ARIZONA'S
STATE WILDLIFE ACTION PLAN:
2012 - 2022

Arizona Game and Fish Department
5000 West Carefree Highway
Phoenix, Arizona 85086-5000

16 May 2012

Civil Rights and Diversity Compliance

The Arizona Game and Fish Commission receives federal financial assistance in Sport Fish and Wildlife Restoration. Under Title VI of the 1964 Civil Rights Act, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, Title IX of the Education Amendments of 1972, the U.S. Department of the Interior prohibits discrimination on the basis of race, color, religion, national origin, age, sex, or disability. If you believe you have been discriminated against in any program, activity, or facility as described above, or if you desire further information please write to:

Arizona Game and Fish Department
Office of the Deputy Director, DOHQ
5000 W Carefree Hwy
Phoenix, Arizona 85086

and

The Office for Diversity and Civil Rights
U.S. Fish and Wildlife Service
4040 North Fairfax Drive, Room 300
Arlington, Virginia 22203

Americans With Disabilities Act Compliance

The Arizona Game and Fish Department complies with all provisions of the Americans with Disabilities Act. This document is available in alternative format by contacting the Arizona Game and Fish Department, Office of the Deputy Director at the address listed above or by calling (623) 236-7290 or TTY 1-800-367-8939.

Recommended Citation

Arizona Game and Fish Department. 2012. Arizona's State Wildlife Action Plan: 2012-2022. Arizona Game and Fish Department, Phoenix, Arizona.

Project Funding

Funding for the development of this strategic plan was provided by a State Wildlife Grant Program Planning Grant and the Arizona Heritage Fund.

FOREWARD

Arizona's State Wildlife Action Plan (SWAP) is more than just another planning document. It is the product of eight years of collaborative work conducted by the Arizona Game and Fish Department and many of our partners in the conservation community. The first two of those years occurred during the development of the first rendition of the plan, a document known as Arizona's Comprehensive Wildlife Conservation Strategy, or CWCS. During that time, the Department, assisted by many of our key partners, undertook the daunting task of developing a comprehensive wildlife conservation strategy for the state. This was done in concert with all the other states and territories of the United States who were developing similar plans.

Following the eight elements required by Congress, those involved in the development of the CWCS completed what could arguably be called the most comprehensive statewide analysis of the condition of Arizona's wildlife and habitats. The group developed criteria for identifying Arizona's Species of Greatest Conservation Need, or SGCN; they described the landscape of Arizona, including descriptions of the habitat types and conditions of those habitats across the state; they examined the status of the state's SGCN, identified stressors to those species, and most importantly, they identified actions that could be taken to address those stressors.

The final document came in at 564 pages, plus another 271 in appendices. The products of that effort were made available on the Department's web page in chapters that were useful to our partners, including the State's SGCN list, information on the habitats associated with the SGCN, a list of stressors, and actions that can be taken to address those stressors. During the six years since the plan was approved, the information contained in the CWCS was used to inform management decisions by many of our partners including but not limited to land management agencies and non-governmental conservation organizations. The Department has used the CWCS to inform development of annual work plans required to receive State Wildlife Grant funding, development of the Nongame and Endangered Wildlife Programs operational and implementation plans, and the evaluation of external grant applications. The current revision will be used even more extensively to inform strategic planning at all levels within the Department. In addition, the data behind the SWAP will now be available to a much wider audience than ever before.

Since publication of the CWCS, the demand for data access and the need for decision making tools has grown. Even during the development of the CWCS, those involved knew that the plan would evolve to meet changing conditions in the state. There was a desire to make the data available to the public in as close to real time as possible. The original developers of the plan envisioned using Geographic Information System (GIS) technology in a web-based system that would allow anyone to access the data that informed the CWCS. With the current revision of the plan, the Department has developed a number of spatial products and the web-based HabiMap™ Arizona, which provides full access to the data behind the SWAP to everyone within the Department, our partners, the planning community, and to the public. Everyone can use this tool to inform decisions that could impact Arizona's diverse wildlife and habitats.

It has taken the Department over three years to make the HabiMap™ Arizona a reality, develop the spatial layers that populate it, and produce the SWAP. Many of you participated, either

knowingly by completing the SWAP revision questionnaire, participating in one of the seven SWAP revisions workshops conducted around the state, participating in the Monitoring Workshop hosted by the Heinz Center, Bureau of Land Management, and the Department, or perhaps unknowingly simply by using, asking questions about, or providing feedback on the original CWCS.

I believe we have succeeded. As I said earlier, the SWAP is more than just a planning document. It is in fact a user's manual for one of the greatest collaborative conservation efforts ever completed in Arizona. This revised plan is much shorter than the original. Instead of having to include printouts from the database in the body of the plan as we did in the original, we can now simply provide an example and then send you to the on-line HabiMap™ Arizona where you can access the information needed, and in many ways, we have refined or formatted the plan in a way that is most useful to you, the end user. Also as a result of the revision, the new plan offers a revised list of SGCN, built upon repeatable and defensible criteria; species distribution models have been updated (and in many cases highly refined); and stressors and actions have been updated. The new plan further acknowledges the impacts of climate change on Arizona's wildlife and habitats and lays out a framework of ongoing climate change initiatives in the state and describes how those efforts will better inform the SWAP over the next 10 years.

I am glad you have shown an interest in the future of Arizona's wildlife by picking up this revised SWAP. I hope you will recognize its value. I encourage you to turn to the HabiMap™ Arizona for information when you are looking to make a decision that could impact Arizona's diverse wildlife resources.

Sincerely,

for Larry D. Voyles Deputy Director
Director, Arizona Game and Fish Department

EXECUTIVE SUMMARY

Arizona's Comprehensive Wildlife Conservation Strategy, or CWCS, was accepted by the U.S. Fish and Wildlife Service's National Acceptance Advisory Team in 2006. It was the culmination of a 2-year effort during which the Arizona Game and Fish Department solicited input from numerous experts, resource professionals, federal and state agencies, sportsmen groups, conservation organizations, Native American tribes, recreational groups, local governments, and private citizens and integrated those ideas and concerns into a single, comprehensive vision for managing Arizona's fish, wildlife, and wildlife habitats over the next ten years.

In the intervening five years, Arizona and its' wildlife have seen many changes. To name just a few, the State's human population continues to grow at a rate above average for the country, generating a need for rural and urban planning. A strengthening demand for development of renewable energy sources has created a drive to consider the impacts of such development on wildlife and habitats. We have seen the emergence of new wildlife diseases, the introduction of new invasive species, the listing of some species under the Endangered Species Act, and the delisting of others. We have even welcomed a new species, the Least Tern, to our State. At Federal, State, and local levels, there is also increased attention on climate change and how it affects our wildlife and their habitats.

Perhaps more important is the ongoing work that the Department has engaged in over those years. The CWCS served as a catalyst to the Department to improve on its data collection, management, and analysis. Specifically, it became readily apparent that we needed to get the wealth of information collected for that plan in front of the people who could use it most. In light of that, we have endeavored to develop data products and analysis tools that would help ourselves and our partners inform planning and decision making with the most current and comprehensive wildlife data available. We have succeeded at that endeavor through development of HabiMap™ Arizona; a web-based planning tool that allows individuals from partnering agencies or the public to fully view and analyze the relationships among different data layers such as individual stressors or species.

This document represents not only a plan, but also a guide to using the conservation products we have developed over the years. If anything, implementation of the CWCS has reinforced the Department's commitment to and belief in the power of collaborative approaches to conservation. We believe this document, now called the State Wildlife Action Plan (SWAP), is a far superior product than the original CWCS because it facilitates data sharing and communication between the Department and its partners. We also believe it to be much simpler to use with each section corresponding to one of the required elements. Throughout this document, blue text indicates a live link to the section of the document. Pressing CTRL + click on any link will take the user directly to that chapter or to an external link where applicable.

The first few sections of the document contain background and introductory material including a short introduction to the SWAP and conservation in Arizona. That is followed by Development of Arizona's SWAP, which contains a quick description of the process involved in the revision and a road map to the location of information regarding the eight elements. The next chapter,

The State Wildlife Action Plan System for Arizona (SWAPSAZ) describes the data management system the Department has developed to store all information related to the SWAP. This section also describes the web-based interface, HabiMap™ Arizona that allows users of the SWAP their own window into the data.

The next five sections form the core of the document and correspond to the first five of the required elements. Species of Greatest Conservation Need (Element 1) describes updates to the master species list, the revised vulnerability criteria to determine the SGCN, and outlines the process used to develop of potential habitat models for the SGCN.

A complete description of Arizona's habitat types and the condition of those habits is found in Wildlife Habitat in Arizona (Element 2). In addition, this section describes the process the Department used to develop a number of products to be used to inform conservation in Arizona. Those models, in the form of GIS layers available in the HabiMap™ Arizona, include: 1) a richness index for the SGCN, 2) an economic potential layer for species of economic and recreational importance, 3) a sport fish importance layer, 4) modeled riparian habitat, and 5) unfragmented habitats. These five layers, combined, form the Species and Habitat Conservation Guide; a spatially explicit model of wildlife conservation potential.

Stressors to Wildlife (Element 3) contains a comprehensive, updated list of the stressors, categorized by the level of severity, and their possible effects of Arizona's wildlife. New to the SWAP is a full treatment of the possible impacts of climate change to wildlife and what the Department and its partners are doing to address those impacts. Finally, this section also describes in detail the spatially explicit models developed to map the potential distribution of individual stressors on the landscape. Actions to address stressors are found in Conservation Actions (Element 4) along with a second set of actions to address issues faced by specific species and/or taxa.

The last section, Monitoring (Element 5): identifies the ongoing and new monitoring efforts that the Department is engaged in, discusses plans to incorporate conceptual models from a monitoring workshop co-sponsored by the Heinz Center, Bureau of Land Management and the Department, and discusses monitoring efforts that the Department is engaged in through our partnerships with other agencies.

TABLE OF CONTENTS

FOREWARD ..... **III**
EXECUTIVE SUMMARY ..... **V**
INTRODUCTION **1**
BRIEF HISTORY OF WILDLIFE AND CONSERVATION IN ARIZONA 1
EIGHT REQUIRED ELEMENTS OF THE SWAP 3
DEVELOPMENT OF ARIZONA'S SWAP **4**
ROAD MAP TO REVISE ARIZONA'S PLAN 4
Element 1: Information on the distribution and abundance of species of wildlife 5
Element 2: Descriptions of locations and relative condition of key habitats 6
Element 3: Descriptions of problems which may adversely affect species 7
Element 4: Descriptions of conservation actions 7
Element 5: Proposed plans for monitoring species and their habitats 8
Element 6: Descriptions of procedures to review the strategy 8
Element 7: Plans for coordinating the development, implementation, review, and revision of the plan 8
Element 8: Broad public participation 9
THE STATE WILDLIFE ACTION PLAN SYSTEM FOR ARIZONA (SWAPSAZ) **11**
SWAP RELATIONAL DATABASE 12
HABIMAP™ ARIZONA 13
SPECIES OF GREATEST CONSERVATION NEED **16**
CRITERIA USED TO DEFINE VULNERABILITY 17
Vulnerability 17
Tiers 18
COMPONENT CRITERIA USED TO IDENTIFY CONSERVATION PRIORITY WILDLIFE 19
Extirpated Status 19
Federal or State Legal Status 19
Declining Status 19
Disjunct Status 20
Demographic Status 20
Concentration Status 21
Fragmentation Status 21
Distribution Status 22
DISTRIBUTION MODELS FOR THE SPECIES OF GREATEST CONSERVATION NEED 22
Species Distribution Models 24
Crustaceans and Mollusks 25
Fish 26
Amphibians 26
Reptiles 27
Birds 28
Mammals 28
WILDLIFE HABITAT IN ARIZONA **30**
STATEWIDE CONDITION OF HABITAT TYPES IN ARIZONA 31
Desertscrub 32
Grasslands 34
Woodlands / Forests 37
Human-dominated Landscapes 40
Riparian / Aquatic Systems 40
MODELING AREAS OF WILDLIFE CONSERVATION POTENTIAL: THE SPECIES AND HABITAT CONSERVATION GUIDE (SHCG) 42
Species of Greatest Conservation Need (SGCN) 43
Species of Economic and Recreational Importance (SERI) 44

Sport Fish 46
Unfragmented Areas 46
Riparian 48
Species and Habitat Conservation Guide (SHCG) 50
STRESSORS TO WILDLIFE 51
GENERAL DISCUSSION OF WILDLIFE STRESSORS THAT AFFECT WILDLIFE AND WILDLIFE HABITAT 51
Historical Perspective 51
Current Status 51
Synergistic Effects of Factors Influencing Species and Habitats 53
DEVELOPMENT OF THE STRESSORS TO WILDLIFE AND WILDLIFE HABITAT MODELS 55
HIGH IMPORTANCE 57
Altered Surface Hydrology 57
Border Effects 58
Climate Change 59
Disease/Pathogens/Parasites 59
Drought 59
Grazing by Ungulates 60
Groundwater Depletion and Springhead Use 61
Illegal Stocking 62
Insect Infestations 63
Invasive Animal Species 64
Invasive Plant Species 65
Management for Game Animals and Sport fish 65
Motorized Recreation Off-Road 67
Nutrients/Algal Blooms 68
Roads for Motorized Vehicles 69
Rural Development 70
Sediment/Ash Flow 70
Shrub and Woodland Invasions 71
Solar Energy Development 72
Unnatural Fire Regimes 72
Urban Growth 73
MEDIUM IMPORTANCE 74
Air Traffic Corridors/Overflights 74
Canals/Pipelines 74
Contaminants from Mine Tailings, Waste Water, and Runoff 75
Feral Animals 76
Fishing Line 76
Forest and Woodland Management 77
Hybridization 78
Lead Contamination 79
Livestock Management Infrastructure 79
Loss of Keystone Species 80
Mining 80
Power Lines/Telephone Lines/Cellular Towers 81
Soil Erosion 81
Wind Energy Development 82
MINOR IMPORTANCE 82
Agricultural Conversion 82
Dispersed Camping 82
Domestication of Wildlife/Game Farming 83
Dredging 83
Drilling for Fuels 84
Harvesting/Collecting Animals 84
Harvesting/Collecting Plants 85
Highway/Roadway De-Icing 85

Illegal Dumping/Littering 85
Landfills/Dumps....86
Military Activities 86
Non-Motorized Recreation Off-Trail 87
Pesticides and Herbicides....87
Railroads 87
Recreational Sites and Facilities 87
Scientific Research and Collection 88
Streambank Alteration/Channelization 88
Watercraft Operation....89
CLIMATE CHANGE 90
CONSERVATION ACTIONS....96
ACTIONS TO ADDRESS STRESSORS 97
Agricultural conversion....97
Air traffic corridors/overflights....97
Altered Surface Hydrology 98
Border Effects 98
Canals/pipelines 99
Climate change....99
Contaminants from mine tailings, waste water and runoff....99
Disease/pathogens/parasites 100
Dispersed camping....100
Domestication of wildlife/game farming 100
Dredging 100
Drilling for fuels....101
Drought 101
Feral animals....101
Fishing line....101
Forest and woodland management....102
Grazing by ungulates 102
Groundwater depletion and springhead use 102
Habitat degradation/shrub invasions 103
Harvesting/collecting animals 103
Highway/roadway de-icing 103
Hybridization 103
Illegal dumping/littering....104
Illegal stocking....104
Insect Infestation 104
Invasive animal species....104
Invasive plant species....105
Landfills/dumps 105
Lead ammunition 105
Light pollution....106
Livestock management....106
Loss of keystone species 106
Management for game animals and sport fish....106
Military activities 107
Mining....107
Motorized recreation off-trail....107
Non-motorized recreation off-trail 107
Nutrients/algal blooms 107
Pesticides/herbicides 108
Power/Telephone lines/cellular towers 108
Railroads 108
Recreational sites/facilities....108
Roads for motorized vehicles....109

Rural development 109
Scientific research and collection 110
Sediment/ash flows 110
Soil erosion 110
Solar energy development 111
Streambank alteration/channelization 111
Unauthorized roads & trails 111
Unnatural fire regimes 112
Urban growth 112
Watercraft operation 113
Wind energy development 113
EXAMPLES OF ACTIONS TO ADDRESS SELECT SPECIES AND/OR OTHER TAXA* 114
Nongame Crustacean and Mollusk Species/Project Information 114
California Floater 114
Kanab Ambersnail and Niobrara Ambersnail 114
Page Springsnail 115
San Bernardino Springsnail 115
San Xavier Talussnail 115
Three Forks Springsnail 116
Wet Canyon Talussnail (and other landsnails of the Pinaleno Mountains) 116
Remaining SGCN Mollusks in Arizona 116
Nongame Native Fish Species/Project Information 117
Gila chub 117
Little Colorado Spinedace 117
Loach Minnow and Spikedace 117
Topminnow and Pupfish 118
Virgin River Fishes 118
Yaqui Drainage Fishes and Sonora Chub 119
Big River Native Fishes 119
Statewide Conservation Agreement and Strategy 6-Species of Suckers and Chubs 120
Remaining SGCN Native Fishes 120
Nongame Amphibian and Reptile Species/Project Information 120
Arizona Treefrog (Huachuca-Canelo Hills DPS) Conservation 120
Chiricahua Leopard Frog Recovery 121
Northern Leopard Frog Conservation 122
Relict Leopard Frog Conservation 123
Sonora Tiger Salamander Recovery 123
Tarahumara Frog Conservation 124
Remaining SGCN Amphibian Conservation 125
Flat-tailed Horned Lizard Conservation 126
Mud Turtle Conservation 126
Narrow-headed Gartersnake Conservation 127
Northern Mexican Gartersnake Conservation 128
Ornate Box Turtle Conservation 129
Sonoran Desert Tortoise Conservation 130
Tucson Shovel-nosed Snake 131
Remaining SGCN Reptile Conservation 131
Nongame Birds and Mammals Species/Project Information 132
Arizona Bird Conservation Initiative 132
Arizona Coordinated Bird Monitoring Program 133
Bald and Golden Eagle Management Program 134
California Condor Reintroduction Program 134
Raptor Management Program 135
Remaining SGCN Bird Conservation 136
Bat Conservation 137
Black-footed Ferret Recovery 137
Black-tailed Prairie Dog and Gunnison's Prairie Dog Conservation 138
Mexican Wolf Reintroduction 139
Mount Graham Red Squirrel Conservation 139
Sonoran Pronghorn Recovery 139

Jaguar and Ocelot Conservation 140
Statewide SGCN Mammal Survey and Routine Monitoring 140
MONITORING 142
MONITORING AND ADAPTIVE MANAGEMENT 142
MONITORING HABITAT CONDITION 144
MONITORING WILDLIFE 146
EXAMPLES OF EXISTING MONITORING PROGRAMS 146
Crustaceans and Mollusks 146
Fishes 147
Amphibians 148
Reptiles 149
Birds 150
Mammals 150
Unknown Status Species and Monitoring Needs 152
MONITORING EFFECTIVENESS AND TRACKING PROGRESS 153
LITERATURE CITED 159

