1	1	1	1	4
Whiskered Screech-Owl	*Otus trichopsis*	1	1	1		1	4
Mexican Spotted Owl	*Strix occidentalis lucida*	1	1	1		1	4
Greater Pewee	*Contopus pertinax*	1	1	1	1	1	5
Wilson's Phalarope	*Phalaropus tricolor*		1	1	1	1	4
Band-tailed Pigeon	*Columba fasciata*	1	1	1	1	1	5
Sprague's Pipit	*Anthus spragueii*		1	1	1	1	4

Selection Criteria
D - Declining
V - Vulnerable
E - Endemic, Disjunct or Keystone
W - Wide-ranging
R - Recreational, Economic, or Charismatic
T - Total Score is the Sum of the Above Criteria

Appendix C Cont.

Common Name	Scientific Name	D	V	E	W	R	T
		Selection Criteria					
Mountain Plover	*Charadrius montanus*	1	1	1	1	1	5
Snowy Plover	*Charadrius alexandrinus*	1	1	1	1	1	5
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	1	1	1		1	4
White-Tailed Ptarmigan	*Lagopus leucurus*	1	1	1		1	4
Montezuma Quail	*Cyrtonyx montezumae*	1	1	1		1	4
Scaled Quail	*Callipepla squamata*	1	1	1		1	4
Painted Redstart	*Myioborus pictus*		1	1	1	1	4
Williamson's Sapsucker	*Sphyrapicus thyroideus*		1	1	1	1	4
Loggerhead Shrike	*Lanius ludovicianus*	1	1	1	1	1	5
Baird's Sparrow	*Ammodramus bairdii*	1	1	1	1	1	5
Botteri's Sparrow	*Aimophila botterii*	1	1	1	1	1	5
Grasshopper Sparrow	*Ammodramus savannarum*	1	1	1	1	1	5
Sage Sparrow	*Amphispiza belli*	1	1	1	1	1	5
Bank Swallow	*Riparia riparia*	1	1	1	1		4
Black Swift	*Cypseloides niger*		1	1	1	1	4
Interior Least Tern	*Sterna antillarum*	1	1	1	1	1	5
Bendire's Thrasher	*Toxostoma bendirei*	1		1	1	1	4
Sage Thrasher	*Oreoscoptes montanus*	1	1	1	1	1	5
Juniper Titmouse	*Baeolophus ridgwayi*	1	1	1		1	4
Abert's Towhee	*Pipilo aberti*	1	1	1		1	4
Elegant Trogon	*Trogon elegans*	1	1	1	1	1	5
Gould's Wild Turkey	*Meleagris gallopavo mexicana*	1	1	1		1	4
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	1	1	1	1	1	5
Bell's Vireo	*Vireo bellii*	1	1	1	1	1	5
Gray Vireo	*Vireo vicinior*	1	1	1	1	1	5
Grace's Warbler	*Dendroica graciae*	1	1	1	1	1	5
Black-Throated Gray Warbler	*Dendroica nigrescens*	1	1	1	1	1	5
Lucy's Warbler	*Vermivora luciae*	1	1	1	1	1	5
Red-faced Warbler	*Cardellina rubrifrons*		1	1	1	1	4
Yellow Warbler	*Dendroica petechia*	1	1	1	1	1	5
Gila Woodpecker	*Melanerpes uropygialis*	1	1	1		1	4
Lewis's Woodpecker	*Melanerpes lewis*	1	1	1	1	1	5
Red-Headed Woodpecker	*Melanerpes erythrocephalus*	1	1	1	1	1	5
Mammals							
Allen's Big-Eared Bat	*Idionycteris phyllotis*		1		1		2
Pocketed Free-Tailed Bat	*Nyctinomops femorosacca*		1		1		2
Lesser Long-Nosed Bat	*Leptonycteris curasoae yerbabuenae*		1		1		2
Mexican Long-Nosed Bat	*Leptonycteris nivalis*		1		1		2
Mexican Long-Tongued Bat	*Choeronycteris mexicana*		1		1		2
Arizona Myotis Bat	*Myotis occultus*		1		1		2
Western Red Bat	*Lasiurus blossevillii*		1		1		2
Spotted Bat	*Euderma maculatum*		1		1		2
Western Yellow Bat	*Lasiurus xanthinus*		1		1		2

Appendix C Cont.

Common Name	Scientific Name	Selection Criteria D	V	E	W	R	T
Black Bear	*Ursus americanus amblyceps*				1	1	2
American Beaver	*Castor canadensis*			1	1	1	3
Organ Mountains Colorado Chipmunk	*Neotamias quadrivittatus australis*		1	1			2
Oscura Mountains Colorado Chipmunk	*Neotamias quadrivittatus oscuraensis*		1	1			2
Penasco Least Chipmunk	*Neotamias minimus atristriatus*		1	1			2
White-Nosed Coati	*Nasua narica*			1		1	2
Mule Deer	*Odocoileus hemionus*	1			1	1	3
Coues' White-Tailed Deer	*Odocoileus virginianus couesi*				1	1	2
Swift Fox	*Vulpes velox velox*		1			1	2
Southern Pocket Gopher	*Thomomys umbrinus emotus*		1	1			2
Snowshoe Hare	*Lepus americanus bairdii*			1			1
Jaguar	*Panthera onca arizonensis*	1	1	1	1	1	5
American Marten	*Martes americana origenes*		1	1		1	3
New Mexico Meadow Jumping Mouse	*Zapus hudsonius luteus*		1	1			2
Northern Pygmy Mouse	*Baiomys taylori ater*		1	1			2
River Otter	*Lontra canadensis*					1	1
Goat Peak Pika	*Ochotona princeps nigrescens*		1	1			2
Black-Tailed Prairie Dog	*Cynomys ludovicianus*		1	1		1	3
Gunnison's Prairie Dog	*Cynomys gunnisoni*		1	1		1	3
White-Sided Jack Rabbit	*Lepus callotis gaillardi*		1	1			2
White-Tailed Jack Rabbit	*Lepus townsendii campanius*		1	1			2
Yellow-Nosed Cotton Rat	*Sigmodon ochrognathus*		1	1			2
Desert Bighorn Sheep	*Ovis canadensis mexicana*		1	1	1	1	4
Rocky Mountain Bighorn Sheep	*Ovis canadensis canadensis*		1	1	1	1	4
Arizona Shrew	*Sorex arizonae*		1	1			2
Least Shrew	*Cryptotis parva*		1	1			2
New Mexico Shrew	*Sorex neomexicanus*		1	1			2
Preble's Shrew	*Sorex preblei*		1	1			2
Abert's Squirrel	*Sciurus aberti*					1	1
Arizona Gray Squirrel	*Sciurus arizonensis arizonensis*			1		1	2
Arizona Montane Vole	*Microtus montanus arizonensis*		1	1			2
Prairie Vole	*Microtus ochrogaster haydenii*		1				1
Mexican Gray Wolf	*Canis lupus baileyi*	1	1	1	1	1	5
Amphibians							
Eastern Barking Frog	*Eleutherodactylus augusti latrans*			1			1
Western Chorus Frog	*Pseudacris triseriata*		1				1
Chiricahua Leopard Frog	*Rana chiricahuensis*			1			1
Lowland Leopard Frog	*Rana yavapaiensis*			1			1
Northern Leopard Frog	*Rana pipiens*			1			1
Plains Leopard Frog	*Rana blairi*			1			1
Rio Grande Leopard Frog	*Rana berlandieri*			1			1
Mountain Tree Frog	*Hyla eximia*		1				1
Jemez Mountain Salamander	*Plethodon neomexicanus*		1	1			2
Sacramento Mountain Salamander	*Aneides hardii*		1	1			2
Tiger Salamander	*Ambystoma tigrinum*		1				1
Arizona Toad	*Bufo microscaphus microscaphus*		1	1			2

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Appendix C Cont.

Common Name	Scientific Name	D	V	E	W	R	T
Western Boreal Toad	*Bufo boreas boreas*	1					1
Colorado River Toad	*Bufo alvarius*			1			1
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*		1	1			2
Reptiles							
Western River Cooter	*Pseudemys gorzugi*	1	1	1			3
Texas Banded Gecko	*Coleonyx brevis*					1	1
California Kingsnake	*Lampropeltis getula californiae*			1		1	2
Gray-banded Kingsnake	*Lampropeltis alterna*					1	1
Sonoran Mountain Kingsnake	*Lampropeltis pyromelana*					1	1
Madrean Alligator Lizard	*Elgaria kingii nobilis*		1				1
Collared Lizard	*Crotaphytus collaris*					1	1
Bleached Earless Lizard	*Holbrookia maculata ruthveni*			1			1
Bunch Grass Lizard	*Sceloporus slevini*	1	1	1			3
Regal Horned Lizard	*Phrynosoma solare*		1				1
Sand Dune Lizard	*Sceloporus arenicolus*	1	1	1			3
Southwestern Fence Lizard	*Sceloporus cowlesi*			1			1
Desert Massasauga	*Sistrurus catenatus edwardsii*	1	1				2
Reticulate Gila Monster	*Heloderma suspectum suspectum*					1	1
Western Diamondback Rattlesnake	*Crotalus atrox*					1	1
New Mexico Ridgenose Rattlesnake	*Crotalus willardi obscurus*		1	1		1	3
Banded Rock Rattlesnake	*Crotalus lepidus klauberi*					1	1
Mottled Rock Rattlesnake	*Crotalus lepidus lepidus*					1	1
Mountain Skink	*Eumeces callicephalus*		1	1			2
Big Bend Slider	*Trachemys gaigeae*		1	1			2
Yaqui Blackhead Snake	*Tantilla yaquia*		1	1			2
Mexican Garter Snake	*Thamnophis eques megalops*	1	1	1			3
Narrowhead Garter Snake	*Thamnophis rufipunctatus rufipunctatus*		1	1			2
New Mexico Garter Snake	*Thamnophis sirtalis dorsalis*		1				1
Milk Snake	*Lampropeltis triangulum*					1	1
Green Rat Snake	*Senticolis triaspis intermedia*		1	1		1	3
Arid Land Ribbon Snake	*Thamnophis proximus diabolicus*		1				1
Blotched Water Snake	*Nerodia erythrogaster transversa*		1	1			2
Ornate Box Turtle	*Terrapene ornata*					1	1
Sonoran Mud Turtle	*Kinosternon sonoriense*		1				1
Western Painted Turtle	*Chrysemys picta bellii*		1				1
Midland Smooth Softshell Turtle	*Apalone mutica mutica*		1				1
Gray-Checkered Whiptail	*Aspidoscelis dixoni*			1			1
Giant Spotted Whiptail	*Aspidoscelis burti*			1			1
Little White Whiptail	*Aspidoscelis gypsi*			1			1

Appendix C Cont.

Common Name	Scientific Name	D	V	E	W	R	T
Molluscs							
Alamosa Springsnail	*Pseudotryonia alamosae*		1	1			2
Blunt Ambersnail	*Oxyloma retusum*	1	1	1			3
Lake Fingernailclam	*Musculium lacustre*			1			1
Long Fingernailclam	*Musculium transversum*			1			1
Swamp Fingernailclam	*Musculium partumeium*			1			1
Texas Hornshell	*Popenaias popeii*	1	1	1			3
Wrinkled Marshsnail	*Stagnicola caperata*		1	1			2
Mountainsnail	*Oreohelix nogalensis*		1	1			2
Bearded Mountainsnail	*Oreohelix barbata*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei concentrica*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei radiata*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei metcalfei*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei hermosensis*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei cuchillensis*		1	1			2
Black Range Mountainsnail	*Oreohelix metcalfei acutidiscus*		1	1			2
Diablo Mountainsnail	*Oreohelix houghi*		1	1			2
Fringed Mountainsnail	*Radiocentrum ferrissi*	1	1	1			3
Hacheta Mountainsnail	*Radiocentrum hachetanum*	1	1	1			3
Magdalena Mountainsnail	*Oreohelix magdalenae*		1	1			2
Mineral Creek Mountainsnail	*Oreohelix pilsbryi*		1	1			2
Morgan Creek Mountainsnail	*Oreohelix swopei*		1	1			2
Pinos Altos Mountainsnail	*Oreohelix confragosa*		1	1			2
Rocky Mountainsnail	*Oreohelix strigosa depressa*			1			1
San Augustin Mountainsnail	*Oreohelix litoralis*		1	1			2
Socorro Mountainsnail	*Oreohelix neomexicana*		1	1			2
Subalpine Mountainsnail	*Oreohelix subrudis*		1	1			2
Paper Pondshell Mussel	*Utterbackia imbecillis*		1	1			2
Lilljeborg's Peaclam	*Pisidium lilljeborgi*		1	1			2
Sangre de Cristo Peaclam	*Pisidium sanguinichristi*	1	1	1			3
Creeping Ancylid Snail	*Ferrissia rivularis*		1	1			2
Pecos Assiminea Snail	*Assiminea pecos*	1	1	1			3
Crestless Column Snail	*Pupilla hebes*			1			1
Amber Glass Snail	*Nesovitrea hammonis electrina*			1			1
Western Glass Snail	*Vitrina pellucida alaskana*		1	1			2
Animas Mountains Holospira Snail	*Holospira animasensis*		1	1			2
Cockerell Holospira Snail	*Holospira cockerelli*		1	1			2
Cross Holospira Snail	*Holospira crossei*		1	1			2
Metcalf Holospira Snail	*Holospira metcalfi*		1	1			2
Vagabond Holospira Snail	*Holospira montivaga*		1	1			2
Texas Liptooth Snail	*Linisa texasiana*		1	1			2
Distorted Metastoma Snail	*Metastoma roemeri*		1	1			2
Chupadera Pyrg Snail	*Pyrgulopsis chupaderae*	1	1	1			3
Gila Pyrg Snail	*Pyrgulopsis gilae*		1	1			2
New Mexico Hotspring Pyrg Snail	*Pyrgulopsis thermalis*		1	1			2
Pecos Pyrg Snail	*Pyrgulopsis pecosensis*	1	1	1			3
Roswell Pyrg Snail	*Pyrgulopsis roswellensis*	1	1	1			3

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Appendix C Cont.

Common Name	Scientific Name	D	V	E	W	R	T
		Selection Criteria					
Socorro Pyrg Snail	*Pyrgulopsis neomexicana*	1	1	1			3
Whitewashed Radabotus Snail	*Radbotus dealbatus neomexicanus*			1			1
New Mexico Ramshorn Snail	*Pecosorbis kansasensis*		1	1			2
Marsh Slug Snail	*Deroceras heterura*		1	1			2
Apache Snaggletooth Snail	*Gastrocopta cochisensis*		1	1			2
Ruidoso Snaggletooth Snail	*Gastrocopta armifera ruidosensis*		1	1			2
Shortneck Snaggletooth Snail	*Gastrocopta dalliana dalliana*		1	1			2
Sonoran Snaggletooth Snail	*Gastrocopta prototypus*		1	1			2
Spruce Snail	*Microphysula ingersolli*			1			1
Star Gyro Snail	*Gyraulus crista*		1	1			2
Obese Thorn Snail	*Carychium exiguum*			1			1
Three-Toothed Column Snail	*Pupilla sonorana*		1	1			2
Northern Treeband Snail	*Humboldtiana ultima*		1	1			2
Koster's Tryonia Snail	*Juturnia kosteri*	1	1	1			3
Bishop Tubeshell Snail	*Coelostemma pyrgonasta*		1	1			2
Vallonia Snail	*Vallonia sonorana*		1	1			2
Blade Vertigo Snail	*Vertigo milium*	1	1	1			3
Cross Vertigo Snail	*Vertigo modesta ingersolli*		1	1			2
Heart Vertigo Snail	*Vertigo hinkleyi*		1	1			2
Ovate Vertigo Snail	*Vertigo ovata*	1	1	1			3
Tapered Vertigo Snail	*Vertigo elatior*		1	1			2
Animas Talussnail	*Sonorella animasensis*		1	1			2
Big Hatchet Mountain Talussnail	*Sonorella hachitana hachitana*	1	1	1			3
Dona Ana Talussnail	*Sonorella todseni*		1	1			2
Florida Mountain Talussnail	*Sonorella hachitana flora*		1	1			2
Franklin Mountain Talussnail	*Sonorella metcalfi*		1	1			2
Organ Mountain Talussnail	*Sonorella orientis*		1	1			2
Peloncillo Mountain Talussnail	*Sonorella hachitana peloncillensis*		1	1			2
San Luis Mountains Talussnail	*Sonorella n. sp.*		1	1			2
Tularosa springsnail	*Juturnia tularosae*		1	1			2
Woodlandsnail	*Ashmunella rhyssa altissima*		1	1			2
Woodlandsnail	*Ashmunella amblya cornudasensis*		1	1			2
Woodlandsnail	*Ashmunella kochii sanandresensis*		1	1			2
Woodlandsnail	*Ashmunella kochii caballoensis*	1	1	1			3
Woodlandsnail	*Ashmunella auriculata*		1	1			2
Animas Peak Woodlandsnail	*Ashmunella animasensis*		1	1			2
Big Hatchet Woodlandsnail	*Ashmunella mearnsii*	1	1	1			3
Black Range Woodlandsnail	*Ashmunella cockerelli cockerelli*		1	1			2
Black Range Woodlandsnail	*Ashmunella cockerelli argenticola*		1	1			2
Black Range Woodlandsnail	*Ashmunella cockerelli perobtusa*		1	1			2
Capitan Woodlandsnail	*Ashmunella pseudodonta*		1	1			2
Cook's Peak Woodlandsnail	*Ashmunella macromphala*		1	1			2
Whitewater Creek Woodlandsnail	*Ashmunella danielsi danielsi*		1	1			2
Whitewater Creek Woodlandsnail	*Ashmunella danielsi dispar*		1	1			2

Appendix C Cont.

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Dry Creek Woodlandsnail	*Ashmunella tetrodon tetrodon*		1	1			2
Dry Creek Woodlandsnail	*Ashmunella tetrodon mutator*		1	1			2
Dry Creek Woodlandsnail	*Ashmunella tetrodon inermis*		1	1			2
Dry Creek Woodlandsnail	*Ashmunella tetrodon animorum*		1	1			2
Dry Creek Woodlandsnail	*Ashmunella tetrodon fragilis*		1	1			2
Florida Mountain Woodlandsnail	*Ashmunella walkeri*		1	1			2
Franklin Mountain Woodlandsnail	*Ashmunella pasonis pasonis*		1	1			2
Goat Mountain Woodlandsnail	*Ashmunella harrisi*		1	1			2
Guadalupe Woodlandsnail	*Ashmunella carlbadensis*		1	1			2
Hacheta Grande Woodlandsnail	*Ashmunella hebardi*	1	1	1			3
Iron Creek Woodlandsnail	*Ashmunella mendax*		1	1			2
Jemez Woodlandsnail	*Ashmunella ashmuni*			1			1
Maple Canyon Woodlandsnail	*Ashmunella todseni*		1	1			2
Mogollon Woodlandsnail	*Ashmunella mogollonensis*		1	1			2
Mount Riley Woodlandsnail	*Ashmunella rileyensis*		1	1			2
Organ Mountain Woodlandsnail	*Ashmunella organensis*		1	1			2
Salinas Peak Woodlandsnail	*Ashmunella salinasensis*		1	1			2
San Andres Woodlandsnail	*Ashmunella kochii kochii*		1	1			2
Sangre de Cristo Woodlandsnail	*Ashmunella thomsoniana*			1			1
Sierra Blanca Woodlandsnail	*Ashmunella rhyssa rhyssa*		1	1			2
Silver Creek Woodlandsnail	*Ashmunella binneyi*		1	1			2
Crustaceans							
Akali Fairy Shrimp	*Branchinecta mackini*		1	1			2
BLNWR cryptic species Amphipod	*Gammarus sp.*		1	1			2
Sit. Bull Sp. cryptic species Amphipod	*Gammarus sp.*		1	1			2
Noel's Amphipod	*Gammarus desperatus*	1	1	1			3
Beavertail Fairy Shrimp	*Thamnocepahlus platyurus*		1	1			2
Brine Shrimp	*Artemia franciscana*		1	1			2
Colorado Fairy Shrimp	*Branchinecta coloradensis*		1	1			2
Conchas Crayfish	*Orconectes deanae*		1	1			2
No Common Name	*Procambarus simulans simulans*		1	1			2
Northern Crayfish (Canadian River)	*Orconectes virilis*		1	1			2
Great Plains Fairy Shrimp	*Streptocephalus texanus*		1	1			2
Socorro Isopod	*Thermosphaeroma thermophilum*		1	1			2
Knobblip Fairy Shrimp	*Eubranchipus bundyi*		1	1			2
Mexican Beavertail Fairy Shrimp	*Thamnocepahlus mexicanus*		1	1			2
Moore's Fairy Shrimp	*Streptocephalus moorei*		1	1			2
No Common Name	*Cyzicus sp. (mexicanus?)*		1	1			2
No Common Name	*Eocyzicus concavus*		1	1			2
No Common Name	*Eocyzicus digueti*		1	1			2
No Common Name	*Eulimnadia antlei*		1	1			2
No Common Name	*Eulimnadia cylindrova*		1	1			2
No Common Name	*Eulimnadia diversa*		1	1			2
No Common Name	*Eulimnadia follismilis*		1	1			2
No Common Name	*Eulimnadia texana*		1	1			2
No Common Name	*Lepidurus lemmoni*		1	1			2

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No Common Name	*Lynceus brevifrons*		1	1			2
No Common Name	*Streptocephalus n. sp. 1*		1	1			2
No Common Name	*Streptocephalus n. sp. 2*		1	1			2
Packard's Fairy Shrimp	*Branchinecta packardi*		1	1			2
Tadpole Shrimp	*Triops sp.*		1				1
Sideswimmers / Scuds	*Hyalella spp.*		1	1			2
Sublette's Fairy Shrimp	*Phallocryptis subletti*		1	1			2
Versatile Fairy Shrimp	*Branchinecta lindahli*		1	1			2
Other Arthropods[1]							
Arachnids (Arachnida)							
Cave Obligate Harvestman	*Texella longistyla*						
Cave Obligate Harvestman	*Texella welbourni*						
Cave Obligate Mite	*Ceuthothrombium cavaticum*		1	1			2
Cave Obligate Pseudoscorpion	*Aphrastochthonius pachysetus*						
Cave Obligate Pseudoscorpion	*Chitrella welbourni*						
Cave Obligate Pseudoscorpion	*Neoallochernes incertus*						
Peloncillo Scorpion	*Diplocentrus pelloncillensis*			1			1
Jemez Spider	*Hypochilus jemez*			1			1
Centipede (Chilopoda)							
Cave Obligate Centipede	*Thalkethops grallatrix*			1		1	2
Millipedes (Diplopoda)							
Cave Obligate Millipede	*Speodesmus tuganbius*						
Chihuahuan Millipede	*Comanchelus chihuanus*			1	1		2
Springtails (Entognatha)							
Cave Obligate Springtail	*Oncopodura prietoi*						
Cave Obligate Springtail	*Pseudosinella vita*						
Cave Obligate Springtail	*Tomocerus grahami*						
Insects (Insecta)							
Ant	*Aphaenogaster punctaticeps*			1			1
Ant	*Leptothorax bestelmeyeri*			1			1
Ant	*Leptothorax colleenae*			1			1
Capulin Mountain Arctic	*Oeneis alberta capulinensis*	1	1	1			3
Andrenid Bee	*Andrena mimbresensis*			1			1
Andrenid Bee	*Andrena neffi*			1			1
Andrenid Bee	*Andrena vogleri*			1			1
Andrenid Bee	*Perdita austini*			1			1
Andrenid Bee	*Perdita biparticeps*			1			1
Andrenid Bee	*Perdita claripennis*			1			1
Andrenid Bee	*Perdita geminata*			1			1
Andrenid Bee	*Perdita grandiceps*			1			1
Andrenid Bee	*Perdita maculipes*			1			1
Andrenid Bee	*Perdita mesillensis*			1			1
Andrenid Bee	*Perdita senecionis*			1			1

Appendix C Cont.

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		Selection Criteria					
Andrenid Bee	*Perdita sidae*			1			1
Andrenid Bee	*Perdita tarda*			1			1
Andrenid Bee	*Perdita viridinotata*			1			1
Centris Bee	*Centris caesalpinneae*		1	1			2
Leaf-Cutter Bee	*Osmia phenax*			1			1
Leaf-Cutter Bee	*Osmia prunorum*			1			1
Mason Bee	*Osmia watsonii*		1	1			2
Melittid Bee	*Hesperapis elegantulus*			1			1
Bark Beetle	*Pityophthorus franseriae*			1			1
Bark Beetle	*Pityophthorus torridus*			1			1
Anthony Blister Beetle	*Lytta mirifica*		1	1			2
Bonita Diving Beetle	*Deronectes neomexicanus*		1	1			2
Southwestern Hercules Beetle	*Dynastes granti*		1	1		1	3
Glorious Jewel Beetle	*Chrysis gloriosa [Plusiotus]*		1	1		1	3
Leconte's Jewel Beetle	*Chrysis lecontei [Plusiotus]*		1	1		1	3
Wood's Jewel Beetle	*Chrysis woodi [Plusiotus]*		1	1		1	3
Animas Minute Moss Beetle	*Limnebius aridus*	1	1	1			3
Tiger Beetle	*Amblychila picolomini*		1	1			2
Glittering Tiger Beetle	*Cicindela fulgoris albilata*			1		1	2
Guadalupe Mountains Tiger Beetle	*Cicindela politula*[2]			1		1	2
Los Olmos Tiger Beetle	*Cicindela nevadica olmosa*		1	1		1	3
Maricopa Tiger Beetle	*Cicindela oregona maricopa*	1	1	1		1	4
Nevada Tiger Beetle	*Cicindela nevadica tubensis*	1	1	1		1	4
Buchholz's Boisduval's Blue	*Plebejus icarioides buchholzi*			1			1
Mogollon Rim Greenish Blue	*Plebejus saepiolus gertschi*		1				1
Buckmoth	*Hemileuca (chinatiensis) comwayae*			1		1	2
Buckmoth	*Hemileuca (nevadensis) artemis*		1	1		1	3
Buckmoth	*Hemileuca hera magnifica*		1	1		1	3
Mountain Checkered-Skipper	*Pyrgus xanthus*		1	1			2
Chalcedon Checkerspot	*Euphydryas chalcedona chuskae*			1			1
Sacramento Mountain Checkerspot	*Euphydryas chalcedona cloudcrofti*		1				1
Tawny Crescent	*Phyciodes batesii*			1			1
Mescalero Camel Cricket	*Ceuthophilus mescalero*		1	1			2
Organ Mountains Camel Cricket	*Ceuthophilus leptopus*		1	1			2
Rodent Burrow Camel Cricket	*Ceuthophilus fissicaudus*		1	1			2
Gypsum Sand-Treader Camel Cricket	*Diahinioides larvale*			1			1
White Sands Sand-Treader Camel Cricket	*Ammobaenetes arenicolus*			1			1
Carlsbad Cave Cricket	*Ceuthophilus longipes*		1	1			2
Mescalero Sands Jerusalem Cricket	*Stenopelmatus mescaleroensis*		1	1			2
Arroyo Darner	*Aeshna dugesi*		1	1			2
Ellis Dotted-Blue	*Euphilotes ellisi*		1	1			2
Spalding's Dotted-Blue	*Euphilotes spaldingi*		1	1			2
Bleached Skimmer Dragonfly	*Libellula omposite*		1	1			2
Scudder's Duskywing	*Erynnis scudderi*			1			1
Dusty-Wing	*Bidesmida morrisoni*			1			1
Desert Elfin	*Callophrys fotis*			1			1
Bee Fly	*Caenotus inornatus*			1			1

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Bee Fly	*Caenotus minutus*			1			1
Long-Legged Fly	*Chrysotus parvulus*			1			1
Long-Legged Fly	*Neurigona perbrevis*			1			1
Long-Legged Fly	*Thinophilus magnipalpus*			1			1
Mydas Fly	*Rhaphiomidas painteri*		1	1			2
Robber Fly	*Efferia cuervana*		1	1			2
Robber Fly	*Furcilla delicatula*			1			1
Robber Fly	*Megaphorus lascrucensis*		1	1			2
Soldier Fly	*Adoxomyia albopilosa*			1			1
Capitan Mountains Fritillary	*Speyeria hesperis capitanensis*			1			1
Freija Fritillary	*Boloria freija*		1				1
Nitocris Fritillary	*Speyeria nokomis nitocris*		1	1		1	3
Nokomis Fritillary	*Speyeria nokomis nokomis*		1	1			2
Raton Mesa Fritillary	*Speyeria hesperis ratonensis*			1			1
Silver-bordered Fritillary	*Boloria selene*		1				1
Grasshopper	*Aeoloplides rotundipennis*			1			1
Grasshopper	*Cibolacris samalayucae*		1	1			2
Band-Winged Grasshopper	*Trimerotropis salina*		1	1			2
Hebard's Blue-Winged Desert Grasshopper	*Anconia hebardi*		1	1			2
Lichen Grasshopper	*Leuronotina ritensis*			1			1
Nevada Point-Headed Grasshopper	*Acrolophitus nevadensis*		1	1	1		3
Shotwell's Range Grasshopper	*Shotwellia isleta*		1	1			2
Spur-Throat Grasshopper	*Melanoplus calidus*			1			1
Spur-Throat Grasshopper	*Melanoplus magdalenae*			1			1
Ilavia Hairstreak	*Fixsenia (Satyrium) ilavia*	1	1	1			3
Poling's Hairstreak	*Satyrium polingi organensis*		1				1
Sandia Hairstreak	*Callophrys mcfarlandi*					1	1
Oslar's Soapberry Hairstreak	*Phaeostrymon alcestis oslari*			1			1
Xami Hairstreak	*Callophrys xami*			1			1
Mescalero Sands Katydid	*Plagiostira mescaleroensis*			1			1
Mayfly	*Hexagenia bilineata*						
Mayfly	*Homoeonuria alleni*		1	1			2
Mayfly	*Lachlania dencyannae*						
Mayfly	*Leucrocuta petersi*						
Arizona Metalmark	*Calephelis rawsoni arizonensis*		1	1			2
Moth	*Carales arizonensis*						
Borer Moth	*Papaipema dribi*		1	1			2
Albarufan Dagger Moth	*Acronicta albarufa*						
Geometrid Moth	*Nemoria rindgei*						
Noctuid Moth	*Schinia zuni*						
Notodontid Moth	*Euhyparpax rosea*			1			1
Notodontid Moth	*Oligocentria delicata*			1		1	2
Pyralid Moth	*Loxostege quaestoralis*						
Tiger Moth	*Alexicles aspersa*						

Appendix C Cont.