FIGURES

FIGURE 1. THE STATE WILDLIFE ACTION PLAN SYSTEM FOR ARIZONA 11
FIGURE 2. STRUCTURE OF THE SWAP RELATIONAL DATABASE 12
FIGURE 3. HABIMAP HOME PAGE. 13
FIGURE 4. BALD EAGLE STRESSOR ANALYSIS 14
FIGURE 5. VEGETATION CLASSIFICATIONS FOR ARIZONA: A) BROWN AND LOWE; AND B) MODIFIED SOUTHWEST REGIONAL GAP LANDCOVER 23
FIGURE 6. PREDICTED APACHE TROUT DISTRIBUTION NEAR GREER, ARIZONA 26
FIGURE 7. PREDICTED SONORAN TIGER SALAMANDER HABITAT DISTRIBUTION 26
FIGURE 8. PREDICTED RIDGE-NOSED RATTLESNAKE DISTRIBUTION 27
FIGURE 9. PREDICTED SPRAGUE'S PIPIT DISTRIBUTION 28
FIGURE 10. PREDICTED LESSER LONG-NOSED BAT DISTRIBUTION 28
FIGURE 11. USING HABIMAP TO EXPLORE THE RELATIONSHIP BETWEEN THE PREDICTED DISTRIBUTION FOR SOUTHERN POCKET GOPHER (DARK PURPLE) AND A) BROWN AND LOWE OR B) SOUTHWEST REGIONAL GAP VEGETATION CLASSIFICATIONS. 31
FIGURE 12. SPECIES OF GREATEST CONSERVATION NEED RICHNESS INDEX 43
FIGURE 13. SPECIES OF ECONOMIC AND RECREATIONAL IMPORTANCE MODEL 44
FIGURE 14. SPORT FISH MODEL 46
FIGURE 15. UNFRAGMENTED AREAS MODEL 47
FIGURE 16. RIPARIAN MODEL 49
FIGURE 17. SPECIES AND HABITAT CONSERVATION GUIDE 50
FIGURE 18. STRESSOR ANALYSIS IN HABIMAP 55
FIGURE 19. PROJECTED SEASONAL CHANGES IN PRECIPITATION FROM 1961-1979 LEVELS TO 2080-2099 LEVELS BASED ON 15 CLIMATE CHANGE MODELS. IMAGE COURTESY OF U.S. GLOBAL CHANGE RESEARCH PROGRAM (WWW. GLOBALCHANGE. GOV) 90
FIGURE 20. PROJECTED TEMPERATURE CHANGES FOR THE SOUTHWEST. THE BRACKETS ON THE THERMOMETERS REPRESENT THE LIKELY RANGE OF MODEL PREDICTIONS FOR TWO EMISSION SCENARIOS. 90
FIGURE 21. PROJECTED PRECIPITATION CHANGES FOR THE SOUTHWEST FROM 1961-1979 LEVELS TO 2080-2099 LEVELS UNDER TWO EMISSIONS SCENARIOS. CONFIDENCE IN THE PROJECTED CHANGES IS HIGHEST IN THE HATCHED AREAS. IMAGE COUTESY OF U.S. GLOBAL CHANGE RESEARCH PROGRAM (WWW.GLOBALCHANGE.GOV) 91

TABLES

TABLE 1: NUMBER OF SPECIES OF GREATEST CONSERVATION NEED IN EACH TIER BY TAXON. 6
TABLE 2: PERCENTAGES OF HABITAT TYPES OWNED BY DIFFERENT ARIZONA LAND OWNERS. 32
TABLE 3: LAND OWNERSHIP IN ARIZONA.....52
TABLE 4: SUMMARY OF ONGOING AND PLANNED MONITORING EFFORTS CURRENTLY CARRIED OUT BY THE DEPARTMENT AND COOPERATORS. 155

APPENDICES

APPENDIX A: ACRONYMS USED IN THE SWAP 189
APPENDIX B: ACKNOWLEDGEMENTS 191
APPENDIX C: VEGETATION CLASSIFICATION CROSSWALK 192
APPENDIX D: MASTERS SPECIES LIST 194
APPENDIX E: SPECIES OF GREATEST CONSERVATION NEED 208
APPENDIX F: PARTICIPATING AGENCIES IN THE PUBLIC MEETINGS AND WORKSHOPS 221
APPENDIX G: PLANNING DOCUMENTS 222

INTRODUCTION

The State of Arizona ranks among the highest for its biological diversity – third in the nation for the number of native bird species, second for reptiles, fifth for mammals, eighth for overall vertebrate diversity, and with more than 800 native wildlife species, the highest diversity of any inland state. The Arizona Game and Fish Commission (Commission) and Department (Department) are proud to serve the people of Arizona as the stewards of that diversity and recognize that these resources are a public trust, managed for the benefit of present and future generations. The Mission of the Department is, in part, "to conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs." However, many factors that influence wildlife management, such as human population growth, drought, and wildfire are beyond the Department's control. In addition, much of the habitat that wildlife relies on occurs on land managed by others. The Department depends on the cooperation of many partners to safeguard wildlife for future generations. The following document is the result of many years of collaborative work done by the Department and multiple partners from federal, state, tribal, county, and municipality agencies; nongovernmental organizations (NGOs); private land owners; and other stakeholder groups, all coming together to ensure the future of Arizona's wildlife.

BRIEF HISTORY OF WILDLIFE AND CONSERVATION IN ARIZONA

The State of Arizona has a long record of commitment and achievement in wildlife conservation. The Commissioners of Fisheries was established as early as 1881 to look after Arizona's fisheries. In 1912 they were replaced by the State Game Warden, expanding the duties to included hunt licensing, permits, and tags. The Game and Fish Commission was created in 1929 and became the Administrators of the Game and Fish Department in 1958. The system has remained relatively unchanged to the present day, with five commissioners overseeing the activities of the Department whose responsibilities under Arizona Revised Statute Title 17 include, among other things, establishing policies and programs to manage, preserve and harvest wildlife, enforcing all laws for wildlife protection, and establishing hunting, trapping and fishing seasons and game limits for all non-Tribal lands in Arizona. The Department manages wildlife in the public trust and that mandate, for stewardship and responsibility, embraces all wildlife, which under Title 17 includes all wild mammals, birds, reptiles, amphibians, mollusks, crustaceans, and fish.

In 1960, Arizona became the first state in the nation to dedicate a full-time employee to nongame wildlife conservation. The Nongame program was officially created in 1983, and consistent with the Department mission, was charged to inventory, monitor, evaluate and plan for the maintenance, recovery or reintroduction of populations and habitats of nongame wildlife (i.e., those wildlife species that are not traditionally hunted or fished), and provide status information and management recommendations to state, federal, and private agencies and organizations for environmental review, protection planning, and public information.

Through the 1980s and 1990s, the Department became widely acknowledged by its peers as being among the nation's preeminent state wildlife agencies. Numerous national and regional awards affirmed the Department's achievements and leadership roles. Many factors contributed

to this recognition, among them: development of a national model for wildlife diversity programs and a national model MOU for State implementation of ESA, the overall depth and breadth of its programs, the expertise and accomplishments of its staff, and the strength and effectiveness of its partnerships and public support. In 1990, the program expanded with funding obtained through the Heritage Fund initiative. The Heritage Fund was created through the efforts of a broad coalition of Arizona citizens and designates up to $10 million a year from lottery ticket sales for the conservation and protection of the state's wildlife and natural areas. Voters passed the Heritage Fund Initiative by an overwhelming 2-1 vote, supported the Heritage Fund again at the polls in 1998, and in 2002 voted 73% in favor to continue the Arizona Lottery, thus continuing support for Heritage.

The Arizona Game and Fish Department uses Heritage Fund dollars to manage our rich wildlife diversity, including threatened and endangered species. The Department also uses Heritage Fund dollars to help urban residents coexist with wildlife, to educate children and the public about the environment and wildlife conservation, and to create new opportunities and provide access for outdoor recreation such as wildlife viewing. Heritage funding has also contributed nearly 18,000 acres for public enjoyment and wildlife conservation and establishment of wildlife areas. Wildlife is an important and growing component of numerous local Arizona economies (Silberman 2001, Southwick Associates 2003), and the Heritage Fund provides critical funding to the Department and benefits communities statewide.

During much of this same time, a national effort was underway to provide additional funding to the states for wildlife conservation. One such effort, called the Conservation and Reinvestment Act passed the House with over 300 votes in 2000. Unfortunately, its large-scale and dedicated funding source did not survive a final compromise with the White House and Senate, but the State Wildlife Grants Program was established. The State Wildlife Grants program provides annual appropriations to the state wildlife agencies on a formula basis for all-wildlife conservation, and mandated the development of Comprehensive Wildlife Conservation Strategies (State Wildlife Action Plans) for each of the 56 States and Territories by October 2005 (TWW 2003a, 2003b). Together, these strategies provided an essential foundation for the future of wildlife conservation and, perhaps more importantly, a stimulus to engage the states, federal agencies, and other conservation partners to think strategically about their individual and coordinated roles in prioritizing conservation efforts. Each individual strategy reflected a different set of issues, management needs, and priorities, however, each plan was required to address the same eight elements (TWW 2003c) ensuring nationwide consistency and a common focus on targeting resources to prevent wildlife from declining to the point of endangerment.

Arizona's plan was completed on time, and to date the state has received nearly $16 million in funding for wildlife conservation as a result of this program. State Wildlife Action Plans are a primary conservation tool for keeping fish and wildlife healthy and off the list of threatened and endangered species. The plans are unique in that they were developed by the nation's top wildlife conservationists in collaboration with private citizens. Each plan identifies the species that are in greatest need of conservation and the actions needed to conserve those species and the full array of wildlife in each state. The principal barrier to implementation of the plans is a lack of sustainable funding.

This newly reviewed and revised Arizona SWAP provides the next 10-year vision for achievement, subject to adaptive management and improvement along the way under the watchful eye of the Commission and its partners. The plan covers the entire state, from low desert to alpine tundra. It identifies wildlife and habitats in need of conservation, insight regarding the stressors to those resources, and suggests actions that can be taken to alleviate those stressors. This new, revised plan not only provides opportunities for many partners to take leadership roles in implementing conservation actions, but it provides innovative web-based resources to encourage and enable those partnerships. Collaboration and synergy continue to be key to shared success in Arizona wildlife conservation and management, and ongoing shared successes will be key to continued Congressional support for the State Wildlife Grants Program.

EIGHT REQUIRED ELEMENTS OF THE SWAP

Congress identified eight elements required to be addressed in each State's SWAP (TWW 2003c). Congress also directed that the plans must identify and be focused on the "species in greatest need of conservation," yet address the "full array of wildlife" and wildlife-related issues. The plans must provide and make use of these eight elements:

(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); and,

(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 proposed 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 10 years; and,

(7) Plans for coordinating the development, implementation, review, and revision of the plan 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; and,

(8) Broad public participation is an essential element of developing and implementing these plans, the projects that are carried out while these plans are developed, and the Species in Greatest Need of Conservation (SGCN).

DEVELOPMENT OF ARIZONA'S SWAP

ROAD MAP TO REVISE ARIZONA'S PLAN

The development of Arizona's original State Wildlife Action Plan (SWAP), known as Arizona's Comprehensive Wildlife Conservation Strategy (CWCS), was a multi-year effort requiring the dedication of various Department workgroups and teams, numerous partners, and the public. The result of that effort was to consolidate a large amount of data and information into one plan. Early in that process, it became apparent that any plan of this magnitude would need to be a "living" document in order to adapt to altered conditions on the landscape, changes to species status, new or changing stressors, and shifting societal pressures.

In the mean time, conditions in Arizona have been anything but static. The human population of the state has continued to grow and the accompanying urban and ex-urban development continues to encroach on wildlife habitat throughout the State. More people also means more infrastructure, such as roads, which without proper planning can fragment remaining habitat. The State has also experienced the emergence of new stressors to wildlife including the drive for development of renewable energy sources, the emergence and spread of new wildlife diseases, the introduction of new invasive species, and the growing importance of climate change. Needless to say, species have responded to existing and new stressors in various ways. Some species have recently been listed as threatened or endangered under the Endangered Species Act while others have been delisted. In 2010, Arizona for the first time became home to a breeding pair of Least Terns. All of these changes, and many others, necessitated a complete review of our existing SGCN, the criteria used to select them, and the list of stressors to wildlife. Any change to the plan that requires revision of two or more elements is defined as a "major" revision by the U.S. Fish and Wildlife Service (USFWS). In keeping with the guidance for plan revisions provided by USFWS, the Department applied for and was approved for a State Wildlife Grant (SWG) planning grant. Shortly thereafter, in October of 2009, the Department sent a formal letter of intent to the USFWS notifying them of the Department's intent to conduct a major revision of the CWCS.

The Department has spent five years since the publication of the CWCS building on that information collected and incorporating it into a comprehensive data management system, the State Wildlife Action Plan System for Arizona (SWAPSAZ, see The State Wildlife Action Plan System for Arizona (SWAPSAZ), p. 11). SWAPSAZ allows for real time management of the data that drive decision making for the Department and its partners and facilitates adaptive management of wildlife. An important part of SWAPSAZ is the web-based data viewer, HabiMap™ Arizona which makes that data accessible to everyone in the Department as well as to our partners and to the public (see HabiMapTM Arizona, p. 13).

This section outlines the major changes to the CWCS and indicates where the details of those changes can be found. Details regarding the development of the original CWCS can be found in that document (AGFD 2006).

Element 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.

Major changes were made to the various components of Element 1, including: 1) the master species list for Arizona was revised to reflect the taxonomic level at which wildlife is managed in Arizona, to include new species reported in the state (e.g., Least Tern), and to update species taxonomy (see appendices F – K in AGFD [2006] and Appendix D:, p. 194 in this document), 2) a new vulnerability analysis was applied to the master species list using revised and more defensible criteria (see Criteria Used to Define Vulnerability, p. 17), 3) a new SGCN list was created based on the vulnerability analysis (see Appendix E: Species of Greatest Conservation Need, p. 208), and 4) the resulting SGCN species distributions were modeled (see Distribution Models for the Species of Greatest Conservation Need, p. 22).

Through a public process, the Department completely reevaluated and made several changes to the vulnerability criteria used to identify SGCN (for a full discussion see Criteria Used to Define Vulnerability, p. 17 and Component Criteria Used to Identify Conservation Priority Wildlife, p. 19). Two criteria were deleted: "Imperiled Status" which repeated other global vulnerability rankings and did not account for differences in spatial scale of the assessments (NatureServe 2010a), and "Element Occurrences" because that category was too sensitive to incomplete data. We also did not use previous Department rankings or those of other regional or national entities to determine vulnerability. The definition of each vulnerability criterion was thoroughly reviewed and rewritten to improve logic and clarity. For example, "Fragmentation" was modified to make it clear that it was a product of anthropogenic changes rather than geographical isolation resulting from a species' unique evolutionary history; that "natural" historical isolation is now reflected in the "Disjunct" category. A new criterion, "Distribution" status, was added to reflect Arizona's "responsibility" for each species with respect to its overall geographic range.

The original Arizona CWCS categorized SGCN according to tiers of vulnerability to reflect the Department's management commitments and priorities. The tier system is still in place, but the definition of the three tiers has changed (see Tiers, p.18). In the spirit of our Section 6 authorities and obligations and the Memorandum of Understanding between the Commission and the USFWS, federally listed or candidate taxa (or those requiring post-delisting monitoring) comprise a large percentage of management resource allocation. Consequently those species, along with closed-season species (according to Commission Order) and species to which the Department has committed resources through signed conservation agreements, all of which scored "vulnerable" under one or more criteria, are our highest priorities and are categorized as Tier 1A.

All species that scored "vulnerable" in one or more categories, but did not fit the criteria above, are categorized as SGCN species in Tier 1B. Finally, there were many species for which existing data are insufficient to score one or more criteria. Those taxa were therefore scored as "unknown" for those criteria and are placed in Tier 1C, the SGCN "Unknown" category. As we learn more about those species they will be rescored and their SGCN status reevaluated. The number of species in each tier is summed in Table 1. The SGCN list, along with the vulnerability criteria scores can be found in Appendix E:.

Species distributions have been completely updated. They are no longer mapped in a hierarchical vegetation classification based on The Nature Conservancy's (TNC) ecoregions and Brown and Lowe (1974) vegetation classes. Rather species potential habitat distributions were modeled for all SGCN based on a number of data sources that have become available since the original Arizona CWCS. These distribution models are much finer in resolution, are spatially explicit, and the models are now easily viewed by our partners and the public via a web interface – the new HabiMap™ Arizona. See Distribution Models for the Species of Greatest Conservation Need, p. 22 for details.

Table 1: Number of species of greatest conservation need in each tier by taxon.

Taxonomic Group	Tier 1A	1B	1C	Total
Amphibians	8	7	4	19
Birds	12	56	77	145
Fish	28	7	0	35
Crustaceans & Mollusks	20	8	156	184
Mammals	10	55	28	94
Reptiles	15	34	5	54
Total	93	167	270	531

Element 2: Descriptions of locations and relative condition of key habitats and community types essential to conservation of species.

The Department did not receive any input from partners, stakeholders, or the public during the revision review process that suggested a need to completely revise Element 2. Although there have undoubtedly been changes in habitat quality in the five years since the original Arizona CWCS, those changes did not necessitate a revision. Arizona is a large, topographically complex state with a wide variety of land uses ranging from protected natural areas such as federal wildernesses to highly developed urban areas. Wildlife occur in and use every habitat type in the state and often rely on variability within and among habitat types to survive. Therefore, we have identified all habitat types as inherently valuable to the natural heritage of Arizona and worthy of conservation actions.

However, the Department also understands that some areas of the landscape are home to a disproportionately large number of species (see Species of Greatest Conservation Need (SGCN), p. 43); have an intrinsic economic importance to the Department and/or the people of Arizona; provide unique hunting, fishing, and other recreational opportunities (see Species of Economic and Recreational Importance (SERI), p. 44 and Sport Fish, p. 46); are exceptionally important habitat (see Riparian, p. 48); and, a few areas, remain relatively unfragmented providing unique management opportunities for wildlife (see Unfragmented Areas, p. 46). To capture these

landscape characteristics and understand their value with respect to managing Arizona's wildlife, for this revision the Department has created the Species and Habitat Conservation Guide (SHCG), a spatially explicit model incorporating each of those values into a GIS layer depicting wildlife conservation potential in the State. The SHCG will help to identify conservation activities and opportunities into the future. See Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG), p. 42 for detailed information on the SHCG.

Finally, all of these layers and many others can be viewed in HabiMap™ Arizona. Through that tool, users can examine the condition of any habitat by overlaying different combinations of GIS layers such as wildlife stressors with habitats and/or species distributions. See Figure 4, p. 14 and Figure 18, p. 55 for examples.

Element 3: Descriptions of problems which may adversely affect species 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.

In the original CWCS, the Department, with the help of numerous partners, completed an exhaustive threats analysis for species and habitats throughout Arizona. As for Element 2, input from the public and partners suggested that this section did not require complete revision. Nonetheless, although the list of stressors in the CWCS was comprehensive, it did little to inform decision makers where on the landscape stressors actually occurred. Also, the original list of stressors was organized by stressor categories adopted from Salafsky et al. (2003), which was an attempt to produce a standardized system for dealing with threats that might eventually be adopted across the conservation community. Although that system has merit, there were aspects of the system and categories that did not apply well to Arizona. Therefore, for this revision, the Department made several changes, including 1) revised the list of stressors to reflect more accurately Arizona's condition; 2) categorized the stressors with respect to their perceived level of impact on wildlife and habitat (see Stressors to Wildlife, p. 51); 3) created spatially explicit models for the potential distributions of many of those stressors (See Development of the Stressors to Wildlife and Wildlife Habitat Models, p. 55), all of which are available for viewing and simple analysis through HabiMap™ Arizona; 4) considered the potential effects of climate change on Arizona's wildlife (see Climate Change, p. 90).