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		Selection Criteria					
Mirid Plant Bug	*Phytocoris alamogordo*			1			1
Dashed Ringtail	*Erpetogomphus heterodon*		1			1	2
Cassus Roadside-Skipper	*Amblyscirtes cassus*		1	1			2
Large Roadside-Skipper	*Amblyscirtes exoteria*		1	1			2
Slaty Roadside-Skipper	*Amblyscirtes nereus*		1	1			2
Texas Roadside-Skipper	*Amblyscirtes texanae*		1	1			2
Silkmoth	*Automeris io neomexicana*			1			1
Zephyr Eyed Silkmoth	*Automeris zephyria*			1			1
Apache Skipper	*Hesperia woodgatei*		1	1			2
Arizona Agave Borer Skipper	*Agathymus neumoegeni neumoegeni*			1			1
Carlsbad Agave Borer Skipper	*Agathymus neumoegeni carlsbadensis*			1			1
Viola’s Yucca Borer Skipper	*Megathymus ursus violae*			1			1
Western Crossline Skipper	*Polites origenes rhena*		1	1			2
Deva Skipper	*Atrytonopsis deva*		1	1			2
Mary's Giant Skipper	*Agathymus mariae*			1			1
Poling's Giant Skipper	*Agathymus polingi*			1			1
Ursine Giant Skipper	*Megathymus ursus ursus*			1			1
Western Hobomok Skipper	*Poanes hobomok wetona*		1	1			2
Moon-Marked Skipper	*Atrytonopsis lunus*		1	1			2
Sunrise Skipper	*Adopaeoides prittwitzi*		1				1
Yuma Skipper	*Ochlodes yuma anasazi*			1			1
Four-Spotted Skipperling	*Piruna polingii*		1	1			2
Arizona Snaketail	*Ophiogomphus arizonicus*		1			1	2
West's Primrose Sphinx	*Euproserpinus wiesti*						
Vega Sphinx	*Proserpinus vega*			1			1
Stonefly	*Capnia caryi*						
Stonefly	*Isoperla jewetti*	1	1	1			3
Stonefly	*Taenionema jacobii*						
Arizona Viceroy	*Limenitis archippus obsoleta*	1	1		1		3
Tarantula Hawk Wasp	*Pepsis formosa*					1	1
Velvet Ant Wasp	*Dasymutilla homole*			1			1
Velvet Ant Wasp	*Odontophotopsis augusta*			1			1
Velvet Ant Wasp	*Odontophotopsis grata*			1			1
Chiricahua White	*Neophasia terlootii*		1				1

[1] Other arthropods (arachnida, chilopoda, diplopoda, entognatha, and insecta) were not placed on the indicative species list using the above selection criteria due to lack of knowledge on most species.

[2] ssp. petrophila, viridimonticola, barbarannae

Appendix D. Codes and descriptions of 89 SWReGAP land cover types that occur in New Mexico (NatureServe 2004).

Code	Description
S002	*Rocky Mountain Alpine Bedrock and Scree* - This ecological system is restricted to the highest elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes, with nonvascular- (lichen) dominated communities. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. There can be sparse cover of forbs, grasses, lichens and low shrubs.
S004	*Rocky Mountain Alpine Fell-Field* - This ecological system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. Small areas are represented in the westside of the Okanagan Ecoregion in the eastern Cascades. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Most fell-field plants are cushioned, or matted, frequently succulent, flat to the ground in rosettes and often densely haired and thickly cutinized. Plant cover is 15-50%, while exposed rocks make up the rest. Fell-fields are usually within or adjacent to alpine tundra dry meadows. Common species include Arenaria capillaris, Carex albonigra, Carex paysonis, Geum rossii, Kobresia myosuroides, Minuartia obtusiloba, Myosotis asiatica, Paronychia pulvinata, Phlox pulvinata, Sibbaldia procumbens, and Silene acaulis.
S006	*Rocky Mountain Cliff and Canyon* - This ecological system of barren and sparsely vegetated landscapes (generally <10% plant cover) is found from foothill to subalpine elevations on steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. It is located throughout the Rocky Mountains and northeastern Cascade Ranges in North America. Also included are unstable scree and talus slopes that typically occur below cliff faces. There may be small patches of dense vegetation, but it typically includes scattered trees and/or shrubs. Characteristic trees includes species from the surrounding landscape, such as Pseudotsuga menziesii, Pinus ponderosa, Pinus flexilis, Populus tremuloides, Abies concolor, Abies lasiocarpa, or Pinus edulis and Juniperus spp. at lower elevations. There may be scattered shrubs present, such as species of Holodiscus, Ribes, Physocarpus, Rosa, Juniperus, and Jamesia americana, Mahonia repens, Rhus trilobata, or Amelanchier alnifolia. Soil development is limited, as is herbaceous cover.
S008	*Western Great Plains Cliff and Outcrop* - This system includes cliffs and outcrops throughout the Western Great Plains Division. Substrate can range from sandstone and limestone, which can often form bands in the examples of this system. Vegetation is restricted to shelves, cracks and crevices in the rock. However, this system differs from Western Great Plains Badlands (CES303.663) in that often the soil is slightly developed and less erodible, and some grass and shrub species can occur at greater than 10%. Common species in this system include short shrubs such as Rhus trilobata and Artemisia longifolia and mixedgrass species such as Bouteloua curtipendula and Bouteloua gracilis and Calamovilfa longifolia. Drought and wind erosion are the most common natural dynamics affecting this system.
S010	*Colorado Plateau Mixed Bedrock Canyon and Tableland* - This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included is vegetation of unstable scree and talus slopes that typically occurs below cliff faces. Widely scattered trees and shrubs may include Abies concolor, Pinus edulis, Pinus flexilis, Pinus monophylla, Juniperus spp., Artemisia tridentata, Purshia tridentata, Cercocarpus ledifolius, Ephedra spp., Holodiscus discolor, and other species often common in adjacent plant communities.

Appendix D Cont.

Code Description

S011 *Inter-Mountain Basins Shale Badlands* - This widespread ecological system of the intermountain western U.S. is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from marine shales but also includes substrates derived from siltstones and mudstones (clay). Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs, e.g., Atriplex corrugata, Atriplex gardneri, Artemisia pedatifida, and herbaceous vegetation.

S012 *Inter-Mountain Basins Active and Stabilized Dunes* - This ecological system occurs in Intermountain West basins and is composed of unvegetated to moderately vegetated (<10-30% plant cover) active and stabilized dunes and sandsheets. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe composed of Achnatherum hymenoides, Artemisia filifolia, Artemisia tridentata ssp. tridentata, Atriplex canescens, Ephedra spp., Coleogyne ramosissima, Ericameria nauseosa, Leymus flavescens, Prunus virginiana, Psoralidium lanceolatum, Purshia tridentata, Sporobolus airoides, Tetradymia tetrameres, or Tiquilia spp.

S013 *Inter-Mountain Basins Volcanic Rock and Cinder Land* - This ecological system occurs in the intermountain western U.S. and is limited to barren and sparsely vegetated volcanic substrates (generally <10% plant cover) such as basalt lava (malpais), basalt dikes with associated colluvium, basalt cliff faces and uplifted "backbones," tuff, cinder cones or cinder fields. It may occur as large-patch, small-patch and linear (dikes) spatial patterns. Vegetation is variable and includes a variety of species depending on local environmental conditions, e.g., elevation, age and type of substrate. At montane and foothill elevations scattered Pinus ponderosa, Pinus flexilis, or Juniperus spp. trees may be present. Shrubs such as Ephedra spp., Atriplex canescens, Eriogonum corymbosum, Eriogonum ovalifolium, and Fallugia paradoxa are often present on some lava flows and cinder fields. Species typical of sand dunes such as Andropogon hallii and Artemisia filifolia may be present on cinder substrates.

S014[4] *Inter-Mountain Basins Greasewood Wash* - This barren and sparsely vegetated (generally <10% plant cover) ecological system is restricted to intermittently flooded streambeds and banks that are often lined with shrubs such as Sarcobatus vermiculatus, Ericameria nauseosa, Fallugia paradoxa, and/or Artemisia cana ssp. cana (in more northern and mesic stands). Grayia spinosa may dominate in the Great Basin. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats. Typically it includes patches of saltgrass meadow where water remains for the longest periods. Soils are generally less alkaline than those found in the playa system. Desert scrub species (e.g., Acacia greggii, Prosopis spp.), that are common in the Mojave, Sonoran and Chihuahuan desert washes, are not present. This type can occur in limited portions of the southwestern Great Plains.

S015[4] *Inter-Mountain Basins Playa* - This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found in the intermountain western U.S. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata, and/or Atriplex spp.

S016 *North American Warm Desert Bedrock Cliff and Outcrop* - This ecological system is found from subalpine to foothill elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus slopes that typically occur bellow cliff faces. Species present are diverse and may include Bursera microphylla, Fouquieria splendens, Nolina bigelovii, Opuntia bigelovii, and other desert species, especially succulents. Lichens are predominant lifeforms in some areas. May include a variety of desert shrublands less than 2 ha (5 acres) in size from adjacent areas.

Appendix D Cont.

Code Description

S018 *North American Warm Desert Active and Stabilized Dunes* - This ecological system occurs across the warm deserts of North America and is composed of unvegetated to sparsely vegetated (generally <10% plant cover) active dunes and sandsheets derived from quartz or gypsum sands. Common vegetation includes Ambrosia dumosa, Abronia villosa, Eriogonum deserticola, Larrea tridentata, Pleuraphis rigida, Poliomintha spp., Prosopis spp., Psorothamnus spp., Artemisia filifolia, and Rhus microphylla. Dune "blowouts" and subsequent stabilization through succession are characteristic processes.

S019 *North American Warm Desert Volcanic Rockland* - This ecological system occurs across the warm deserts of North America and is restricted to barren and sparsely vegetated (<10% plant cover) volcanic substrates such as basalt lava (malpais) and tuff. Vegetation is variable and includes a variety of species depending on local environmental conditions, e.g., elevation, age and type of substrate. Typically scattered Larrea tridentata, Atriplex hymenelytra, or other desert shrubs are present.

S020[4] *North American Warm Desert Wash* - This ecological system is restricted to intermittently flooded washes or arroyos that dissect bajadas, mesas, plains and basin floors throughout the warm deserts of North America. Although often dry, the intermittent fluvial processes define this system, which are often associated with rapid sheet and gully flow. This system occurs as linear or braided strips within desert scrub- or desert grassland-dominated landscapes. The vegetation of desert washes is quite variable ranging from sparse and patchy to moderately dense and typically occurs along the banks, but may occur within the channel. The woody layer is typically intermittent to open and may be dominated by shrubs and small trees such as Acacia greggii, Brickellia laciniata, Baccharis sarothroides, Chilopsis linearis, Fallugia paradoxa, Hymenoclea salsola, Hymenoclea monogyra, Juglans microcarpa, Prosopis spp., Psorothamnus spinosus, Prunus fasciculata, Rhus microphylla, Salazaria mexicana, or Sarcobatus vermiculatus.

S021 *North American Warm Desert Pavement* - This ecological system occurs throughout much of the warm deserts of North America and is composed of unvegetated to very sparsely vegetated (<2% plant cover) landscapes, typically flat basins where extreme temperature and wind develop ground surfaces of fine to medium gravel coated with "desert varnish." Very low cover of desert scrub species such as Larrea tridentata or Eriogonum fasciculatum is usually present. However, ephemeral herbaceous species may have high cover in response to seasonal precipitation, including Chorizanthe rigida, Eriogonum inflatum, and Geraea canescens.

S022[4] *North American Warm Desert Playa* - This system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found across the warm deserts of North America, extending into the extreme southern end of the San Joaquin Valley in California. Playas form with intermittent flooding, followed by evaporation, leaving behind a saline residue. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. Subsoils often include an impermeable layer of clay or caliche. Large desert playas tend to be defined by vegetation rings formed in response to salinity. Given their common location in wind-swept desert basins, dune fields often form downwind of large playas. In turn, playas associated with dunes often have a deeper water supply. Species may include Allenrolfea occidentalis, Suaeda spp., Distichlis spicata, Eleocharis palustris, Oryzopsis spp., Sporobolus spp., Tiquilia spp., or Atriplex spp. Ephemeral herbaceous species may have high cover periodically. Adjacent vegetation is typically Sonora-Mojave Desert Mixed Salt Desert Scrub (CES302.749), Chihuahuan Mixed Salt Desert Scrub (CES302.017), Gulf of California Coastal Mixed Salt Desert Scrub (CES302.015), Baja California del Norte Gulf Coast Ocotillo-Limberbush-Creosotebush Desert Scrub (CES302.014), or Chihuahuan Creosotebush Basin Desert Scrub (CES302.731).

S023 *Rocky Mountain Aspen Forest and Woodland* - This widespread ecological system is more common in the southern and central Rocky Mountains, but occurs throughout much of the western U.S. and north into Canada, in the montane and subalpine zones. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily is limited by the length of the growing season or low temperatures. These are upland forests

Appendix D Cont.
Code Description

S023 Cont. and woodlands dominated by Populus tremuloides without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Associated shrub species include Symphoricarpos spp., Rubus parviflorus, Amelanchier alnifolia, and Arctostaphylos uva-ursi. Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests.

S024[4] *Rocky Mountain Bigtooth Maple Ravine Woodland* - This ecological system occurs in cool ravines, on toeslopes and slump benches associated with riparian areas in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico and the Trans-Pecos of Texas. Substrates are typically rocky colluvial or alluvial soils with favorable soil moisture. These woodlands are dominated by Acer grandidentatum but may include mixed stands codominated by Quercus gambelii or with scattered conifers. Some stands may include Acer negundo or Populus tremuloides as minor components. It also occurs on steeper, north-facing slopes at higher elevations, often adjacent to Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818) or Rocky Mountain Aspen Forest and Woodland (CES306.813).

S025 *Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland* - This ecological system occurs throughout the Rocky Mountains on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the central and northern Rocky Mountains and northeastern Great Basin mountains where dominated by Pinus flexilis, particularly along the Front Range north into Canada. Sites are harsh, exposed to desiccating winds, with rocky substrates and a short growing season that limit plant growth. Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly westfacing slopes and exposed ridges. Calcareous substrates are important for Pinus flexilis-dominated communities in the northern Rocky Mountains and possibly elsewhere. The open tree canopy is often patchy and is strongly dominated by Pinus flexilis or Pinus aristata with the latter restricted to southern Colorado, northern New Mexico and the San Francisco Mountains in Arizona. In the northern Rockies and northern Great Basin, Pinus albicaulis is found in some occurrences. Other trees such as Juniperus spp., Pinus contorta, Pinus ponderosa, or Pseudotsuga menziesii are occasionally present. Arctostaphylos uva-ursi, Cercocarpus ledifolius, Juniperus communis, Mahonia repens, Purshia tridentata, Ribes montigenum, or Vaccinium spp. may form an open shrub layer in some stands. The herbaceous layer, if present, is generally sparse and composed of xeric graminoids, such as Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis, Festuca thurberi, or Pseudoroegneria spicata, or more alpine plants.

S028 *Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland* - Engelmann spruce and subalpine fir forests comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico and the Intermountain region. They are the matrix forests of the subalpine zone, with elevations ranging from 1275 m in its northern distribution to 3355 m in the south (4100-11,000 feet). They often represent the highest elevation forests in an area. Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snowpacks are deep and late-lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. Despite their wide distribution, the tree canopy characteristics are remarkably similar, with Picea engelmannii and Abies lasiocarpa dominating either mixed or alone. Pseudotsuga menziesii may persist in occurrences of this system for long periods without regeneration. Pinus contorta is common in many occurrences, and patches of pure Pinus contorta are not uncommon, as well as mixed conifer/Populus tremuloides stands. In some areas, such as Wyoming, Picea engelmannii-dominated forests are on limestone or dolomite, while nearby codominated spruce-fir forests are on granitic or volcanic rocks. Xeric species may include Juniperus communis, Linnaea borealis, Mahonia repens, or Vaccinium scoparium. More northern occurrences often have taller, more mesic shrub and herbaceous species, such as Empetrum nigrum, Rhododendron albiflorum, and Vaccinium membranaceum. Disturbance includes occasional blow-down, insect outbreaks and stand-replacing fire.

Appendix D Cont.
Code Description

S030 *Rocky Mountains Subalpine Mesic Spruce-fir Forest and Woodland* - This is a high-elevation system of the Rocky Mountains, dominated by Picea engelmannii and Abies lasiocarpa. It extends eastward into the northeastern Olympic Mountains and the northeastern side of Mount Rainier in Washington. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. These forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. In the Olympics and northern Cascades, the climate is more maritime than typical for this system, but due to the lower snowfall in these rainshadow areas, summer drought may be more significant than snowpack in limiting tree regeneration in burned areas. Picea engelmannii is rare in these areas. Mesic understory shrubs include Menziesia ferruginea, Vaccinium membranaceum, Rhododendron albiflorum, Amelanchier alnifolia, Rubus parviflorus, Ledum glandulosum, Phyllodoce empetriformis, and Salix spp. Herbaceous species include Actaea rubra, Maianthemum stellatum, Cornus canadensis, Erigeron eximius, Gymnocarpium dryopteris, Rubus pedatus, Saxifraga bronchialis, Tiarella spp., Lupinus arcticus ssp. subalpinus, Valeriana sitchensis, and graminoids Luzula glabrata var. hitchcockii or Calamagrostis canadensis. Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire.

S031 *Rocky Mountains Lodgepole Pine Forest* - This system is widespread in upper montane to subalpine elevations of the Rocky Mountains, Intermountain region, and north into the Canadian Rockies. These are subalpine forests where the dominance of Pinus contorta is related to fire history and topo-edaphic conditions. Following stand-replacing fires, Pinus contorta will rapidly colonize and develop into dense, even-aged stands. Most forests in this ecological system are early- to mid-successional forests which developed following fires. Some Pinus contorta forests will persist on sites that are too extreme for other conifers to establish. These include excessively well-drained pumice deposits, glacial till and alluvium on valley floors where there is cold air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash. Soils supporting these forests are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. These forests are dominated by Pinus contorta with shrub, grass, or barren understories. Sometimes there are intermingled mixed conifer/Populus tremuloides stands with the latter occurring with inclusions of deeper, typically fine-textured soils. The shrub stratum may be conspicuous to absent; common species include Arctostaphylos uva-ursi, Ceanothus velutinus, Linnaea borealis, Mahonia repens, Purshia tridentata, Spiraea betulifolia, Spiraea douglasii, Shepherdia canadensis, Vaccinium caespitosum, Vaccinium scoparium, Vaccinium membranaceum, Symphoricarpos albus, and Ribes spp. In southern interior British Columbia, this system is usually an open lodgepole pine forest found extensively between 500 and 1600 m elevation in the Columbia range. In the Interior Cedar Hemlock and Interior Douglas-fir zones, Tsuga heterophylla or Pseudotsuga menziesii may present.

S032[5] *Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland* - This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40-60 cm) with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. Pseudotsuga menziesii and Abies concolor are most frequent, but Pinus ponderosa may be present to codominant. Pinus flexilis is common in Nevada. Pseudotsuga menziesii forests occupy drier sites, and Pinus ponderosa is a common codominant. Abies concolor-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. Picea pungens is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii, and Festuca arizonica. This system was

Appendix D Cont.

Code Description

S032[5] Cont. undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval.

S034[5] *Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland* - These are mixed-conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland (CES306.823). Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently. Pseudotsuga menziesii and Abies concolor are most common canopy dominants, but Picea engelmannii, Picea pungens, or Pinus ponderosa may be present. This system includes mixed conifer/Populus tremuloides stands. A number of cold-deciduous shrub species can occur, including Acer glabrum, Acer grandidentatum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Robinia neomexicana, Vaccinium membranaceum, and Vaccinium myrtillus. Herbaceous species include Bromus ciliatus, Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia virescens, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale, and Thalictrum fendleri. Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions.

S035[3] *Madrean Pine-Oak Forest and Woodland* - This system occurs on mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. These forests and woodlands are composed of Madrean pines (Pinus arizonica, Pinus engelmannii, Pinus leiophylla, or Pinus strobiformis) and evergreen oaks (Quercus arizonica, Quercus emoryi, or Quercus grisea) intermingled with patchy shrublands on most mid-elevation slopes (1500-2300 m elevation). Other tree species include Cupressus arizonica, Juniperus deppeana, Pinus cembroides, Pinus discolor, Pinus ponderosa (with Madrean pines or oaks), and Pseudotsuga menziesii. Subcanopy and shrub layers may include typical encinal and chaparral species such as Agave spp., Arbutus arizonica, Arctostaphylos pringlei, Arctostaphylos pungens, Garrya wrightii, Nolina spp., Quercus hypoleucoides, Quercus rugosa, and Quercus turbinella. Some stands have moderate cover of perennial graminoids such as Muhlenbergia emersleyi, Muhlenbergia longiligula, Muhlenbergia virescens, and Schizachyrium cirratum. Fires are frequent with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent ground fires on gentle slopes.

S036 *Rocky Mountain Ponderosa Pine Woodland* - This very widespread ecological system is most common throughout the cordillera of the Rocky Mountains, from the Greater Yellowstone region south. It is also found in the Colorado Plateau region, west into scattered locations in the Great Basin, and in the Black Hills of South Dakota and Wyoming. These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in northern Wyoming to 2800 m in the New Mexico mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Northern Rocky Mountain Ponderosa Pine Woodland (CES306.030) in the eastern Cascades, Okanagan and northern Rockies regions receives winter and spring rains, and thus has a greater spring "green-up" than the drier woodlands in the central Rockies. Pinus ponderosa (primarily var. scopulorum and var. brachyptera) is the predominant conifer; Pseudotsuga menziesii, Pinus edulis, and Juniperus spp. may be present in the tree canopy. The understory is usually shrubby, with Artemisia nova, Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Symphoricarpos oreophilus, Prunus virginiana, Amelanchier alnifolia, and Rosa spp. common species. Pseudoroegneria spicata and species of Hesperostipa, Achnatherum, Festuca, Muhlenbergia, and Bouteloua are some of the common grasses. Mixed fire regimes and ground fires of variable return intervals maintain these woodlands, depending on climate, degree of soil development, and understory density.

Appendix D Cont.

Code Description

S038 *Southern Rocky Mountain Pinyon-Juniper Woodland* - This southern Rocky Mountain ecological system occurs on dry mountains and foothills in southern Colorado east of the Continental Divide, in mountains and plateaus of north-central New Mexico, and extends out onto limestone breaks in the southeastern Great Plains. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Pinus edulis and/or Juniperus monosperma dominate the tree canopy. Juniperus scopulorum may codominate or replace Juniperus monosperma at higher elevations. Stands with Juniperus osteosperma are representative the Colorado Plateau and are not included in this system. In southern transitional areas between Madrean Pinyon-Juniper Woodland (CES305.797) and Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835) in central New Mexico, Juniperus deppeana becomes common. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau and include Artemisia bigelovii, Cercocarpus montanus, Quercus gambelii, Achnatherum scribneri, Bouteloua gracilis, Festuca arizonica, or Pleuraphis jamesii.

S039 *Colorado Plateau Pinyon-Juniper Woodland* - This ecological system occurs in dry mountains and foothills of the Colorado Plateau region including the Western Slope of Colorado to the Wasatch Range, south to the Mogollon Rim and east into the northwestern corner of New Mexico. It is typically found at lower elevations ranging from 1500-2440 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Pinus edulis and/or Juniperus osteosperma dominate the tree canopy. In the southern portion of the Colorado Plateau in northern Arizona and northwestern New Mexico, Juniperus monosperma and hybrids of Juniperus spp may dominate or codominate the tree canopy. Juniperus scopulorum may codominate or replace Juniperus osteosperma at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species include Arctostaphylos patula, Artemisia tridentata, Cercocarpus intricatus, Cercocarpus montanus, Coleogyne ramosissima, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Bouteloua gracilis, Pleuraphis jamesii, or Poa fendleriana. This system occurs at higher elevations than Great Basin Pinyon-Juniper Woodland (CES304.773) and Colorado Plateau shrubland systems where sympatric.

S042 *Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland* - This ecological system occurs on montane slopes and plateaus in Utah, western Colorado, northern Arizona, eastern Nevada, southern Idaho and western Wyoming. Elevations range from 1700 to 2800 m. Occurrences are typically on gentle to steep slopes on any aspect but are often found on clay-rich soils in intermontane valleys. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials but most typically occur on sedimentary rocks. The tree canopy is composed of a mix of deciduous and coniferous species, codominated by Populus tremuloides and conifers, including Pseudotsuga menziesii, Abies concolor, Abies lasiocarpa, Picea engelmannii, Picea pungens, Pinus contorta, Pinus flexilis, and Pinus ponderosa. As the occurrences age, Populus tremuloides is slowly reduced until the conifer species become dominant. Common shrubs include Amelanchier alnifolia, Prunus virginiana, Acer grandidentatum, Symphoricarpos oreophilus, Juniperus communis, Paxistima myrsinites, Rosa woodsii, Spiraea betulifolia, Symphoricarpos albus, or Mahonia repens. Herbaceous species include Bromus carinatus, Calamagrostis rubescens, Carex geyeri, Elymus glaucus, Poa spp., and Achnatherum, Hesperostipa, Nassella, and/or Piptochaetium spp. (= Stipa spp.), Achillea millefolium, Arnica cordifolia, Asteraceae spp., Erigeron spp., Galium boreale, Geranium viscosissimum, Lathyrus spp., Lupinus argenteus, Mertensia arizonica, Mertensia lanceolata, Maianthemum stellatum, Osmorhiza berteroi (= Osmorhiza chilensis), and Thalictrum fendleri. Most occurrences at present represent a late-seral stage of aspen changing to a pure conifer occurrence. Nearly a hundred years of fire suppression and livestock grazing have converted much of the pure aspen occurrences to the present-day aspen-conifer forest and woodland ecological system.

Appendix D Cont.

Code	Description
S042 cont.	In order to capture important habitat characteristics of an aspen-mixed conifer ecological system for vertebrate habitat modeling, SWReGAP land cover mappers mapped patches of aspen-mixed conifer stands outside its normal range into the Southern Rocky Mountains. In the Southern Rocky Mountains, this system occurs as small to large patches of aspenmixed conifer woodland that could also be interpreted as seral stands within several Rocky Mountain conifer forest and woodland systems including: S028 Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland, S030 Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland, S031 Rocky Mountain Lodgepole Pine Forest, S032 Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland, S034 Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland, and S036 Rocky Mountain Ponderosa Pine Woodland (see individual descriptions for additional information).
S046	*Rocky Mountain Gambel Oak-Mixed Montane Shrubland* - This ecological system occurs in the mountains, plateaus and foothills in the southern Rocky Mountains and Colorado Plateau including the Uinta and Wasatch ranges and the Mogollon Rim. These shrublands are most commonly found along dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 2000 to 2900 m in elevation, and are often situated above pinyon-juniper woodlands. Substrates are variable and include soil types ranging from calcareous, heavy, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. The vegetation is typically dominated by Quercus gambelii alone or codominant with Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Robinia neomexicana, Symphoricarpos oreophilus, or Symphoricarpos rotundifolius. There may be inclusions of other mesic montane shrublands with Quercus gambelii absent or as a relatively minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics. Density and cover of Quercus gambelii and Amelanchier spp. often increase after fire.
S047	*Rocky Mountains Lower Montane-Foothill Shrubland* - This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Wyoming, and west into the Intermountain region. These shrublands occur between 1500-2900 m elevations and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. It is common where Quercus gambelii is absent such as the northern Colorado Front Range and in drier foothills and prairie hills. This system is generally drier than Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818), but may include mesic montane shrublands where Quercus gambelii does not occur. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including Amelanchier utahensis, Cercocarpus montanus, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, or Yucca glauca. In northeastern Wyoming and north into adjacent Montana, Cercocarpus ledifolius, usually with Artemisia tridentata, is the common dominant shrub. Grasses are represented as species of Muhlenbergia, Bouteloua, Hesperostipa, and Pseudoroegneria spicata. Fires play an important role in this system as the dominant shrubs usually have a severe dieback, although some plants will stump sprout. Cercocarpus montanus requires a disturbance such as fire to reproduce, either by seed sprout or root crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth.
S048[1]	*Western Great Plains Sandhill Sagebrush Shrubland* - This system is found mostly in south-central areas of the Western Great Plains Division ranging from the Nebraska Sandhill region south to central Texas, although some examples may reach as far north as the Badlands of South Dakota. The climate is semi-arid to arid for much of the region in which this system occurs. This system is found on somewhat excessively to excessively well-drained, deep sandy soils that are often associated with dune systems and ancient floodplains. In some areas, this system may actually occur as a result of overgrazing in Western Great Plains Tallgrass Prairie (CES303.673) or Western Great Plains Sand Prairie (CES303.670). This system is characterized by a sparse to moderately dense woody layer dominated by Artemisia filifolia. Associated species can vary with geography, amount and season of precipitation, disturbance and soil texture. Several graminoid species such as Andropogon hallii, Schizachyrium scoparium, Sporobolus cryptandrus,

Appendix D Cont.

Code Description

S048[1] Cont. Calamovilfa gigantea, Hesperostipa comata, and Bouteloua spp. can be connected with this system. Other shrub species may also be present including Yucca glauca, Prosopis glandulosa, Rhus trilobata, and Prunus angustifolia. In the southern range of this system, Quercus havardii may also be present and represents one succession pathway that develops over time following a disturbance. Quercus havardii is able to resprout following a fire and thus may persist for long periods of time once established. Fire and grazing are the most important dynamic processes for this type, although drought stress can impact this system significantly in some areas. Overgrazing can lead to decreasing dominance of some of the grass species such as Andropogon hallii, Calamovilfa gigantea, and Schizachyrium scoparium.

S051[1] *Madrean Encinal* - Madrean Encinal occurs on foothills, canyons, bajadas and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, extending north into Trans-Pecos Texas, southern New Mexico and sub-Mogollon Arizona. These woodlands are dominated by Madrean evergreen oaks along a low-slope transition below Madrean Pine-Oak Forest and Woodland (CES305.796) and Madrean Pinyon-Juniper Woodland (CES305.797). Lower elevation stands are typically open woodlands or savannas where they transition into desert grasslands, chaparral or in some cases desertscrub. Common evergreen oak species include Quercus arizonica, Quercus emoryi, Quercus intricata, Quercus grisea, Quercus oblongifolia, Quercus toumeyi, and in Mexico Quercus chihuahuensis and Quercus albocincta. Madrean pine, Arizona cypress, pinyon and juniper trees may be present, but do not codominate. Chaparral species such as Arctostaphylos pungens, Cercocarpus montanus, Purshia spp., Garrya wrightii, Quercus turbinella, Frangula betulifolia (= Rhamnus betulifolia), or Rhus spp. may be present but do not dominate. The graminoid layer is usually prominent between trees in grassland or steppe that is dominated by warm-season grasses such as Aristida spp., Bouteloua gracilis, Bouteloua curtipendula, Bouteloua rothrockii, Digitaria californica, Eragrostis intermedia, Hilaria belangeri, Leptochloa dubia, Muhlenbergia spp., Pleuraphis jamesii, or Schizachyrium cirratum, species typical of Chihuahuan Piedmont Semi-Desert Grassland (CES302.735). This system includes seral stands dominated by shrubby Madrean oaks typically with a strong graminoid layer. In transition areas with drier chaparral systems, stands of chaparral are not dominated by Madrean oaks; however, Madrean Encinal may extend down along drainages.

S054[1] *Inter-Mountain Basins Big Sagebrush Shrubland* - This ecological system occurs throughout much of the western U.S., typically in broad basins between mountain ranges, plains and foothills between 1500 and 2300 m elevation. Soils are typically deep, well-drained and non-saline. These shrublands are dominated by Artemisia tridentata ssp. tridentata and/or Artemisia tridentata ssp. wyomingensis. Scattered Juniperus spp., Sarcobatus vermiculatus, and Atriplex spp. may be present in some stands. Ericameria nauseosa, Chrysothamnus viscidiflorus, Purshia tridentata, or Symphoricarpos oreophilus may codominate disturbed stands. Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species include Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus, Festuca idahoensis, Hesperostipa comata, Leymus cinereus, Pleuraphis jamesii, Pascopyrum smithii, Poa secunda, or Pseudoroegneria spicata.

S056 *Colorado Plateau Mixed Low Sagebrush Shrubland* - This ecological system occurs in the Colorado Plateau, Tavaputs Plateau and Uinta Basin in canyons, gravelly draws, hilltops, and dry flats at elevations generally below 1800 m. Soils are often rocky, shallow, and alkaline. This type extends across northern New Mexico into the southern Great Plains on limestone hills. It includes open shrublands and steppe dominated by Artemisia nova or Artemisia bigelovii sometimes with Artemisia tridentata ssp. wyomingensis codominant. Semi-arid grasses such as Achnatherum hymenoides, Aristida purpurea, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii, or Poa fendleriana are often present and may form a graminoid layer with over 25% cover.

S057 *Mogollon Chaparral* - This ecological system occurs across central Arizona (Mogollon Rim), western New Mexico and southern Utah and Nevada. It often dominants along the mid-elevation transition from the Mojave, Sonoran, and northern Chihuahuan deserts into mountains (1000-2200 m). It occurs on foothills, mountain slopes and canyons in drier habitats below the encinal and Pinus ponderosa woodlands. Stands are often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium,

Appendix D Cont.
Code Description

S057 Cont. especially in transition areas with more mesic woodlands. The moderate to dense shrub canopy includes species such as Quercus turbinella, Quercus toumeyi, Cercocarpus montanus, Canotia holacantha, Ceanothus greggii, Forestiera pubescens (= Forestiera neomexicana), Garrya wrightii, Juniperus deppeana, Purshia stansburiana, Rhus ovata, Rhus trilobata, and Arctostaphylos pungens and Arctostaphylos pringlei at higher elevations. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires.

S058 *Chihuahuan Mesquite Upland Scrub* - This ecological system occurs as upland shrublands that are concentrated in the extensive grassland-shrubland transition in foothills and piedmont in the Chihuahuan Desert. It extends into the Sky Island region to the west and the Edwards Plateau to the east. Substrates are typically derived from alluvium, often gravelly without a well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers. Prosopis spp. and other deep-rooted shrubs exploit this deep soil moisture that is unavailable to grasses and cacti. Vegetation is typically dominated by Prosopis glandulosa or Prosopis velutina and succulents. Other desert scrub that may codominate or dominate includes Acacia neovernicosa, Acacia constricta, Juniperus monosperma, or Juniperus coahuilensis. Grass cover is typically low. During the last century, the area occupied by this system has increased through conversion of desert grasslands as a result of drought, overgrazing by livestock, and/or decreases in fire frequency. It is similar to Chihuahuan Mixed Desert and Thorn Scrub (CES302.734) but is generally found at higher elevations where Larrea tridentata and other desert scrub are not codominant. It is also similar to Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub (CES302.737) but does not occur on eolian-deposited substrates.

S059 *Colorado Plateau Blackbrush-Mormon Tea Shrubland* - This ecological system occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1650 m. Substrates are shallow, typically calcareous, non-saline and gravelly or sandy soils over sandstone or limestone bedrock, caliche or limestone alluvium. It also occurs in deeper soils on sandy plains where it may have invaded desert grasslands. The vegetation is characterized by extensive open shrublands dominated by Coleogyne ramosissima often with Ephedra viridis, Ephedra torreyana, or Grayia spinosa. Sandy portions may include Artemisia filifolia as codominant. The herbaceous layer is sparse and composed of graminoids such as Achnatherum hymenoides, Pleuraphis jamesii, or Sporobolus cryptandrus.

S061 *Chihuahuan Succulent Desert Scrub* - This ecological system is found in the Chihuahuan Desert on colluvial slopes, upper bajadas, sideslopes, ridges, canyons, hills and mesas. Sites are hot and dry. Gravel and rock are often abundant on the ground surface. The vegetation is characterized by the relatively high cover of succulent species such as Agave lechuguilla, Euphorbia antisyphilitica, Fouquieria splendens, Ferocactus spp., Opuntia engelmannii, Opuntia imbricata, Opuntia spinosior, Yucca baccata, and many others. Perennial grass cover is generally low. The abundance of succulents is diagnostic of this desert scrub system, but desert shrubs are usually present. This system does not include desert grasslands or shrub-steppe with a strong cacti component.

S062 *Chihuahuan Mixed Desert and Thorn Scrub* - This widespread Chihuahuan Desert land cover type is composed of two ecological systems the Chihuahuan Creosotebush Xeric Basin Desert Scrub (CES302.731) and the Chihuahuan Mixed Desert and Thorn Scrub (CES302.734). This cover type includes xeric creosotebush basins and plains and the mixed desert scrub in the foothill transition zone above, sometimes extending up to the lower montane woodlands. Vegetation is characterized by Larrea tridentata alone or mixed with thornscrub and other desert scrub such as Agave lechuguilla, Aloysia wrightii, Fouquieria splendens, Dasylirion leiophyllum, Flourensia cernua, Leucophyllum minus, Mimosa aculeaticarpa var. biuncifera, Mortonia scabrella (= Mortonia sempervirens ssp. scabrella), Opuntia engelmannii, Parthenium incanum, Prosopis glandulosa, and Tiquilia greggii. Stands of Acacia constricta Acacia neovernicosa or Acacia greggii dominated thornscrub are included in this system, and limestone substrates appear important for at least these species. Grasses such as Dasyochloa pulchella, Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua ramosa, Muhlenbergia porteri and Pleuraphis mutica may be common, but generally have lower cover than shrubs.

Appendix D Cont.
Code Description

S063 *Sonoran Palo Verde-Mixed Cacti Desert Scrub* - This ecological system occurs on hillsides, mesas and upper bajadas in southern Arizona and extreme southeastern California. The vegetation is characterized by a diagnostic sparse, emergent tree layer of Carnegia gigantea (3-16 m tall) and/or a sparse to moderately dense canopy codominated by xeromorphic deciduous and evergreen tall shrubs Parkinsonia microphylla and Larrea tridentata with Prosopis sp., Olneya tesota, and Fouquieria splendens less prominent. Other common shrubs and dwarf-shrubs include Acacia greggii, Ambrosia deltoidea, Ambrosia dumosa (in drier sites), Calliandra eriophylla, Jatropha cardiophylla, Krameria erecta, Lycium spp., Menodora scabra, Simmondsia chinensis, and many cacti including Ferocactus spp., Echinocereus spp., and Opuntia spp. (both cholla and prickly pear). The sparse herbaceous layer is composed of perennial grasses and forbs with annuals seasonally present and occasionally abundant. On slopes, plants are often distributed in patches around rock outcrops where suitable habitat is present.

S065 *Inter-Mountain Basins Mixed Salt Desert Scrub* - This extensive ecological system includes open-canopied shrublands of typically saline basins, alluvial slopes and plains across the Intermountain western U.S. This type also extends in limited distribution into the southern Great Plains. Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more Atriplex species such as Atriplex confertifolia, Atriplex canescens, Atriplex polycarpa, or Atriplex spinifera. Other shrubs present to codominate may include Artemisia tridentata ssp. wyomingensis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra nevadensis, Grayia spinosa, Krascheninnikovia lanata, Lycium spp., Picrothamnus desertorum, or Tetradymia spp. Sarcobatus vermiculatus is generally absent, but if present does not codominate. The herbaceous layer varies from sparse to moderately dense and is dominated by perennial graminoids such as Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Pleuraphis jamesii, Pleuraphis rigida, Poa secunda, or Sporobolus airoides. Various forbs are also present.

S068 *Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub* - This ecological system includes the open shrublands of vegetated coppice dunes and sandsheets found in the Chihuahuan Desert. Usually dominated by Prosopis glandulosa but includes Atriplex canescens, Ephedra torreyana, Ephedra trifurca, Poliomintha incana, and Rhus microphylla coppice sand scrub with 10-30% total vegetation cover. Yucca elata, Gutierrezia sarothrae, and Sporobolus flexuosus are commonly present.

S069 *Sonora-Mojave Creosotebush-white Bursage Desert Scrub* - This ecological system forms the vegetation matrix in broad valleys, lower bajadas, plains and low hills in the Mojave and lower Sonoran deserts. This desert scrub is characterized by a sparse to moderately dense layer (2-50% cover) of xeromorphic microphyllous and broad-leaved shrubs. Larrea tridentata and Ambrosia dumosa are typically dominants, but many different shrubs, dwarf-shrubs, and cacti may codominate or form typically sparse understories. Associated species may include Atriplex canescens, Atriplex hymenelytra, Encelia farinosa, Ephedra nevadensis, Fouquieria splendens, Lycium andersonii, and Opuntia basilaris. The herbaceous layer is typically sparse, but may be seasonally abundant with ephemerals. Herbaceous species such as Chamaesyce spp., Eriogonum inflatum, Dasyochloa pulchella, Aristida spp., Cryptantha spp., Nama spp., and Phacelia spp. are common.

S071 *Inter-Mountain Basins Montane Sagebrush Steppe* - This ecological system includes sagebrush communities occurring at montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins. Climate is cool, semi-arid to subhumid. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general this system shows an affinity for mild topography, fine soils, and some source of subsurface moisture. It is composed primarily of Artemisia tridentata ssp. vaseyana (mountain sagebrush) and related taxa such as Artemisia tridentata ssp. spiciformis (= Artemisia spiciformis). Purshia tridentata may codominate or even dominate some stands. Other common shrubs include Symphoricarpos spp., Amelanchier spp., Ericameria nauseosa, Peraphyllum ramosissimum, Ribes cereum, and Chrysothamnus

Appendix D Cont.

Code Description

S071 Cont. viscidiflorus. Most stands have an abundant perennial herbaceous layer (over 25% cover), but this system also includes Artemisia tridentata ssp. vaseyana shrublands. Common graminoids include Festuca arizonica, Festuca idahoensis, Hesperostipa comata, Poa fendleriana, Elymus trachycaulus, Bromus carinatus, Poa secunda, Leucopoa kingii, Deschampsia caespitosa, Calamagrostis rubescens, and Pseudoroegneria spicata. In many areas, frequent wildfires maintain an open herbaceous-rich steppe condition, although at most sites, shrub cover can be unusually high for a steppe system (>40%), with the moisture providing equally high grass and forb cover.

S074 *Southern Rocky Mountain Juniper Woodland and Savanna* - This ecological system occupies the lower and warmest elevations, growing from 1370 to 1830 m in a semi-arid climate, primarily along the east and south slopes of the southern Rockies and Arizona-New Mexico mountains. It is best represented just below the lower elevational range of ponderosa pine and often intermingles with grasslands and shrublands. This system is best described as a savanna that has widely spaced, mature (>150 years old) juniper trees and occasionally Pinus edulis. Juniperus monosperma and Juniperus scopulorum (at higher elevations) are the dominant tall shrubs or short trees. These savannas may have inclusions of more dense juniper woodlands and have expanded into adjacent grasslands during the last century. Graminoid species are similar to those found in Western Great Plains Shortgrass Prairie (CES303.672), with Bouteloua gracilis and Pleuraphis jamesii being most common. In addition, succulents such as species of Yucca and Opuntia are typically present.

S075 *Inter-Mountain Basins Juniper Savanna* - This widespread ecological system occupies dry foothills and sandsheets of western Colorado, northwestern New Mexico, northern Arizona, Utah, west into the Great Basin of Nevada and southern Idaho. It is typically found at lower elevations ranging from 1500-2300 m. This system is generally found at lower elevations and more xeric sites than Great Basin Pinyon-Juniper Woodland (CES304.773) or Colorado Plateau Pinyon-Juniper Woodland (CES304.767). These occurrences are found on lower mountain slopes, hills, plateaus, basins and flats often where juniper is expanding into semi-desert grasslands and steppe. The vegetation is typically open savanna, although there may be inclusions of more dense juniper woodlands. This savanna is typically dominated by Juniperus osteosperma trees with high cover of perennial bunch grasses and forbs, with Bouteloua gracilis, Hesperostipa comata, and Pleuraphis jamesii being most common. In the southern Colorado Plateau, Juniperus monosperma or juniper hybrids may dominate the tree layer. Pinyon trees are typically not present because sites are outside the ecological or geographic range of Pinus edulis and Pinus monophylla.

S077[2] *Chihuahuan Piedmont Semi-Desert Grassland* - This ecological system is a broadly defined desert grassland, mixed shrub-succulent or xeromorphic tree savanna that is typical of the Borderlands of Arizona, New Mexico and northern Mexico [Apacherian region] but extends west to the Sonoran Desert, north into the Mogollon Rim and throughout much of the Chihuahuan Desert. It is found on gently sloping bajadas that supported frequent fire throughout the Sky Islands and on mesas and steeper piedmont and foothill slopes in the Chihuahuan Desert. It is characterized by typically diverse perennial grasses. Common grass species include Bouteloua eriopoda, Bouteloua hirsuta, Bouteloua rothrockii, Bouteloua curtipendula, Bouteloua gracilis, Eragrostis intermedia, Muhlenbergia porteri, Muhlenbergia setifolia, Pleuraphis jamesii, Pleuraphis mutica, and Sporobolus airoides, succulent species of Agave, Dasylirion, and Yucca, and tall-shrub/short-tree species of Prosopis and various oaks (e.g., Quercus grisea, Quercus emoryi, Quercus arizonica). Many of the historical desert grassland and savanna areas have been converted, some to Chihuahuan Mesquite Upland Scrub (CES302.733) (Prosopis spp.-dominated), through intensive grazing and other land uses.

S079 *Inter-Mountain Basins Semi-Desert Shrub Steppe* - This widespread ecological system occurs throughout the intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesatops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy or loamy-textured soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothill grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all

Appendix D Cont.

Code Description

S079 Cont. very drought-resistant plants. These grasslands are typically dominated or codominated by Achnatherum hymenoides, Aristida spp., Bouteloua gracilis, Hesperostipa comata, Muhlenbergia sp., or Pleuraphis jamesii and may include scattered shrubs and dwarfshrubs of species of Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia, or Krascheninnikovia lanata.

S080 *Chihuahuan Gypsophilous Grassland and Steppe* - This ecological system is restricted to gypsum outcrops or sandy gypsiferous and/or often alkaline soils that occur in basins and slopes in the Chihuahuan Desert. Elevation range is from 1100-2000 m. These typically sparse grasslands, steppes or dwarf-shrublands are dominated by a variety of gypsophilous plants, many of which are endemic to these habitats. Characteristic species include Tiquilia hispidissima, Atriplex canescens, Calylophus hartwegii, Ephedra torreyana, Frankenia jamesii, Bouteloua breviseta, Mentzelia perennis, Nama carnosum, Calylophus hartwegii (= Oenothera hartwegii), Selinocarpus lanceolatus, Sporobolus nealleyi, Sporobolus iroides, and Sartwellia flaveriae. This system does not include the sparsely vegetated gypsum dunes that are included in North American Warm Desert Active and Stabilized Dune (CES302.744).

S081 *Rocky Mountains Dry Tundra* - This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Deschampsia caespitosa, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Kobresia myosuroides, Phlox pulvinata, and Trifolium dasyphyllum. Although alpine tundra dry meadow is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarfshrubland, and alpine/subalpine wet meadow systems.

S083 *Rocky Mountain Subalpine Mesic Meadow* - This Rocky Mountain ecological system is restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. It is found typically above 3000 m in elevation in the southern part of its range and above 1500 m in the northern part. These upland communities occur on gentle to moderategradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include Erigeron spp., Asteraceae spp., Mertensia spp., Penstemon spp., Campanula spp., Lupinus spp., Solidago spp., Ligusticum spp., Thalictrum occidentale, Valeriana sitchensis, Balsamorhiza sagittata, Wyethia spp., Deschampsia caespitosa, Koeleria macrantha, and Dasiphora fruticosa. Burrowing mammals can increase the forb diversity.

S085 *Southern Rocky Mountain Montane Grassland* - This Rocky Mountain ecological system typically occurs between 2200 and 3000 m on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend up to 3350 m on warm aspects. Soils resemble prairie soils in that the Ahorizon is dark brown, relatively high in organic matter, slightly acid, and usually well-drained. An occurrence usually consists of a mosaic of two or three plant associations with one of the following dominant bunch grasses: Danthonia intermedia, Danthonia parryi, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia filiculmis, or Pseudoroegneria spicata. The subdominants include Muhlenbergia montana, Bouteloua gracilis, and Poa secunda. These large-patch grasslands are intermixed with matrix stands of spruce-fir, lodgepole, ponderosa pine, and aspen forests. In limited circumstances (e.g., South Park in Colorado), they form the "matrix" of high-elevation plateaus.

S086 *Rocky Mountains Foothill Grassland* - This system typically occurs between 1600-2200 m in elevation. It is best characterized as a mixed-grass to tallgrass prairie on mostly moderate to gentle slopes, usually at the

Appendix D Cont.
Code Description

S086 Cont. base of foothill slopes, e.g., the hogbacks of the Rocky Mountain Front Range where it typically occurs as a relatively narrow elevational band between montane woodlands and shrublands and the shortgrass steppe, but extends east on the Front Range piedmont alongside the Chalk Bluffs along the Colorado-Wyoming border, out into the Great Plains on the Palmer Divide, and on piedmont slopes below mesas and foothills in northeastern New Mexico. A combination of increased precipitation from orographic rain, temperature, and soils limits this system to the lower elevation zone with approximately 40 cm of precipitation/year. It is maintained by frequent fire and associated with well-drained clay soils. Usually occurrences of this system have multiple plant associations that may be dominated by Andropogon gerardii, Schizachyrium scoparium, Muhlenbergia montana, Nassella viridula, Pascopyrum smithii, Sporobolus cryptandrus, Bouteloua gracilis, Hesperostipa comata, or Hesperostipa neomexicana. In Wyoming, typical grasses found in this system include Pseudoroegneria spicata, Festuca idahoensis, Hesperostipa comata, and species of Poa. Typical adjacent ecological systems include foothill shrublands, ponderosa pine savannas, juniper savannas, as well as shortgrass prairie.

S088[1] *Western Great Plains Shortgrass Prairie* - This system is found primarily in the western half of the Western Great Plains Division in the rainshadow of the Rocky Mountains and ranges from the Nebraska Panhandle south into Texas and New Mexico, although grazing-impacted examples may reach as far north as southern Canada where it grades into Northwestern Great Plains Mixedgrass Prairie (CES303.674). This system occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sandy to clayey. In much of its range, this system forms the matrix system with Bouteloua gracilis dominating this system. Associated graminoids may include Aristida purpurea, Bouteloua curtipendula, Bouteloua hirsuta, Buchloe dactyloides, Hesperostipa comata, Koeleria macrantha (= Koeleria cristata), Pascopyrum smithii (= Agropyron smithii), Pleuraphis jamesii, Sporobolus airoides, and Sporobolus cryptandrus. Although mid-height grass species may be present, especially on more mesic land positions and soils, they are secondary in importance to the sod-forming short grasses. Sandy soils have higher cover of Hesperostipa comata, Sporobolus cryptandrus, and Yucca elata. Scattered shrub and dwarf-dwarf species such as Artemisia filifolia, Artemisia frigida, Artemisia tridentata, Atriplex canescens, Eriogonum effusum, Gutierrezia sarothrae, and Lycium pallida may also be present. Also, because this system spans a wide range, there can be some differences in the relative dominance of some species from north to south and from east to west. Large-scale processes such as climate, fire and grazing influence this system. High variation in amount and timing of annual precipitation impacts the relative cover of cool- and warm-season herbaceous species. In contrast to other prairie systems, fire is less important, especially in the western range of this system, because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency within the system. However, historically, fires that did occur were often very expansive. Currently, fire suppression and more extensive grazing in the region have likely decreased the fire frequency even more, and it is unlikely that these processes could occur at a natural scale. A large part of the range for this system (especially in the east and near rivers) has been converted to agriculture. Areas of the central and western range have been impacted by the unsuccessful attempts to develop dryland cultivation during the Dust Bowl of the 1930s. The short grasses that dominate this system are extremely drought- and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing. This system in combination with the associated wetland systems represents one of the richest areas for mammals and birds. Endemic bird species to the shortgrass system may constitute one of the fastest declining bird populations.

S090 *Inter-Mountain Basins Semi-Desert Grassland* - This widespread ecological system occurs throughout the intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesatops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy or loamy-textured soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothill grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by Achnatherum hymenoides, Aristida spp., Bouteloua gracilis, Hesperostipa comata, Muhlenbergia sp., or Pleuraphis jamesii

Appendix D Cont.