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

In the original CWCS we created a comprehensive list of actions to address the stressors in Element 3. In this revision, we refined that list of conservation actions to reflect changes made to the stressors, and reworked those actions to make them more explicit. In addition, we produced a series of species or project specific conservation actions in which the Department and partners might engage to benefit a variety of SGCN species (see Examples of Actions to Address Select Species and/or Other Taxa, p. 114). These actions are not linked specifically to stressors, but reflect much of the ongoing nongame priorities. We defined conservation actions to address each of the stressors identified in Stressors to Wildlife, p. 51 and displayed in the HabiMap™ Arizona (see Actions to Address Stressors, p. 97).

Finally, we added a Climate Change section (p. 90) and identified many actions that can address climate change and its effects, both directly and indirectly. Some of those actions are being implemented currently by the Department and many can best be accomplished by our partners and the public.

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

The monitoring section (see Monitoring p. 142) was revised primarily for clarity, to update the literature, update ongoing monitoring efforts, and to incorporate concepts from a monitoring workshop held in September 2010 and co-sponsored by the Heinz Center, the Bureau of Land Management (BLM) and AGFD. The workshop included state and federal agency and tribal representatives and members of the Audubon Society, and focused on monitoring in the context of climate change. The Department did not receive any input from partners, stakeholders or the public during the revision review process that suggested a need to completely revise this element.

Element 6: Descriptions of procedures to review the strategy at intervals not to exceed 10 years.

Arizona's new SWAP is far more than a document. It is a fully integrated data management system that allows the Department to share data on the SGCN, the stressors, and the landscape models with all of our partners and with the public. The advantage of taking an approach to the SWAP that combines the document with a fully integrated data management system is that the Department will be able to continuously revise species, habitat, and stressor data as information becomes available, and that information may be served via our web tool, HabiMap™ Arizona, to our partners and the public. Feedback from cooperators can also be incorporated in real time. This ability, while allowing the Department to engage in true adaptive management, limits the need for constant revisions of the plan itself. However, the Department recognizes that there will be changes as programs are completed, new programs are begun, priorities change, species status changes, and alterations occur across the State, all of these changes will need to be incorporated into the SWAP, and the Department commits to reviewing this document as required by USFWS guidelines and performing a full review and revision as needed by 2022. The Department fully expects that revision to be a major revision, thus requiring re-assessment of the status of species, habitat conditions, stressors to wildlife, and monitoring. The Department will continuously monitor public comment through HabiMap™ Arizona, but also expects to hold public meetings to review the revision at that time.

Element 7: Plans for coordinating the development, implementation, review, and revision of the plan 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.

The Department is fully committed to collaboration with its many partners. The development of a number of web-based planning tools, including HabiMap™ Arizona, are meant to facilitate collaboration by making SWAP data available for review and analysis by our partners. In addition the SHCG provides a spatially explicit depiction of wildlife conservation potential allowing partners to easily engage in conservation activities.

The Department also partnered with federal and state agencies, tribes, and non-governmental organizations to get technical and expert opinion on various SWAP processes relating to criteria selection for identifying SGCN, reviewing the species and threat distributions, identifying habitats of conservation value, and reviewing threats and actions that address SGCN and their habitats. A stakeholders meeting was held in Phoenix in May 18, 2010. Prior to the meeting we sent personal invitations to the leadership and/or to natural resource program directors of Arizona's 22 Native American tribes, BLM districts, USBR, USFWS Ecological Services offices, USFS National Forests, National Parks, military installations, as well as various academics and NGOs. A total of 87 participants attended the public meetings, as private citizens or representing stakeholders.

The Department, the BLM, and the Heinz Center also hosted a monitoring workshop for Arizona SWAP partners on September 20-24, 2010, in Phoenix. This workshop focused on identifying existing monitoring programs, conceptual models of stressors/actions/conservation targets and their inter-relationships, indicators of wildlife and habitat condition, desired future conditions, developing performance measures for wildlife conservation, data management systems, and adaptive management. Workshop discussions also highlighted the topic of climate change as a key stressor to wildlife and habitat, and how monitoring and conservation actions could address this stressor. See Appendix F: for a list of the Agencies which participated in this revision and Table 4 for a list of ongoing partnering efforts.

During August 2011, the Department hosted three workshops giving 38 partners and stakeholders hands-on demonstrations of HabiMap™ Arizona and soliciting feedback from them through a zoomerang survey. Participating agencies are included in Appendix F:.

Element 8: Broad public participation is an essential element of developing and implementing these plans, the projects that are carried out while these plans are developed, and the Species in Greatest Need of Conservation (SGCN).

With the release of the HabiMap™ Arizona, the Department has made all of the information contained in the SWAP transparent to our public. Anyone can access the HabiMap™ Arizona and analyze species and stressors occurring anywhere in the state and evaluate the conservation actions. In this way, interested parties can become actively engaged in conservation. The SHCG, in particular, provides an easy to use, graphical interface that allows the public easily to locate areas of high wildlife value. Feedback from users of these tools will further inform the data contained therein and decisions based on that data.

To solicit input from the public and stakeholders for the 2012 revision of Arizona's SWAP, the Department held a series of seven public meetings statewide from December 2009 through February 2010 (one in each Department Region and one at Department headquarters in Phoenix)

and hosted an online survey on the agency's website (www. azgfd. gov). A total of 87 participants attended the public meetings, as private citizens or representing stakeholders (see Appendix F: for complete list).

The online survey and public meetings were announced to the public and stakeholders via the Department's website, press releases, E-news subscription updates, and through social networking notices on the Department's Facebook and Twitter links. Proposed new and existing components of the SWAP were made available to the public from the Department's website, including draft maps of species, habitat, and threat distribution models.

THE STATE WILDLIFE ACTION PLAN SYSTEM FOR ARIZONA (SWAPSAZ)

Development of the Arizona's original SWAP, the CWCS (AGFD 2006), was a multi-year effort requiring the dedication of various Department workgroups and teams, numerous partners and other stakeholders. One result of that effort was to collect a large amount of information about Arizona species and habitats into a centralized repository and consolidate it into one plan. Early in that process, it became apparent that the information being collected was and would continue to be dynamic, presenting a "snap shot" of conditions at any particular point in time. The plan would need to be a "living document to reflect dynamic conditions on the landscape, changes to species conservation status, new or intensifying stressors, and shifting societal pressures. The Department has spent five years building on the initial CWCS data, tracking changes, and developing dynamic processes to incorporate the information into an integrated data management system that would make the dynamic data available to users, the State Wildlife Action Plan System for Arizona. The SWAPSAZ allows for real time management of the data driving the Department's and partners' decision making processes and facilitating adaptive management of wildlife. The system consists of a centralized, relational database, over 400 geospatial data layers, a number of complex spatial models, and HabiMap™ Arizona (see figure 1).

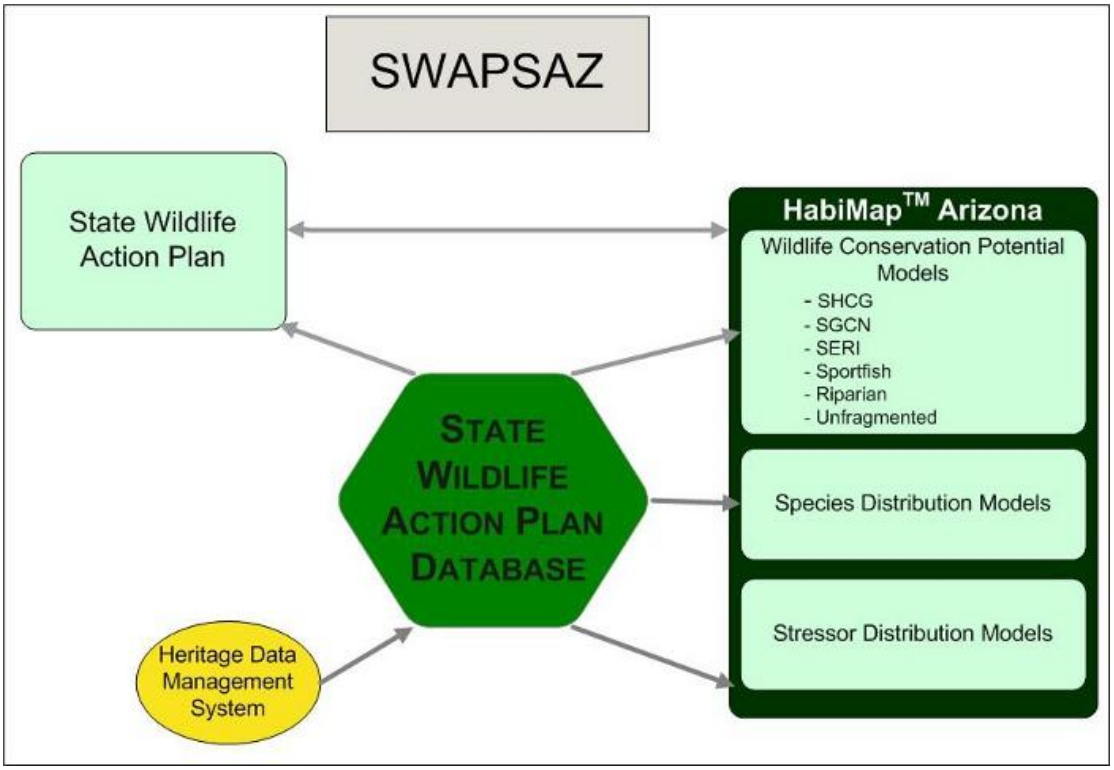


Figure 1. The State Wildlife Action Plan System for Arizona

SWAPSAZ's core component is the SWAP database. This database tracks all of the information that informs the SWAP itself, and the data layers that make up HabiMap™ Arizona. In turn, the database is informed by the Department's Heritage Data Management System (HDMS) which is used to update taxonomy and to validate the species distribution models. Those updates are then

pushed into HabiMap™ Arizona via the species distributions or the wildlife conservation potential models. Any changes to an existing stressor or the addition of an emergent stressor can also be pushed through the database and reflected in the data layers in HabiMap™ Arizona. Additional conservation actions to address emergent or intensifying stressors will be added to the database and amended to the SWAP (this document) via the process set forth in the USFWS's revision guidelines. Individual components of SWAPSAZ, along with other planning tools, can be accessed through the Planning for Wildlife website (http://www.azgfd.gov/WildlifePlanning).

SWAP RELATIONAL DATABASE

All data collected and generated during the SWAP processes are stored in one centralized relational database. The database holds all of the species information including scientific and common names, vulnerability scores, tier level, parameters used to develop the distribution model, and a link to the distribution model for each species. In addition, the database holds all of the stressor information including definitions and links to relevant conservation actions. The Actions to Address Stressors section of this document is generated directly from the database as are all species tables.

The database is meant to be "living" in that changes to any component of the SWAP can be made in real time and instantly compiled, linked, and applied to all relevant areas. For example, a change to a single stressor would automatically be reported at the habitat type and species levels, and in applicable planning documents. In addition, the centralized location of all SWAP data facilitates sharing of information and planning across work units and among cooperators.

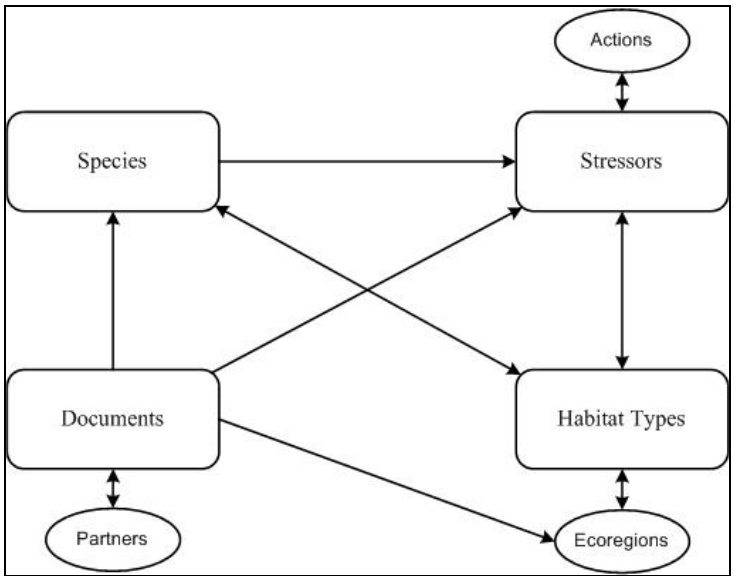


Figure 2. Structure of the SWAP Relational Database

The structure of the SWAP database is complex but can be conceptualized as consisting of four main sections: Species, Stressors, Habitat Types and Documents. Each of these sections consists of multiple, interrelated tables which will be explained in more detail below.

Figure 2 shows the simplified structure of the SWAP database. The main sections of the SWAP database are shown in the large boxes. Arrows connecting those boxes, indicate relationships among different sections. The direction of the arrow indicates the type of relationship. For example, the double headed arrow between "stressors" and "habitat types" indicates that all Stressors are linked to one or more "habitat types" and all "habitat types" are linked to one or more "stressors." The single headed arrow between "species" and

"documents" indicates that while all "documents" are linked to one or more "species", the converse is not necessarily true. Not all "species" are linked to specific "documents."

The species section of the database contains the master species list of all wildlife for which there is historical evidence of occurrence in Arizona. Species information may be retrieved from the database grouped by higher level taxon (e.g., fishes, mammals, etc.) or by scientific or common name. Each species is linked to specific information including but not limited to: vulnerability criteria scores, conservation priority level, habitat types used by the species, parameters used to model the distribution, and a link to the GIS layer for the species. This allows the retrieval of any species or group of species based on geographic distribution and/or vulnerability status.

The stressors section contains all data collected during the CWCS (AGFD 2006) threat assessment exercise. The main table for this section contains a comprehensive list of habitat type and species level stressors and their definitions. In addition, as indicated in figure 2, each stressor is associated with specific conservation actions (See Actions to Address Stressors).

The documents portion of the database contains references to planning documents and conservation agreements, both signed and draft, with which the Department is involved. Each document is linked to a separate table identifying the partners involved in each plan. This section also provides a document tracking mechanism which facilitates cooperation among Department work units and among cooperators.

HABIMAP™ ARIZONA

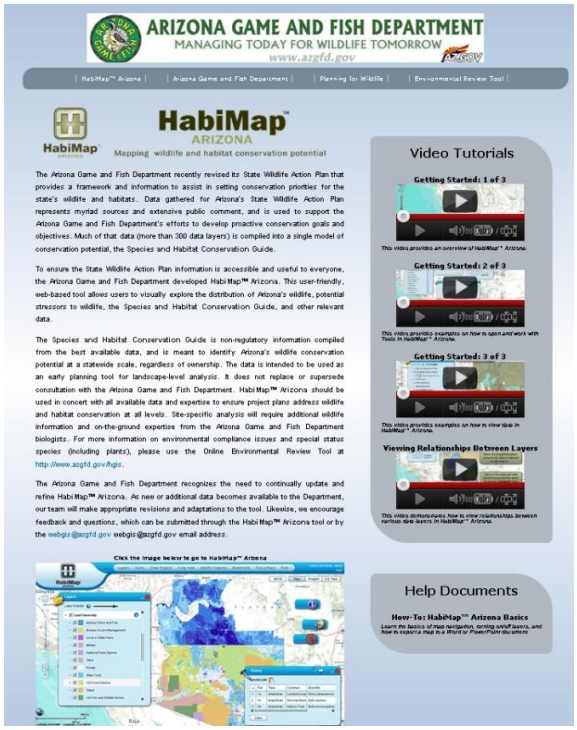


Figure 3. HabiMap Home Page.

HabiMap™ Arizona is an interactive, web-based GIS tool that was built to display and query the spatial components of the SWAP, such as stressors to wildlife, species distribution models, and the wildlife conservation potential models including the SHCG (see Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG)). The ability to display the spatial components of the SWAP at a landscape level allows users to identify relationships between data layers; perform threat assessments for specific sites, species, and/or groups of species; locate the best areas for conservation action based on any of the wildlife conservation potential models; and explore potential wildlife related conflicts when planning for development.

The home page of HabiMap™ Arizona (figure 3) contains links to the web tool, video tutorials, and help documents; the Department's home page; and the Environmental Review

Tool. Additional links will be added as more help materials and other planning tools are developed. Clicking on the image of HabiMap™ Arizona opens the data viewer where the user can begin to explore and interact with the data collected in developing the SWAP. Those data layers include distribution models for each species on the SGCN list and wildlife stressors, the wildlife conservation potential models, vegetation classifications, and various other layers from the Department and other agencies. In addition, the tool utilizes three different base maps: two topographic formats and one satellite and aerial imagery format. The user can view those base maps alone or with any combination of the available data layers. This allows the user to do simple overlay analyses without any GIS experience. For example, a user who was interested in the effects of air traffic on bald eagle populations might begin by looking first at the predicted distribution of bald eagles (figure 4A) and proceed to look at the relationship between the

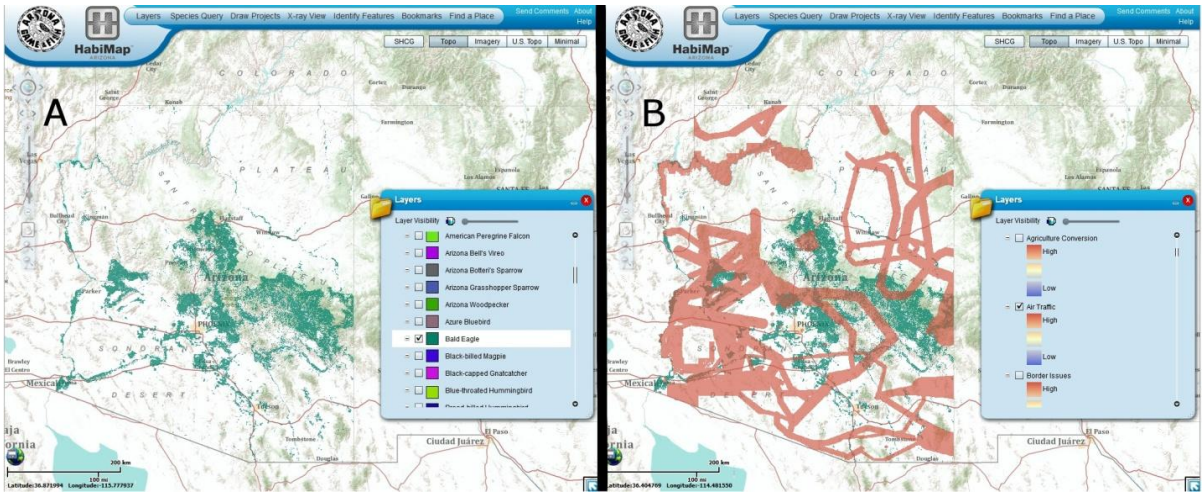


Figure 4. Bald Eagle Stressor Analysis

predicted distribution of bald eagles and the modeled distribution of air traffic (figure 4B). Other HabiMap™ Arizona functions include the ability to zoom in and out; bookmark areas to easily share information; draw study sites on the map and share those with others; and query the database to get a complete list of SGCN predicted to be in any area. Both the data and the tool functionality will be updated on a regular basis to insure that users have access to the best available data and the tools to analyze it effectively.

The Department envisions HabiMap™ Arizona as a primary means of sharing information not only internally but also with our partners and the public. Currently, the Department has hired a public relations firm to help us develop a communication and marketing plan to bring the HabiMap™ Arizona to as wide an audience as possible.

HabiMap™ Arizona and this document are the user's guides to wildlife conservation in Arizona. Interested parties (e.g., planners, landowners, government agencies) can examine different data layers to see where species may exist and where stressors may impact those species. This document then provides recommended conservation actions to lessen the effects of those stressors. Other agencies and partners can use the two together to determine the optimal places to concentrate conservation activities. Planners and developers can use the wildlife potential conservation models (see Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG)) as a starting point to identify areas with the least potential for wildlife related conflict early in the planning process. However, later in the process further analysis of known species locations can be done in the Department's Online Environmental Review Tool. The conservation actions contained in this document can be used to guide mitigation efforts to avoid or minimize negative impacts to wildlife. Additional wildlife conservation guidance is available through the Planning for Wildlife website (http://www.azgfd.gov/Wildlifeplanning).

SPECIES OF GREATEST CONSERVATION NEED

Element 1 requires states to include 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. Those species that each State identified as most in need of conservation actions are often referred to as the Species of Greatest Conservation Need (SGCN). As a first step in identifying the SGCN for the CWCS, the Department compiled a master species list for the State of Arizona. Briefly, all species known to exist in the State were compiled into an exhaustive list from a number of existing data sources. The resulting list was refined by Departmental experts working with external collaborators to reflect the taxonomic level at which the Department manages wildlife. While most wildlife are managed at the species level, others are managed at the subspecific level (e.g., Sonoran tiger salamander), or when appropriate at the distinct population segment level (e.g., Arizona treefrog). Thus, throughout this section while we refer to vulnerable "species," the reader should recognize the possibility of different taxonomic ranks.

The master species list was further refined to include only those species for which the Department has statutory responsibility as defined in Arizona Revised statutes Title 17. That includes all vertebrate species, crustaceans and mollusks. Although the Department recognizes the conservation needs of a number of plants and insects, lack of authority, resources and expertise limits the Department's ability to respond to those needs. However, we offer encouragement and support to our partners that do so. Finally, the master species list was limited to those species that actually depend on Arizona habitats for survival. Thus, anecdotal species accounts as well as casual and accidental bird sightings were not included. Feral or pet trade species were also excluded. However, nonnative species that the Department actively manages (most sport fish are in this category) were included on the master species list (Appendix D:).

The second step in identifying the SGCN was to evaluate each wildlife species in terms of its conservation needs and vulnerability. To accomplish that in the CWCS, the Department developed a number of "vulnerability" criteria, designed to evaluate a species' conservation status and risk level by evaluating the abundance and distribution of the species. In addition, the criteria included indicators of population stability (e.g., demographic status and declining status) and population risk (e.g., fragmentation status and concentration status). Thus, the vulnerability assessment provided us with a means to answer questions regarding the distribution, health, and abundance of wildlife species and populations.

For this revision, we have updated the master species list to reflect changes in taxonomy including name changes and subspecies determinations. We have also refined the definitions of the vulnerability criteria to better assess each species' vulnerabilities. The species were rescored using the refined criteria, to produce more robust species evaluations that reflect the current state of knowledge per species. Species that were determined to be at risk (i.e., vulnerable in some criteria) through that assessment were added to the SGCN list (Appendix E:). That list was further prioritized into three tiers, 1A, 1B, and 1C (see Tiers). Tier 1A contains those species for which the Department has entered into an agreement or has legal or other contractual obligations, or warrants the protection of a closed season. Tier 1B represents the remainder of the vulnerable species. Tier 1C contains those species for which insufficient information is available to fully

assess the vulnerabilities and therefore need to be watched for signs of stress. This tier replaces the species of unknown status from the CWCS. These changes have resulted in a better and more realistic SGCN list. The current tiers, vulnerability scores, and the tier designation from the CWCS are in Appendix E:. Finally, a potential distribution model was developed for each of the tier 1A and tier 1B species (see Species Distribution Models). Those models can be viewed and their relationship to habitat explored using HabiMap™ Arizona.

CRITERIA USED TO DEFINE VULNERABILITY

For Element 1 of Arizona's SWAP, the Department must identify wildlife of conservation priority, i.e., Species of Greatest Conservation Need (SGCN). For this purpose, all of Arizona's native species of wildlife (ranging from big game species to crustaceans and mollusks) were evaluated with the process described below. Those species that scored "1" for any vulnerability category, or scored "0" (insufficient data) are included in the list of SGCN. The SGCN were further prioritized into three tiers based on vulnerability scores and legal status.

Vulnerability

There are potentially many ways to assess the degree to which any species in Arizona is vulnerable to the impacts of specific threats. Accordingly, the Department developed a set of criteria to capture different types of vulnerability in the context of the Department's mission to "conserve, enhance and restore Arizona's diverse wildlife resources and habitats."

All of the vulnerability assessments are based on expert opinion of Department biologists and diverse partners. In addition, the Department has been and is engaged in numerous monitoring programs across the spectrum of wildlife species (see Monitoring), and those monitoring efforts greatly informed the assessment. However, we make no claim to have thoroughly analyzed population status parameters for all species. In fact, there are very few, if any, recent comprehensive population analyses for any wildlife species in Arizona, although there are exceptions (e.g., bald eagles [McCarty and Jacobson 2011]). Those few analyses that have been done are typically spatially or temporally constrained, out of date, or all of the above, and difficult or impossible to extrapolate range wide; examples include, Gila chub (Griffith and Tiersch 1989), Sonora mud turtles (Stone 2001, Hensley et al. 2010), kangaroo rat species (Zeng and Brown 1987). Recovery plans and status reviews for federally listed and candidate species provide useful data, but those taxa remain a relatively small subset of Arizona's wildlife species.

This vulnerability assessment did not use available national or global vulnerability rankings (e.g., NatureServe) because rankings based on species evaluations across their entire geographical distribution are too coarsely scaled. We also did not attempt to match rankings done previously by the Department (e.g., Wildlife of Special Concern in Arizona [WSCA]), or rankings done by other agencies or entities, e.g., U.S. Forest Service (USFS) Southwestern Region Sensitive Animals list (USFS 2010), BLM sensitive species list for Arizona (BLM 2005), Birds of Conservation Concern 2008 (USFWS 2008), Southwest Partners in Amphibian and Reptile Conservation (PARC) draft priority amphibian and reptile species list (SW PARC unpublished), etc., again because of issues of scale, as well as differing management and conservation priorities across agencies, NGOs, etc.. It is important to note that lists compiled by other entities are based on other, perhaps similar or dissimilar, criteria in different geographic and management settings,

therefore the resulting vulnerability ranks herein are not meant to replace, update or invalidate any of those lists.

We did not include a vulnerability category specifically for climate change. It is evident that the scientific community's understanding of the ways in which climate change will manifest itself (e.g., precipitation or temperature changes, its intensity, topological and geographic patterns, direct and indirect effects on species, etc.), is incomplete. Further, some recent models have suggested that species might be affected physiologically in ways that confound relatively simple predictions of distributional shifts (e.g., Sinervo et al. 2010). It is likely that climate change will affect all species, and although contributions to our understanding continue to be made, the manner and degree to which individual species will be affected requires considerably more data. Therefore we did not attempt to predict the relative vulnerability to climate change among Arizona's wildlife (see Climate Change).

Each species was scored for each of the following vulnerability criteria. If a species ranked as "vulnerable" (i.e., score = "1") under one or more of the vulnerability criteria it was included in the SGCN. Ranks were not additive. The rank was based on the following criteria:

- Extirpated from Arizona
- Federal or State status
- Declining status
- Disjunct status
- Demographic status
- Concentration status
- Fragmentation status
- Distribution status

Species were considered to have "unknown status" if there was insufficient information to determine the species' vulnerability under one or more of the criteria, i.e., if none of the eight criteria were scored as "1", but one or more of the eight categories scored "0".

Tiers

The resulting list of SGCN was further categorized into three tiers reflecting the Department's management commitments and priorities; tiers were ranked as follows:

Tier 1A: Scored "1" for Vulnerability in at least one of the eight categories and matches at least one of the following:

- Federally listed as endangered or threatened under the Endangered Species Act (ESA).
- Candidate species under ESA.
- Is specifically covered under a signed conservation agreement (CCA) or a signed conservation agreement with assurances (CCAA).
- Recently removed from ESA and currently requires post-delisting monitoring.
- Closed season species (i.e., no take permitted) as identified in Arizona Game and Fish Commission Orders 40, 41, 42 or 43.

Tier 1B: Scored "1" for Vulnerability in at least one of the eight categories, but match none of the above criteria.

Tier 1C: Unknown status species. Scored "0" for Vulnerability in one of the eight categories, meaning there are no data with which to address one or more categories, and vulnerability status cannot be assessed. These species are those for which we are unable to assess status, and thus represent priority research and information needs. As more information becomes available, their tier status will be re-evaluated.

COMPONENT CRITERIA USED TO IDENTIFY CONSERVATION PRIORITY WILDLIFE

Each species was ranked for each of the eight vulnerability criteria, with a ranking of '1' (= High Priority), '2' (= Medium Priority), or '3' or '4' (= Low Priority) was assigned. Scoring was conducted by Wildlife Management Division staff (primarily Nongame, Game, and Fisheries branch specialists) and reviewed by Regional staff and external partners. Species lists (by taxonomic group) and evaluation scores were compiled in the Department's SWAP database.

Extirpated Status
Description: Species that historically occurred in Arizona, but are thought to no longer exist here; populations continue to persist in other states or in México.

CRITERION SCORE	DESCRIPTION - EXTIRPATED STATUS
1	Extirpated from Arizona
3	Not extirpated from Arizona

Federal or State Legal Status
Description: The legal status of each species, subspecies or Distinct Population Segment determines this criterion score. High-ranking species include: those that are currently listed federally under ESA as endangered, threatened or are candidates for listing, including those populations considered essential or nonessential experimental under section 10(j) of the ESA; recently de-listed species that are undergoing post-delisting monitoring; and species of mollusk, fish, amphibian or reptile for which there is no open season in Arizona as identified in Commission Orders 40, 41, 42 or 43.

CRITERION SCORE	DESCRIPTION – LEGAL STATUS
1	Listed endangered or threatened **or** Candidate for listing **or** No open season in Arizona **or** Has a signed CCA or CCAA
3	No status

Declining Status
Description: Reflects the extent to which population numbers or habitats were recently, are currently, or are anticipated to be in decline. The scores evaluate the degree of change that has been observed, estimated, inferred, or suspected in the area of interest over 10 years or three

generations, whichever is longer (up to a maximum of 100 years); see definition of "Global Short Term Trend" (NatureServe 2010b). The period of time overlaps with the present, so that declines in the immediate past (whether considered ongoing or not), continuing trends, and trends projected to begin immediately are all included. Without evidence to the contrary, and if habitats remain largely intact, status was assumed to be stable.

CRITERION SCORE	DESCRIPTION – DECLINING STATUS
0	Insufficient data
1	Severely declining = Decline of >70% **or** Very rapidly declining = Decline of 50-70% **or** Substantially declining = Decline of 30-50%
2	Decline = 10-30%
3	Stable = Unchanged or within +/- 10% fluctuation
4	Increase of > 10%

Disjunct Status

Description: High-ranking species are represented by populations that have been historically geographically separated from the main population and, thus, vulnerable to declines or local extirpation because of the distance from other major population centers (i.e., other geographic areas where large percentages of that species population occur naturally) and the low likelihood of immigration. An example is the montane vole (*Microtus montanus*) that in Arizona occurs only in the White Mountains, yet the species is widespread from northern New Mexico throughout much of the intermountain West. Vulnerability of species populations that are disjunct as a result of anthropogenic changes to the landscape are captured in Fragmentation Status.

CRITERION SCORE	DESCRIPTION – DISJUNCT STATUS
0	Insufficient data
1	Disjunct population: 1 to few populations in Arizona separated by large relative distance from larger core distribution of the species outside of Arizona, **or** Isolated populations: the core of the species range is within Arizona, and consists of 1 to few populations that are separated by relatively large distances from one another.
2	Peripheral populations: Arizona populations at the margins of the species distribution.
3	Continuous: the distribution of Arizona populations is within the core of the species' range.

Demographic Status

Description: This criterion considers birth and death rates of each species and known factors impacting those rates. Rates can be affected by intrinsic factors such as low genetic diversity, generation time, reproductive potential and other life history characteristics; and from extrinsic

factors including environmental change, illegal harvest, disturbance, and disease. California condors are an example of a species with high demographic concerns.

CRITERION SCORE	DESCRIPTION – DEMOGRAPHIC STATUS
0	Insufficient data
1	Demographically poor situation: Unusually low birth rates or high death rates combined with small or declining population size. Demographic rates are affected by known stressors likely causing a worsening situation in parts of Arizona.
2	Demographically challenging situation: Low birth rates or high death rates combined with small population size. No anticipated worsening of these rates in next 10 years.
3	Demographically stable situation: Birth and death rates anticipated to contribute to normal population size variation in next 10 years.
4	Demographic growth situation: Birth and death rates anticipated to contribute to overall population growth over next 10 years.

Concentration Status

Description: species that have a portion of their life history in which large numbers of individuals, representing a significant portion of the population, are concentrated in relatively small geographic areas, and thus are more vulnerable to local threats and catastrophic events (for example, birds that congregate at a few major migratory stopover sites, communal bat roosts or maternity sites, breeding aggregations of some amphibians).

CRITERION SCORE	DESCRIPTION – CONCENTRATION STATUS
0	Insufficient data
1	Colonial species: found in a limited number of groups at high concentration for all, much, or a critical portion of their life cycle.
2	Aggregating species: found in a limited number of groups at high concentration for a limited part of their life cycle.
3	Diffuse species: not found in a limited number of groups at high concentration for part or all of their life cycle.

Fragmentation Status

Description: Scoring reflects the extent to which populations are separated by human-created barriers to dispersal or gene flow (examples include major highways, railroads, impoundments, dewatered streams, habitats occupied by exotic species, etc.). It does not address species with inherent lack of ability to disperse. Chiricahua leopard frogs are an example of a species with populations that are highly fragmented by habitat loss, presence of exotic species, etc. Note: widely ranging, highly vagile species might be impacted by highways, etc., but not to the extent that effective gene flow is inhibited.

CRITERION	DESCRIPTION – FRAGMENTATION STATUS

SCORE	
0	Insufficient data
1	Within Arizona, fragmentation has resulted in populations that are small and isolated from one another.
2	Within Arizona, populations are large but fragmentation has isolated them from one another.
3	Within Arizona, populations are not or have been little affected by human-created barriers to dispersal.

Distribution Status

Description: This criterion is meant to assess the percentage of a species' reproducing population that occurs in Arizona. Because population data are difficult to compile, from an operational standpoint scoring reflects the percentage of a species geographical distribution that occurs in Arizona. Species that score high have a significant proportion of their global or U.S. breeding range within Arizona, thus indicating Arizona has a high responsibility for maintaining viable populations in the state, even if the species is locally abundant (e.g., Abert's towhee).

CRITERION SCORE	DESCRIPTION – DISTRIBUTION STATUS
0	Insufficient data
1	Endemic: > 90% of the global species' breeding range is within Arizona; **or** Occurs primarily in Arizona: 70–90% of the global species' breeding range is within Arizona; **or** Southwestern: > 90% of the United States segment of the species' breeding range is within Arizona.
2	Southwestern: 50-90% of the United States segment of the species' breeding range is within Arizona.
3	< 50% of the species breeding range is within Arizona, or is widespread elsewhere.

DISTRIBUTION MODELS FOR THE SPECIES OF GREATEST CONSERVATION NEED

During development of the original CWCS, species distribution information was developed by assigning species to a coarse scale vegetation model for Arizona (Figure 5A) (Brown and Lowe 1974). Upon completion of acceptance of that plan, we began to formulate a conservation landscape model (see Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG)) to address Element 2. It soon became apparent that species distributions at such a coarse scale were not useful in assessing the conservation value of the landscape. Fortunately, four data sources have since become available that allow us the freedom of modeling species distributions at much finer resolutions: the Arizona Breeding Bird Atlas (ABBA; Corman and Wise-Gervais 2005), the Southwest Regional GAP (Figure 5B) (SWReGAP) Land Cover Dataset (Lowry et al. 2007), the SWReGAP Animal Habitat Models (Boykin et al. 2007), and the Lower Colorado River Basin (LCRB) Aquatic Gap Analysis project (Whittier et al. 2010).

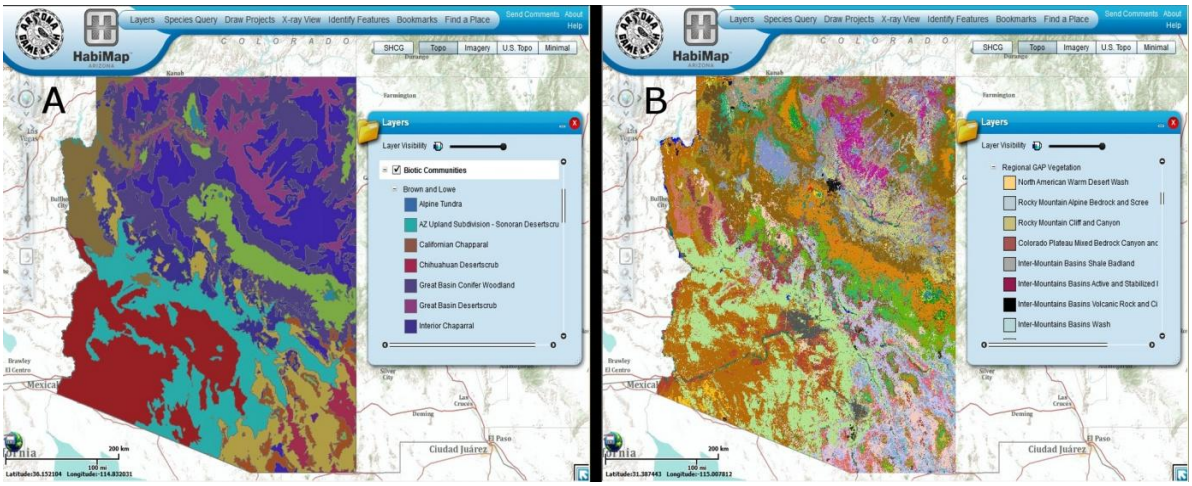


Figure 5. Vegetation Classifications for Arizona: A) Brown and Lowe; and B) Modified Southwest Regional GAP Landcover

The ABBA and its attendant database are the culmination of a 10-year effort by the Department, partners, and many volunteers. It represents the first statewide survey of Arizona birds and contains a wealth of information regarding the actual locations and habitat preferences of over 370 species of birds. The survey was based on the U.S. Geological Survey's (USGS) 7.5 minute topographic maps. Each quad was divided into six blocks and a block from each quad was randomly selected for sampling. Each block was visited several times during the breeding season to detect each bird species and confirm breeding of as many species as possible. In addition, field personnel noted other environmental information such as vegetation types and elevational ranges in which each species was detected (Corman and Wise-Gervais 2005).