Code	Description
S090 Cont.	and may include scattered shrubs and dwarfshrubs of species of Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia, or Krascheninnikovia lanata.
S091[4]	*Rocky Mountain Subalpine-Montane Riparian Shrubland* - This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous areas of the Intermountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally it is found at higher elevations, but can be found anywhere from 1700-3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub- and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include Alnus incana, Betula nana, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia, and Salix wolfii. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.
S092[4]	*Rocky Mountain Subalpine-Montane Riparian Woodland* - This riparian woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes Abies lasiocarpa and/or Picea engelmannii; other important species include Pseudotsuga menziesii, Picea pungens, Picea engelmannii X glauca, Populus tremuloides, and Juniperus scopulorum. Other trees possibly present but not usually dominant include Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera ssp. trichocarpa, and Juniperus osteosperma.
S093[4]	*Rocky Mountain Lower Montane Riparian Woodland and Shrubland* - This system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. They can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. Dominant trees may include Acer negundo, Populus angustifolia, Populus balsamifera, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides, or Juniperus scopulorum. Dominant shrubs include Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea, or Symphoricarpos spp. Exotic trees of Elaeagnus angustifolia and Tamarix spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests.
S094[4]	*North American Warm Desert Lower Montane Riparian Woodland and Shrubland* - This ecological system occurs in mountain canyons and valleys of southern Arizona, New Mexico, and adjacent Mexico and consists of mid- to low-elevation (1100-1800 m) riparian corridors along perennial and seasonally

Appendix D Cont.

Code	Description
S094[4] Cont.	intermittent streams. The vegetation is a mix of riparian woodlands and shrublands. Dominant trees include Populus angustifolia, Populus deltoides ssp. wislizeni, Populus fremontii, Platanus wrightii, Juglans major, Fraxinus velutina, and Sapindus saponaria. Shrub dominants include Salix exigua, Prunus spp., Alnus oblongifolia, and Baccharis salicifolia. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the water table for growth and reproduction.
S095[4]	*Western Great Plains Riparian Woodland and Shrubland* - This system is found in the riparian areas of medium and small rivers and streams throughout the Western Great Plains. It is likely most common in the Shortgrass Prairie and Northern Great Plains Steppe but extends west and as far as the Rio Grande in New Mexico and into the Wyoming Basins in the north. It is found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. Hydrologically, these sites tended to be more flashy with less developed floodplain than on larger rivers, and typically dried down completely for some portion of the year. Dominant vegetation shares much with generally drier portions of larger floodplain systems downstream, but overall abundance of vegetation is generally lower. Communities within this system range from riparian forests and shrublands to gravel/sand flats. Dominant species include Populus deltoides, Salix spp., Artemisia cana ssp. cana, Pascopyrum smithii, Sporobolus cryptandrus, and Schizachyrium scoparium. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Tamarix spp. and less desirable grasses and forbs can invade degraded examples up through central Colorado. Another factor is that groundwater depletion and lack of fire have created additional species changes. SWReGAP land cover mappers interpreted most of the riparian woodland and shrubland areas in the Western Great Plains as this ecological system. Therefore, the SWReGAP map may include woody patches of a similar landcover type, S120 Western Great Plains Floodplain, in this map class. The reverse may also be true, where herbaceous patches of the S095 Western Great Plains Riparian Woodland and Shrubland system may be mapped as S120.
S096[4]	*Inter-Mountain Basins Greasewood Flat* - This ecological system occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains. It typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by Sarcobatus vermiculatus. Atriplex canescens, Atriplex confertifolia, or Krascheninnikovia lanata may be present to codominant. Occurrences are often surrounded by mixed salt desert scrub. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of Sporobolus airoides, Distichlis spicata (where water remains ponded the longest), or Eleocharis palustris herbaceous types.
S097[4]	*North American Warm Desert Riparian Woodland and Shrubland* - This ecological system consists of low-elevation (<1200 m) riparian corridors along medium to large perennial streams throughout canyons and the desert valleys of the southwestern United States and adjacent Mexico. The vegetation is a mix of riparian woodlands and shrublands. Dominant trees include Acer negundo, Fraxinus velutina, Populus fremontii, Salix gooddingii, Salix lasiolepis, Celtis laevigata var. reticulata, and Juglans major. Shrub dominants include Salix geyeriana, Shepherdia argentea, and Salix exigua. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the water table for growth and reproduction.
S098[4]	*North American Warm Desert Riparian Mesquite Bosque* - This ecological system consists of low-elevation (<1100 m) riparian corridors along intermittent streams in valleys of southern Arizona and New Mexico, and adjacent Mexico. Dominant trees include Prosopis glandulosa and Prosopis velutina. Shrub dominants include Baccharis salicifolia, Pluchea sericea, and Salix exigua. Vegetation, especially the mesquites, tap groundwater below the streambed when surface flows stop. Vegetation is dependent upon annual rise in the water table for growth and reproduction.

Appendix D Cont.
Code Description

S100[4] *North American Arid West Emergent Marsh* - This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of Scirpus and/or Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar, and Phalaris. This system may also include areas of relatively deep water with floating-leaved plants (Lemna, Potamogeton, and Brasenia) and submergent and floating plants (Myriophyllum, Ceratophyllum, and Elodea).

S102[4] *Rocky Mountain Alpine-Montane Wet Meadow* - These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi, and Trollius laxus. Often alpine dwarf-shrublands, especially those dominated by Salix, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

S108[4] *Western Great Plains Saline Depression* - This system is very similar to Northwestern Great Plains Open Freshwater Depression (CES303.675) and Western Great Plains Closed Depression Wetland (CES303.666). However, strongly saline soils cause both the shallow lakes and depressions and the surrounding areas to be more brackish. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as Distichlis spicata, Sporobolus airoides, and Hordeum jubatum. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some of examples of this system which may allow for less salt-tolerant species to occur. Communities found within this system may also occur in floodplains (i.e., more open depressions), but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain.

S109[2] *Chihuahuan-Sonoran Desert Bottomland and Swale Grassland* - This ecological system occurs throughout the northern Chihuahuan Desert and adjacent Sky Islands and Sonoran Desert, as well as limited areas of the southern Great Plains and Edwards Plateau in relatively small depressions on broad mesas, plains and valley bottoms that receive runoff from adjacent areas. Water generally infiltrates relatively quickly. These depressions have deep, fine-textured soils that are neutral to slightly saline/alkaline. Vegetation is typically dominated by Pleuraphis mutica (tobosa swales) or other mesic graminoids such as Pascopyrum smithii, Panicum obtusum, Sporobolus airoides, or Sporobolus wrightii. With tobosa swales, sand-adapted species such as Yucca elata may grow at the swale's edge in the deep sandy alluvium that is deposited there from upland slopes. Sporobolus airoides and Sporobolus wrightii are more common in alkaline soils.

Appendix D Cont.

Code Description

S111[3] *Madrean Upper Montane Conifer-Oak Forest and Woodland* - This system occurs at the upper elevations in the Sierra Madre Occidentale and Sierra Madre Orientale. In the U.S., it is restricted to north and east aspects at high elevations (1980-2440 m) in the Sky Islands (Chiricahua, Huachuca, Pinaleno, Santa Catalina, and Santa Rita mountains) and along the Nantanes Rim. It is more common in Mexico and does not occur in Arizona central highlands. The vegetation is characterized by large- and small-patch forests and woodlands dominated by Pseudotsuga menziesii, Abies coahuilensis, or Abies concolor and Madrean oaks such as Quercus hypoleucoides and Quercus rugosa. It is similar to Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland (CES306.823).

S112 *Madrean Pinyon-Juniper Woodland* - This system occurs on foothills, mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. Substrates are variable, but soils are generally dry and rocky. The presence of Pinus cembroides, Pinus discolor, or other Madrean trees and shrubs is diagnostic of this woodland system. Juniperus coahuilensis, Juniperus deppeana, Juniperus pinchotii, Juniperus monosperma, and/or Pinus edulis may be present to dominant. Madrean oaks such as Quercus arizonica, Quercus emoryi, Quercus grisea, or Quercus mohriana may be codominant. Pinus ponderosa is absent or sparse. If present, understory layers are variable and may be dominated by shrubs or graminoids.

S113 *Chihuahuan Sandy Plains Semi-Desert Grassland* - This ecological system occurs across the Chihuahuan Desert and extends into the southern Great Plains where soils have a high sand content. These dry grasslands or steppe are found on sandy plains and sandstone mesas. The graminoid layer is dominated or codominated by Achnatherum hymenoides, Bouteloua eriopoda, Bouteloua hirsuta, Hesperostipa neomexicana, Pleuraphis jamesii, Sporobolus cryptandrus, Sporobolus airoides, or Sporobolus flexuosus. Typically, there are found scattered desert shrubs and stem succulents such as Ephedra torreyana, Ephedra trifurca, Fallugia paradoxa, Prosopis glandulosa, Yucca elata, and Yucca torreyi that are characteristic of the Chihuahuan Desert.

S115 *Madrean Juniper Savanna* - This Madrean ecological system occurs in lower foothills and plains of southeastern Arizona, southern New Mexico extending into west Texas and Mexico. These savannas have widely spaced mature juniper trees and moderate to high cover of graminoids (>25% cover). The presence of Madrean Juniperus spp. such as Juniperus coahuilensis, Juniperus pinchotii, and/or Juniperus deppeana is diagnostic. Juniperus monosperma may be present in some stands, and Juniperus deppeana has a broader range than this Madrean system and extends north into southern stands of Southern Rocky Mountain Juniper Savanna and Woodland (CES306.834). Stands of Juniperus pinchotii may be short and resemble a shrubland. Graminoid species are a mix of those found in Western Great Plains Shortgrass Prairie (CES303.672) and Chihuahuan Piedmont Semi-Desert Grassland (CES302.735), with Bouteloua gracilis and Pleuraphis jamesii being most common. In addition, these areas include succulents such as species of Yucca, Opuntia, and Agave. Juniper savanna expansion into grasslands has been documented in the last century.

S116 *Chihuahuan Mixed Salt Desert Scrub* - This system includes extensive open-canopied shrublands of typically saline basins in the Chihuahuan Desert. Stands often occur on alluvial flats and around playas. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of one or more Atriplex species such as Atriplex canescens, Atriplex obovata, or Atriplex polycarpa along with species of Allenrolfea, Flourensia, Salicornia, Suaeda, or other halophytic plants. Graminoid species may include Sporobolus airoides, Pleuraphis mutica, or Distichlis spicata at varying densities.

S117 *Coahuilan Chaparral* - This ecological system occurs in mountains across southeastern New Mexico (Guadalupe Mountains) and Trans-Pecos Texas (Chisos Mountains). It often dominants along the mid-elevation transition from the Chihuahuan Desert into mountains (1700-2500 m). It occurs on foothills, mountain slopes and canyons in drier habitats below the encinal and pine woodlands and is often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands. The moderate to dense shrub canopy includes many shrub oak species such as Quercus intricata, Quercus pringlei, Quercus invaginata, Quercus laceyi, Quercus grisea, Quercus emoryi, Quercus toumeyi, several widespread chaparral species such as Arctostaphylos pungens, Ceanothus

Appendix D Cont.

Code Description

S117 Cont. greggii, Fallugia paradoxa, and Garrya wrightii, and species characteristic of this system such as Arbutus arizonica, Arbutus xalapensis (= Arbutus texana), Fraxinus greggii, Fendlera rigida (= Fendlera linearis), Garrya ovata, Purshia mexicana (= ssp. mexicana), Rhus virens var. choriophylla (= Rhus choriophylla), and endemics Salvia lycioides (= Salvia ramosissima), Salvia roemeriana, and Salvia regla. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires.

S129 *Sonoran Mid-Elevation Desert Scrub* - This transitional desert scrub system occurs along the northern edge of the Sonoran Desert in an elevational band along the lower slopes of the Mogollon Rim/Central Highlands region between 750 and 1300 m. Stands occur in the Bradshaw, Hualapai, and Superstition mountains, among other desert ranges, and are found above Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761) and below Mogollon Chaparral (CES302.741). Sites range from a narrow strip on steep slopes to very broad areas such as the Verde Valley. Climate is too dry for chaparral species to be abundant, and freezing temperatures during winter are too frequent and prolonged for many of the frost-sensitive species that are characteristic of Sonoran Paloverde-Mixed Cacti Desert Scrub (CES302.761), such as Carnegia gigantea, Parkinsonia microphylla, Prosopis spp., Olneya tesota, Ferocactus sp., and Opuntia bigelovii. Substrates are generally rocky soils derived from parent materials such as limestone, granitic rocks or rhyolite. The vegetation is typically composed of an open shrub layer of Larrea tridentata, Ericameria linearifolia, or Eriogonum fasciculatum with taller shrub such as Canotia holacantha (limestone or granite) or Simmondsia chinensis (rhyolite). The herbaceous layer is generally sparse.

S136 *Southern Colorado Plateau Sand Shrubland* - This large-patch ecological system is found on the south-central Colorado Plateau in northeastern Arizona extending into southern and central Utah. It occurs on windswept mesas, broad basins and plains at low to moderate elevations (1300-1800 m). Substrates are stabilized sandsheets or shallow to moderately deep sandy soils that may form small hummocks or small coppice dunes. This semi-arid, open shrubland is typically dominated by short shrubs (10-30 % cover) with a sparse graminoid layer. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include Ephedra cutleri, Ephedra torreyana, Ephedra viridis, and Artemisia filifolia. Coleogyne ramosissima is typically not present. Poliomintha incana, Parryella filifolia, Quercus havardii var. tuckeri, or Ericameria nauseosa may be present to dominant locally. Ephedra cutleri and Ephedra viridis often assume a distinctive matty growth form. Characteristic grasses include Achnatherum hymenoides, Bouteloua gracilis, Hesperostipa comata, and Pleuraphis jamesii. The general aspect of occurrences is an open low shrubland but may include small blowouts and dunes. Occasionally grasses may be moderately abundant locally and form a distinct layer. Disturbance may be important in maintaining the woody component. Eolian processes are evident, such as pediceled plants, occasional blowouts or small dunes, but the generally higher vegetative cover and less prominent geomorphic features distinguish this system from Inter-Mountain Basins Active and Stabilized Dune (CES304.775).

S138 *Western Great Plains Mesquite Woodland and Shrubland* - This system is found primarily in the southern portion of the Western Great Plains Division, primarily in Texas, Oklahoma and eastern New Mexico. This system is dominated by Prosopis glandulosa with shortgrass species in the understory. Ziziphus obtusifolia and Atriplex canescens can codominate in some examples as can Opuntia species in heavily grazed areas. Historically this system probably occurred as a natural component on more fertile soils and along drainages.

D02 *Recently Burned* - Areas that have burned in the recent past that are clearly evident in the imagery (images acquired between 1999-2001).

D03 *Recently Mined or Quarried* - Areas where open pit mining or quarries are visible in the imagery (images acquired between 1999-2001), and are 2 hectares or greater in size.

D04[4] *Invasive Southwest Riparian Woodland and Shrubland* - Areas that are dominated by introduced riparian woody species such as: Tamarix spp. and Elaeagnus angustifolius.

Appendix D Cont.

Code	Description
D06	*Invasive Perennial Grassland* - Areas that are dominated by introduced perennial grass species such as: Agropyron cristatum, Bromus inermis, Eragrostis lehmannianna, Pennisetum spp., Poa bulbosa, P. pratensis, Thinopyrum intermedium.
D09	*Invasive Annual and Biennial Forbland* - Areas that are dominated by introduced annual and/or biennial forb species such as: Halogeton glomeratum, Kochia scoparia, Salsola spp., .
D10	*Recently Logged Areas* - Areas that have recently been clear-cut or thinned by 50% or more and are clearly evident in the imagery (images acquired between 1999-2001).
D11	*Recently Chained Pinyon-Juniper Areas* - Areas that have recently been chained to remove Pinyon-Juniper and are clearly evident in the imagery (images acquired between 1999-2001).
N11	*Open water* - Areas of open water, generally with less than 25% cover of vegetation or soil.
N21	*Developed, Low Intensity* - Open Space: Includes areas with a mixture of some construction materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include largelot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Developed, Low Intensity: Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include singlefamily housing units.
N22	*Developed, Medium - High Intensity* - Developed, Medium Intensity: Includes areas with a mixture of constructed materials and vegetation. Impervious surface accounts for 50-79 percent of the total cover. These areas most commonly include single-family housing units. Developed, High Intensity: Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.
N31	*Barren, Non-Specific* - (Rock/Sand/Clay)-Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulation of earthen material. Generally, vegetation accounts for less than 15% of total cover.
N80	*Agriculture* - An aggregated landcover type that includes both Pasture/Hay (N81): areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle, where pasture/hay vegetation accounts for greater than 20 percent of total vegetation, and Cultivated Crops (N82): areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards, where crop vegetation accounts for greater than 20 percent of total vegetation. N82 also includes all land being actively tilled.

[1] Priority habitats for New Mexico CWCS.
[2] Aggregated SWReGAP land cover types into Chihuahuan Semi-Desert Grassland priority habitat.
[3] Aggregated SWReGAP land cover types into Madrean Pine-Oak/Conifer-Oak Forest and Woodland priority habitat.
[4] Aggregated SWReGAP land cover types into Riparian priority habitat.
[5] Aggregated SWReGAP land cover types into Rocky Mountain Montane Mixed Conifer Forest and Woodland priority habitat.

Appendix E. Codes of aquatic habitat types in New Mexico identified by the New Mexico Department of Game and Fish. Descriptions complied from the Glossary of Aquatic Habitat Inventory Terminology published by the American Fisheries Society (1998).

Code	Description
A901[1]	*Perennial Spring/Seep* – Area where groundwater continuously flows naturally from a rock or soil substrate to the surface to form a stream, pond, marsh, or other type of water body. A seep is a small groundwater discharge that slowly oozes to the surface of the ground or into a stream, which differs from a spring that visibly flows from the ground.
A902	*Perennial Small Reservoir* – Natural or artificial impoundment less than 2,471 ac (1,000 ha) where water is collected, stored, regulated, and released for human use. Examples include Elephant Butte, Navajo, Heron, El Vado, Abiquiu, Ute, Summner, Brantly, Red Bluff, Caballo, Conchas, Cochiti, and Eagle Nest Reservoirs.
A903[2]	*Perennial Large Reservoir* – Natural or artificial impoundment greater than 2,471 ac (1,000 ha) where water is collected, stored, regulated, and released for human use. Examples include Clayton, Charlette Lakes, Stubblefield, Maxwell 13, Miami, Laguna Madre, Springer, Bill Evans, Lake Rolsals, Bea-Canyon, Storrie McAllister, Carlsbad, Jackson, Hopewell, Snow Lake, Farmington Lake, Bonita Lake, Artic Lake, Willow, Bluewater, Ramal, Quemado, Fenton, San Gregorio, and Murphy Reservoirs.
A904[2]	*Perennial 1st and 2nd Order Stream* – Natural water course containing flowing water together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. A first order stream is an unforked or unbranched stream. Two first order streams flow together to form a second order stream. First and second order stream are usually headwater streams.
A905[2]	*Perennial 3rd and 4th Order Stream* – Natural water course containing flowing water together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. Two second order streams flow together to form a third order stream and two third order streams flow together to form a fourth order stream. Third and fourth order streams are usually intermediate streams flowing out of mountains.
A906[2]	*Perennial 5th Order Stream* – Natural water course containing flowing water together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. Two fourth order streams flow together to form a fifth order stream.
A907	*Perennial Natural Lake* – Body of fresh or saline water (usually at least 20 ac; 8 ha in surface area) that is completely surrounded by land and is persistent and relatively unchanged over a period of years.
A908	*Perennial Pool, Playa, Tinaja, Kettle* – Bodies of standing water formed in depressions, basins or in streams. A pool is formed in a small depression found in a marsh or on a floodplain. A playa is an internally drained lake found in a sandy, salty, or muddy flat floor of an arid basin occupied by shallow water. A tinaja is a permanent pool in seasonal streams. A kettle is formed in a depression by melting ice blocks deposited in glacial drift or in the outwash plain.
A909	*Perennial Cirque* – Body of standing water that occurs where valleys are shaped into structures resembling amphitheaters by the action of freezing and thawing ice usually found in the upper portion of a glaciated area or in mountains and always containing water.
A910[2]	*Perennial Tank* – Artificial pond to hold water for livestock, wildlife (sometimes including fish) and other uses and always containing water.

Appendix E Cont.
Code Description

A911 *Perennial Pond* – Natural or artificial body of standing water that is typically smaller than a lake (less than 20 ac; 8 ha), characterized by a high ratio of littoral zone relative to open water.

A912[1] *Perennial Marsh/Cienega* – Water-saturated, poorly drained wetland area that is permanently inundated to a depth of 7 ft (2 m) and that supports an extensive cover of emergent, non-woody vegetation, without peat-like accumulations (marsh) and associated with perennial spring and seep systems in isolated arid basins of the Southwest (cienega).

A951 *Ephemeral Spring/Seep* – Areas where groundwater intermittently flows naturally from a rock or soil substrate to the surface to form a stream, pond, marsh, or other type of water body. A seep is a small groundwater discharge that slowly oozes to the surface of the ground or into a stream, which differs from a spring that visibly flows from the ground.

A952[3] *Ephemeral Small Reservoir* – Natural or artificial impoundment less than 2,471 ac (1,000 ha) where water is collected, stored, regulated, and released for human use containing water for short and irregular periods of time usually after a period of heavy precipitation.

A954[2] *Ephemeral 1st and 2nd Order Stream* – Natural water course containing flowing water, at least part of the year, together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. A first order stream is an unforked or unbranched stream. Two first order streams flow together to form a second order stream. First and second order stream are usually headwater streams.

A955 *Ephemeral 3rd and 4th Order Stream* – Natural water course containing flowing water, at least part of the year, together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. Two second order streams flow together to form a third order stream and two third order streams flow together to form a fourth order stream. Third and fourth order streams are usually intermediate streams flowing out of mountains.

A956 *Ephemeral 5th Order Stream* – Natural water course containing flowing water, at least part of the year, together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone. Two fourth order streams flow together to form a fifth order stream.

A957[4] *Ephemeral Natural Lake* – Body of fresh or saline water (usually at least 20 ac; 8 ha in surface area) that is completely surrounded by land containing water for short and irregular periods of time usually after a period of heavy precipitation.

A958[4] *Ephemeral Pool, Playa, Tinaja, Kettle* – Bodies of standing water formed in depressions, basins or in streams. A pool is formed in a small depression found in a marsh or on a floodplain. A playa is an internally drained lake found in a sandy, salty, or muddy flat floor of an arid basin, usually occupied by shallow water only after periods of prolonged heavy precipitation. A tinaja is a pool in seasonal streams that may support a flora upon desiccation. A kettle is formed in a depression by melting ice blocks deposited in glacial drift or in the outwash plain.

A959[4] *Ephemeral Cirque* – Body of water that occurs where valleys are shaped into structures resembling amphitheaters by the action of freezing and thawing ice usually found in the upper portion of a glaciated area or in mountains containing water for short and irregular periods of time usually after a period of heavy precipitation.

A960[3] *Ephemeral Tank* – Artificial pond to hold water for livestock, wildlife (sometimes including fish) and other uses containing water for short and irregular periods of time usually after a period of heavy precipitation.

Appendix E Cont.

Code Description

A961[3] *Ephemeral Pond* – Natural or artificial body of standing water that is typically smaller than a lake (less than 20 ac; 8 ha), characterized by a high ratio of littoral zone relative to open water containing water for short and irregular periods of time usually after a period of heavy precipitation.

A962[2] *Ephemeral Marsh/Cienega* - Water-saturated, poorly drained wetland area that is periodically inundated to a depth of 7 ft (2 m) and that supports an extensive cover of emergent, nonwoody vegetation, without peat-like accumulations (marsh) and associated with ephemeral spring and seep systems in isolated arid basins of the Southwest (cienega).

[1] Aggregated aquatic types into Perennial Marsh/Cienega/Spring/Seep priority habitat.
[2] Priority habitats for New Mexico's CWCS.
[3] Aggregated aquatic types into Ephemeral Man-made Catchments priority habitat.
[4] Aggregated aquatic types into Ephemeral Natural Catchments priority habitat.

Appendix F. Key terrestrial habitat types (9) in New Mexico for New Mexico's CWCS. Several SWReGAP land cover types were aggregated into nine key habitats. Descriptions of each SWReGAP land cover type can be found in Appendix D.

Terrestrial Habitats	CWCS Codes	SWReGAP Codes
Chihuahuan Semi-Desert Grassland	G077	
Chihuahuan Piedmont Semi-Desert Grassland		S077
Chihuahuan-Sonoran Desert Bottomland and Swale Grassland		S109
Inter-Mountain Basins Big Sagebrush Shrubland		S054
Madrean Encinal		S051
Madrean Pine-Oak/Conifer-Oak Forest and Woodland	G035	
Madrean Pine-Oak Forest and Woodland		S035
Madrean Upper Montane Conifer-Oak Forest and Woodland		S111
Riparian	Rip	
Inter-Mountain Basins Greasewood Flat[3]		S096
Inter-Mountain Basins Greasewood Wash[3]		S014
Inter-Mountain Basins Playa[3]		S015
Invasive Southwest Riparian Woodland and Shrubland		D04
North American Arid West Emergent Marsh[2]		S100
North American Warm Desert Lower Montane Riparian Woodland and Shrubland[1]		S094
North American Warm Desert Playa[3]		S022
North American Warm Desert Riparian Mesquite Bosque[2]		S098
North American Warm Desert Riparian Woodland and Shrubland[2]		S097
North American Warm Desert Wash[3]		S020
Rocky Mountain Bigtooth Maple Ravine Woodland[1]		S024
Rocky Mountain Lower Montane Riparian Woodland and Shrubland[1]		S093
Rocky Mountain Subalpine-Montane Riparian Shrubland[1]		S091
Rocky Mountain Subalpine-Montane Riparian Woodland[1]		S092
Western Great Plains Riparian Woodland and Shrubland[2]		S095
Western Great Plains Saline Depression[2]		S108
Rocky Mountain Alpine-Montane Wet Meadow		S102
Rocky Mountain Montane Mixed Conifer Forest and Woodland	G032	
Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland		S032
Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland		S034
Western Great Plains Sandhill Sagebrush Shrubland		S048
Western Great Plains Shortgrass Prairie		S088

1 Habitat type considered Montane Riparian
2 Habitat type considered Floodplain Riparian
3 Habitat type considered Xeric Riparian

Appendix G. Key aquatic habitat types (10) in New Mexico for New Mexico's CWCS. Several habitat types were aggregated into ten key habitats. Descriptions of each aquatic habitat type can be found in Appendix E.

Aquatic Habitats	Aggregated Codes	CWCS Codes
Ephemeral 1st and 2nd Order Stream		A954
Ephemeral Man-made Catchments	G952	G952
Ephemeral Pond		A961
Ephemeral Small Reservoir		A952
Ephemeral Tank		A960
Ephemeral Marsh/Cienega		A962
Ephemeral Natural Catchments	G957	G957
Ephemeral Cirque		A959
Ephemeral Natural Lake		A957
Ephemeral Pool, Playa, Tinaja, Kettle		A958
Perennial 1st and 2nd Order Stream		A904
Perennial 3rd and 4th Order Stream		A905
Perennial 5th Order Stream		A906
Perennial Large Reservoir		A903
Perennial Marsh/Cienega/Spring/Seep	G901	G901
Perennial Marsh/Cienega		A912
Perennial Spring/Sseep		A901
Perennial Tank		A910

Appendix H. Species of Greatest Conservation Need (SGCN) identified in New Mexico. Adjusted NatureServe state and national conservation status codes, federal and state status designation, New Mexico Authority designation, and game species status are presented. Codes to table precede species list.

State Codes			Federal Status		
0	-	Possibly Extirpated	C	-	Candidate Species
1	-	Cricitally Imperiled	T	-	Listed Federally Threatened
2	-	Imperiled	E	-	Listed Federally Endangered
3	-	Vulnerable	SC	-	Species of Concern
4	-	Apparently Secure	State Status		
5	-	Secure	T	-	Listed State Threatened
X	-	Extinct	E	-	Listed State Endangered
National Codes			S	-	Sensitive Species
0	-	Possibly Extirpated	Ch 17 Authority		
1	-	Cricitally Imperiled	F	-	Full Authority
2	-	Imperiled	L	-	Limited Authority
3	-	Vulnerable	N	-	No Authority
4	-	Apparently Secure	Game Species		
5	-	Secure	H	-	Harvested
			N	-	Not Harvested

Common or Scientific Name[1]	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Fish						
Smallmouth Buffalo	2	3			L	N
Blue Catfish	4	4			F	H
Headwater Catfish	1	1	SC	S	F	H
Chihuahua Chub	1	1	T	E	F	N
Gila Chub	1	1		E	F	N
Headwater Chub	1	2		E	F	N
Rio Grande Chub	2	2		S	L	N
Roundtail Chub	1	2	SC	E	F	N
Speckled Chub	2	2			L	N
Canadian Speckled Chub	1	2	SC	T	L	N
Southern Redbelly Dace	1	3		E	F	N
Greenthroat Darter	1	2		T	F	N
Pecos Gambusia	1	1	E	E	F	N
Rainwater Killifish	1	3			L	N
Bigscale Logperch (Native pop.)	1	2		T	F	N
Loach Minnow	1	1	T	T	L	N
Rio Grande Silvery Minnow	1	1	E	E	F	N
Suckermouth Minnow	1	3		T	L	N
Colorado Pikeminnow	1	1	E	E	F	N
Pecos Pupfish	1	1		T	L	N
White Sands Pupfish	1	1	SC	T	L	N
Gray Redhorse	1	2		T	L	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Mottled Sculpin	1	3			L	N
Pecos Bluntnose Shiner	1	1	T	T	L	N
Rio Grande Shiner	2	2	SC	S	L	N
Spikedace	1	1	T	T	L	N
Central Stoneroller	2	4			L	N
Blue Sucker	1	2	SC	E	F	N
Zuni Bluehead Sucker	1	1	SC	E	F	N
Desert Sucker	2	2	SC	S	L	N
Razorback Sucker	1	1	E	S	L	N
Rio Grande Sucker	2	2			L	N
Sonora Sucker	2	2	SC	S	L	N
Mexican Tetra	1	2		T	L	N
Gila Topminnow	2	2	E	T	L	N
Rio Grande Cutthroat Trout	3	3		S	F	H
Gila Trout	1	1	E	T	F	N
Birds						
American Bittern	3	4			L	N
Common Black-Hawk	2	3		T	F	N
Painted Bunting	2	5			F	N
Varied Bunting	2	3		T	F	N
Neotropic Cormorant	2	5		T	L	N
Sandhill Crane	3	5			F	H
Yellow-Billed Cuckoo	3	4	C	S	F	N
Long-Billed Curlew	3	4			F	N
Mourning Dove	5	5			F	H
Northern Pintail	2	4			F	H
Bald Eagle	3	4	T	T	F	N
Golden Eagle	3	3			F	N
Aplomado Falcon	1	2	E	E	F	N
Peregrine Falcon	3	4		T	F	N
Olive-Sided Flycatcher	4	4			F	N
Southwestern Willow Flycatcher	2	4	E	E	F	N
Northern Goshawk	2	4	SC	S	F	N
Eared Grebe	3	5			L	N
Common Ground-Dove	3	4			F	N
Blue Grouse	4	5		E	F	H
Northern Harrier	3	3			F	N
Ferruginous Hawk	2	4			F	N
Broad-Billed Hummingbird	2	4		T	F	N
Costa's Hummingbird	2	4		T	F	N
Lucifer Hummingbird	2	5		T	F	N
Violet-Crowned Hummingbird	1	3		T	F	N
White-Faced Ibis	2	5			L	N
Pinyon Jay	3	3			F	N
Yellow-Eyed Junco	2	3		T	F	N
Thick-Billed Kingbird	1	4		E	F	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Hooded Oriole	4	4			F	N
Osprey	2	4			F	N
Boreal Owl	1	4		T	F	N
Burrowing Owl	4	5			F	N
Elf Owl	3	5			F	N
Whiskered Screech-Owl	2	4		T	F	N
Mexican Spotted Owl	2	3	T	S	F	N
Greater Pewee	3	4			F	N
Wilson's Phalarope	3	5			F	N
Band-Tailed Pigeon	3	4			F	H
Sprague's Pipit	3	3			F	N
Mountain Plover	2	2	SC	S	F	N
Snowy Plover	3	2			F	N
Lesser Prairie-Chicken	2	2	C	S	F	H
White-Tailed Ptarmigan	4	4		E	F	N
Montezuma Quail	4	5			F	H
Scaled Quail	3	3			F	H
Painted Redstart	3	4			F	N
Williamson's Sapsucker	3	3			F	N
Loggerhead Shrike	3	4		S	F	N
Baird's Sparrow	2	3	SC	T	F	N
Botteri's Sparrow	2	3		S	F	N
Grasshopper Sparrow	1	3			F	N
Sage Sparrow	3	5			F	N
Bank Swallow	3	5			F	N
Black Swift	3	4		S	F	N
Interior Least Tern	1	3	E	E	F	N
Bendire's Thrasher	3	2			F	N
Sage Thrasher	3	3			F	N
Juniper Titmouse	3	4			F	N
Abert's Towhee	2	3		T	F	N
Elegant Trogon	1	3		E	F	N
Gould's Wild Turkey	2	3		T	F	N
Northern Beardless-Tyrannulet	2	4		E	F	N
Bell's Vireo	2	4		T	F	N
Gray Vireo	2	4		T	F	N
Grace's Warbler	4	5			F	N
Black-Throated Gray Warbler	3	4			F	N
Lucy's Warbler	4	4			F	N
Red-Faced Warbler	3	3			F	N
Yellow Warbler	3	5			F	N
Gila Woodpecker	3	4		T	F	N
Lewis's Woodpecker	4	5			F	N
Red-headed Woodpecker	3	5			F	N

State Codes	National Codes	Federal Status
0 - Possibly Extirpated	0 - Possibly Extirpated	C - Candidate Species
1 - Cricitally Imperiled	1 - Cricitally Imperiled	T - Listed Federally Threatened
2 - Imperiled	2 - Imperiled	E - Listed Federally Endangered
3 - Vulnerable	3 - Vulnerable	SC - Species of Concern
4 - Apparently Secure	4 - Apparently Secure	State Status
5 - Secure	5 - Secure	T - Listed State Threatened
X - Extinct	Ch 17 Authority	E - Listed State Endangered
Game Species	F - Full Authority	S - Sensitive Species
H - Harvested	L - Limited Authority	
N - Not Harvested	N - No Authority	

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Mammals						
Allen's Big-Eared Bat	2	3	SC	S	L	N
Pocketed Free-Tailed Bat	1	3			L	N
Lesser Long-Nosed Bat	1	2	E	T	L	N
Mexican Long-Nosed Bat	1	2	E	E	F	N
Mexican Long-Tongued Bat	1	2	SC	S	L	N
Arizona Myotis Bat	3	3		S	L	N
Western Red Bat	2	4		S	L	N
Spotted Bat	3	3		T	L	N
Western Yellow Bat	1	2		T	L	N
Black Bear	4	5			F	H
American Beaver	5	5			F	H
Organ Mountains Colorado Chipmunk	1	1	SC	T	L	N
Oscura Mountains Colorado Chipmunk	1	1		T	L	N
Penasco Least Chipmunk	1	1		E	F	N
White-Nosed Coati	4	4		S	F	
Mule Deer	5	5			F	H
Coues' White-Tailed Deer	4	4			F	H
Swift Fox	3	3		S	F	H
Southern Pocket Gopher	1	3		T	L	N
Snowshoe Hare	3	5			L	N
Jaguar	1	1	E		F	N
American Marten	2	4		T	F	N
New Mexico Meadow Jumping Mouse	2	2	SC	T	L	N
Northern Pygmy Mouse	2	4			L	N
River Otter	0	5	SC	S	F	N
Goat Peak Pika	3	1	SC	S	F	N
Black-tailed Prairie Dog	1	2	C	S	L	N
Gunnison's Prairie Dog	3	3		S	L	N
White-Sided Jack Rabbit	1	1	SC	T	L	N
White-Tailed Jack Rabbit	3	4		S	L	N
Yellow-Nosed Cotton Rat	2	3	SC		L	N
Desert Bighorn Sheep	2	3		E	F	N
Rocky Mountain Bighorn Sheep	4	5			F	H
Arizona Shrew	1	2	SC	E	F	N
Least Shrew	1	5		T	L	N
New Mexico Shrew	2	2			L	N
Preble's Shrew	1	4			L	N
Abert's Squirrel	4	5			F	H
Arizona Gray Squirrel	2	4			F	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Arizona Montane Vole	1	4		E	F	N
Prairie Vole	1	5		S	L	N
Mexican Gray Wolf	1	1	E	E	F	N
Amphibians						
Eastern Barking Frog	3	3			L	N
Western Chorus Frog	5	5			L	N
Chiricahua Leopard Frog	1	1	T	S	L	N
Lowland Leopard Frog	0	2	SC	E	F	N
Northern Leopard Frog	2	3			L	N
Plains Leopard Frog	3	3			L	N
Rio Grande Leopard Frog	3	3			L	N
Mountain Tree Frog	3	3			L	N
Jemez Mountain Salamander	2	2	SC	E	L	N
Sacramento Mountain Salamander	3	3	SC	T	L	N
Tiger Salamander	5	5			L	N
Arizona Toad	3	3	SC	S	L	N
Western Boreal Toad	0	1	C	E	F	N
Colorado River Toad	2	3		T	L	N
Great Plains Narrowmouth Toad	1	5		E	F	N
Reptiles						
Western River Cooter	3	3		T	L	N
Texas Banded Gecko	4	5			L	N
California Kingsnake	3	5		S	L	N
Gray-Banded Kingsnake	2	2		E	F	N
Sonoran Mountain Kingsnake	4	4		T	L	N
Madrean Alligator Lizard	4	4			L	N
Collared Lizard	5	4			L	N
Bunch Grass Lizard	2	2		T	L	N
Regal Horned Lizard	3	5			L	N
Sand Dune Lizard	1	1	C	E	L	N
Desert Massasauga	3	3			L	N
Reticulate Gila Monster	3	3		E	F	N
Western Diamondback Rattlesnake	3	5			L	N
New Mexico Ridgenose Rattlesnake	2	3	T	E	F	N
Banded Rock Rattlesnake	3	4			L	N
Mottled Rock Rattlesnake	3	4		T	L	N
Mountain Skink	3	4		T	L	N
Big Bend Slider	2	2		S	L	N
Yaqui Blackhead Snake	3	3		S	L	N
Mexican Garter Snake	0	2	SC	E	F	N
Narrowhead Garter Snake	2	2	SC	T	L	N
New Mexico Garter Snake	3	3			L	N
Milk Snake	3	4			L	N
Green Rat Snake	3	3		T	L	N
Arid Land Ribbon Snake	2	4		T	L	N

State Codes	National Codes	Federal Status
0 - Possibly Extirpated	0 - Possibly Extirpated	C - Candidate Species
1 - Cricitally Imperiled	1 - Cricitally Imperiled	T - Listed Federally Threatened
2 - Imperiled	2 - Imperiled	E - Listed Federally Endangered
3 - Vulnerable	3 - Vulnerable	SC - Species of Concern
4 - Apparently Secure	4 - Apparently Secure	State Status
5 - Secure	5 - Secure	T - Listed State Threatened
X - Extinct	Ch 17 Authority	E - Listed State Endangered
Game Species	F - Full Authority	S - Sensitive Species
H - Harvested	L - Limited Authority	
N - Not Harvested	N - No Authority	

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Blotched Water Snake	2	4		E	F	N
Ornate Box Turtle	5	5			L	N
Sonoran Mud Turtle	4	4			L	N
Western Painted Turtle	4	5			L	N
Midland Smooth Softshell Turtle	3	5			L	N
Gray-Checkered Whiptail	2	2	SC	E	F	N
Giant Spotted Whiptail	3	3		T	L	N
Molluscs						
Alamosa Springsnail	1	1	E	E	F	N
Blunt Ambersnail	1	5			L	N
Lake Fingernailclam	1	5		T	L	N
Long Fingernailclam	2	5		T	L	N
Swamp Fingernailclam	1	5		T	L	N
Texas Hornshell	1	1	C	E	F	N
Wrinkled Marshsnail	1	5		E	F	N
Bearded Mountainsnail	1	1			L	N
Black Range Mountainsnail	1	1			L	N
Black Range Mountainsnail	1	1			L	N
Fringed Mountainsnail	1	1			L	N
Hacheta Mountainsnail	1	1			L	N
Mineral Creek Mountainsnail	1	1	SC	T	L	N
Rocky Mountainsnail	5	5			L	N
Socorro Mountainsnail	3	3		S	L	N
Paper Pondshell Mussel	1	5		E	F	N
Lilljeborg's Peaclam	1	5		T	L	N
Sangre de Cristo Peaclam	1	1	SC	T	L	N
Creeping Ancylid Snail	4	5			L	N
Pecos Assiminea Snail	1	1	C	E	F	N
Crestless Column Snail	3	5			L	N
Amber Glass Snail	4	5			L	N
Western Glass Snail	4	5			L	N
Animas Mountains Holospira Snail	1	1			L	N
Cockerell Holospira Snail	2	2			L	N
Cross Holospira Snail	1	1			L	N
Metcalf Holospira Snail	1	1			L	N
Texas Liptooth Snail	4	5			L	N
Distorted Metastoma Snail	2	2			L	N
Chupadera Pyrg Snail	1	1	C	E	F	N
Gila Pyrg Snail	2	2	C	T	F	N
New Mexico Hotspring Pyrg Snail	1	1	C	T	F	N
Pecos Pyrg Snail	1	1	SC	T	F	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Roswell Pyrg Snail	1	1	C	E	F	N
Socorro Pyrg Snail	1	1	E	E	F	N
Whitewashed Radabotus Snail	4	4			L	N
New Mexico Ramshorn Snail	3	3			L	N
Marsh Slug Snail	1	1			L	N
Shortneck Snaggletooth Snail	1	2	SC	E	F	N
Sonoran Snaggletooth Snail	3	4			L	N
Spruce Snail	4	4			L	N
Star Gyro Snail	1	5		T	L	N
Obese Thorn Snail	2	5			L	N
Three-Toothed column Snail	3	3			L	N
Northern Treeband Snail	2	2			L	N
Koster's Tryonia Snail	1	1	C	E	L	N
Vallonia Snail	1	3			L	N
Blade Vertigo Snail	0	5			L	N
Ovate Vertigo Snail	1	5	SC	T	L	N
Animas Talussnail	1	1			L	N
Big Hatchet Mountain Talussnail	1	1			L	N
Dona Ana Talussnail	1	1	SC	T	L	N
Florida Mountain Talussnail	1	1			L	N
Franklin Mountain Talussnail	1	2			L	N
Organ Mountain Talussnail	3	3			L	N
Peloncillo Mountain Talussnail	1	1			L	N
San Luis Mountains Talussnail	1	1			L	N
Tularosa Springsnail	1	1			L	N
Woodlandsnail	1	1			L	N
Animas Peak Woodlandsnail	1	1			L	N
Big Hatchet Woodlandsnail	1	1			L	N
Cook's Peak Woodlandsnail	1	1	SC	T	L	N
Hacheta Grande Woodlandsnail	1	1	SC	T	L	N
Iron Creek Woodlandsnail	1	1			L	N
Jemez Woodlandsnail	3	3			L	N
Sangre de Cristo Woodlandsnail	3	3			L	N
Crustaceans						
Akali Fairy Shrimp	1	4			L	N
BLNWR cryptic species Amphipod	1	1			L	N
Sit. Bull Sp. cryptic species Amphipod	1	1			L	N
Noel's Amphipod	1	1	E	E	F	N
Beavertail Fairy Shrimp	5	5			L	N
Brine Shrimp	5	5			L	N
Colorado Fairy Shrimp	3	5			L	N
Conchas Crayfish	1	3		S	L	N
Procambarus simulans simulans	3	5			L	N
Northern (Canadian River) Crayfish	5	5			L	N
Cyzicus sp. (mexicanus?)	5	5			L	N
Eocyzicus concavus	3	5			L	N

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N - Not Harvested	N - No Authority	

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Eocyzicus digueti	5	5			L	N
Eulimnadia antlei	1	5			L	N
Eulimnadia cylindrova	5	5			L	N
Eulimnadia diversa	1	5			L	N
Eulimnadia follismilis	1	1			L	N
Eulimnadia texana	2	5			L	N
Great Plains Fairy Shrimp	3	5			L	N
Socorro Isopod	1	1	E	E	F	N
Knobblip Fairy Shrimp	2	5			L	N
Lepidurus lemmoni	1	4			L	N
Lynceus brevifrons	3	5			L	N
Mexican Beavertail Fairy Shrimp	3	5			L	N
Moore's Fairy Shrimp	1	1			L	N
Packard's Fairy Shrimp	2	5			L	N
Tadpole Shrimp	5	5			L	N
Sideswimmers / Scuds	5	5			L	N
Streptocephalus n. sp. 1	1	1			L	N
Streptocephalus n. sp. 2	1	1			L	N
Sublette's Fairy Shrimp	1	1			L	N
Versatile Fairy Shrimp	5	5			L	N
Other Arthropods						
Arachnid (Arachnida)						
Texella longistyla		1			N	N
Texella welbourni		2			N	N
Cave Obligate Mite		1			N	N
Aphrastochthonius pachysetus		1			N	N
Chitrella welbourni		1			N	N
Neoallochernes incertus		1			N	N
Peloncillo Scorpion			SC	S	N	N
Centipedes (Chilopoda)						
Cave Obligate Centipede		1			N	N
Jemez Spider					N	N
Millipedes (Diplopoda)						
Cave Obligate Millipede		2			N	N
Chihuahuan Millipede					N	N
Springtails (Entognatha)						
Oncopodura prietoi		1			N	N
Pseudosinella vita		1			N	N
Tomocerus grahami		1			N	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
<u>*Insects (Insecta)*</u>						
Aphaenogaster punctaticeps					N	N
Leptothorax bestelmeyeri					N	N
Leptothorax colleenae					N	N
Capulin Mountain Arctic		2			N	N
Andrena mimbresensis					N	N
Andrena neffi					N	N
Andrena vogleri					N	N
Perdita austini					N	N
Perdita biparticeps					N	N
Perdita claripennis					N	N
Perdita geminata					N	N
Perdita grandiceps					N	N
Perdita maculipes					N	N
Perdita mesillensis					N	N
Perdita senecionis					N	N
Perdita sidae					N	N
Perdita tarda					N	N
Perdita viridinotata					N	N
Centris Bee					N	N
Osmia phenax					N	N
Osmia prunorum					N	N
Mason Bee					N	N
Melittid Bee					N	N
Pityophthorus franseriae					N	N
Pityophthorus torridus					N	N
Anthony Blister Beetle	0		SC	S	N	N
Bonita Diving Beetle			SC	S	N	N
Southwestern Hercules Beetle					N	N
Glorious Jewel Beetle					N	N
Leconte's Jewel Beetle					N	N
Wood's Jewel Beetle					N	N
Animas Minute Moss Beetle	0		SC	S	N	N
Tiger Beetle					N	N
Glittering Tiger Beetle		4			N	N
Guadalupe Mtns Tiger Beetle		3			N	N
Los Olmos Tiger Beetle		2	SC		N	N
Maricopa Tiger Beetle		3	SC		N	N
Nevada Tiger Beetle		3			N	N
Buchholz's Boisduval's Blue					N	N
Mogollon Rim Greenish Blue					N	N
Hemileuca (chinatiensis) comwayae					N	N
Hemileuca (nevadensis) artemis					N	N
Hemileuca hera magnifica					N	N
Mountain Checkered-Skipper					N	N
Chalcedon Checkerspot		2			N	N
Sacramento Mountain Checkerspot		1		S	N	N

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Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Tawny Crescent					N	N
Mescalero Camel Cricket					N	N
Organ Mountains Camel Cricket					N	N
Rodent Burrow Camel Cricket					N	N
Gypsum Sand-Treader Camel Cricket					N	N
White Sands Sand-Treader Camel Cricket					N	N
Carlsbad Cave Cricket					N	N
Mescalero Sands Jerusalem Cricket					N	N
Arroyo Darner	1	2			N	N
Ellis Dotted-Blue		4			N	N
Spalding's Dotted-Blue		3			N	N
Bleached Skimmer Dragonfly		3			N	N
Scudder's Duskywing					N	N
Dusty-Wing					N	N
Desert Elfin		3			N	N
Caenotus inornatus					N	N
Caenotus minutus					N	N
Chrysotus parvulus					N	N
Neurigona perbrevis					N	N
Thinophilus magnipalpus					N	N
Mydas Fly					N	N
Efferia cuervana					N	N
Furcilla delicatula					N	N
Megaphorus lascrucensis					N	N
Soldier Fly					N	N
Capitan Mountains Fritillary					N	N
Freija Fritillary					N	N
Nitocris Fritillary		3			N	N
Nokomis Fritillary	1	1	SC		N	N
Raton Mesa Fritillary					N	N
Silver-bordered Fritillary					N	N
Aeoloplides rotundipennis		2			N	N
Cibolacris samalayucae		2			N	N
Band-Winged Grasshopper		1			N	N
Hebard's Blue-Winged Desert Grasshopper		2			N	N
Lichen Grasshopper		1			N	N
Nevada Point-Headed Grasshopper		2			N	N
Shotwell's Range Grasshopper		0			N	N
Spur-Throat Grasshopper		1			N	N
Spur-Throat Grasshopper		2			N	N
Ilavia Hairstreak		4			N	N
Poling's Hairstreak		1			N	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Sandia Hairstreak	4	4			N	N
Oslar's Soapberry Hairstreak					N	N
Xami Hairstreak					N	N
Mescalero Sands Katydid					N	N
Hexagenia bilineata		1			N	N
Homoeonuria alleni		2			N	N
Lachlania dencyannae	1	5			N	N
Leucrocuta petersi					N	N
Arizona Metalmark		2			N	N
Carales arizonensis					N	N
Borer Moth	0	0			N	N
Albarufan Dagger Moth	X		SC	S	N	N
Geometrid Moth					N	N
Noctuid Moth					N	N
Euhyparpax rosea		1			N	N
Oligocentria delicata		2			N	N
Pyralid Moth					N	N
Tiger Moth		1			N	N
Mirid Plant Bug					N	N
Dashed Ringtail		2			N	N
Cassus Roadside-Skipper					N	N
Large Roadside-Skipper					N	N
Slaty Roadside-Skipper					N	N
Texas Roadside-Skipper					N	N
Silkmoth					N	N
Zephyr Eyed Silkmoth		2			N	N
Apache Skipper					N	N
Arizona Agave Borer Skipper					N	N
Carlsbad Agave Borer Skipper		2			N	N
Viola's Yucca Borer Skipper		3			N	N
Western Crossline Skipper					N	N
Deva Skipper					N	N
Mary's Giant Skipper					N	N
Poling's Giant Skipper					N	N
Ursine Giant Skipper		3			N	N
Western Hobomok Skipper					N	N
Moon-marked Skipper					N	N
Sunrise Skipper					N	N
Yuma Skipper		1			N	N
Four-Spotted Skipperling		3			N	N
Arizona Snaketail	1	3			N	N
West's Primrose Sphinx					N	N
Vega Sphinx		2			N	N
Capnia caryi		2			N	N
Isoperla jewetti					N	N
Taenionema jacobii					N	N
Arizona Viceroy		2			N	N

Appendix H Cont.

Common or Scientific Name	State Codes	National Codes	Federal Status	State Status	Ch 17 Authority	Game Species
Tarantula Hawk Wasp					N	N
Dasymutilla homole					N	N
Odontophotopsis augusta					N	N
Odontophotopsis grata					N	N
Chiricahua White					N	N

[1] Scientific name provided for species with no recognized common name. Scientific names of other species can be found in Appendix C.

Appendix I. Specific factors that influence the integrity of Species of Greatest Conservation Need populations in New Mexico. Factors compiled by New Mexico Department of Game and Fish.

Common or Scientific Name[1]	Species Specific Factors	References
Fish		
Canadian Speckled Chub	Water diversion, groundwater pumping, regulated reservoir releases	NMDGF 2004a, Propst 1999
Bigscale Logperch	Predation by non-native fishes, fluctuating water levels, drying of habitat, Predation by non-native centrarchids	Propst 1999
Blue Catfish	Habitat deterioration	Sublette *et al.* 1990
Blue Sucker	Habitat fragmentation, water diversion, drying of habitat, Golden algae blooms	Propst 1999, Larson 2004
Central Stoneroller	Sedimentation, reduction in flows	NMDGF 2004a, Propst 1999
Chihuahua Chub	Non-native predators (salmonids & centrarchids) and competitors (longfin dace & rainbow trout), stream desiccation, habitat loss (debris removal, bank erosion, channelization), range fragmentation, irrigation diversion entrainment, parasites, disease	Propst 2004
Colorado Pikeminnow	Non-native fishes (particularly predators such as channel catfish), habitat fragmentation (diversion dams), loss of low-velocity habitats, entrainment in irrigation systems, modified flow regimes (loss of peaking flows as spawning cue), insufficiency of prey base, disease	Propst 1999, USFWS 1991, USFWS 2003
Desert Sucker	Non-native predators (mainly centrarchids & ictalurids), sedimentation, band erosion, in-channel debris removal, channelization, stream desiccation, wildfire ash flows, disease	
Gila Chub	Non-native predators (mainly centrarchids & ictalurids), habitat modification (sedimentation, bank erosion, debris removal), wildfire ash flows, disease	
Gila Topminnow	Interactions with introduced gambusia species, lowered water levels	Sublette *et al.* 1990, Propst 1999
Gila Trout	Non-native competitors (mainly brown trout) and congenerics (hybridizing rainbow trout), illegal angling, wildfire ash flows, disease, habitat loss (bank erosion), sedimentation	
Gray Redhorse	Drying of habitat, Golden algae blooms	Larson 2004
Greenthroat Darter	Lowered water tables, drying of springs, Predation by introduced Centrarchids, predation by non-native fishes, sediment deposition, water diversion	Propst 1999, Sublette *et al.* 2004, Brooks and Wood 1988, Hubbs and Strawn 1957, Cowley and Sublette 1987

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Headwater Catfish	Hybridization with *I. punctatus,* Drying of habitat	Sublette *et al.* 1990, Kelsch 1995
Headwater Chub	Non-native predators (mainly centrarchids & ictalurids), habitat modification (sedimentation, bank erosion, debris removal), wildfire ash flows, removal woody riparian vegetation, disease	
Loach Minnow	Non-native predators (mainly centrarchids & ictalurids) and competitors (mainly red shiner *Cyprinella lutrensis*), substrate armoring, bank instability, loss riparian vegetation, stream drying (diversion & groundwater pumping), sedimentation, channelization, wildfire ash flows, disease	
Mexican Tetra	Lowered water tables, drying of springs	Propst 1999
Mottled Sculpin	Habitat desiccation (irrigation withdrawals/diversion), habitat modification (sedimentation, channelization), disease	
Pecos Bluntnose Shiner	Drying of habitat, altered flow regimes	USFWS 1992, Hoagstom 2003, USFWS 2002
Pecos Gambusia	Lowered water tables, drying of springs, Predation by introduced Centrarchids, hybridization with *G. affinis*, loss of habitat	Echelle *et al.* 1989, Brooks and Wood 1988, USFWS 1983
Pecos Pupfish	Lowered water tables, drying of springs, Hybridization with *C. variegatus*	TPWD *et al.* 1998, Hoagstom and Brooks 1998, Minckley *et al.* 1991, Brooks and Wood 1988, Platania 2001
Rainwater Killifish	Lowered water tables, drying of springs, Predation by introduced Centrarchids, loss of habitat	Sublette *et al.* 2004, Brooks and Wood 1988, USFWS 1983
Razorback Sucker	Non-native fishes (predators), habitat modification (channalization, bank revetments), modified flow regimes, irrigation diversion entrainment, range fragmentation (diversion dams), modified flow regime, temperature modification, loss debris pool habitats, disease	USFWS 2003, Brandenburg *et al.* 2001
Rio Grande Chub	Habitat deterioration, non-native species, water diversion	Propst 1999, Douglas and Douglas 2003
Rio Grande Cutthroat Trout	Non-native species, habitat deterioration	NMDGF 2004a, Pflieger 1975, Pittinger 2004
Rio Grande Shiner	Drying of habitat	Sublette *et al.* 1990
Rio Grande Silvery Minnow	Water withdrawal, habitat fragmentation, channelization, water quality, non-native species	Sublette *et al.* 1990, USFWS 1983
Rio Grande Sucker	Habitat deterioration, non-native species, disease	NMDGF 1994a, Sublette *et al.* 1990