The SWReGAP was a USGS effort that was designed to create a number of products including seamless maps of land cover and terrestrial vertebrate species over a five state region (Prior-MaGee et al. 2007). This land cover map formed the basis of most of our species distribution models. Landsat imagery from 1999-2001 was used to classify vegetation into 125 vegetation classes, 78 of which occur in Arizona. This dataset was modified prior to use to more accurately reflect conditions on the ground in Arizona. For example, "SWReGAP code D02 – Recently burned" was recoded to match the surrounding vegetation type with the assumption that the burns would return to that type and to ensure species were mapped to the burned area. Large areas along the foothills in southeast, Arizona that were coded to "S098 - North American Warm Desert Riparian Mesquite Bosque" were field truthed as non-riparian mesquite and were recoded to "AZ04 – Mesquite." Existing SWReGAP riparian was supplemented with modeled riparian (see Riparian for model details) and coded to "AZ05 – Riparian." In addition, the development team felt that xeric riparian, an important vegetation type for many species, was seriously under represented. We addressed that problem with a very simple modeling exercise in which named washes were extracted from the Arizona State Lands Department's Arizona streams dataset. The washes were assumed buffered by 60 meters below 4000 feet elevation and by 30 meters at

higher elevations. The 4000 foot elevational limit corresponds roughly to the elevational ranges of Fremont cottonwood (lower elevations) and sycamore (higher elevations).

A second group of products from the SWReGAP are the animal habitat models. SWReGAP developed a total of 819 terrestrial vertebrate models. The models are a form of traditional niche modeling based on environmental parameters. For each species, a set of parameters defining the "wildlife habitat relationships" (WHRs) were developed. The primary parameter was the vegetation alliances associated with a species that was gleaned from historical records and other sources, but other parameters, such as elevation and distance to water, were also used. Once the WHRs were developed, they were restricted to the 8-digit Hydrological Unit Codes ([HUC], drainage sub-basins delimited by USGS) in which the species had historically occurred. A full description of the modeling process can be found in chapter 3 of the Southwest Regional Gap Analysis Final Report (Boykin et al. 2007).

The goal of the LCRB Aquatic Gap Analysis project was to identify areas with native aquatic fauna diversity, and help in the development of future conservation strategies for the LCRB (Whittier et al. 2010). In pursuit of that goal, the project collected fish location data from federal and state agencies, universities, online fish databases, and museums. The project kindly agreed to share those data with us early in our modeling process and provided fish species localities at the stream reach level.

Species Distribution Models

In order to address Element 1 of Arizona's SWAP, species distribution models were created for each of the SGCN. These species distribution models were developed to represent the historic, present, and potential distribution for an individual species. A specific set of parameters was used for each species distribution model, including vegetation, elevation and slope associations, and known occurrences.

We used several base data layers for a majority of the predictive distribution models. The USGS's SWReGAP land cover layer (Figure 5B), as modified above, was used to map vegetation associations for individual SGCN species. A digital elevation model (DEM) for Arizona was used to map elevational and slope associations for individual SGCN species. HUC boundaries at the 10-digit level created by the Natural Resources Conservation Service (NRCS), along with species occurrence data were used to identify watersheds associations for individual SGCN species.

After the SGCN species distribution models were created, the parameters that went into each model were entered into SWAPSAZ. This created a straightforward way to access the model parameters via queries and tables. The species distribution parameters database is fully linked to the SWAP database, so future updates to the SWAP database (e.g., taxonomic or legal status changes) will be reflected in the species parameters database.

Methods for species distribution models were generally consistent within higher taxonomic levels (e.g., invertebrates, amphibians, birds, etc.), but occasionally species specific parameters were employed (see discussions below). However, all of the data sources discussed above were used in compiling the distribution models for the SGCN, and were further refined through expert

opinion and through validation with the HDMS element occurrence data (if those data were available). For most species, validation with HDMS data has not yet occurred. We are continuing to refine models as time permits, and welcome input from partners and the public.

Regardless of methods, there are assumptions inherent in all of the models:

1. Most of the models are built using SWReGAP Land Cover as a base layer and have a base pixel size of 30 m. However, the models, as is the Land Cover database, are meant to be used for landscape level analysis at a scale of 1,000 ha or greater (Boykin et al. 2007).

2. Each model represents a *predicted* range distribution for a species. Species are expected to occur within that range, but are not assumed to be present at every point within the geographic range. Also, the models do not provide information on species abundance or on habitat quality within the predicted range.

All of the SGCN species distribution models were reviewed by Department biologists before they became finalized. The SGCN species distribution models were created using the best available data at the time, and will be updated as data become available in the future.

Crustaceans and Mollusks

The species distribution models for the SGCN crustaceans and mollusk species were created using several approaches. Aspect, slope, elevational and vegetation associations for individual species were identified by Department staff. The aspect, slope, and elevational associations were extracted from a 30 m DEM of Arizona, and the vegetation associations were extracted from SWReGAP vegetation layer. Occurrence data from the HDMS were used to identify watersheds in which each species occurs at the HUC 10-digit level. The identified watershed range was used to restrict the vegetation association layer down to only those watersheds in which the individual species occurs. Then the aspect, slope, and elevational association layers were used to further restrict the updated vegetation association layer.

In some cases, the watershed distributions identified by HDMS occurrence data were used to locate water springs that are within the selected watersheds. When the water springs were used in the invertebrate species distribution models, a spatial buffer (in meters) was used around each spring to ensure that the springs are present in the final version of each distribution model.

Fish

Figure 6. Predicted Apache Trout Distribution near Greer, Arizona

The species distribution models for the SGCN fish species were created using similar methods. Three hydrological data layers were used to create the species distribution models. Two hydrologic data layers with stream features created by the Department were used to extract intermittent and perennial stream features. A hydrologic data layer with lake features created by the Arizona Department of Environmental Quality (ADEQ) was used to extract lake features for species that have an association with lakes.

Watersheds at the HUC 10-digit level were identified by Department staff using information from the LCRB Aquatic GAP Analysis Project. The identified watershed range was used to restrict hydrological features to only those watersheds in which the individual fish species was known to occur. The hydrological features were merged together to create a final distribution model for each SGCN fish species.

Amphibians

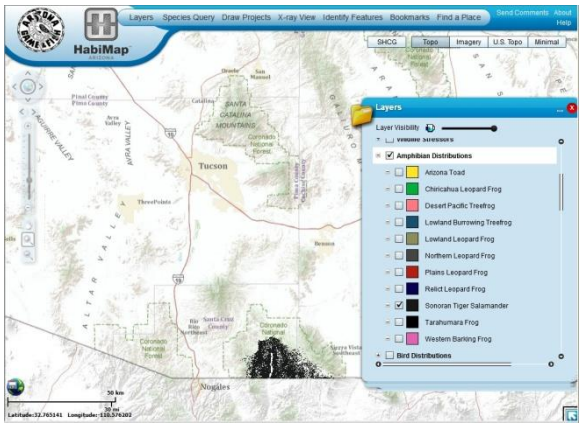


Figure 7. Predicted Sonoran Tiger Salamander Habitat Distribution

The species distribution models for amphibian species were created using several approaches. Elevation and vegetation associations for individual species were identified by Department staff, and those associations were extracted from a DEM of Arizona and the SWReGAP vegetation layer, respectively. Occurrence data from the primary literature, the Riparian Herpetofauna Database, HDMS and other Department sources (e.g., internal reports) were used to identify watersheds in which each species occurs at the HUC 10-digit level. The identified watershed range was used to restrict the vegetation association layer to only those watersheds in which the individual species was known to occur. Then, the elevation association layer was used to further restrict the updated vegetation association layer. This method created predictive species distribution models that assumed that if a species was known to occur in a portion of a watershed within a specific elevational range and within specific vegetation types, then it should occur in other areas of the watershed that have the associated vegetation types and fall within that elevational range.

In some cases species distributions were inferred from distribution maps in field guides (e.g., Brennan and Holycross, 2007) or species accounts in the Catalogue of American Amphibians

and Reptiles (published by the Society for the Study of Amphibians and Reptiles). This information was coupled with staff knowledge and literature reviews of habitat types and elevational ranges. Furthermore, species distribution models created by the SWReGAP project were used to map a few amphibian species distributions for the SWAP. When Arizona-specific species information was available, such as elevational range, vegetation associations, and occurrence information, the SWReGAP species distribution models were modified to incorporate those data.

Reptiles

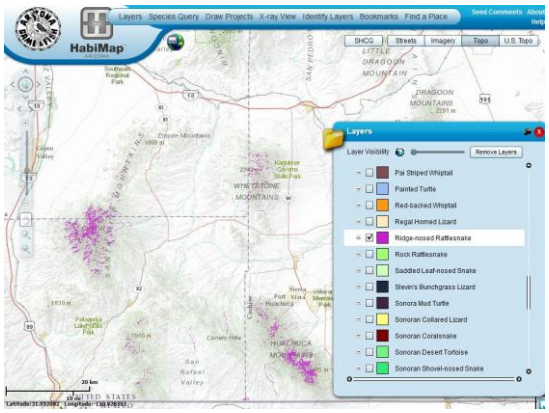


Figure 8. Predicted Ridge-nosed Rattlesnake Distribution

The species distribution models for SGCN reptile species were created using a similar approach to that for amphibians. Elevation and vegetation associations for individual species were identified by Department staff, and those associations were extracted from a DEM of Arizona and the SWReGAP vegetation layer, respectively. Occurrence data from the primary literature, the Riparian Herpetofauna Database, Desert Tortoise Database, HDMS and other Department sources (e.g., internal reports) were used to identify watersheds in which each species occurs at the HUC 10-digit level. The identified watershed range was used to restrict the vegetation association layer to only those watersheds in which the individual species was known to occur. Then the elevation association layer was used to further restrict the updated vegetation association layer. This method created predictive species distribution models that assumed that if a species was known to occur in a portion of a watershed within a specific elevational range and within specific vegetation types, then it should occur in other areas of the watershed that have the associated vegetation types and fall within that elevational range.

In some cases species distributions were inferred from distribution maps in field guides (e.g., Brennan and Holycross, 2007) or species accounts in the Catalogue of American Amphibians and Reptiles (published by the Society for the Study of Amphibians and Reptiles). This information was coupled with staff knowledge and literature reviews of habitat types and elevational ranges. Furthermore, species distribution models created by the SWReGAP project were used to map a few reptile species distributions for the SWAP. When Arizona-specific species information was available, such as elevational range, vegetation associations, and occurrence information, the SWReGAP species distribution models were modified to incorporate those data.

Birds

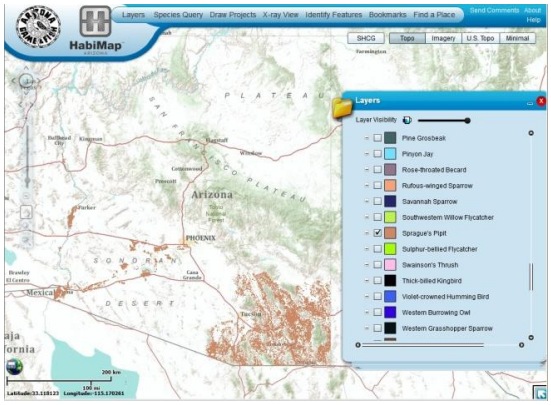


Figure 9. Predicted Sprague's Pipit Distribution

All species distribution models for SGCN bird species were created using the same methods. Elevational and vegetation associations for individual species were identified from the ABBA database and reviewed by Department staff, and those associations were extracted from a DEM of Arizona and the SWReGAP vegetation layer respectively. Occurrence data from the Arizona Breeding Bird Atlas (ABBA) were used to identify watersheds in which each species occurs at the HUC 10-digit level. The identified watershed range was used to restrict the vegetation association layer down to only those watersheds in which the individual species was known to occur, and then the elevational association layer was used to further restrict the updated vegetation association layer. This method created predictive species distribution models that assumed that if a species was known to occur in a portion of a watershed within a specific elevational range and within specific vegetation types, then it should occur in other areas of the watershed that have the associated vegetation types and fall within that elevational range.

Mammals

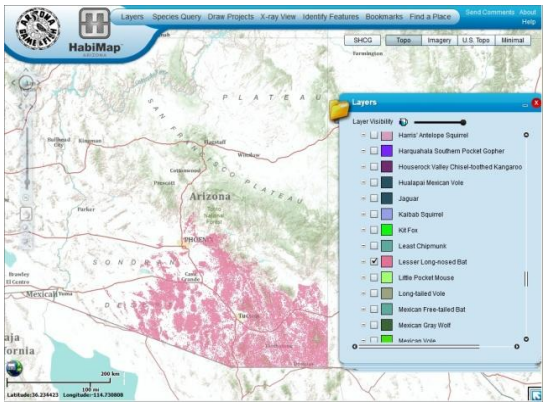


Figure 10. Predicted Lesser Long-nosed Bat Distribution

The species distribution models for SGCN mammal species were created using a combination of new modeling and reuse of the distribution models created for the SWReGAP project. Elevational and vegetation associations for individual species were identified by Department staff and those associations were extracted from a DEM of Arizona and the SWReGAP vegetation layer respectively. Occurrence data from a variety of sources such as the HDMS were used to identify watersheds in which each species occurs at the HUC 10-digit level. The identified watershed range was used to restrict the vegetation association layer down to only those watersheds in which the individual species occurs, and then the elevational association layer was used to further restrict the updated vegetation association layer. This method created predictive species distribution models that assumed that if a species was known to occur in a portion of a watershed within a specific elevational range and within specific vegetation types, then it should occur in other areas of the watershed that have the associated vegetation types and fall within that elevational range.

In some cases species distributions models created for the SWReGAP project were used as the species distribution models for the SWAP. If Arizona specific species information was available the SWReGAP species distribution models were modified to incorporate the refined data such as elevational range, vegetation associations, and occurrence information.

WILDLIFE HABITAT IN ARIZONA

The State of Arizona contains approximately 73 million acres with a large range of topographic and geologic diversity. Elevations in Arizona range from about 75 ft above sea level (near Yuma) up to 12,643 feet at its highest point (San Francisco Peaks near Flagstaff). Generally, elevation increases moving from west to east and from south to north. Precipitation ranges from less than 3 inches to over 30 inches per year depending on elevation and location. Most precipitation in Arizona comes from summer monsoons and winter storms carrying moisture from the Pacific Ocean. The Sonoran Desert in the southwestern corner of the State typically receives nearly equal amounts of summer and winter rain. Winter rain or snow dominates more in northern portions of the State, while summer rain dominates more in the southern portion.

Variability in climates, elevations, landforms, vegetative communities, watercourses, and soil types create many different environments throughout Arizona. These environments range through all six of Merriam's life-zones (Betancourt 1990, Brown 1994)—from the hot, dry deserts of southern Arizona through grasslands and woodlands in mid-elevations, to the cold, moist, montane and alpine forest environments in the higher elevations. In addition, isolated mountains throughout southeastern Arizona, known as "sky islands" (Marshall 1957), create steep elevation gradients resulting in rapid environmental changes over very short distances that can effectively operate as an isolating mechanism for many plants and animals.

Throughout Arizona, aquatic systems and associated riparian areas play a major role in maintaining biodiversity. Riparian communities provide migratory birds and pollinating insects and bats with vital travel corridors for their migrations between North and South America. The State is home to a number of large rivers. The Colorado River runs through the Grand Canyon and forms the western boundary of Arizona. The Gila, Salt, and Verde rivers drain the northern-central portion of Arizona, and carry water to reservoirs supporting the cities in central and southern Arizona. Many smaller creeks and tributaries have perennial or intermittent flow. Springs, cienegas (marshes), and stock tanks provide valuable aquatic and riparian habitat and water for wildlife use. The complexity of the Arizona landscape gives rise to a diversity of habitats that support diverse wildlife communities.

Arizona ranks third in the nation for the number of native bird species, second for reptiles, fifth for mammals, and eighth for overall vertebrate animal diversity (Stein et al. 2000). Wildlife that reside in or regularly migrate through Arizona include: about 25 species of native amphibians, 297 species of birds (not including accidental and casual migrants), 72 species of fish, 164 species of mammals, about 107 species of native reptiles, and over 20,000 species of macro-invertebrates (note: the Department has management authority over all vertebrate species and 270 known species of crustaceans and mollusks). Each of these species has associated habitat needs—shelter from the elements and predators, food and water, and materials and locations for nesting or raising young. Some species require very specific conditions that exist in only a few localized sites. For example, springsnails as a group exhibit narrow tolerances for spring water quality and substrates on which to forage. Other species are habitat generalists, existing in or ranging across a variety of habitats. For example, coyotes are found statewide. Some wildlife, like migratory birds and bats, change their habitat requirements depending on season or life history stages. Arizona's wildlife depends on many resources at different scales in both space

and time. For this reason, the Department considers all wildlife habitat types to be equally important to the conservation of wildlife.

However, the Department also recognizes that some areas are home to a disproportionately large number of species, including not only SGCN but recreationally important species also. These areas represent unique conservation opportunities because any conservation action can affect many different species. In an attempt to capture the location of those places, the Department engaged in an effort to model where those places are in the state. That effort culminated in the Species and Habitat Conservation Guide and is described in "Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG)," p. 42.

STATEWIDE CONDITION OF HABITAT TYPES IN ARIZONA

Traditionally, the Department has managed wildlife and evaluated resources at the landscape level (habitat type) and below. Brown and Lowe (1974) vegetation communities (Figure 11A) were used to represent habitat types in the CWCS since this classification is imbedded in most of the commonly used ecoregion and province classifications for Arizona. Although the current

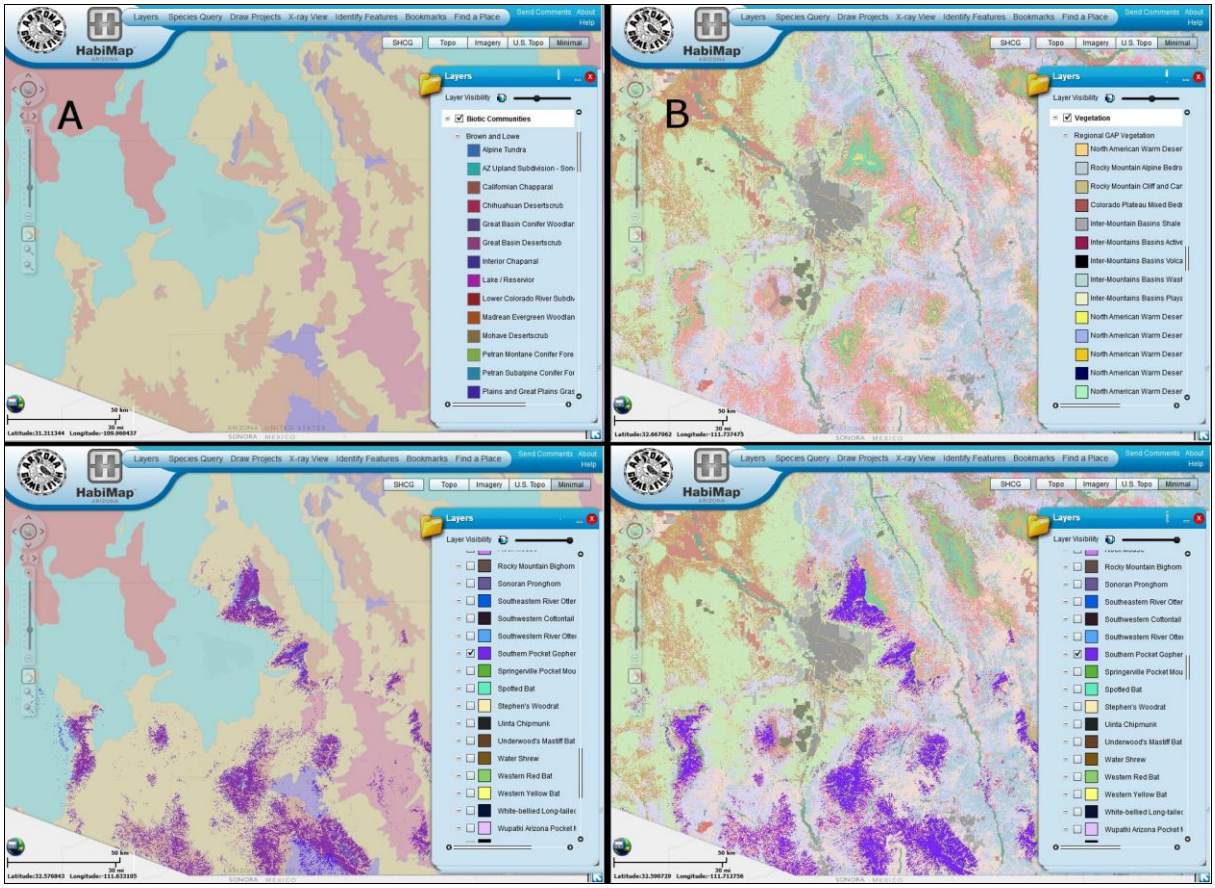


Figure 11. Using HabiMap to explore the relationship between the predicted distribution for Southern Pocket Gopher (dark purple) and A) Brown and Lowe or B) Southwest Regional GAP vegetation classifications.

species distributions are built on the SWReGAP vegetation classification (Figure 11B), the much coarser resolution Brown and Lowe communities are still useful in describing broad scale habitat conditions. The percentage of each of those habitat types under various landowners shown in table 2. We have included a table cross-walking the two systems and the ABBA classification codes in Appendix C: for the convenience of the reader. Both vegetation communities and their relationship to species distributions can also be viewed in HabiMap™ Arizona (see figure 11).