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Roundtail Chub	Non-native fishes (particularly predators), habitat fragmentation (dams, diversions), habitat desiccation (irrigation withdrawals/diversions), habitat modification (channelization, vegetation removal, bank revetments), modified flow regimes (loss of spring runoff and storm spike flows), irrigation diversion entrainment, wildfire ash flows (Mesa Verde Wildfire), disease, and temperature modification	UDNR 2004, Propst 1999
Smallmouth Buffalo	Habitat deterioration, harvest, non-native fishes	Minckley *et al.* 1991, Douglas and Douglas 2003
Sonora Sucker	Non-native predators (mainly centrarchids & ictalurids), sedimentation, band erosion, in-channel debris removal, channelization, stream desiccation, wildfire ash flows, disease	
Southern Redbelly Dace	Dewatering of springs, sedimentation	NMDGF 2004a, Propst 1999
Speckled Chub	Drying of habitat	Sublette *et al.* 1990
Spikedace	Non-native predators (mainly centrarchids & ictalurids) and competitors (mainly red shiner *Cyprinella lutrensis*), substrate armoring, bank instability, loss riparian vegetation, stream drying (diversion & groundwater pumping), sedimentation, channelization, wildfire ash flows, disease	
Suckermouth Minnow	Sedimentation, habitat desiccation and fragmentation.	NMDGF 2004a, Propst 1999
White Sands Pupfish	Habitat loss due to drought and water withdrawal, non-native species, military maneuvers	Ortiz *et al.* 2000, Propst 1999
Zuni Bluehead Sucker	Habitat degradation and loss, non-native aquatic species	NMDGF 2005, Propst 1999, Propst and Hobbes 1996
Birds		
American Bittern	Loss, degradation, or fragmentation of wetland habitat, pesticides and contaminants, acid precipitation, human disturbance, small, isolated populations	Gibbs *et al.* 1992
Common Black-Hawk	Loss/fragmentation/degradation of southwestern cottonwood-sycamore riparian habitat, stream dewatering, human disturbance at nest sites, illegal shooting	NMDGF 2004a
Boreal Owl	Loss of undisturbed spruce-fir and similar forests from timber harvest or other factors	Hayward and Hayward 1993, NMDGF 2004
Painted Bunting	Loss or degradation of riparian habitats, including programs to eradicate non-native plants, documented population declines	Lowther *et al.* 1999

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Varied Bunting	Loss of dense, shrubby riparian habitats from clearing, conversion, burning, improper grazing practices, and/or urbanization	Groschupf and Thompson 1998, NMDGF 2004a
Neotropic Cormorant	Loss/degradation of breeding sites, including loss of trees/snags for nest substrate, disturbance to breeding colonies, fluctuations in fish prey base, illegal shooting and other persecution	Telfair and Morrison 1995, NMDGF 2004a
Sandhill Crane	Loss or degradation of limited wetland and playa habitats, disturbance to roosting birds, disease, low recruitment rates	Tacha *et al.* 1992
Yellow-Billed Cuckoo	Loss, fragmentation, and degradation of riparian habitats from clearing for urban or agricultural development, improper grazing practices, flood control, schemes to eradicate exotic vegetation	pers. comm., S. Williams, NMDGF
Long-Billed Curlew	Loss, alteration, and fragmentation of native prairie breeding habitat from agricultural conversion, urbanization, improper grazing practices, shrub encroachment	Dugger and Dugger 2002, NMPIF 2004a
Mourning Dove	Persistent declining population trends, competition with expanding populations of native and non-native dove species, disease	Dolton and Rau 2004, pers. comm., J. Haskins, USFWS
Northern Pintail	Rangewide population decline related to drought and wetland conversion, wintering habitat losses from increased urbanization of agricultural lands and native habitats, degradation of playa habitats	Millar and Duncan 1999
Bald Eagle	Human disturbance to nests and winter roosts, loss/degradation of breeding and wintering habitat, including declines in prey populations and in nest/roost site availability, environmental contamination, electrocution, illegal killing by shooting and poisoning	NMDGF 2004a
Golden Eagle	Degradation of habitat, especially shrublands, from clearing, fires, surface mining, urbanization and human population growth, declining prey populations related to habitat degradation, disturbance and taking, electrocution, collision, lead poisoning, illegal shooting and poisoning	Kochert *et al.* 2002
Aplomado Falcon	Loss, degradation, or alteration of desert grassland habitat leading to reduced grass cover, increased brush encroachment, and reduced prey populations, resulting from improper grazing practices or agricultural conversion, fire, pesticides and other contaminants, electrocution, accidental drowning, human disturbance including research activities, lack of regulatory protection measures for individuals and habitats	USFWS 1990, Keddy-Hector 2000, NMDGF 2004a

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Peregrine Falcon	Chemical contamination of environment, disturbance of nesting pairs, illegal taking	NMDGF 2004a, Johnson and Williams 2004
Olive-Sided Flycatcher	Significant and accelerating rangewide population declines potentially linked to forest habitat losses from timber management or fire suppression	Altman and Sallabanks 2000
Southwestern Willow Flycatcher	Loss, fragmentation, or alteration of riparian habitat from water manipulation, urbanization, improper grazing practices, fire, and vegetation eradication programs, negative impacts from recreation and research, demography of fragmented populations	NMDGF 2004a
Northern Goshawk	Loss or alteration of forest habitat from timber harvest, fire, disturbance to nesting birds, illegal shooting and taking	Squires and Reynolds 1997
Eared Grebe	Loss/degradation of higher elevation wetland breeding habitat through drainage, conversion, flooding and/or dewatering for irrigation, grazing of emergent vegetation, contaminants	Cullen *et al.* 1999, pers. comm., D. Krueper, USFWS
Common Ground-Dove	Loss of lower elevation riparian shrublands, altered hydrology leading to dewatered riparian areas	NMDGF 2004a
Blue Grouse	Habitat loss or alteration from urbanization, agriculture, timber harvest, fire, improper grazing practices, and road building	Zwickel 1992
Northern Harrier	Loss/alteration of marsh/wet meadow breeding habitat from draining/drying marshes, conversion to monotypic agriculture, improper grazing practices, disturbance of nest sites from agricultural practices, pesticides and contaminants, illegal shooting	MacWhirter and Bildstein 1996
Ferruginous Hawk	Loss or alteration of native grassland habitats, including through urbanization, conversion, energy development, road construction, and shrub encroachment, decreased prey populations due to human activities, human disturbance at nest sites, illegal shooting	Bechard and Schmutz 1995, NMPIF 2004a
Broad-Billed Hummingbird	Loss of southwestern riparian canyon woodlands from fire, improper grazing practices, and clearing	NMDGF 2004a
Costa's Hummingbird	Loss of native xeric hillside vegetation and adjacent riparian habitats in southwestern New Mexico from burning or improper grazing practices	NMDGF 2004a
Lucifer Hummingbird	Loss of native dry-canyon/hillside habitats, including loss of food plants from burning or improper grazing practices	NMDGF 2004a
Violet-Crowned Hummingbird	Loss of low-elevation broadleaf riparian canyon woodlands, especially loss of scarce big-tree riparian habitats from fire, loss of food sources such as agaves from fire	Williams 2002, NMDGF 2004a

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
White-Faced Ibis	Loss /degradation of wetland habitat, disturbance to breeding colonies, pesticides and other contaminants/toxicants	Ryder and Manry 1994
Pinyon Jay	Loss, degradation, or fragmentation of pinyon-juniper woodlands from conversion, clearing, firewood cutting, improper grazing practices, and altered fire regimes, illegal shooting	Balda 2002
Yellow-Eyed Junco	Small, isolated populations vulnerable to montane forest habitat loss or modification	NMDGF 2004a
Thick-Billed Kingbird	Loss or degradation of broadleaf riparian woodland habitat from fire, lowered water tables, improper grazing practices	NMDGF 2004a
Hooded Oriole	Loss or fragmentation of broadleaf riparian habitat from clearing, dewatering, fire, and improper grazing practices, cowbird parasitism	Krueper *et al.* 2003
Osprey	Human disturbance and shoreline development, prey population fluctuations, pesticides and contaminants, electrocution, collision, illegal shooting	Poole *et al.* 2002
Burrowing Owl	Loss or fragmentation of grassland habitat to agricultural conversion or urbanization, elimination of burrowing rodents such as prairie dogs, improper grazing practices, burning, mowing, illegal shooting	Klute *et al.* 2003
Elf Owl	Loss or degradation of mature riparian and canyon forest nesting habitat, human disturbance	NMPIF 2004
Whiskered Screech-Owl	Loss of pine-oak and oak woodland within restricted range from vegetation removal and natural and prescribed fires, human disturbance	NMDGF 2004a
Mexican Spotted Owl	Loss of preferred mature and old growth forest habitat from timber harvest and other cutting, altered fire regimes, stand-replacing fires	USFWS 1993, USFWS 1995
Greater Pewee	Loss, alteration, or degradation of southwestern pine-oak and mixed conifer habitats, especially loss of large conifers, reduced prey base from pesticide use in forest habitats	Chase and Twite 1999
Wilson's Phalarope	Loss of wetland/wet meadow breeding areas from water diversion, improper grazing practices, agricultural conversion, chemical contamination	pers. comm., W. Howe, USFWS
Band-Tailed Pigeon	Long-term population declines potentially linked to habitat alteration due to fire or drought, disease	Keppie and Braun 2000, pers. comm., J. Haskins, USFWS
Sprague's Pipit	Loss or fragmentation of native grassland habitats from improper grazing practices, land conversion, brush encroachment, and oil and gas development	Robbins and Dale 1999, pers. Comm.., W. Howe, USFWS

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Mountain Plover	Loss or alteration of prairie breeding areas from agricultural conversion, energy development, surface mining, exotic vegetation, loss of native grazers including prairie dogs, loss or fragmentation of migration and wintering areas from conversion, urbanization, environmental contamination	Knopf 1996, NMPIF 2004
Snowy Plover	Loss or degradation of breeding alkali flats and playas from flooding, drying, and/or vegetation encroachment, disturbance to nesting birds	Page *et al.* 1995, NMPIF 2004
Lesser Prairie-Chicken	Loss, degradation, fragmentation of habitat through improper grazing practices, shrub control, and oil and gas development, small-population phenomena	Bailey and Williams 2000
White-Tailed Ptarmigan	Loss or alteration of limited alpine tundra habitat through overuse by grazing ungulates including elk and bighorn, increased human use, ski area development, construction of snow catchment fences, construction and operation of microwave relay stations	Braun *et al.* 1993, NMDGF 2004a
Montezuma Quail	Improper grazing practices of understory grasses necessary for food and nesting cover, altered fire regimes leading to replacement of required habitat, habitat loss to development and urbanization	Stromberg 2000, NMPIF 2004
Scaled Quail	Improper grazing practices compounded by periodic drought, habitat loss related to brush control	pers. comm., W. Howe, USFWS
Painted Redstart	Loss or alteration of middle elevation oak and pine-oak riparian woodlands from timber management, fire, and drought, human disturbance to nesting birds	pers. comm., S. Williams, NMDGF
Williamson's Sapsucker	Loss or alteration of mature mixed and deciduous forest habitats, especially mature aspen groves, from fire and timber operations	Dobbs *et al.* 1997, NMPIF 2004
Loggerhead Shrike	Significant rangewide declines potentially linked to habitat loss/degradation from changing agricultural practices, brush control programs or other land use changes, pesticide contamination, collision with vehicles	Pruitt 2000
Baird's Sparrow	Loss or degradation of native grassland habitat from improper grazing practices, shrub encroachment, land development, and oil and gas development	Green *et al.* 2002, NMDGF 2004a
Botteri's Sparrow	Loss or degradation of limited tall-grass habitat from improper grazing practices and fire	pers. comm., S. Williams, NMDGF
Grasshopper Sparrow	Loss or degradation of native grassland habitat, primarily from improper grazing practices and ill-timed (late spring-early summer) fires	NMDGF 2004a

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Sage Sparrow	Rangewide declines linked to fragmentation, degradation, or destruction of sagebrush habitat from mechanical, chemical, and burning programs, improper grazing practices of disturbed/treated sagelands, altered fire regimes, exotic plant encroachment	Martin and Carlson 1998
Bank Swallow	Destruction or alteration of streambank nesting habitat from flood- and erosion-control projects, bank stabilization projects, inundation, road building	Garrison 1999
Black Swift	Disturbance at nesting caves	pers. comm., S. Williams, NMDGF
Interior Least Tern	Loss or alteration of riverine habitats from altered flow regimes, channelization, inundation, chemical contamination of prey base, human disturbance of nesting flats	1990, NMDGF 2004a
Bendire's Thrasher	Total population small and restricted, significant rangewide population declines potentially related to habitat changes or to unknown factors	pers. comm., S. Williams, NMDGF
Sage Thrasher	Loss or degradation of sagebrush habitat through mechanical or chemical clearing, invasion of non-native plants, conversion to agriculture, fire	Reynolds *et al.* 1999
Juniper Titmouse	Rangewide declining trends potentially related to loss of pinyon-juniper habitat from clearing, range conversion, excessive firewood and fence post cutting	Cicero 2000
Abert's Towhee	Loss, alteration, or degradation of native southwestern riparian habitats from improper grazing practices, clearing, or conversion	NMDGF 2004a
Elegant Trogon	Loss of limited broadleaf riparian foraging and breeding habitat, including large trees with suitable nesting cavities, from fire, wood cutting, and improper grazing practices, human disturbance of nesting birds	NMDGF 2004a
Gould's Wild Turkey	Habitat loss from removal of vegetation, fire, improper grazing practices, lack of water sources, hybridization with non-native turkeys, human killing and disturbance	NMDGF 2004a
Northern Beardless-Tyrannulet	Loss or degradation of native riparian habitat through clearing, burning, and improper grazing practices	NMDGF 2004a
Bell's Vireo	Loss or fragmentation of dense shrubby/woody riparian habitats from urbanization, agricultural conversion, improper grazing practices, firewood cutting, flood control, and reservoir construction, cowbird parasitism	Brown 1993, NMDGF 2004a
Gray Vireo	Loss or alteration of quality juniper-grassland habitat from clearing, burning, and improper grazing practices, cowbird parasitism	NMDGF 2004a

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Grace's Warbler	Loss, alteration, or fragmentation of ponderosa pine habitat from timber harvest, firewood harvest, improper grazing practices, fire suppression, and urban development	Block and Finch 1997, Stacier and Guzy 2002
Black-Throated Gray Warbler	Loss or alteration of pinyon-juniper and oak-juniper woodlands through thinning, clearing, fire, or disease	pers. comm., W. Howe, USFWS
Lucy's Warbler	Loss or degradation of southwestern riparian habitats from clearing, firewood cutting, improper grazing practices, fire, and inundation	Johnson *et al.* 1997
Red-Faced Warbler	Loss or alteration of undisturbed montane riparian and forest habitats from timber harvest, catastrophic fire, and improper grazing practices, human disturbance to nesting birds	NMPIF 2004
Yellow Warbler	Loss or degradation of willow and other riparian habitats from improper grazing practices, clearing, and flood control projects	Lowther *et al.* 1999, Krueper *et al.* 2003
Gila Woodpecker	Habitat destruction from cutting or other destructive clearing (burning, inundation) of mature cotton and sycamore riparian stands, progressive fragmentation of remaining habitat patches, competition for nest sites with exotic European starlings	NMDGF 2004a
Lewis's Woodpecker	Loss or alteration of ponderosa pine nesting habitat from altered fire regimes, timber harvest including salvage logging, improper grazing practices, progressive loss of mature cottonwood bosque breeding habitat	NMFIF 2004
Red-Headed Woodpecker	Loss or degradation of breeding habitat, especially mature cottonwood bosque, from urbanization, clearing and other cutting, agricultural conversion, river channelization, competition for nest sites with exotic European starlings	Smith *et al.* 2000, pers. comm., W. Howe, USFWS
Mammals		
Allen's Big-Eared Bat	Roost disturbance	CO Committee, Western Bat Working Group 2003
Pocketed Free-Tailed Bat	Poorly known, probably roost disturbance	AZ Bat Resource Group 2003
Lesser Long-Nosed Bat	Roost disturbance, wildfire, loss of nectar plants	NMDGF 2004a
Mexican Long-Nosed Bat	Roost disturbance, wildfire, loss of nectar plants	NMDGF 2004a
Mexican Long-Tongued Bat	Roost disturbance, wildfire, loss of nectar plants	AZ Bat Conservation Stategic Plan 2003
Arizona Myotis Bat	Habitat loss/conversion, roost disturbance	CO Committee, Western Bat Working Group 2003

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Western Red Bat	Riparian habitat loss/conversion, small populations	AZ Bat Conservation Stategic Plan 2003
Spotted Bat	Roost/foraging habitat disturbance, pesticides	NMDGF 200a4
Western Yellow Bat	Riparian habitat loss/conversion, small populations	NMDGF 2004a
Black Bear	Upland habitat loss/conversion, drought, human conflicts	pers. comm., R. Winslow, NMDGF
American Beaver	Water withdrawals, habitat loss/fragmentation, depredation control	pers. comm., J. Stuart, NMDGF
Penasco Least Chipmunk	Habitat loss/fragmentation, species competition	NMDGF 2004a
White-Nosed Coati	Madrean/riparian habitat loss/fragmentation, small populations, spring loss	pers. comm., J.K. Frey, NMSU
Mule Deer	Habitat loss/fragmentation, ecological succession, drought	pers. comm., B. Hale, NMDGF
Coues' White-Tailed Deer	Habitat loss/fragmentation, ecological succession, drought	pers. comm., B. Hale, NMDGF
Swift Fox	Grassland habitat loss/conversion, road mortality	pers. comm., J. Stuart, NMDGF
Southern Pocket Gopher	Habitat loss/conversion, wildfire, small populations	NMDGF 2004a
Snowshoe Hare	Loss of dense forest through logging, development, wildfire	pers. comm., J.K. Frey, NMSU
Jaguar	Habitat loss/conversion/fragmentation, illegal shooting	FWS 1997
American Marten	Timber overharvest, forest habitat loss/conversion, wildfire	NMDGF 2004a
New Mexico Meadow Jumping Mouse	Improper grazing practices, wetland habitat loss/conversion, small populations	NMDGF 2004a
Northern Pygmy Mouse	Improper grazing practices, grassland habitat loss/conversion, small populations	pers. comm., J. Stuart, NMDGF
River Otter	Riverine habitat loss/conversion, water pollution	pers. comm., J.K. Frey, NMSU
Goat Peak Pika	Habitat loss/conversion, climate change, small populations	pers. comm., J. Stuart, NMDGF
Black-Tailed Prairie Dog	Sylvatic plague, habitat loss/fragmentation, unregulated taking	USFWS 2000
Gunnison's Prairie Dog	Sylvatic plague, unregulated taking, habitat loss/fragmentation	Knowles 2002
White-Sided Jack Rabbit	Improper grazing practices, habitat loss/conversion, small populations	NMDGF 2004a

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
White-Tailed Jack Rabbit	Grassland loss w/in sage community, fragmentation, improper grazing practices	pers. comm., J.K. Frey, NMSU
Yellow-Nosed Cotton Rat	Improper grazing practices, grassland habitat loss/conversion, small populations	pers. comm., J. Stuart, NMDGF
Desert Bighorn Sheep	Woody vegetation encroachment, improper grazing practices, disease from domestic livestock, inbreeding, lion predation	pers. comm., E. Rominger, NMDGF
Rocky Mountain Bighorn Sheep	Woody vegetation encroachment, climate change, disease from domestic livestock	pers. comm., E. Rominger, NMDGF
Arizona Shrew	Habitat loss/conversion, wildfire, small populations	NMDGF 2004a
Least Shrew	Improper grazing practices, habitat loss/conversion, wetland drying	NMDGF 2004a
New Mexico Shrew	Timber overharvest, wildfire, habitat loss/conversion	pers. comm., J.K. Frey, NMSU
Preble's Shrew	Habitat loss/conversion, improper grazing practices, drought/climate change	pers. comm., J.K. Frey, NMSU
Abert's Squirrel	Forest habitat loss/conversion, drought, wildfire	pers. comm., J.K. Frey, NMSU
Arizona Gray Squirrel	Riparian habitat loss/conversion, small populations	pers. comm., J.K. Frey, NMSU
Arizona Montane Vole	Improper grazing practices, wetland habitat loss/conversion, small populations	NMDGF 2004a
Prairie Vole	Improper grazing practices, wetland habitat loss/conversion, small populations	pers. comm., J. Stuart, NMDGF
Mexican Gray Wolf	Illegal killing, road mortality, disease, small populations, habitat fragmentation	NMDGF 2004a
Amphibians		
Western Chorus Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), conversion of habitat to agriculture, draining of wetlands	Kats *et al.* 2003, Daszak *et al.* 2004, pers. comm., C. Painter, NMDGF
Chiricahua Leopard Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), habitat modification, drought	Kats *et al.* 2003, Daszak *et al.* 2004, USFWS (In Prep) 2002
Lowland Leopard Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), limited range in NM	Kats *et al.* 2003, Daszak *et al.* 2004, Degenhardt *et al.* 1996
Northern Leopard Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), habitat modification, drought	Kats *et al.* 2003, Daszak *et al.* 2004, pers. comm., C. Painter, NMDGF

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Plains Leopard Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), habitat modification, drought	Kats *et al.* 2003, Daszak *et al.* 2004, pers. comm., C. Painter, NMDGF
Rio Grande Leopard Frog	disease, non-native predators (bullfrogs, non-native fishes, crawfish), habitat modification, drought	Kats *et al.* 2003, Daszak *et al.* 2004, pers. comm., C. Painter, NMDGF
Mountain Tree Frog	disease, habitat modification	pers. comm., C. Painter, NMDGF
Jemez Mountains Salamander	disease, silvicultural activities, drought, wildfire	Degenhardt *et al.* 1996, pers. comm., C. Painter, NMDGF
Sacramento Mountain Salamander	disease, Silvicultural activities, drought, wildfire	Ramotnik 1996, Ramotnik 1997, NMDGF 2000
Tiger Salamander	disease, use and transportation as fish bait (direct moratlity and genetic swamping), pet trade	Collins *et al.* 2004, Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Arizona Toad	disease, hybridization, conversion of habitat to agriculture	Sullivan 1986, pers. comm., C. Painter, NMDGF
Western Boreal Toad	disease, introduced trout, habitat alteration	Hammerson 1999, Goettl 1997
Colorado River Toad	modification of wetland habitat, conversion to agriculture, highway mortality	pers. comm., C. Painter, NMDGF
Great Plains Narrowmouth Toad	elimination of wetland habitat, conversion to agriculture, non-native predators (bullfrogs)	Stuart and Painter 1996
Reptiles		
Western River Cooter	indiscriminate shooting, drought, water diversion, pet trade, market hunting	Fitzgerald *et al.* 2004
Texas Banded Gecko	pet trade	NMDGF Collecting Permit files, Fitzgerald *et al.* 2004
California Kingsnake	highway mortality, limited NM range, pet trade	Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Gray-Banded Kingsnake	pet trade, lack of life history data, isolated small population, periphery of range	Hakkila 1994, NMDGF 2002, Fitzgerald *et al.* 2004
Sonoran Mountain Kingsnake	wildfire, habitat alteration, pet trade	Fitzgerald *et al.* 2004, Hubbs 2004
Madrean Alligator Lizard	wildfire, conversion of habitat	pers. comm., C. Painter, NMDGF

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Collared Lizard	extensive urbanization, agricultural development and associated pesticides and herbicides, invasion of non-native grasses (cheatgrass), pet trade, oil/gas industry opening roads thus increasing access to habitat	NMDGF Collecting Permit files, Hamerson 1999
Bunch Grass Lizard	improper grazing practices, wildfire, conversion of habitat	Bock and Bock 2000, pers. comm., C. Painter, NMDGF
Regal Horned Lizard	wildfire, limited range in NM	pers. comm., C. Painter, NMDGF
Sand Dune Lizard	habitat conversion, herbicide spraying, oil/gas exploration and development,	Painter *et al.* 1999, Fitzgerald *et al.* 1997
Desert Massasauga	conversion of grasslands to agriculture herbicide spraying, improper grazing practices, pet trade, indiscriminate killing, fragmentation of populations (=habitat)	Hammerson 1999, Holycross 2002
Reticulate Gila Monster	wildfire, habitat conversion to agriculture, indiscriminate killing, pet trade	Brown and Carmony 1991, Beck 2005, NMDGF 2000, pers. comm., C. Painter, NMDGF
Western Diamondback Rattlesnake	highway mortality, commercial trade, indiscriminate killing, addition of new roads opening habitat and thus exposure to people	Fitzgerald and Painter 2000, pers. comm., C. Painter, NMDGF
New Mexico Ridgenose Rattlesnake	wildfire, commercial trade, small isolated population	Degenhardt *et al.* 1996, NMDGF 2000, Holycross 2002, pers. comm., C. Painter, NMDGF
Banded Rock Rattlesnake	commercial trade, indiscriminate killing, addition of new roads opening habitat and thus exposure to people	Degenhardt *et al.* 1996, NMDGF 2000, Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Mottled Rock Rattlesnake	commercial trade, indiscriminate killing, addition of new roads opening habitat and thus exposure to people	Degenhardt *et al.* 1996, NMDGF 2000, Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Mountain Skink	wildfire, conversion of habitat	pers. comm., C. Painter, NMDGF
Big Bend Slider	indiscriminate shooting, drought, water diversion, pet trade, market hunting	Fitzgerald *et al.* 2004
Yaqui Blackhead Snake	wildfire, limited NM distribution, isolated, small population	Degenhardt *et al.* 1996, NMDGF 2000, pers. comm., C. Painter, NMDGF
Mexican Garter Snake	limited NM distribution, draining and destruction of wetlands, non-native predators, indiscriminate killing	Degenhardt *et al.* 1996, NMDGF 2000, pers. comm., C. Painter, NMDGF

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Narrowhead Garter Snake	disease, non-native predators (bullfrogs, non-native fishes, crawfish), improper grazing practices of streamside vegetation, erosion of banks, siltation, recreational use of habitat, indiscriminate killing	Nowak and Santana-Bendix 2003a, Nowak and Santana-Bendix 2003b, pers. comm., C. Painter, NMDGF
New Mexico Garter Snake	limited NM distribution, conversion to agriculture, draining of wetlands, drought, highway mortality, indiscriminate killing	pers. comm., C. Painter, NMDGF
Milk Snake	lack of life history data, highway mortality, intensive urbanization, pet trade	NMDGF permit files, Hammerson 1999, Fitzgerald *et al.* 2004
Green Rat Snake	wildfire, limited NM distribution, isolated, small population, pet trade	Degenhardt *et al.* 1996, NMDGF 2000, Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Arid Land Ribbon Snake	limited NM distribution, draining of wetlands, non-native predators, indiscriminate killing	Degenhardt *et al.* 1996, NMDGF 2000, pers. comm., C. Painter, NMDGF
Blotched Water Snake	indiscriminate shooting, drought, water diversion, pet trade	Degenhardt *et al.* 1996, NMDGF 2000, Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Ornate Box Turtle	highway mortality, pet trade, turtle races (Clovis), conversion to agriculture, improper grazing practices	Degenhardt *et al.* 1996, Hammerson 1999, pers. comm., C. Painter, NMDGF
Sonoran Mud Turtle	habitat modification, drought	pers. comm., C. Painter, NMDGF
Western Painted Turtle	indiscriminate shooting, drought, water diversion, pet trade, market hunting	Fitzgerald *et al.* 2004
Midland Smooth Softshell Turtle	indiscriminate shooting, drought, water diversion, pet trade, market hunting	Fitzgerald *et al.* 2004, pers. comm., C. Painter, NMDGF
Gray-Checkered Whiptail	improper grazing practices, competition with native species (genetic swamping), herbicide treatment of creosotebush	Cole *et al.* (In Prep), pers. comm., C. Painter, NMDGF
Giant Spotted Whiptail	wildfire, conversion of habitat	pers. comm., C. Painter, NMDGF
Molluscs		
Paper Pondshell Mussel	habitat modification (damming, stream channelization, regulated flows), non-native bivavles	Lang and Mehlhop 1996, NMDGF 2004a, website[2]
Texas Hornshell	habitat modification (damming, diversion), aquifer depletion, surface water contamination, drought, sedimentation, non-native molluscs, golden algae	Lang 2004