Table 2: Percentages of habitat types owned by different Arizona land owners.

Community Type	Community Description	AZ Game & Fish	Federal	Other	Private	State Trust	Tribal	Sum*
Desertscrub	Upland Sonoran	0.03	43.95	3.84	11.94	16.61	23.62	100%
	Chihuahuan	0	30.58	0.18	25.85	43.39	0	100%
	Great Basin	0.01	20.67	0	5.88	3.49	69.93	100%
	Lower Colorado River Sonoran	0.06	45.02	10.10	22.54	10.17	12.12	100%
	Mohave	0.03	72.52	0.11	17.41	5.03	4.90	100%
Desertscrub Total		0.04	42.86	4.88	15.84	11.81	24.57	100%
Grasslands	Plains & Great Basin	0.06	11.82	0.02	28.51	15.82	43.77	100%
	Semidesert	0.05	26.31	1.60	33.67	32.68	5.70	100%
	Subalpine	0	85.50	0	0.47	0	14.03	100%
Grasslands Total		0.05	18.11	0.68	30.55	22.77	27.84	100%
Woodlands	Alpine Tundra	0	100.00	0	0	0	0	100%
	Great Basin Conifer	0 07	38.12	0	13.00	7.71	41.10	100%
	Interior Chaparral	0	66.67	0	10.13	15.36	7.84	100%
	Madrean Evergreen	0.06	71.92	0.06	10.36	8.10	9.49	100%
	Montane Conifer	0.07	64.80	0	3.82	1.30	30.01	100%
	Subalpine Conifer	0	70.70	0	0.16	0	29.14	100%
Woodlands Total		0. 06	50.51	0.01	10.39	7.39	31.65	100%

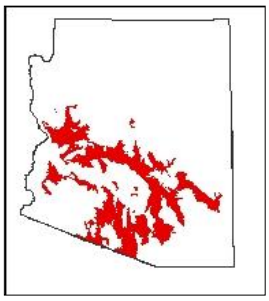
* Each row represents 100% of that habitat type; columns are not additive. Percentages based on Arizona State Land Department's (ASLD) GIS data.

Desertscrub

Lowland Sonoran: elevation 100-3000 ft

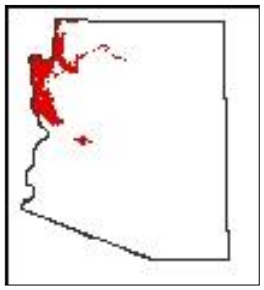
This is the most arid portion of the Sonoran Desert. Vegetation is dominated by low, open stands of creosotebush and white bursage. Cacti, though present, are less abundant than in the neighboring upland division. Trees and taller vegetation are largely confined to washes and other drainages. Smaller areas of low, undrained and salt-affected soils commonly are dominated by saltbush, acacia, and mesquites. Other conspicuous species include: desert broom, chuparosa, ocotillo, cholla, ironwood, palo verdes, and desert willow (Turner 1994c).

More than 21% of the area formerly occupied by lowland Sonoran desertscrub has been replaced by development or agriculture, the highest proportion of any vegetation community in the state. The remainder is rapidly shrinking and being fragmented by urban expansion and energy development, especially on private and former State Trust lands, and particularly in the vicinity of Yuma and Phoenix. This is the only region where hot-desert sand dunes habitats are found in Arizona. Although animal and plant diversity is not as great as that of upland communities in the Sonoran Desert, many of the species that inhabit this region are not found elsewhere in the state, for example flat-tailed and Goode's horned lizards, Yuman Desert and Mohave fringe-toed lizards, Le Conte's thrasher, round-tailed ground squirrel, desert kangaroo rat, and kit fox (Turner 1994c). Wildlife habitat values on much of the undeveloped land are somewhat degraded due to livestock grazing (Hall et al. 2005, Nabhan and Holdsworth 1999). However, 45% of this community is within federal lands, including National Wildlife Refuges and military lands which are ungrazed and have limited other human disturbances.



Upland Sonoran: elevation 500-3500 ft
Leguminous trees and succulents are abundant. Tree species include: foothill and blue palo verde, ironwood, mesquites, and cat-claw acacia. The giant saguaro cactus is found in this community, as are numerous other succulent species including: chollas, pincushions, barrel cacti, organpipe, ocotillo, hedgehog, and prickly-pear. Other conspicuous species include: creosotebush, jojoba, brittlebush, desert hackberry, triangle-leaf bursage, ratany, desert broom, desert willow, and chuparosa (Turner 1994c).

The area occupied by upland Sonoran desertscrub has lost about 8% due to development or agriculture. The remainder is rapidly shrinking and being fragmented by urban expansion, especially on private and former State Trust lands in the vicinity of Tucson and Phoenix. This is the most biologically diverse desert habitat found in Arizona (Turner 1994c) but is rapidly being invaded by non-native vegetation species that are introducing fire in a system where they were historically rare. There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few other habitat types, for example Phoenix talussnail, Papago talussnail, Sonoran desert tortoise, Mexican rosy boa, variable sand snake, Sonoran shovel-nosed snake, cactus ferruginous pygmy- owl, gilded flicker, and gray vireo (winter) (Turner 1994c). Habitat values on much of the undeveloped land are somewhat degraded due to livestock grazing (Hall et al. 2005, Nabhan and Holdsworth 1999). However, 44% of this community is within federal lands, including National Park Service (NPS) lands and BLM National Monuments.



Mohave: elevation 1000-5500 ft
Landscapes are typically quite barren and desolate in appearance with low, scattered shrubs; predominately creosotebush, brittlebush, white bursage, desert holly, shadscale, and blackbrush. Annuals cover the ground in wet years. Although this landscape is shrub-dominated and lacks giant cacti and many tree species, several large plants such as the Joshua tree and Mohave yucca are common, and mesquites and cat-claw acacia are present (Turner 1994b). There are few SGCN species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types. A

couple of examples are relict leopard frog and Mojave desert tortoise.

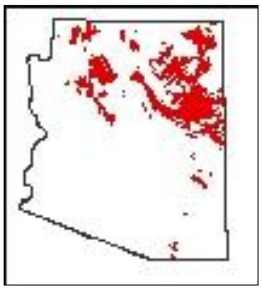
Mohave desertscrub has lost about 5% of its historic distribution in Arizona due to agriculture and low-density development. More than 75% of its distribution is federally managed, including NPS and BLM national monument lands, and thus probably secure from those stressors.

Chihuahuan: elevation 2000-5500 ft
Vegetative community consists of many species of shrubs, leaf succulents, and small cacti. Indicator species include: creosotebush, tarbush, and whitethorn acacia. Trees are rare, but numerous species of small cacti such as prickly pear, cholla, barrel, and hedgehog are present. Other conspicuous species present include: ocotillo, mesquites, desert zinnias, agaves, century plant, sandpaperbush, and a number of yuccas (Brown 1994). Chihuahuan desertscrub occupies a small portion of Arizona and is far more widespread elsewhere. While several SGCN occur in this habitat, e.g., Gila monster, banner-tailed kangaroo rat, Harris' antelope squirrel, no SGCN are restricted completely or nearly so to Chihuahuan desertscrub.

The area occupied by upland Chihuahuan desertscrub has lost about 9% due to development or agriculture. Additional losses are expected due to low-density housing development, especially along the San Pedro River valley. Livestock grazing impacts, especially in the late 1800s, caused significant changes in the soils and vegetation which may be slow to recover (Bahre and Shelton 1996, Sayre 1999).

Great Basin: elevation 3000-6500 ft
Vegetation consists mostly of scattered low, small-leafed shrubs and almost no trees or succulents. Indicator species are big sagebrush and shadscale. Other conspicuous species present include: blackbrush, Mormon-tea, four-wing saltbush, greasewood, rabbitbrush, horsebrush, and winterfat (Turner 1994c). There are a few species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example, sage thrasher, sage sparrow, Prospect Valley white-tailed antelope squirrel, and chisel-toothed kangaroo rat.

The area occupied by Great Basin desertscrub has remained largely unchanged within historic times. However, from the late 1800s through the early 1900s intensive grazing practices caused widespread habitat degradation across its range (Tuhy et al. 2002).



Grasslands

Plains and Great Basin: elevation 5000-7000 ft
Perennial grass dominated landscape usually composed of mixed or short-grass communities. Blue, black, and sideoats gramas are important. Other important grasses include: buffalo-grass, Indian rice grass, Galleta grass, prairie Junegrass, Plains lovegrass, vine mesquite grass, Texas Timothy,

and alkali sacaton. Shrubs such as four-wing saltbush, sagebrush, winterfat, cholla, and rabbitbrush may be scattered throughout. Junipers have invaded large areas of all types of grasslands in the Southwest. Forbs are abundant (Brown 1994). There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example, Sonoran tiger salamander, eastern yellow-bellied racer, Arizona grasshopper sparrow, Gunnison's prairie dog, and black-footed ferret.

The area occupied by Plains and Great Basin grasslands has remained largely unchanged within historic times. These grasslands are in good condition across about 38% of their distribution. Moderate levels of shrub invasion (10-35% cover) affect about 45%, and the remaining 16% is dominated by shrubs or nonnative grasses, or suffers from severe erosion (TNC data; Schussman and Gori 2004). Lack of regular fires and high grazing pressure, including historic periods of overgrazing combined with drought, may have led to conversion of areas from grassland to Great Basin desertscrub or Great Basin conifer woodland (Finch 2004, ACERP 1995). Due to the attractiveness of low-lying valley bottoms for housing development, losses from this source are expected to grow with increasing population pressures in Arizona.

Semidesert: elevation 3500-4500 ft

Originally, the grasses were perennial bunch grasses, the bases of the clumps separated by intervening bare ground. Currently, three-awn and tobosa species together with grama grasses dominate. Some areas are essentially pure stands of grass. In other places, an open savanna with grasses beneath oaks or mesquites is common. Most areas are characterized by short-grasses interspersed with a variety of low-growing trees, shrubs, and cacti. Grass species include: black, blue, sideoats and hairy gramas, buffalo grass, Plains lovegrass, little bluestem, Plains bristlegrass, fluffgrass, burrograss, Lehmann lovegrass, and hairy tridens. Forbs and weeds are abundant. Other conspicuous species present include: acacias, prickly-pear cactus, century plant, cholla, and yuccas (Brown 1994). There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example, San Xavier talussnail, Plains leopard frog, ornate box turtle, Slevin's bunchgrass lizard, Arizona striped whiptail, massasauga, northern aplomado falcon, rufous-winged sparrow, tawny-bellied cotton rat, and black-tailed prairie dog.

Subtropical grasslands were found at elevations below 3,500 feet elevation. This community is unique in that it has essentially become extirpated from the state with only fragments, severely degraded, remaining. Subtropical grasslands were characterized by annual warm season grasses and shallowly rooted perennial grasses, with annual forbs. Woody vegetation such as mesquites, ironwoods and palo verdes are present but widely separated presenting a savannah-like aspect. This habitat was home to the masked bobwhite, crested caracara, antelope jackrabbit, Sonoran green toad, and frequented by the state's once extensive pronghorn herds. Subtropical grasslands ranged northward to the vicinity of Phoenix and were particularly vulnerable to grazing. The demise of subtropical grasslands was due to intensive overgrazing leading to the loss of topsoil, soil compaction and increasing aridity (Brown 1994).

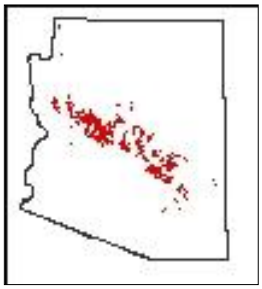
The condition of semidesert grasslands is good across about 9% of its range. Moderate levels of shrub invasion (10-35% cover) affect about 39%, and the remaining 52% is dominated by shrubs or nonnative grasses, or suffers from severe erosion (TNC data; Schussman and Gori 2004). Lack of regular fires and high grazing pressure, including historic periods of overgrazing combined with drought, may have led to conversion of large areas from grassland to Chihuahuan desertscrub. This community has also lost about 10% of its historic extent to development and agriculture. Due to the attractiveness of low-lying valley bottoms for housing development, losses are expected to continue as population pressures increase in Arizona.

There are several separate issues involved in restoration of this habitat type, and the scientific community has different opinions on potential for restoration. Some scientists believe that native grasses cannot be restored because of changes in soil characteristics and lowering of the water table. Some places have been restored with long periods of decreased grazing pressure. Grazing rest or reduction of grazing pressure is generally not occurring on most State Trust and private lands. Drought and climate change impact the ability of this vegetative community to recover. Natural fire, which historically maintained this community, no longer occurs in much of the habitat due to lack of grasses to carry the fire. A natural fire regime is not likely to be restored on most of the Semidesert Grassland because of continued grazing pressure and development of human communities within the vegetation type. There have been some successes at restoring Semidesert Grassland with herbicides to reduce shrubs and thereby promote grasses, but these efforts have been on a small scale and expensive. High human use, both because of the increasing human population and because of heavy border activity, is degrading the habitat and decreasing the value of the habitat for wildlife. In some places, introduced nonnative plants (for example, Lehmann lovegrass and bufflegrass) have invaded the natural vegetation and caused ecosystem changes that may not be reversible. In places where nonnative grasses have become established, an unnaturally frequent and intense fire regime is established, which furthers the spread and dominance of the nonnatives.

Subalpine: elevation 8500+ft
Typically a high elevation, lush grassland habitat dominated by perennial bunchgrasses and forbs. Unlike plains and desert grasslands, subalpine grasslands receive relatively high average annual precipitation.

The area covered by subalpine grasslands has remained somewhat stable through historic times, although there are areas, such as the North Kaibab plateau, which have seen conifer and aspen incursion at the expense of grasslands. The vegetation communities of subalpine grasslands have been affected by grazing or, less commonly, fire, leading to reductions in native bunchgrasses and increases in shrubs and herbaceous plants (Brown 1994). There are a few species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example, Arizona tiger salamander, thirteen-lined ground squirrel, and savannah sparrow.

Woodlands / Forests

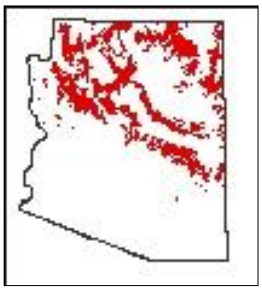


Chaparral: elevation 4000-6000 ft
Typically a dense, nearly impenetrable thicket dominated by two species of manzanita and shrub live oak. Because of the high percentage of crown cover, forbs and grasses are not abundant except in the scattered interscrub openings or after a fire event. Other conspicuous species present include: birchleaf mountain-mahogany, skunkbush sumac, silktassels, and desert ceanothus. Succulents such as prickly-pear cactus, agaves, and yuccas commonly grow alongside shrubs. Most wildlife species that occur in chaparral are widespread and common, and SGCN that occupy chaparral also occur in woodland or grassland habitats where chaparral meets those communities at its upper elevation limits, or in desertscrub at lower elevations; examples include Arizona night lizard, western red-tailed skink, and black-chinned sparrows.

The area occupied by chaparral has remained largely unchanged within historic times. Chaparral ecosystems were subjected to treatments such as mechanical manipulation, and herbicides in the 1950's and 1960's to increase water yield and grazing potential. Because of their high accessibility and relatively gentle terrain, these ecosystems were heavily grazed by goats, especially between 1880 and 1920, and until 1940 (Pase and Brown 1994). Many of the important range grasses were eliminated from most of the sites and, as a result, have been confined to rocky protected areas (ACERP 1995). This habitat is fire adapted and quickly regenerates after a burning event (Pase and Brown 1994).

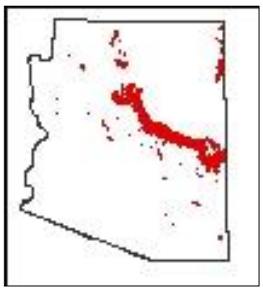
Madrean: elevation 5000-7000 ft
Evergreen oaks dominate with junipers and sometimes pines also growing in the mix. Open savannas are common in some areas with numerous grasses growing beneath the oaks. Common tree species include: Emory oak, Mexican blue oak, Arizona oak, silverleaf oak, alligator bark juniper, one-seed juniper, and Mexican pinyon pine. There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example Huachuca talussnail, Rosemont talussnail, barking frog, brown vine snake, ridge-nosed rattlesnake, Gould's turkey, Montezuma quail, Mexican jay, bridled titmouse, and southern pocket gopher.

The area occupied by Madrean woodlands has remained largely unchanged within historic times. Fire suppression has altered the community composition to favor trees and shrubs over grasses (McPherson 1992). Only about 6% of the Madrean woodlands have fire regimes which are severely altered from their historical range, but another 77% are moderately altered, creating a moderate risk of losing key ecosystem components (USFS data; Schmidt et al. 2002). About 20% of Madrean woodland area is within areas managed with permanent protection for a primarily natural state (TNC 2004a).



Great Basin Conifer: elevation 3400-8800 ft
Evergreen woodland dominated by juniper and pinyon-pine species. North of the Mogollon Rim, Utah and one-seed juniper are intermixed with pinyon and to the south, alligator juniper grows. Colorado Pinyon-pine is the characteristic species throughout nearly the entire zone. Singleleaf pinyon grows locally intermixed with Utah juniper, mostly in northwestern Arizona. Grassland, desertscrub, or chaparral woodland may form an understory beneath and among woodland trees, depending on the area. There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example pinyon jay, juniper titmouse and gray vireo (breeding).

Great Basin conifer woodlands have been significantly affected by changes in fire regime, livestock grazing, and mechanical or chemical treatments (Monsen and Stevens 1999, Stevens and Monson 2004). Due to increased density of tree canopies and of invasive grass species, widespread crown fires are predicted and the area of these woodlands may decline, to be replaced by shrublands or grasslands (Gruell 1999, Tausch 1999). Only about 11% of the Great Basin conifer woodlands have fire regimes which are severely altered from their historical range, but another 70% are moderately altered, creating a moderate risk of losing key ecosystem components (USFS data; Schmidt et al. 2002). Pinyon pines have recently experienced widespread mortality due to drought and insects, affecting 1.2 million acres (9% of total distribution in Arizona) during 2002-2004 (Breshears et al. 2005; USFS 2003, 2004, 2005). The area occupied by Great Basin conifer woodland has remained largely unchanged within historic times. About 69% of this community is within areas managed with permanent protection for a primarily natural state (TNC 2004a).



Montane Conifer: elevation 6000-9000 ft
Ponderosa pine dominates this forest, with Douglas fir and white fir growing in varying proportions. Other tree species include limber pine, southwestern white pine, Gambel oak, silverleaf oak, bigtooth maple, and quaking aspen. Many stands of ponderosa pine are relatively open or park-like, which permits the growth of grasses, forbs, shrubs, and broadleaf trees as understory. In southern Arizona, the Montane Conifer Forest grows primarily on the larger mountains as "islands." There are several species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, for example, Wet Canyon talussnail, northern leopard frog, mountain treefrog, Arizona tiger salamander, western skink, dusky grouse, Mexican spotted owl, red crossbill, evening grosbeak, southwestern cottontail, New Mexican jumping mouse, Arizona montane vole, and Kaibab squirrel.

The area of forested lands in Arizona, primarily conifer forests, has been reduced by about 10% since 1630, based on historic estimates. More detailed estimates of timberland suggest a reduction of about 2.6% for the period 1953-2002 (USFS 2003). Only about 7.6% of montane conifer area is within areas managed with permanent protection for a primarily natural state (TNC 2004a).

Changes in fire regime and forest management have changed many conifer forest stands from well-spaced groups of large trees to closed thickets of small trees, resulting in decreased diversity of grasses, forbs and shrubs. Mortality of large trees by disease, insects, or high-intensity crown fires has replaced the understory thinning action of low-intensity ground fires (Dahms and Geils 1997). Approximately 58% of the montane conifer forests have fire regimes which are severely altered from their historical range, creating a high risk of losing key ecosystem components (USFS data; Schmidt et al. 2002). Insect outbreaks, amplified by drought and high winter temperatures, caused widespread die-off in ponderosa pines affecting 1.3 million acres (27% of total distribution in Arizona) during 2002-2004 (USFS 2003, 2004, 2005). These dead trees will likely support additional large fires in the future.

Alpine Conifer: elevation 8000-9000 ft

A mix of many coniferous and one deciduous species characterize these spruce-alpine fir woodlands. The principal boreal conifers are: Engelmann spruce, blue spruce, corkbark fir, white fir, Douglas fir, bristlecone pine and limber pine. Quaking aspen is the dominant deciduous species; both intermixed with various coniferous species and in pure stands. Dense overstories common to these forests severely limit or prevent growth of herbaceous vegetation. There are few species that inhabit this region that are not found elsewhere in the state or in only one or a few habitat types, but examples include, northern pocket gopher, southern red-backed vole, gray jay, Lincoln's sparrow (in riparian habitats), and pine grosbeak.

Due to their limited distribution in Arizona, the alpine conifer forests have been disproportionately affected by a small number of development projects such as ski runs, communication towers, and observatories (Patten and Stromberg 1995, Dahms and Geils 1997). They also experienced significant tree mortality due to drought and insects, affecting 77,000 acres (32% of total distribution in Arizona) during 2002-2004 (USFS 2003, 2004, 2005). Historically, subalpine conifer forest was insulated from fire by the surrounding lower-elevation fire-resistant mixed conifer, which historically burned regularly but not catastrophically; the mixed conifer was thinned naturally by fire, and fire did not usually invade into the wetter subalpine spruce fir forest. With the current unnaturally high tree density in mixed conifer, and the resulting high fuel loads, the subalpine conifer forest is now being lost to fire and disease. Approximately 79% of the alpine conifer forests have fire regimes which are severely altered from their historical range, creating a high risk of losing key ecosystem components due to destructive crown fires (USFS data; Schmidt et al. 2002).

Tundra: elevation 11,000-12,600 ft

Located on the peaks of the San Francisco Mountains in northern Arizona. Extreme cold temperatures exclude trees and succulents. Dominant plants are ground-hugging woody shrubs and perennial herbs. Few species inhabit this region that are not found elsewhere in the state, however dwarf shrews are often found in tundra and in nearby subalpine meadows (Hoffmeister 1986), and it is the only part of the state where white-crowned sparrows breed.

This community has very limited distribution in Arizona, occurring on just two mountain peaks (Brown 1994). The only significant stressor is trampling and other disturbance by hikers, but climate change could lead to reductions in this community due to an upward shift in treeline (Bowman et al. 2002, Tuhy et al. 2002).

Human-dominated Landscapes

The current status of many species in Arizona, especially birds, depends on the quality of non-traditional habitat. Some native wildlife species are attracted to pastures and irrigated agricultural lands. In particular during migration and winter, many species of birds including raptors, egrets, herons, ibis, shorebirds, waterfowl, blackbirds, and sparrows often congregate locally in exceptional numbers in these human-altered landscapes. Urban sprawl is rapidly converting adjacent agricultural lands into residential and commercial developments, much to the detriment of many species. Conversely, residential and urban ponds, lakes, and canals often attract thousands of wintering waterfowl and other waterbirds such as coots, grebes and cormorants. These permanent urban water impoundments and subsequent fish populations have also encouraged the local establishment of heron and cormorant nesting colonies.

Riparian / Aquatic Systems

Maintaining aquatic and riparian habitats is critical to maintaining the biological diversity of the state. Water resources throughout the state are currently over-allocated such that conflicts are increasing between human uses and maintenance of biological diversity. Active land and water management planning will be critical to accommodating the anticipated human population growth while maintaining biological diversity.

Riparian and aquatic systems throughout Arizona have been uniformly impacted in dramatic fashion from the pre-settlement condition. Three major sources of impact are worthy of discussion: prevailing drought; impacts from livestock management to riparian areas and watersheds; and introduction of nonnative organisms. Other factors causing significant local impact include pollution; off-road vehicular use; changes to watercourses from diversion, impoundments and beaver removal; and fire on watersheds resulting in high siltation.

Prevailing drought conditions in Arizona are at their most extreme within recorded history. This directly results in lower input to both surface and subsurface water resources. Many springs and seeps have dried up within the last several years for the first time in living memory. This has direct severe impact on the wildlife and plant communities dependent on them. Rivers and streams have lower flow regimes and reduced seasonal peaks. This affects the life histories of riparian and aquatic organisms in multiple ways.

Many rangeland watersheds have been damaged by grazing since European settlement, such that soils have been lost and plant communities altered. This impacts the nature of runoff events into streams, rivers and lakes, and also impacts groundwater recharge. Stream flow patterns have become more "flashy," that is, more prone to high runoff events characterized by high velocities and silt loading, followed by dramatic reduction in flow. Previously, watersheds with better plant cover allowed vegetation to slow the impact of falling precipitation, reducing erosion, and

downed vegetation on the soils surface slowed runoff, allowing more recharge of soil moisture and subsurface aquifers. Degradation of this system by continued removal of plant biomass and reduction in vigor is a positive feedback loop; deteriorating conditions further restrict plant vigor and moisture retention, leading to further degradation of the plant community. Currently many watercourses have been reduced from perennial meandering small streams and wetlands to gullies with ephemeral flows of high velocity and short duration. Gullies lower the effective wet zone below the reach of many riparian plant types, limiting banks to upland vegetation only. These processes are essentially irreversible at the landscape scale within human lifetimes.

Grazing by livestock and by elk (in some areas) has resulted in loss of recruitment of new individuals to the plant communities, especially among riparian trees. In many areas there is a near total lack of riparian tree recruitment during most of the last 100 years. Trends are generally positive regarding this issue, with most land managers moving toward proper management of grazing in riparian areas. Areas that have received the most extensive relief have generally shown positive, sometimes remarkable improvement.

Nonnative organisms introduced deliberately and inadvertently have greatly modified the biota of riparian and aquatic systems throughout Arizona. In the aquatic environment, exotic fishes, crayfish, and mollusks have essentially converted many aquatic communities to a different biota. Crayfish are a threat of large magnitude in these aquatic systems. Native fish in Arizona are considered the most threatened taxa among Arizona native species, largely as a result of predation and competition with these exotic organisms (Mueller and Marsh 2002).

Off-road vehicle use has similarly affected localized riparian and aquatic areas throughout the state. In many areas, access by motorized vehicle is only possible by following the stream courses. This has resulted in extensive damage by trampling banks and vegetation. This travel, and cross-channel fording adds to sediment loading of aquatic systems, reducing productivity and the integrity of systems downstream, and creating erosive actions that can lead to head-cutting upstream, with all of the associated adverse effects.

Artificial impoundments and diversion of watercourses occur throughout the state to varying degrees, dramatically changing many watercourses from the pre-settlement condition. Especially in smaller watercourses, loss of once-widespread beaver impoundments has altered aquatic habitats. Early explorers found many beaver in streams and wetlands throughout Arizona. These were profoundly reduced in the mid-1800s. Many watercourses apparently have changed as a result, with loss of more continuously connected wetland areas, increases in flow rate peaks, decreases in flow duration, and increases in both seasonal and area extent of periods of no flow. This has had profound effects on riparian and aquatic plant communities and their associated wildlife.

High intensity fires and those burning larger areas have profound effects on riparian and aquatic systems. Although direct consumption by fire can, in the short term, be locally destructive, the largest impacts result from impacts to the watershed, where ash and silt runoff results in erosive damage to the physical structure of watercourses. Silt and ash smother organisms, change water chemistry, destroy spawning habitat, and create turbidity that disrupts essential behaviors. Erosion resulting from fire impacts to watersheds can cause dramatic down cutting of

watercourses, with all the resulting damage to both aquatic and riparian communities as discussed regarding gullies above.

In summary, every habitat type in Arizona has experienced some alterations due to development or other anthropogenic causes. Every habitat in the state is also home to multiple species and most rely on multiple habitat types. Our understanding of the dependencies between species and habitats is limited for many species. In light of those limitations, the Department recognizes the difficulties associated with mapping essential habitat for every SGCN. However, the Department also realizes that the conservation potential of the landscape does vary around the State and has developed the Species and Habitat Conservation Guide (described below) to model that variation.

MODELING AREAS OF WILDLIFE CONSERVATION POTENTIAL: THE SPECIES AND HABITAT CONSERVATION GUIDE (SHCG)

Determining what factors the Department wanted to include in a model of conservation potential was a monumental task requiring input from numerous experts from every branch of the Department and many external partners. In the end, the Department decided to include five indicators of wildlife conservation value in the model. Each of those indicators, or sub models, was developed as a separate layer that can be used independently of the SHCG model.

1) The importance of the landscape in maintaining biodiversity - represented by the **Species of Greatest Conservation Need**.
2) The economic importance of the landscape to the Department and the community – represented by the **Species of Economic and Recreational Importance (SERI)**.
3) The economic importance of the water bodies and aquatic systems to the Department and the community - represented by **sport fish**.
4) Large areas of relatively intact habitats - represented by **unfragmented areas**.
5) The importance of riparian habitat to wildlife – represented by **riparian habitat**.

It is necessary to point out that each of these submodels and the SHCG represent a temporal "snapshot" of conditions on the ground. The models will continue to be refined as necessary and made available as they are updated.

In addition to these indicators, the Department recognizes that wildlife movement corridors and linkages are critical to maintaining landscape connectivity and also represent crucial habitat. While identifying existing and potential wildlife movement corridors and linkages for a single species in a known area is a difficult task, identifying them to serve the needs of all of the SGCN and the SERI at a statewide scale is a massive undertaking. Nonetheless, the Department is collaborating with our partners in a number of efforts using regional and expert knowledge, as well as GIS-based modeling to identify these crucial areas. Wildlife corridor information will be added to the above models as it becomes available.

Species of Greatest Conservation Need (SGCN)

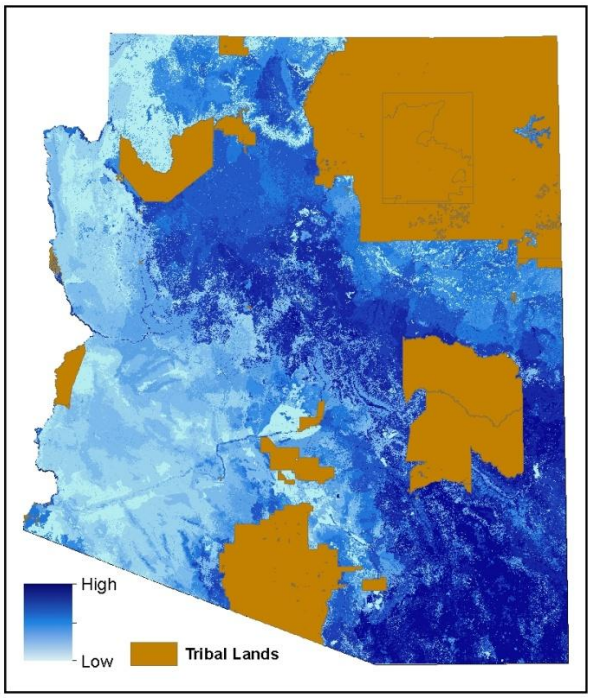


Figure 12. Species of Greatest Conservation Need Richness Index

This category represents a weighted richness index for the SGCN. Once the SGCN list was compiled (see Criteria Used to Define Vulnerability for criteria), distribution models for each of the SGCN were developed (see Distribution Models for the Species of Greatest Conservation Need) for more information). The SGCN richness index was developed by summing the number of Tier 1A and Tier 1B SGCN distributions that occurred in any one pixel. Tier 1C species (unknown status) were not considered in the analysis because of the difficulties associated with creating distribution maps for those species. Tier 1A species include those species that are currently federally listed under ESA as endangered, threatened, or are candidates for listing, including those populations considered essential or nonessential experimental under section 10(j) of the ESA; recently de-listed species that are undergoing post-delisting monitoring; and species of fish, mollusk, amphibian or reptile for which there is no open season in Arizona as identified in Commission Orders 40, 41, 42 or 43. Although not necessarily more vulnerable than the Tier 1B species, the vulnerability of these species and the stressors affecting them are widely recognized and well documented. Therefore these species are given a weight twice that of the Tier 1B species.

Weighting – The SGCN richness model was developed by combining individual species distributions into richness values for Tier 1A and Tier 1B species. Those richness values were weighted according to tier where:

$$\textit{SGCN Score} = (\text{Tier 1A} \times 2) + \text{Tier 1B}$$

The final score for the SGCN were re-scaled from 1-10 and also included in the final score for the SHCG described below.

Species of Economic and Recreational Importance (SERI)

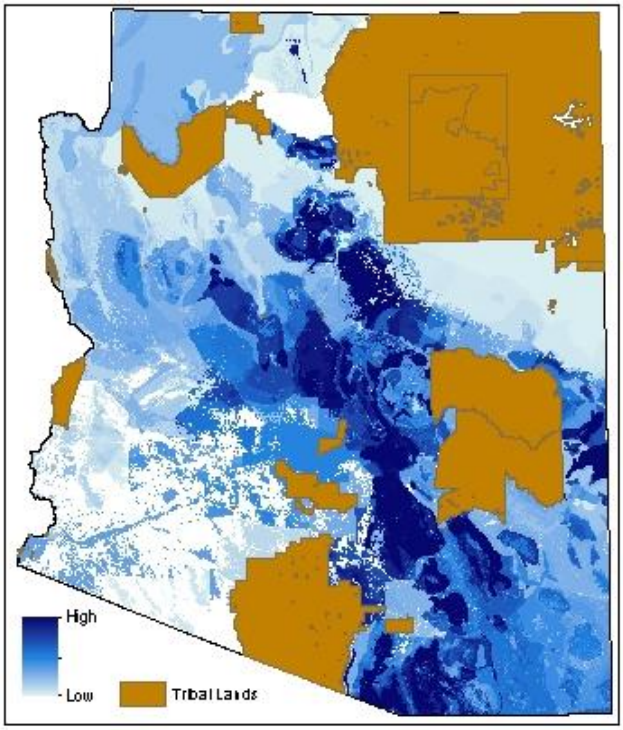


Figure 13. Species of Economic and Recreational Importance model.

This category represents the economic and recreational importance of 13 of Arizona's huntable species. The distribution of these species influences important aspects of wildlife related recreation and the distribution of consumer spending across the state. Together, the economic and recreational importance of game species to hunters, the community, and the Department provide a realistic view of the importance of game habitat for conservation.

Large Game Species**:** The Department considered three aspects in determining the importance value of the large game species (deer, pronghorn antelope, elk, turkey, javelina, and bighorn sheep): *demand* for the game resource, *economic value* of the game resource for communities in Arizona, and the *revenue* generated by the game resource for the Department. Hunt data from 2008 was used for modeling (see AGFD 2008b).

Demand for the game resource provides an indication of how important a particular piece of habitat is to the hunters of Arizona for a given species and is represented by the number of first choice applicants divided by the available number of permits for that species in a game management area. Areas with higher demand are likely to be more important to hunters than areas with lower demand.

Revenue generated by the game resource for communities in Arizona provides an indication of the economic importance of a particular area and is represented by the measured hunter days multiplied by the value of a hunter day in purchases of goods and commodities (e.g., gas, food, motel) (USFWS 2006). Areas with high value are used more frequently and provide a greater contribution to Arizona's economy than do areas with lower values.

License and tag revenue generated by the game resource provides an indication of how critical an area is economically to the Department.

Weighting – Large game species distributions were scored per game management unit based on three factors related to demand, economics, and revenue. The values of those individual scores were re-scaled to a standard scale and added together for a total weight. The weight was assigned

to the species' distribution within each game management unit. The individual species' score represents its economic and recreational value relative to the other SERI species.

Demand = First Choice Applicants ÷ Permits Issued
Economic Value = Daily Expenditure × Hunter Days/mile^2
Revenue = (Tag + License cost) × Permits Issued/mile^2

Small Game Species: The Department considered two aspects in determining the importance value for the small game species (tree squirrel, white-winged dove, band-tailed pigeon, blue grouse, Gambel's quail, scaled quail, and Mearn's quail): demand for the game resource and economic value of the game resource for communities. Demand for the game resource provides an indication of how important a particular piece of habitat is to the hunters of Arizona for a given species and is represented by the number of hunters in that game management unit. Revenue generated by the game resource for communities in Arizona provides an indication of the economic importance of a particular area and is represented by the measured hunter days multiplied by the value of a hunter day in purchases of goods and commodities (e.g., gas, food, motel) (Silberman, 2001). Hunter days and the number of hunters are from the 2007 small game questionnaire and from the 2008 preliminary dove and band-tailed pigeon questionnaire.

Weighting – Small game species distributions were scored per game management unit based on two factors related to demand and economics. The values of those individual scores were re-scaled to a standard scale and added together for a total weight. The weight was assigned to the species' distribution within each game management unit. The individual species' score represents its economic and recreational value relative to the other SERI species.

Demand = Number of Hunters
Economic = Daily Expenditure × Hunter Days/mile^2

Score for each of the 13 SERI were summed to arrive at a total score. That score was re-scaled from 1 – 10 and also included in the final score for the SHCG described below.