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Swamp Fingernailclam	stream channel incisement/aggradation from poor watershed management practices, water pollution	NMDGF 2004a
Lake Fingernailclam	stream channel incisement/aggradation from poor watershed management practices, water pollution	NMDGF 2004a
Long Fingernailclam	stream channel incisement/aggradation from poor watershed management practices, water pollution	NMDGF 2004a
Chupadera Pyrg Snail	spring diversion/impoundment, improper grazing practices riparian corridor, non-native species (crayfish, New Zealand mudsnail)	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a, website[3]
Gila Pyrg Snail	recreational bathing, non-native species (crayfish, New Zealand mudsnail)	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a, website[3]
Socorro Pyrg Snail	spring diversion/impoundment, non-native crayfish	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a
Pecos Pyrg Snail	spring diversion/impoundment, improper grazing practices riparian corridor, groundwater depletion/contamination, non-native species (crayfish, New Zealand mudsnail)	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a, Lang 2005a, website[3]
Roswell Pyrg Snail	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs	Lang 2005a, NMDGF 2005a, website[3]
New Mexico Hotspring Pyrg Snail	recreational bathing, non-native species (crayfish, New Zealand mudsnail)	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a, website[3]
Alamosa Springsnail	beryllium mining, non-native species (crayfish, New Zealand mudsnail, tamarisk)	Fernandez and Rosen 1996, Childs 1999, NMDGF 2004a, website[3]
Koster's Tryonia Snail	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs	Lang 2005a, NMDGF 2005a, website[3]
Pecos Assiminea Snail	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs	Lang 2005a, NMDGF 2005a, website[3]
Wrinkled Marshsnail	habitat loss (improper grazing practices, arroyo entrenchment/sedimentation, fire frequency), drought, water contamination from sewage effluent, hydroperiod alteration, vegetative loss within drainage catchment	NMDGF 2004a, Lang 2005a
Star Gyro Snail	habitat modification (wetland filling, change in hydrology)	NMDGF 2004a
New Mexico Ramshorn Snail	arroyo entrenchment/sedimentation, hydroperiod alteration, drought, human alteration of swales and depressions	Taylor 1985, Leibowitz and Nadeau 2003, pers. comm., B. Lang, NMDGF
Creeping Ancylid Snail	habitat modification (damming, diversion), non-native fish introductions	Hoving 2004

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Obese Thorn Snail	human habitat modification	Metcalf and Smartt 1997
Crestless Column Snail	human alteration of high elevation wetlands	pers. comm., B. Lang, NMDGF
Three-Toothed Column Snail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Sonoran Snaggletooth Snail	human habitat modification	pers. comm., B. Lang, NMDGF
Shortneck Snaggletooth Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Blade Vertigo Snail	groundwater depletion, wetland habitat alterations (improper grazing practices, human modification)	pers. comm., B. Lang, NMDGF
Ovate Vertigo Snail	groundwater depletion, wetland habitat alterations (improper grazing practices, human modification)	Metcalf and Smartt 1997
Vallonia Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Distorted Metastoma Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Cockerell Holospira Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Cross Holospira Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Metcalf Holospira Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Animas Mountain Holospira Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Whitewashed Radabotus Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Rocky Mountainsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Mineral Creek Mountainsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Black Range Mountainsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Socorro Mountainsnail	fire, mining, deforestation, road & bldg. construction, land-use on Ft. Bliss and WSMR	Lang 2000, Lang 2005b, Sullivan 1997, Boykin *et al.* 2001
Bearded Mountainsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Hacheta Mountainsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Fringed Mountainsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Blunt Ambersnail	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination,beryllium mining	Metcalf and Smartt 1997, NMDGF 2000, pers. comm., B. Lang, NMDGF
Amber Glass Snail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Western Glass Snail	human alteration of high elevation wetlands	pers. comm., B. Lang, NMDGF
Marsh Slug Snail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Texas Liptooth Snail	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, human habitat modification, saltcedar invasion, improper grazing practices	Metcalf and Smartt 1997, pers. comm., B. Lang, NMDGF
Sangre de Cristo Woodlandsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Jemez Woodlandsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Woodlandsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Iron Creek Woodlandsnail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Cook's Peak Woodlandsnail	fire, mining, deforestation, improper grazing practices	Lang 2000, Lang 2005b, Sullivan 1997
Big Hatchet Woodlandsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Animas Peak Woodlandsnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Spruce Snail	fire, mining, deforestation, road & bldg. construction	Lang 2000, Lang 2005b, Sullivan 1997
Big Hatchet Mountain Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Organ Mountain Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Franklin Mountain Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Dona Ana Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Animas Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Florida Mountain Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
San Luis Mountains Talussnail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Northern Treeband Snail	fire, mining, deforestation	Lang 2000, Lang 2005b, Sullivan 1997
Crustaceans		
Akali Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
BLNWR cryptic species Amphipod	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs	Lang 2005a, NMDGF 2005a, website[3]
Sit. Bull Sp. cryptic species Amphipod	spring habitat alterations, wildfire, non-native molluscs and crayfish	Fernandez and Rosen 1996, Childs 1999, pers. comm., B. Lang, NMDGF, website[3]
Noel's Amphipod	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs	Lang 2005a, NMDGF 2005a, website[3]
Beavertail Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Brine Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Colorado Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Conchas Crayfish	stream channel incisement/aggradation from poor watershed management practices, non-native molluscs and crayfish	Lang and Mehlhop 1996, Lodge *et al.* 2000, website[2]
Crayfish	regulated flows, stream channel incisement/aggradation, non-native molluscs and crayfish	Taylor *et al.* 1996, Lodge *et al.* 2000, website[2]
Northern (Canadian River) Crayfish	non-native molluscs and crayfish	Lang and Mehlhop 1996, website[2]
Cyzicus sp. (mexicanus)	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Eocyzicus concavus	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Eocyzicus digueti	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Eulimnadia antlei	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Eulimnadia cylindrova	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Eulimnadia diversa	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Eulimnadia follismilis	hydroperiod alteration	Lang and Rogers 2002
Eulimnadia texana	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Great Plains Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Socorro Isopod	habitat vandalism, diminution/loss of spring flow	NMDGF 2004a
Knobblip Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Lepidurus lemmoni	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Lynceus brevifrons	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Mexican Beavertail Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Moore's Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Packard's Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Tadpole Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Sideswimmers / Scuds	groundwater depletion, spring habitat alterations, wildfire, ground/surface water contamination, non-native molluscs & crayfish	Fernandez and Rosen 1996, Childs 1999, pers. comm., B. Lang, NMDGF, website[3]
Streptocephalus n. sp. 1	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Streptocephalus n. sp. 2	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Sublette's Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Tularosa Springsnail	diminution/loss of spring flow, non-native species (tamarisk, molluscs, crayfish), wetland jursidiction (SWANCC)	Fernandez and Rosen 1996, Childs 1999, Leibowitz and Nadeau 2003, pers. comm., S. Carmen, NMDGF, website[3]
Versatile Fairy Shrimp	wetland jursidiction, hydroperiod alteration, non-point discharge of contaminants	Lang and Rogers 2002, Leibowitz and Nadeau 2003
Other Arthropods		
Arachnids (Arachnida)		
Texella longistyla	Alteration of cave environments.	NatureServe 2005
Texella welbourni	Alteration of cave environments.	NatureServe 2005
Cave Obligate Mite	Alteration of cave environments.	Diana Northup, NatureServe 2005
Aphrastochthonius pachysetus	Alteration of cave environments.	NatureServe 2005
Chitrella welbourni	Alteration of cave environments.	NatureServe 2005
Neoallochernes incertus	Alteration of cave environments.	NatureServe 2005
Peloncillo Scorpion	Local Endemic, none known	
Jemez Spider	Local Endemic, none known	
Centipede (Chilopoda)		
Cave Obligate Centipede	Alteration of cave environments.	
Millipedes (Diplopoda)		
Cave Obligate Millipede	Alteration of cave environments.	Diana Northup
Chihuahuan Millipede	Land Development	
Springtails (Entognatha)		
Oncopodura prietoi	Alteration of cave environments	Christiansen and Bellinger 1980, NatureServe 2005
Pseudosinella vita	Alteration of cave environments	Christiansen and Bellinger 1980, NatureServe 2005
Tomocerus grahami	Alteration of cave environments	Christiansen and Bellinger 1980, NatureServe 2005

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
<u>*Insects (Insecta)*</u>		
Aphaenogaster punctaticeps	Local Endemic, none known	
Leptothorax bestelmeyeri	Local Endemic, none known	
Leptothorax colleenae	Local Endemic, none known	
Capulin Mountain Artic	global warming, fire suppression, improper grazing practices. Over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Andrena mimbresensis	Local Endemic, none known	
Andrena neffi	Local Endemic, none known	
Andrena vogleri	Local Endemic, none known	
Perdita austini	Local Endemic, none known	
Perdita biparticeps	Local Endemic, none known	
Perdita claripennis	Local Endemic, none known	
Perdita geminata	Local Endemic, none known	
Perdita grandiceps	Local Endemic, none known	
Perdita maculipes	Local Endemic, none known	
Perdita mesillensis	Local Endemic, none known	
Perdita senecionis	Local Endemic, none known	
Perdita sidae	Local Endemic, none known	
Perdita tarda	Local Endemic, none known	
Perdita viridinotata	Local Endemic, none known	
Centris Bee	Outside of aggregated nests, individuals never found, but never nest in same place twice. Nests must be protected when found	pers. comm., J. McIntyre, UNM
Osmia phenax	Local Endemic, none known	
Osmia prunorum	Local Endemic, none known	
Mason Bee	Limited distribution	pers. comm., J. McIntyre, UNM

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Melittid Bee	Local Endemic, none known	
Pityophthorus franseriae	Local Endemic, none known	
Pityophthorus torridus	Local Endemic, none known	
Anthony Blister Beetle	Habitat disturbance (ground activities) that would affect solitary bees. Pesticide spraying	USFWS Federal Register 1994, NatureServe 2005
Bonita Diving Beetle	degradation of habitat, loss of water or water quality	USFWS Federal Register 1994, NatureServe 2005
Southwestern Hercules Beetle	Highly prized by insect collectors. Loss of native riparian woodlands	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Glorious Jewel Beetle	Highly prized by insect collectors	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Leconte's Jewel Beetle	Highly prized by insect collectors	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Wood's Jewel Beetle	Highly prized by insect collectors. Loss of native riparian woodlands.	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Animas Minute Moss Beetle	Siltation, improper grazing practices	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Tiger Beetle	Over-collecting	
Glittering Tiger Beetle	Lowering of groundwater due to irrigation, drought. Over-collection.	pers. comm., B. Knisley, UNM, pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Guadalupe Mountains Tiger Beetle	Over-collection.	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Los Olmos Tiger Beetle	Improper grazing practices and hydrologic developments. Over-collection.	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Maricopa Tiger Beetle	Usual threats to riparian, improper grazing practices, withdrawal of water. Over-collectiong.	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Nevada Tiger Beetle	Increased agriculture and development, grading and drainage of playa. Over-collection.	pers. comm., B. Knisley, UNM,, pers. comm., D. Lightfoot, UNM

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Buchholz's Boisduval's Blue	Forest management practices, global warming	
Mogollon Rim Greenish Blue	Forest management practices, global warming	
Hemileuca (chinotiensis) comwayae	Unknown.	Richard Holland, pers. Comm. March 2005
Hemileuca (nevadensis) artemis	Unknown.	Richard Holland, pers. Comm. March 2005
Hemileuca hera magnifica	Urban development	Richard Holland, pers. Comm. March 2005
Mountain Checkered-Skipper	Forest management practices, global warming	
Chalcedon Checkerspot	Improper grazing practices	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Sacramento Mountain Checkerspot	OHV's, development, invasive plants, improper grazing practices. Over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Tawny Crescent	Improper grazing practices	
Mescalero Camel Cricket	No specific threats, local endemic.	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Organ Mountains Camel Cricket	No specific threats, local endemic	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Rodent Burrow Camel Cricket	Extripation of blacktailed and Gunnison's praire dogs, and other large burrowing rodents	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Gypsum Sand-Treader Camel Cricket	No specific threats, protected by White Sands National Monument	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
White Sands Sand-Treader Camel Cricket	No specific threats, protected by White Sands National Monument	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Carlsbad Cave Cricket	Alteration of cave environments	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Mesdalero Sands Jerusalem Cricket	Herbicide control of shin-oak, off-highway vehicles	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Arroyo Darner	Fires, lumbering and improper grazing practices, especially removal of grass along streams	NatureServe 2005
Ellis Dotted-Blue	Improper grazing practices, invasive exotics, particularly cheatgrass.	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Spalding's Dotted-Blue	Exotic invasives, particularly cheatgrass	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Bleached Skimmer Dragonfly	improper grazing practices, possibly predation from fish or competition with other dragonflies	Robert Larsen, AZGF 2002
Scudder's Duskywing	Unknown	
Dusty-Wing	Local Endemic, none known	
Desert Elfin	Unknown	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Caenotus inornatus	Unknown	
Caenotus minutus	Unknown	
Chrysotus parvulus	Local Endemic, none known	
Neurigona perbrevis	Local Endemic, none known	
Thinophilus magnipalpus	Local Endemic, none known	
Mydas Fly	Sand dune habitats threatened by development and off-road vehicles	
Efferia cuervana	Sand dune habitats threatened by development and off-road vehicles	
Furcilla delicatula	Unknown	
Megaphorus lascrucensis	Playa grasslands highly impacted by improper grazing practices	
Soldier Fly	Local Endemic, none known	

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Capitan Mountains Fritillary	Forest management	
Freija Fritillary	Improper grazing practices	
Nitocris Fritillary	Colonies are small and isolated., Herbicide, improper grazing practices, hydrology changes. Some colonies extirpated.. Over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Nokomis Fritillary	Colonies are small and isolated, Herbicide, improper grazing practices, hydrology changes, overcollecting	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Raton Mesa Fritillary	Suburban development, improper grazing practices, forest management	
Silver-Bordered Fritillary	Improper grazing practices, forest management, hydro modification	
Aeoloplides rotundipennis	Habitat distruction from agricultural developments	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Cibolacris samalayucae	Off-highway vehicles	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Band-Winged Grasshopper	Hydrologic developments, improper grazing practices	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Hebard's Blue-Winged Desert Grasshopper	No specific threats, isolated small populations limited to specific microhabitats	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Lichen Grasshopper	No specific threats, isolated small populations limited to specific microhabitats	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Nevada Point-Headed Grasshopper	Improper grazing practices, disturbance to montane meadows	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Shotwell's Range Grasshopper	Improper grazing practices, especially stock tanks and heavy impacts around tanks	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Melanoplus calidus	Improper grazing practices	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Melanoplus magdalenae	Improper grazing practices, impacts to montane meadows	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM, NatureServe 2005
Ilavia Hairstreak	Unknown	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Poling's Hairstreak	Improper grazing practices, possible exotic weeds. Maintenance of oaks important, over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Sandia Hairstreak	Relatively widespread and no known threat, over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Oslar's Soapberry Hairstreak	Unknown	
Xami Hairstreak	Small colonies with narrow habitat requirements. South TX population extirpated	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Mescalero Sands Katydid	Herbicide control of shin-oak, off-highway vehicles	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM
Hexagenia bilineata	Siltation, pollution, damming, withdrawal of water	pers. comm., G. Jacobi, UNM, pers. comm., Pat McCafferty
Homoeonuria alleni	Local Endemic, none known	
Lachlania dencyannae	Improper grazing practices, excessive lumbering, or fires destabilize stream flow	Jerry Jacobi, Pat McCafferty
Leucrocuta petersi	Improper grazing practices, excessive lumbering, or fires destabilize stream flow	Jerry Jacobi, Pat McCafferty, NatureServe 2005
Arizona Metalmark	improper grazing practices, hydrology changes. Over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Moth	Unknown	Richard Holland, pers. Comm. March 2005
Borer Moth	Drying of region, improper grazing practices, burning	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Albarufan Dagger Moth	Unknown	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Geometrid Moth	Unknown	Richard Holland, pers. Comm. March 2005

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Noctuid Moth	Unknown	Richard Holland, pers. Comm. March 2005
Euhyparpax rosea	Development, fires, alien weed impact	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Oligocentria delicata	Limited range, urbanization	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Pyralid Moth	Urban development	Richard Holland, pers. Comm. March 2005
Tiger Moth	Over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Mirid Plant Bug	Local Endemic, none known	
Dashed Ringtail	Improper grazing practices, excessive lumbering, or fires destabilize stream flow	Robert Larsen, AZGF 2002, NatureServe 2005
Cassus Roadside-Skipper	Forest & fire management, improper grazing practices	
Large Roadside-Skipper	Forest & fire management, improper grazing practices	
Slaty Roadside-Skipper	Improper grazing practices	
Texas Roadside-Skipper	Improper grazing practices	
Silkmoth	Unknown	Richard Holland, pers. Comm. March 2005
Zephyr Eyed Silkmoth	Spraying programs and different managmenet programs in fragmented ranges, over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Apache Skipper	Forest & fire management, improper grazing practices	
Arizona Agave Borer Skipper	Improper grazing practices, fire management	
Carlsbad Agave Borer Skipper (Orange Giant Skipper)	Impacts to Host Plant, over-collection.	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Viola's Yucca Borer Skipper	Impacts to host plants	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Western Crossline Skipper	Fire management, improper grazing practices	
Deva Skipper	Fire management, improper grazing practices	
Mary's Giant Skipper	Fire management, improper grazing practices	
Poling's Giant Skipper	Unknown	
Ursine Giant Skipper	Impacts to host plants. Over-collection.	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Western Hobomok Skipper	Forest & fire management, improper grazing practices	
Moon-Marked Skipper	Forest & fire management, improper grazing practices	
Sunrise Skipper	Hydro modification, improper grazing practices	
Yuma Skipper	Impacts to riparian areas, one small isolated colony in NM	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Four-Spotted Skipperling	Improper grazing practices, gullying, drainage of wet meadows. Over-collection.	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Arizona Snaketail	Water degradation, timber harvest, improper grazing practices and fires that destabilize stream flow.	Robert Larsen, AZGF 2002 NatureServe 2005
West's Primrose Sphinx	Unknown.	NatureServe 2005
Vega Sphinx	No specific threats, other than possible relative lack of protected populations, over-collection.	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM, NatureServe 2005
Capnia caryi	Improper grazing practices and fire	
Isoperla jewetti	Hydrologic modification, streamflow regulation & manipulation, water quality	
Taenionema jacobii	Stream disturbance, water devopments, turbid runoff from improper grazing practices	NatureServe 2005
Arizona Viceroy	Impacts to riparian areas, improper grazing practices, over-collection	pers. comm., S. Cary, NMDGF, pers. comm., J. McIntyre, UNM
Tarantula Hawk Wasp	No specific threats, other than possible relative lack of protected populations	pers. comm., D. Lightfoot, UNM, pers. comm., S. Brantley, UNM

Appendix I Cont.

Common or Scientific Name[1]	Species Specific Factors	References
Dasymutilla homole	Local Endemic, none known	
Odontophotopsis augusta	Local Endemic, none known	
Odontophotopsis grata	Local Endemic, none known	
Chiricahua White	Forest & fire management	

[1] Scientific name provided for species with no recognized common name. Scientific names of other species can be found in Appendix C.

[2] http://el.erdc.usace.army.mil/zebra/zmis/

[3] http://www.esg.montana.edu/aim/mollusca/nzms/nzmsbib.html

Appendix J. Categories and generic factors that influence habitats in New Mexico identified for New Mexico's CWCS. Categories of factors that influence habitats were adapted from Salafsky *et al.* (2003). Definitions of these categories can be found in the Approach chapter. Descriptions of each generic factor can be found in Appendix K.

Category	Generic Factor
Abiotic Resource Use	
	Geothermal energy
	Hydropower
	Mining
	Oil and Gas exploration/development
	Water withdrawal/dewatering
	Wind farms
Consumptive Biological Use	
	Deforestation
	Fuel wood collection
	Hunting/gathering
	Logging
	Improper grazing practices
	Predator extermination
	Removal of wildlife by collectors
Habitat Conversion	
	Agricultural production/Livestock production
	Altered hydro period
	Channelization
	Dams
	Drainage of wetlands
	Ground water depletion (agriculture/urban development)
	Herbicide shrub control
	Irrigation diversion/return
	Regulated flows
	Sediment load
	Urban, commercial/industrial, or recreational development
Invasive Species	
	Disease/parasites/pathogens
	Competition/predation
	Exotic or invasive plants
	Exotic or invasive wildlife
	Hybridization
Modification of Natural Processes and Ecological Drivers	
	Drought
	Ecological sustainability and integrity
	Fire management
	Loss of keystone species
Non-consumptive Biological Use	
	ATVs/snowmobiles/off-road vehicles
	Military maneuvers
	Outdoor recreation
	Scientific research

Appendix J Cont.

Category	Generic Factor
Pollution	
	Agricultural chemicals
	Livestock/dairy groundwater contamination
	Sewage/septic
	Solid waste
	Toxic waste contamination
Transportation Infrastructure	
	Roads, highways, railroads, and utility corridors

Appendix K. Descriptions of factors that influence species and habitats identified for New Mexico's CWCS.

Agricultural chemicals- The application of pesticides or fertilizers to large tracts of land for farming purposes.

Agricultural production/Livestock production- Agriculture production includes the growing of field crops, fruits, nuts, vegetables, or flowers. Livestock production includes the production of livestock and livestock products, especially dairies.

Altered hydro period- Any physical activity that will change the natural hydoperiod of the wetland.

ATVs/snowmobiles/off-road vehicles- Any motor vehicle designed for use on unimproved or open terrain for recreational purposes.

Channelization- The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

Competition/predation- The use or defense of a resource by one individual or species that reduces the availability of that resource to another individual or species; the consumption of one organism by another organism. Usually to the detriment of an unstable population.

Dams- Barriers across perennial or ephemeral drainages that obstructs, directs, or retards water flow and creates a reservoir, lake, or impoundment.

Deforestation- Removal of large blocks of forested lands to provide land for agricultural, development, or timber purposes.

Disease/parasites/pathogens- A native or exotic organism that can negatively impact the habitat.

Drainage of wetlands- The artificial removal of surface and sub-surface water from a wetland.

Drought- A drought is an prolonged period where precipitation, and thus water availability, falls below the requirements for a region.

Ecological sustainability & integrity- Maintenance/restoration of the composition, structure, and processes of ecosystems (i.e. biotic diversity, ecosystem productive capacity, ecological processes, disturbance regimes, soil productivity, water quality and air quality).

Exotic or invasive plants- A plant (often non-native) that becomes established and spreads aggressively into new areas and environments, often with detrimental effects on native plant species.

Exotic or invasive wildlife- A non-native wildlife species that encroaches into habitat and/or niches occupied by other species.

Fire management- All activities associated with the management of fire on a given landscape, including prescribed fires, aggressive initial attack, decisions regarding let burn policies, and fuel loading.

Fuel wood collection- Collection of any woody biomass for use as fuel.

Geothermal energy- Natural heat from within the earth usually carried to the surface as superheated water and steam and captured for production of electric power or space heating. Factors that influence habitats include the development and maintenance of geothermal facilities.

Ground water depletion- A sustained removal of groundwater through anthropogenic uses such as agriculture, urban or industrial uses that lowering the water table.

Herbicide shrub control- The application of herbicides at large scales to remove or control woody vegetation such as salt cedar, shinnery oak, and creosotebush.

Hunting/gathering- Legal harvesting of wildlife or the collecting of wild non-endangered plants.

Hybridization- Production of offspring from genetically different strains, populations, or species.

Hydropower- Development and maintenance of facilities that use flowing water to generate electricity.

Improper grazing practices- Practices that reduce long-term plant and animal productivity, and include both domestic livestock and wildlife.

Irrigation diversion/return- Artificially supplying land with water for agriculture, usually through ditches, pipes, or diverting rivers.

Livestock/dairy groundwater contamination- Contamination of groundwater from livestock manure, runoff, silage storage, milkhouse waste water, and/or improperly disposed of dead animals.

Logging- The practice of harvesting timber from forests.

Loss of keystone species- The loss of specific species whose presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life.

Military maneuvers- Military training exercises that negatively impact the environment, e.g. tank movement.

Mining- Extraction of minerals from surface and subsurface areas from the earth.

Oil and Gas exploration/development- Conducting geological and geophysical surveys, exploratory drilling in the most promising areas, and finally, drilling of oil and gas wells for production. Factors that influence habitats include exploration and development of oil and gas.

Outdoor recreation- The use of public and private lands for human enjoyment and relaxation. These activities typically have a low impact to the surrounding habitat.

Predator extermination- Legal harvesting of carnivores that negatively impact or are in conflict with humans and human activities.

Regulated flows- Surface flows downstream from a dam or other controlled structure that modifies natural flow conditions.

Removal of wildlife by collectors- Legal harvesting of wildlife, usually herpetofauna, at a rate detrimental to the sustainability of the species.

Roads, highways, railroads, and utility corridors- Development and maintenance of roads, railroads, pipelines, transmission lines, and utility corridors including the adjacent right of way.

Scientific research- Scientific research, including treatments, which disrupt the habitat or behavior of species in the course of the study.

Sediment load- The natural inorganic soil materials suspended in or transported by a stream.

Sewage/septic- Wastewater generated by commercial, industrial, or domestic use of the water supply that is normally eliminated by the local sewer system. Exposure to sewage may cause disease transmission.

Solid waste- Household garbage, yard waste, and recyclable items illegally or improperly discarded.

Toxic waste contamination- Contamination from waste that poses a substantial hazard to human health or the environment when improperly handled.

Urban, commercial/industrial, and recreational development- Urban development entails the conversion or expansion of urban, suburbia, and exurbia areas into previous wildland areas. Likewise, commercial and industrial development entails the conversion or expansion of commercial or industrial operations, building, or development into previous wildland areas. Recreational development is similar, where commercial industry is based on recreational opportunities, such as skiing.

Water withdrawal/dewatering- Removal of surface water from any natural source or reservoir for human use.

Wind farms- A cluster of wind turbines placed in a location that has an above-average occurrence of strong and steady winds used to generate electricity. Factors that influence habitats include the development and maintenance of these wind turbines.

Appendix L. Magnitude scores for categories of factor that influence key habitats in New Mexico. Categories and generic factors are in Appendix K. Descriptions of categories are in Chapter 2; Table 2-7.

Factor Categories
- HC - Habitat Conversion
- AR - Abiotic Resource Use
- P - Pollution
- CB - Consumptive Biological Use
- MNP - Modification of Natural Processes and Ecological Drivers
- IS - Invasive Species
- NCB - Non-Consumptive Biological Use
- TI - Transportation Infrastructure

Key Habitats	HC	AR	P	CB	MNP	IS	NCB	TI	Total
Aquatic									
Ephemeral 1st and 2nd Order Stream	34	24	15	15	10	3	0	2	103
Ephemeral Man-made Catchments	45	20	28	10	14	3	4	5	129
Ephemeral Marsh/Cienega	25	23	25	12	13	2	2	7	109
Ephemeral Natural Catchments	47	26	33	18	16	10	7	8	165
Perennial 1st and 2nd Order Stream	31	19	18	15	13	10	3	5	114
Perennial 3rd and 4th Order Stream	36	22	24	14	13	14	3	5	131
Perennial 5th Order Stream	38	24	28	12	13	15	0	5	135
Perennial Large Reservoir	17	23	14	10	13	12	0	4	93
Perennial Marsh/Cienega/Spring/Seep	47	27	27	17	16	15	3	6	158
Perennial Tank	23	20	16	15	14	13	2	6	109
Terrestrial									
Chihuahuan Semi-Desert Grassland	12	4	0	7	4	7	12	7	53
Intermountain Basins Big Sagebrush Shrubland	8	8	0	6	11	0	7	6	46
Madrean Encinal	16	6	0	18	15	0	14	7	76
Madrean Pine-Oak/Conifer-Oak Forest and Woodland	14	6	0	12	16	3	13	7	71
Riparian	43	20	18	23	16	13	17	6	156
Rocky Mountain Alpine-Montane Wet Meadow	5	3	0	7	6	4	9	5	39
Rocky Mountain Montane Mixed Conifer Forest and Woodland	15	4	0	16	16	7	10	7	75
Western Great Plains Sandhill Sagebrush Shrubland	20	11	0	7	11	0	4	7	60
Western Great Plains Shortgrass Prairie	19	20	13	7	6	7	10	3	85

Appendix M. Summarized information gaps that impair our ability to make informed conservation decisions of key terrestrial habitats and associated SGCN in New Mexico. Detailed information gaps are located in the Assessments and Strategies for Species of Greatest Conservation Need and Key Habitats Chapter.

Habitat Associations
- CG - Chihuahuan Semi-Desert Grassland
- ME - Madrean Encinal
- MF - Madrean Pine-Oak Conifer-Oak Forest and Woodland
- MC - Rocky Mountain Montane Mixed Conifer Forest and Woodland
- SP - Western Great Plains Shortgrass Prairie
- SS - Western Great Plains Sandhill Sagebrush Shrubland
- IB - Intermountain Basins Big Sagebrush Shrubland
- AM - Rocky Mountain Alpine-Montane Wet Meadow
- RP - Riparian

Information Gaps	CG	ME	MF	MC	SP	SS	IB	AM	RP
Accurate maps depicting long term historical changes or current acreage estimates.								X	X
Aspen succession				X					
Early detection landscape degradation attributes	X								X
Effect and extent of diseases, parasites, and pathogens on habitats and SGCN.									X
Effects of energy exploration and development	X	X	X		X	X	X		
Effects of habitat fragmentation on SGCN	X	X	X	X	X	X	X		X
Effects of water withdrawal					X				X
Estimates of ecological condition and trend, as well as hydrologic patterns necessary to sustain ecosystem functions.					X	X			X
Existing conditions that limit populations of SGCN or their response to human disturbances	X			X	X	X	X	X	X
Extent of habitat fragmentation	X	X	X	X	X	X	X		X
Extent to which invasive species may alter habitat	X	X	X	X	X	X	X		X
Extent to which off-road vehicle use is affecting SGCN	X				X	X	X		
Healthy Forest Initiative and Healthy Forest Restoration Act will affect SGCN				X					
Life history of most of the SGCN, including abundance, distribution habitat use, and trend information.	X			X	X		X	X	X
Military or borderland security activities	X	X	X		X				
Ongoing activities of the Joint Task Force Six		X	X						

Appendix M Cont.

Information Gaps	CG	ME	MF	MC	SP	SS	IB	AM	RP
Restoration techniques and vegetation management	X					X		X	X
Sources of pollution and extent in which it is altering habitats					X				
Specific effects of grazing practices	X	X	X	X	X	X	X	X	X
The role that natural fire and differing intensities of fire has played within habitat type	X	X	X	X	X		X	X	X

Appendix N. Summarized information gaps that impair our ability to make informed conservation decisions associated with key aquatic habitats and associated SGCN in New Mexico. Detailed information gaps are located in the Assessments and Strategies for Species of Greatest Conservation Need and Key Habitats Chapter.

Aquatic Habitats		
LR	-	Large Reservoir
MCSS	-	Marsh/ Cienega/ Spring/ Seep
1/2OS	-	1st/2nd Order Stream
3/4OS	-	3rd/4th Order Stream
5OS	-	5th Order Stream
T	-	Tanks
GIW	-	Geographically Isolated Wetlands
MMC	-	Man-Made Catchments

	Perennial						*Ephemeral*	
Information Gaps	**LR**	**MCSS**	**1/2OS**	**3/4OS**	**5OS**	**T**	**GIW**	**MMC**
Distribution, abundance, status and trends, habitat requirements, movement, and natural history of SGCN	X	X	X	X	X	X	X	X
Extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN	X	X	X	X	X	X	X	
Environmental conditions or thresholds that preclude populations of SGCN	X	X	X	X	X	X	X	X
The affects of altered hydrological patterns on aquatic habitats and their SGCN, including identifing modifications that may benefit native SGCN	X	X	X	X	X		X	
Predator-prey relationships in aquatic habitats.	X	X	X	X	X			
Water quality and its affects upon associated SGCN	X	X	X	X	X		X	
Factors causing pathogen outbreaks and the potential for diseases.	X	X	X	X				
The extent to which land use activities (e.g., grazing, human development, road-building, and oil and gas development, etc...) fragment and alter habitats in relation to size, edge effect, and use by SGCN is unknown		X	X	X	X			

Appendix N Cont.

	Perennial						*Ephemeral*	
Information Gaps	**LR**	**MCSS**	**1/2OS**	**3/4OS**	**5OS**	**T**	**GIW**	**MMC**
Interactions among the various native species and introduced species		X	X	X	X		X	
Long-term effects of wildfire on SGCN			X	X	X			
The locations and condition of aquatic habitats		X	X			X	X	X
Affects of recreational activities on habitats and SGCN			X					
Suitability of habitats for restoration of SGCN			X					
Differences and similarities between and among the biotic diversity of ephermeral and perennial habitats						X	X	X

Appendix O. Research, survey, and monitoring needs that would enhance conservation efforts for key terrestrial habitats and associated SGCN in New Mexico. Detailed research, survey, and monitoring needs are located in the Assessments and Strategies for Species of Greatest Conservation Need and Key Habitats Chapter.

Habitat Associations

- CG - Chihuahuan Semi-Desert Grassland
- ME - Madrean Encinal
- MF - Madrean Pine-Oak Conifer-Oak Forest and Woodland
- MC - Rocky Mountain Montane Mixed Conifer Forest and Woodland
- SP - Western Great Plains Shortgrass Prairie
- SS - Western Great Plains Sandhill Sagebrush Shrubland
- IB - Intermountain Basins Big Sagebrush Shrubland
- AM - Rocky Mountain Alpine-Montane Wet Meadow
- RP - Riparian

Research, Survey, and Monitoring Needs	CG	ME	MF	MC	SP	SS	IB	AM	RP
Assess the impacts of livestock grazing on habitat composition and structure and determine how the timing, intensity, and duration of grazing affect SGCN	X	X	X	X	X	X	X	X	X
Assess the impacts of logging and fuelwood harvesting on the structure of habitat types and their affect SGCN		X	X	X					
Conduct research to enhance knowledge of the natural history, population biology, and community ecology of SGCN within key habitats, including SGCN distribution, abundance, habitat use, and population trend information	X	X	X	X	X	X	X		X
Consistent landscape health and condition descriptions or protocols, and monitoring standards need to be identified or developed	X				X	X	X		X
Determine conditions that limit populations of SGCN and SGCN response to human disturbances	X	X	X	X	X	X			X
Determine how climate change or drought will affect vegetation patterns and community and ecosystem-level dynamics	X	X	X	X	X	X			X
Develop collaborative survey and monitoring protocols for invertebrate SGCN that are not currently being monitored	X	X	X	X					X
Examine type, extent, and structural characteristics of habitat fragmentation and how such habitat alterations influence patch size, edge effect, and use by SGCN	X	X	X	X	X	X	X		X
Identify wildlife travel corridors, and determine habitat connectivity for SGCN		X	X	X	X				

Appendix O Cont.

Research, Survey, and Monitoring Needs	CG	ME	MF	MC	SP	SS	IB	AM	RP
Investigate early detection methods that indicate when habitats are shifting to another habitat type and indicators of biological integrity	X								X
Investigate hydrologic relationships in key habitats	X	X	X	X				X	X
Investigate invasive species early detection protocols and estimate vectors and pathways of potential invasive species. Determine invasive species affects to key habitats and SGCN	X			X	X	X	X		X
Investigate the extent to which Military or Borderland Security Activities affect SGCN	X								
Investigate the extent to which off-road vehicle use affects SGCN	X					X			X
Investigate the impacts, benefits or detrimental effects of habitat restoration practices, such as tree and shrub removal, reseeding, fire, etc…, and determine effective restoration methods					X	X	X		X
Investigate the role of natural fire and the effectiveness of prescribed fire in reducing the potential for catastrophic stand-replacing fires and maintaining habitats		X	X	X					X
Quantify the effects of energy exploration and development on habitats and SGCN	X				X	X	X		

Appendix P. Research, survey, and monitoring needs that would enhance conservation efforts for key aquatic habitats and associated SGCN in New Mexico. Detailed research, survey, and monitoring needs are located in the Assessments and Strategies for Species of Greatest Conservation Need and Key Habitats Chapter.

Aquatic Habitats

LR	-	Large Reservoir
MCSS	-	Marsh/ Cienega/ Spring/ Seep
1/2OS	-	1st/2nd Order Stream
3/4OS	-	3rd/4th Order Stream
5OS	-	5th Order Stream
T	-	Tanks
GIW	-	Geographically Isolated Wetlands
MMC	-	Man-Made Catchments

	Perennial						*Ephemeral*	
Research, Survey, and Monitoring Needs	**LR**	**MCSS**	**1/2OS**	**3/4OS**	**5OS**	**T**	**GIW**	**MMC**
Investigate SGCN presence, abundance and population status, distribution, movement, and life history requirements	X	X	X	X	X	X	X	X
Determine SGCN habitat requirements	X	X	X	X	X	X	X	X
Determine environmental conditions or thresholds that preclude populations of SGCN	X	X	X	X	X	X	X	X
Investigate hydrologic relationships and their effects on SGCN to provide a better understanding of the physicochemical and hydrologic processes that will allow for sustainable watershed conservation and management practices	X	X	X	X	X	X	X	X
Investigate the extent to which land use activities (e.g., grazing, human development, road-building, and oil and gas development, etc...) fragment and alter habitats in relation to size, edge effect, and use by SGCN		X	X	X	X			
Determine the extent to which invasive and non-native species may alter aquatic community structure and preclude populations of SGCN and identify methods to minimize impacts from non-native species	X		X	X		X	X	
Investigate the relationships between non-native piscivores and SGCN	X		X	X				
Quantify the effects of recreational use of aquatic habitats on the persistence of habitats and SGCN	X		X	X				

Appendix P Cont.

Research, Survey, and Monitoring Needs	*Perennial* LR	MCSS	1/2OS	3/4OS	5OS	T	*Ephemeral* GIW	MMC
Determine and monitor habitat condition and water quality		X			X		X	
Develop spatial data designating the location, area and quality of aquatic habitats to provide the foundation for monitoring impacts and facilitating risk assessment for SGCN that occupy this habitat type		X	X			X	X	X
Investigate methods to reduce the spread of pathogens through aquatic environments			X	X		X		
Identify habitats suitable for restoration and SGCN restoration			X	X		X		X
Evaluate the relative efficacy of mechanical versus piscicide removal of non-native species for Gila trout restoration			X	X				
Investigate the extent to which wildfire and associated ash flow has diminished habitat quality			X					
Studies are needed to quantify and compare the diversity of perennial and ephemeral habitats relative to each other and to other ecosystems						X	X	X

Appendix Q. Habitat associations for other arthropod classes (Arachnida, Chilopoda, Diplopoda, Entognatha, and Insecta) within ecoregions. The full extent of their habitat associations and geographic distribution is uncertain. Known habitat associations are indicated with an 'x'. Habitat associations for all other SGCN can be found in the Assessment and Strategies for Species of Greatest Conservation Need and Key Habitats Chapter.

Habitat Associations
- AM - Rocky Mountain Alpine-Montane Wet Meadow
- CG - Chihuahuan Semi-Desert Grassland
- IB - Intermountain Basins Big Sagebrush Shrubland
- MC - Rocky Mountain Montane Mixed Conifer Forest and Woodland
- ME - Madrean Encinal
- MF - Madrean Pine-Oak Conifer-Oak Forest and Woodland
- SP - Western Great Plains Shortgrass Prairie
- SS - Western Great Plains Sandhill Sagebrush Shrubland

	Apache Highlands			Arizona-New Mexico Mountains				Chihua-huan Desert		Colo-rado Plat-eau	Southern Rocky Mountains			Southern Short-grass Prairie	
Common or Scientific Name[1]	CG	ME	MF	ME	MF	MC	SP	CG	SS	IB	IB	AM	MC	SS	SP
<u>*Arachnids (Arachnida)*</u>															
Texella longistyla[2]															
Texella welbourni[2]															
Cave Obligate Mite[2]															
Aphrastochthonius pachysetus[2]															
Chitrella welbourni[2]															
Neoallochernes incertus[2]															
Peloncillo Scorpion		x	x												
Jemez Spider													x		
<u>*Centipedes (Chilopoda)*</u>															
Cave Obligate Centipede				x	x		x								
<u>*Millipedes (Diplopoda)*</u>															
Cave Obligate Millipede[2]															
Chihuahuan Millipede								x	x						
<u>*Springtails (Entognatha)*</u>															
Oncopodura prietoi[2]															
Pseudosinella vita[2]															
Tomocerus grahami[2]															
<u>*Insects (Insecta)*</u>															
Aphaenogaster punctaticeps								x	x						
Leptothorax bestelmeyeri								x	x						
Leptothorax colleenae								x	x						
Capulin Mountain Arctic[2]															
Andrena mimbresensis				x	x		x								

Appendix Q Cont.

	Apache Highlands			Arizona-New Mexico Mountains				Chihuahuan Desert		Colorado Plateau	Southern Rocky Mountains			Southern Shortgrass Prairie	
Common or Scientific Name	CG	ME	MF	ME	MF	MC	SP	CG	SS	IB	IB	AM	MC	SS	SP
Andrena neffi				x	x		x								
Andrena vogleri				x	x		x								
Perdita austini								x	x						
Perdita biparticeps								x	x						
Perdita claripennis								x	x						
Perdita geminata								x	x						
Perdita grandiceps								x	x						
Perdita maculipes								x	x						
Perdita mesillensis								x	x						
Perdita senecionis								x	x						
Perdita sidae								x	x						
Perdita tarda								x	x						
Perdita viridinotata								x	x						
Centris Bee								x							
Osmia phenax								x	x						
Osmia prunorum								x	x						
Mason Bee								x							
Melittid Bee								x	x						
Pityophthorus franseriae				x	x										
Pityophthorus torridus				x	x										
Anthony Blister Beetle									x						
Bonita Diving Beetle						x									
Southwestern Hercules Beetle				x	x										
Glorious Jewel Beetle				x	x	x									
Leconte's Jewel Beetle					x	x									
Wood's Jewel Beetle				x	x										
Animas Minute Moss Beetle		x	x												
Tiger Beetle								x	x						
Glittering Tiger Beetle								x	x						
Guadalupe Mountains Tiger Beetle				x	x										
Los Olmos Tiger Beetle								x	x						
Maricopa Tiger Beetle				x	x	x	x	x	x						
Nevada Tiger Beetle										x					
Buchholz's Boisduval's Blue[2]															
Mogollon Rim Greenish Blue[2]															
Hemileuca (chinatiensis) comwayae								x							
Hemileuca (nevadensis) artemis										x					
Hemileuca hera magnifica										x					
Mountain Checkered-Skipper[2]															
Chalcedon Checkerspot[2]															
Sacramento Mountain Checkerspot						x									
Tawny Crescent[2]															
Mescalero Camel Cricket						x									

Appendix Q Cont.

Common or Scientific Name	*Apache Highlands*			*Arizona-New Mexico Mountains*				*Chihuahuan Desert*		*Colorado Plateau*	*Southern Rocky Mountains*			*Southern Shortgrass Prairie*	
	CG	ME	MF	ME	MF	MC	SP	CG	SS	IB	IB	AM	MC	SS	SP
Organ Mountains Camel Cricket				x	x										
Rodent Burrow Camel Cricket							x	x	x						
Gypsum Sand-Treader Camel Cricket									x						
White Sands Sand-Treader Camel Cricket									x						
Carlsbad Cave Cricket[2]															
Mescalero Sands Jerusalem Cricket														x	x
Arroyo Darner				x	x		x	x	x						
Ellis Dotted-Blue				x	x		x			x					
Spalding's Dotted-Blue				x	x		x								
Bleached Skimmer Dragonfly								x	x						
Scudder's Duskywing[2]															
Dusty-Wing									x						
Desert Elfin				x	x										
Caenotus inornatus								x	x						
Caenotus minutus								x	x						
Chrysotus parvulus				x			x								
Neurigona perbrevis								x							
Thinophilus magnipalpus								x							
Mydas Fly									x						
Efferia cuervana								x	x						
Furcilla delicatula								x	x						
Megaphorus lascrucensis								x	x						
Soldier Fly								x	x						
Capitan Mountains Fritillary[2]															
Freija Fritillary[2]															
Nitocris Fritillary						x									
Nokomis Fritillary												x	x		
Raton Mesa Fritillary[2]															
Silver-Bordered Fritillary[2]															
Aeoloplides rotundipennis								x	x						
Cibolacris samalayucae								x	x						
Band-Winged Grasshopper								x	x					x	x
Hebard's Blue-Winged Desert Grasshopper								x	x						
Lichen Grasshopper		x	x												
Nevada Point-Headed Grasshopper					x										
Shotwell's Range Grasshopper								x	x						
Spur-Throat Grasshopper						x									
Spur-Throat Grasshopper						x									
Ilavia Hairstreak				x	x										
Poling's Hairstreak				x	x										

Habitat Associations
- AM - Rocky Mountain Alpine-Montane Wet Meadow
- CG - Chihuahuan Semi-Desert Grassland
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- MC - Rocky Mountain Montane Mixed Conifer Forest and Woodland
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Appendix Q Cont.

	Apache Highlands			Arizona-New Mexico Mountains				Chihuahuan Desert		Colorado Plateau	Southern Rocky Mountains			Southern Shortgrass Prairie	
Common or Scientific Name	**CG**	**ME**	**MF**	**ME**	**MF**	**MC**	**SP**	**CG**	**SS**	**IB**	**IB**	**AM**	**MC**	**SS**	**SP**
Sandia Hairstreak				x	x		x				x				
Oslar's Soapberry Hairstreak[2]															
Xami Hairstreak					x	x									
Mescalero Sands Katydid														x	
Hexagenia bilineata[2]															
Homoeonuria alleni								x	x						
Lachlania dencyannae[2]															
Leucrocuta petersi[2]															
Arizona Metalmark	x	x	x												
Carales arizonensis[2]															
Borer Moth						x									
Albarufan Dagger Moth[2]															
Geometrid Moth[2]															
Noctuid Moth[2]															
Euhyparpax rosea				x	x										
Oligocentria delicata		x	x												
Pyralid Moth[2]															
Tiger Moth[2]															
Mirid Plant Bug[2]															
Dashed Ringtail				x	x	x									
Cassus Roadside-Skipper[2]															
Large Roadside-Skipper															
Slaty Roadside-Skipper[2]															
Texas Roadside-Skipper[2]															
Silkmoth				x	x										
Zephyr Eyed Silkmoth				x	x										
Apache Skipper[2]															
Arizona Agave Borer Skipper[2]															
Carlsbad Agave Borer Skipper				x	x										
Viola’s Yucca Borer Skipper				x	x		x	x							
Western Crossline Skipper[2]															
Deva Skipper															
Mary's Giant Skipper[2]															
Poling's Giant Skipper[2]															
Ursine Giant Skipper	x	x	x												

Appendix Q Cont.

	Apache Highlands			*Arizona-New Mexico Mountains*				*Chihuahuan Desert*		*Colorado Plateau*	*Southern Rocky Mountains*			*Southern Shortgrass Prairie*	
Common or Scientific Name	**CG**	**ME**	**MF**	**ME**	**MF**	**MC**	**SP**	**CG**	**SS**	**IB**	**IB**	**AM**	**MC**	**SS**	**SP**
Western Hobomok Skipper[2]															
Moon-Marked Skipper[2]															
Sunrise Skipper[2]															
Yuma Skipper											x				
Four-Spotted Skipperling					x	x									
Arizona Snaketail					x										
West's Primrose Sphinx[2]															
Vega Sphinx								x	x						
Capnia caryi[2]															
Isoperla jewetti[2]															
Taenionema jacobii[2]															
Arizona Viceroy							x	x	x						
Tarantula Hawk Wasp	x							x	x					x	x
Dasymutilla homole				x	x		x								
Odontophotopsis augusta				x	x		x								
Odontophotopsis grata				x	x		x								
Chiricahua White[2]															

1 Scientific name provided for species with no recognized common name. Scientific names of other species can be found in Appendix B.

2 Other arthropods with unknown distributions and habitat associations.

Appendix R. Federal, tribal, state, and local agencies, non-governmental organizations, conservation organizations, sportsmen associations, agricultural interests, other interests, universities, and news media contacted for involvement in the development of the CWCS for New Mexico.

Federal Agencies

- Army Corps of Engineers
- Bureau of Indian Affairs
  - Albuquerque Area Office
  - Jicarilla Agency
  - Laguna Agency
  - Mescalero
  - Northern Pueblos Agency
  - Ramah Navajo Agency
  - Southern Pueblos Agency
  - Southern Ute Agency
  - Zuni Agency
- Bureau of Land Management
- Department of Defense
  - Cannon Air Force Base
  - Holoman Air Force Base
- National Park Service
  - Carlsbad Caverns National Park
  - White Sands National Monument
- Natural Resources Conservation Service
- Soil and Water Conservation District
  - Region I
  - Region II
  - Region III
  - Region IV
  - Region V
  - Region VI
- State Land Office
- United States Fish and Wildlife Service
  - Bitter Lake National Wildlife Refuge
  - Bosque del Apache National Wildlife Refuge
  - San Andreas National Wildlife Refuge
- United States Forest Service
  - Rocky Mountain Research Station

Tribal Agencies

- Jicarilla Apache Nation
- Mescalero Apache Tribe
- Navajo Nation
- Pueblo of Acoma
- Pueblo of Cochiti
- Pueblo of Isleta
- Pueblo of Jemez
- Pueblo of Laguna
- Pueblo of Nambe
- Pueblo of Picuris
- Pueblo of Pojoaque
- Pueblo of San Felipe
- Pueblo of San Ildefonso
- Pueblo of San Juan
- Pueblo of Sandia
- Pueblo of Santa Ana
- Pueblo of Santa Clara
- Pueblo of Santo Domingo
- Pueblo of Taos
- Pueblo of Tesuque
- Pueblo of Zia
- Pueblo of Zuni
- Ute Mountain Ute Tribe

State Agencies

- Governor's Office - Energy/Environment Advisor
- New Mexico Department of Agriculture
- New Mexico Department of Transportation
- New Mexico Energy, Minerals, and Natural Resources
- New Mexico Highway and Transportation Department
- New Mexico State Parks
- State Forestry Division
- State Game Commissioners

Appendix R. Cont.
Local Government

County Commissioners
- Bernalillo County
- Catron County
- Chaves County
- Colfax County
- Curry County
- De Baca County
- Dona Ana County
- Eddy County
- Grant County
- Guadalupe County
- Harding County
- Hidalgo County
- Lea County
- Lincoln County
- Los Alamos County
- Luna County

County Commissioners Cont.
- McKinley County
- Mora County
- Otero County
- Quay County
- Rio Arriba County
- Roosevelt County
- San Juan County
- San Miguel County
- Sandoval County
- Santa Fe County
- Sierra County
- Socorro County
- Taos County
- Torrance County
- Union County
- Valencia County

Non-Governmental Organizations

Bat Conservation International
Defenders of Wildlife - New Mexico Field Office
Ducks Unlimited
Ecosystem Management Research Institute
Forest Guardians
Forest Trust
Foundation for North American Wild Sheep
Hawk Watch
Hawks Aloft
Mule Deer Foundation
National Audubon Society - Central New Mexico
National Wild Turkey Federation
Native American Fish and Wildlife Society
New Mexico Highlands Wildlands Network
New Mexico Oil and Gas Association
Partners in Flight - New Mexico Chapter
People for the Ethical Treatment of Animals
Albuquerque Wildlife Federation
Amigos Bravos
Animal Protection of New Mexico
Animas Foundation
Malpais Group
Natural Heritage New Mexico
New Mexico Acequia Association
New Mexico Council of Trout Unlimited
New Mexico Highlands Project
New Mexico Natural History Institute
New Mexico River Otter Working Group
Quail Unlimited
Rocky Mountain Elk Foundation
- Hobbs Chapter
- Roswell Chapter

Safari Club International - New Mexico Chapter
Sierra Club
- New Mexico Office
- Rio Grande Chapter
- Southern New Mexico Chapter

The Leopold Education Project
The Nature Conservancy
The Peregrine Fund
The Trust for Public Land
The Wilderness Society
Trout Unlimited
Turner Endangered Species Fund
Valles Caldera National Preserve
New Mexico Wilderness Alliance
New Mexico Wildlife Federation
People for Native Ecosystems
Playa Lakes Joint Venture
Rio Grande Bird Research
Rivers and Birds
Sandia Mountain Bearwatch
Sangre de Cristo Bird Observatory
Santa Fe Conservation Trust
Southwest Center for Biodiversity
Southwest Environmental Center

Appendix R. Cont.

Sportsmen Associations

- Carlsbad Sportsmen's Club
- Concerned Sportsmen for New Mexico
- Council of Outfitters and Guides
- Dona Ana County Associated Sportsmen
- Mesilla Valley Flyfishers
- New Mexico Council of Outfitters and Guides
- New Mexico Houndsmen Association
- New Mexico Trappers Association
- New Mexico Trout
- Otero County Sportsmen's Association
- Picacho Gun Club
- Southwest Consolidated Sportsmen
- Sportsmen for Fish and Wildlife
- Wild Turkey Sportsmen Association

Agricultural Interests

- Bell Ranch
- CS Ranch
- Chase Ranch
- Dairy Producer's of New Mexico
- New Mexico Cattle Grower's Association
- New Mexico Farm and Livestock Bureau
- New Mexico Woolgrowers Association
- New Mexico Federal Lands Council
- Posey Springs Ranch
- Turner Enterprises
- Vermejo Park Ranch

Other Interests

- Chihuahuan Desert Nature Park
- Heritage Ranches
- Hummel Open Space Division
- Parsons Biological Consulting

Universities

- New Mexico State University
  - Department of Fishery & Wildlife Sciences
  - Extension Animal Resources Department
- University of New Mexico
  - Center for Wildlife Law
  - Museum of Southwestern Biology
  - Wild Friends Program

News Media

- News Journals
  - Alamogordo Daily News
  - Albuquerque Journal
  - Albuquerque Tribune
  - Artesia Daily Press
  - Carlsbad Current-Argus
  - Cibola County Beacon
  - Clovis News Journal
  - De Baca County News
  - Deming Headlight
  - El Defensor Chiefton
  - Farmington Daily Times
  - Hobbs News Sun
  - Las Cruces Sun-News
  - Las Vegas Optic
  - Los Alamos Monitor
- News Journals Cont.
  - Lovington Daily Leader
  - Portales News Tribune
  - Quay County Sun
  - Raton Range
  - Rio Grande Sun
  - Roswell Daily Record
  - Ruidoso News
  - Sangre de Cristo Chronicle
  - Santa Rosa News
  - Sante Fe New Mexican
  - Sierra County Sentinel
  - Silver City Daily Press
  - Taos News
  - Union County Leader
  - Valencia County News Bulletin