Sport Fish

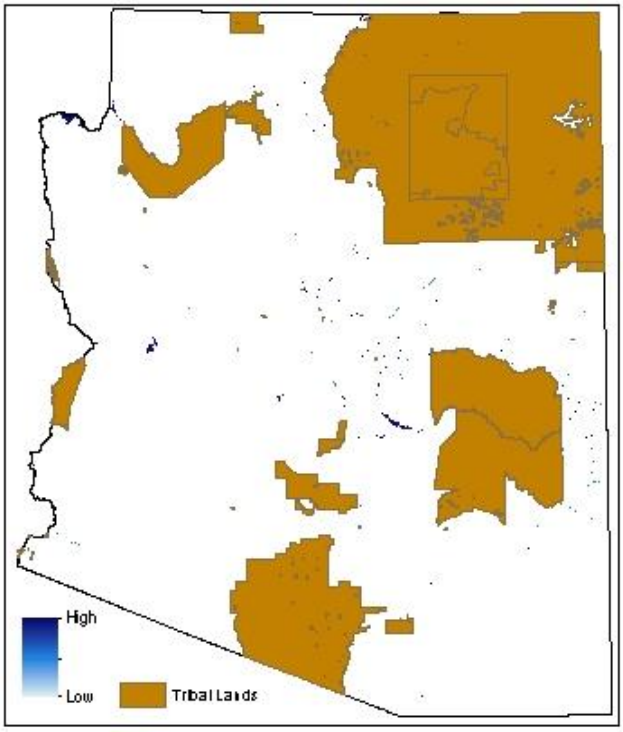


Figure 14. Sport fish model

Sport fishing is a significant contributor to Arizona's outdoor recreation and economy. In 2006, there were approximately 422,000 anglers in Arizona that spent over 4. 1 million days fishing within the State, and created over $802 million in economic value to the State and local communities that year (USFWS 2006). Unlike other species, no effort was made to map the distributions of individual sport fish species. Instead, sport fish were considered as a group based on their collective economic benefit to the Department and Arizona communities and demand as defined by angler use days (AUD).

Weighting – The Department analyzed sport fish populations and their habitats for importance by assigning values 1-3 based on AUDs. The percent AUDs was calculated separately for lotic (e.g. rivers) and lentic (e.g. lakes) systems. Special management waters without AUD data were weighted 1-10 by the Department's Fisheries Branch and added to the sport fish model.

The final scores were also included in the final score for the SHCG described below.

Unfragmented Areas

This category analyzes large swaths of contiguous, unfragmented blocks of habitat. The Department has identified the importance of maintaining unfragmented habitats as a critical component in the conservation of wildlife and wildlife habitat as well as addressing existing and predicted global climate change (i.e., protecting blocks of habitat across an elevational and vegetation gradient). Determining contiguous habitat was based on GIS analyses using all major barriers (i.e., roads, railways, canals, etc.) to delineate areas.

Methodology – Unfragmented blocks of habitats were defined by first mapping barriers to wildlife movement including:

1.) *Major roads:* The source was the Trans123 dataset, derived from the U.S. Census Bureau TIGER/Line® files, downloaded from the AGIC GeoData portal. Roads regional staff had previously identified as incorrectly categorized as a major road were erased.
2.) *Arizona railroads:* The source was the railroads dataset from the National Atlas (http://www.nationalatlas.gov/). These railroads were revised to match the current railroads as shown on the BqAZ framework map.

3.) *Colorado River:* The Colorado River and the Grand Canyon have long been recognized as a geographic barrier to some species (Grinnell 1914, Goldman 1937) and has been hypothesized to be the cause of genetic drift in tree squirrels (Lamb et al. 1997) and mule deer (Travis and Keim 1995). The river was traced from Lake Mead to the Utah border including the outlines of Lake Mead and Lake Powell.
4.) *Canals:* Regions 4, 5, and 6 provided input into which canals are barriers to wildlife movement. These datasets were combined into one layer.
5.) *Developed areas:* Codes 111 and 112 were extracted from the SWReGAP landcover dataset.

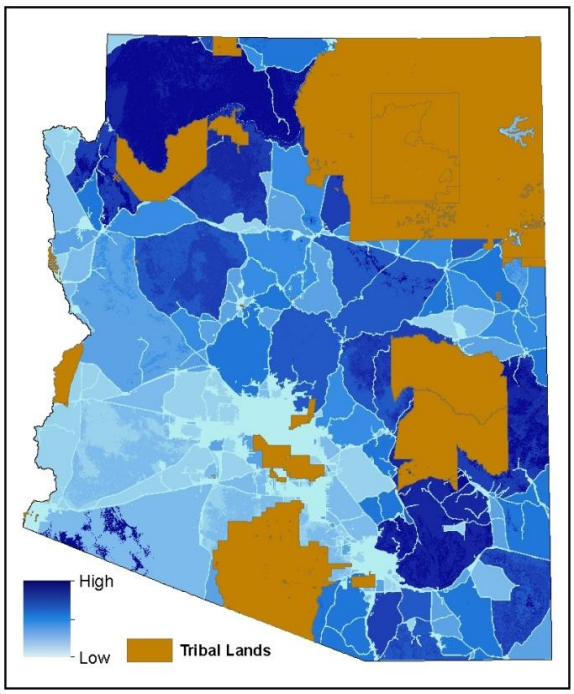


Figure 15. Unfragmented Areas Model

Weighting – Blocks smaller than 2000 acres were excluded from weighting. These represent highly fragmented areas primarily near development. The contiguous blocks resulting from removing the barriers from the state boundary were weighted with two criteria: the diversity of vegetation types within a single block and the percentage of the total vegetation type available in the state contained in the block.

1.) *Vegetation for Weighting***:** The source was the SWReGAP Landcover database modified to include the riparian model and xeric riparian vegetation (See Distribution Models for the Species of Greatest Conservation Need for a full description). The following vegetation classes were considered to have little or no wildlife value and were recoded to NULL to remove them from further analysis:

Value	ReGap Code	ReGap Description
111	N21	Developed, Open Space – Low Intensity
112	N22	Developed, Medium – High Intensity
113	N31	Barren Lands, Non-specific
114	N80	Agriculture
117	D03	Recently mined or Quarried
119	D06	Invasive Perennial Grassland
121	D08	Invasive Annual Grassland
122	D09	Invasive Annual and Biennial Forbland

The following vegetation classes were all considered to represent wet and xeric riparian and were combined into a single class.

Value	ReGap Code	ReGap Description
0	AZ01	North American Warm Desert Wash
80		Riparian
83	S097	North American Warm Desert Riparian Woodland and Shrubland
84	S098	North American Warm Desert Riparian Mesquite Bosque
85		Riparian
110	N11	Open Water
118	D04	Invasive Southwest Riparian Woodland and Shrubland
124		Riparian
125		Wash

2.) *Vegetation Diversity Index***:** We modified the Simpson's dominance index to accommodate vegetation classes rather than individuals. The index was calculated as:

$$\text{VDI} = 1 - \sum_{i=1}^{n} (\text{Area of Vegetation in Block / Area of Block}) \text{ ^ } 2$$

Where *n* is the total number of vegetation classes within the block. This score was applied to the entire block

3.) *Calculate Vegetation Percentage:* The amount of a vegetation class contained within a block relative to the amount of that class available within the state was considered to be important for maintaining larger, contiguous areas of the same vegetation type and adding importance value to small, unique vegetation classes. The percentage was calculated as:

$$\text{VP} = (\text{Area of class in a block / Area of class in the state}) \text{ ^ } 2$$

This score was applied only to the vegetation class within the block for which it was calculated.

4.) *Sum the Indices:* All vegetation percentages were rescaled from 0 to 1 and added to the vegetation diversity index for the block.

Unfragmented areas were included in the final score for the SHCG below.

Riparian

Riparian areas in the southwest are crucial habitats for wildlife sustainability and often serve as wildlife movement corridors within the landscape. Riparian communities and aquatic habitat make up less than 2% of the total land area in the arid western United States, but are considered the most productive and ecologically diverse habitats in Arizona. The role of riparian areas is disproportionate to their size because of their many ecological functions**,** most importantly:

- Providing fish and wildlife habitat – 70% of all threatened and endangered vertebrate species in Arizona depend on riparian areas;
- Increasing water storage and recharge for aquifers;
- Reducing floodwater runoff;
- Filtering and retaining upland sediment;
- Reducing chemical inputs from uplands by immobilizing, storing, and transforming;
- Stabilizing stream banks and building up of new stream banks.

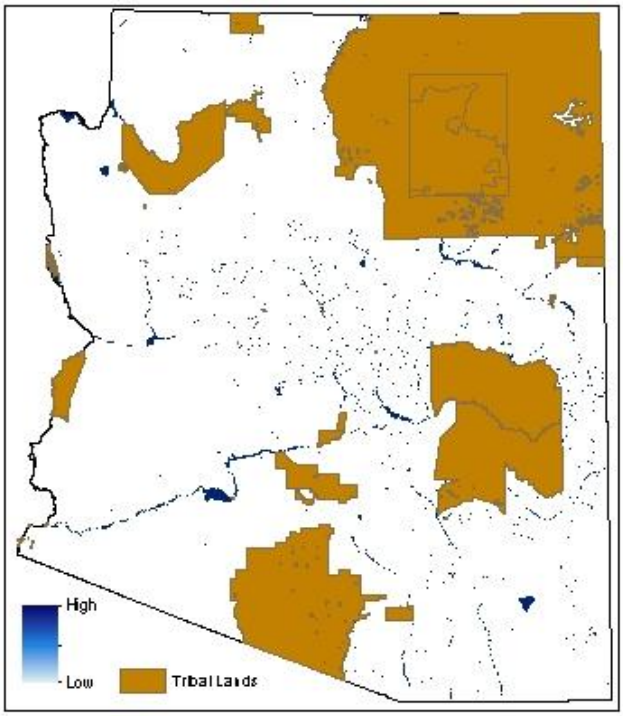


Figure 16. Riparian Model

Methodology - At the time this model was developed, two sources of riparian data were available for Arizona: the Southwest Regional Gap Analysis Project (SWReGAP) landcover database (Lowry et al 2007) and the Department's Riparian Inventory (Valencia 1993). Both were reviewed for accuracy by an internal team familiar with riparian areas throughout the state. The SWReGAP landcover layer was found to under represent riparian in much of the state while misclassifying large areas of mesquite woodlands as riparian. These misclassified pixels were re-assigned to mesquite forest in the original data. The 1993 Department's Riparian Inventory was discovered to be out-of-date and incomplete since riparian vegetation was only mapped along perennial drainages and not intermediate ones.

In an attempt to fill in the blanks left by those datasets, the Department modeled the potential riparian vegetation along lakes and perennial and intermittent streams by calculating cost weighted distance from each stream and lake using slope as the cost surface, essentially mapping the flood plain around each stream and lake. The resulting output was constrained by an upper cost limit and by distance from the stream or lake. The model was combined with the Department's riparian inventory and the SWReGAP riparian categories to create a comprehensive map of potential riparian vegetation. Known areas of development, agriculture or dewatering were erased from the model. In recognizing the importance of riparian vegetation in Arizona, the Department chose methodology that over represents the presence of riparian habitat in Arizona as opposed to methodology that under represents riparian habitat.

Weighting – Riparian areas represent some of the most important areas in Arizona for wildlife conservation and therefore were given a score of 10 and included in the final score for the SHCG described below.

Species and Habitat Conservation Guide (SHCG)

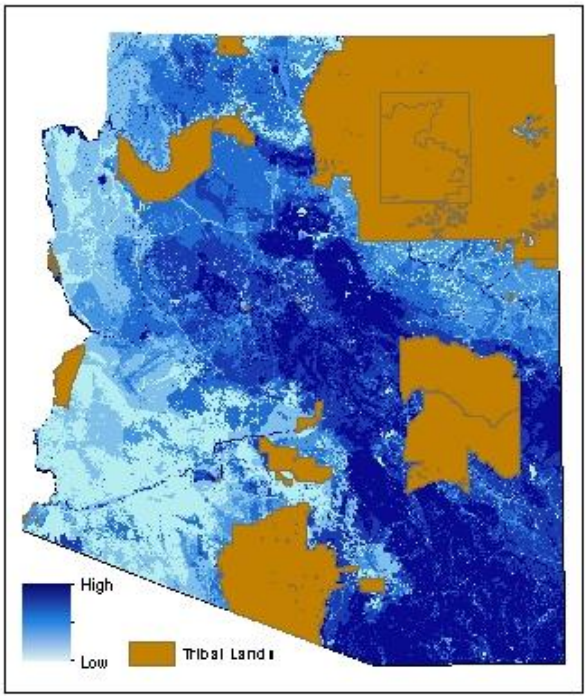


Figure 17. Species and Habitat Conservation Guide

The Department's Species and Habitat Conservation Guide is intended to identify areas of wildlife conservation potential in Arizona at a landscape/statewide scale, ultimately guiding the Department's strategic wildlife goals and objectives. This product represents the current understanding of these areas as of this point in time, and is subject to continual refinement. The status of a wildlife resource can change quickly, and the availability of new data will necessitate the refinement of this assessment.

All layers (SGCN, SERI, Sport fish, Riparian, and Unfragmented Areas) were rescaled from 1-10 and combined per the following equation:

$$SHCG = 3.5 \times (\text{SGCN} + \text{SERI} + \text{Sportfish}) + \text{Riparian} + \text{Unfragmented Areas}$$

The resulting gradient was reclassified to six classes based on quantiles in ArcMAP. These classes identify areas on the landscape based on their wildlife conservation potential where a class of 1 (light blue) indicates the lowest potential and a class of 6 (dark blue) indicates the highest wildlife conservation potential.

STRESSORS TO WILDLIFE

GENERAL DISCUSSION OF WILDLIFE STRESSORS THAT AFFECT WILDLIFE AND WILDLIFE HABITAT

Historical Perspective

Arizona's wildlife and wildlife habitats have been affected by numerous land management actions and human activities throughout the state's history. Even prior to Spanish occupation in the 1500s, the landscapes and ecosystems of Arizona were influenced by human activities. Aboriginal cultures used wildlife resources as forage, they cultivated crops, diverted water, extracted timber, and may have used fire as a hunting tool (Turner et al., 2003). Spanish settlers brought additional agriculture to Arizona, along with horses, sheep, and cattle. However, it wasn't until the 1880s, when railroads linked the Arizona Territory with other states, that Arizona's natural resources were exploited and shipped elsewhere. Over the next few decades mining, agriculture, timber harvest, and livestock production dominated the State's economy (Sheridan 1995). Over time these pioneering industries eventually gave way to emerging service and technological fields, but they still remain integral to Arizona's current economy and operate at varying levels of intensity throughout the State (Arizona Department of Commerce 2007). The impacts from historic high levels of these industries still persist in many of the state's landscapes and recovery of those areas is slow (Cooper 1960, Cooke and Reeves 1976, Turner et al. 2003).

By the early twentieth century, new constituencies began to influence Arizona's economy. With the establishment of national forests, parks, and monuments by the federal government, tourism flourished in Arizona (Sheridan 1995). Over time, regulated hunting and fishing replaced subsistence harvesting of wildlife. Other outdoor recreational pursuits increased as well, especially after World War II, when Arizona's population growth accelerated rapidly, to the current estimate of 6. 4 million residents today (U.S. Census Bureau 2010).

Current Status

The intent of the Department's SWAP is to evaluate the current status of Arizona's wildlife, identify actions that may be taken to address stressors to wildlife and the landscapes they occupy, and develop strategies on how best to make meaningful improvements to benefit SGCN. This effort also addresses the many stressors that occur as a result of natural processes, such as drought, or by human influence over the landscape, such as habitat loss and fragmentation, or border security activities. While many current stressors to wildlife are related to the legacy of the use and stewardship of Arizona's landscapes in years past, the most significant stressors to Arizona's wildlife today stem from the state's explosive rate of human population growth. The Department recognizes that the manner in which a human activity or practice is conducted determines the degree of any negative or positive effects on wildlife and habitat, especially where their activities overlap.

Conservation opportunities are available at this interface of land and resource use, yet as the State agency responsible for wildlife management, the Department only has direct control over land use on lands it owns, comprising less than 1% of the total area of the State (Table 3). These areas include various Commission-designated Wildlife Areas, state fish hatcheries, several shooting ranges, and administrative offices.

Table 3: Land Ownership in Arizona	
	Percentage of State
Bureau of Land Management	16. 69
Bureau of Reclamation	0. 24
National Forests	15. 30
National Parks and Monuments	3. 55
Military	3. 78
National Wildlife Refuges	2. 35
Total Federal Lands	**41. 43%**
Tribal Governments	27. 57
State Trust	12. 73
AZ Game and Fish Department	0. 05
Local or State Parks	0. 22
Private	17. 52
Total	**100%**
Percentages based on Arizona State Land Department Ownership GIS Data, October 2010	

The Federal government is the largest landowner in the State (42%), and excluding tribal lands the Federal government controls about 58% of the remaining lands over which the Department has wildlife management authority. Federal agencies work under a variety of laws and policies in which conservation of wildlife is mandated and are important conservation partners for the Department. Many of the lands within USFS and BLM jurisdiction allow 'multiple-use' activities, including recreational and economic pursuits. And, although most of these lands are under some amount of protection and are unlikely to be subdivided or developed for commercial or residential uses, currently, there are over 1,000,000 acres of BLM lands proposed for solar energy development.

Tribal governments manage about 28% of the land in Arizona. Each Tribe is a sovereign nation, and as such is not subject to state jurisdictions. Many Tribes maintain their own wildlife management departments, and the Department continues to develop working relationships with the individual Tribes to facilitate conservation of wildlife across the habitat types and jurisdictions in Arizona.

Arizona State Lands Department manages nearly 13% of the lands in Arizona. Under State law, these State Trust lands are managed, leased, sold, and traded to provide revenue to support education in Arizona. These lands are primarily leased for commercial purposes or occasionally sold for private development.

Private lands make up about 18% of Arizona's total area with concentrations near river corridors, watersheds, and other locations that are often important resources for wildlife. Because aquatic and riparian habitats are critical to many of Arizona's wildlife, private landowners have a large role in helping to conserve wildlife populations.

Although the Department certainly manages wildlife through its own actions, it is often through partnership and collaboration with other landowners and resource agencies that work gets done on the ground. Beside these entities, the Department actively partners with NGOs, the planning and development community and regional groups such as the Western Governors Association, PARC, the Association of Fish and Wildlife Agencies (AFWA), and many others.

Planning for smart and sustainable growth is critical for the future of Arizona's wildlife. Population growth in the State is among the highest in the nation, second only to Nevada. The population of Arizona grew 24. 6% from 5. 1 to 6. 4 million from 2000 – 2010 (U.S. Census Bureau 2010). Arizona is preparing for an increase in human population by building communities and transportation infrastructure. In particular, the desert urban centers, Phoenix and Tucson, are anticipated to eventually grow together into what is termed a "megapolitan" or "megalopolous" (Morrison Institute for Public Policy 2008), with rural development occurring throughout the rest of the State.

As growth and development continue, more and more habitat will be lost to development as population pressures increase the need for infrastructure. Many of the constructs on which society depends, such as roads, railroads, canals, development areas, and fences, can form barriers to wildlife movement and fragment habitat. Individual species are affected by each barrier differently—some species can cross over lightly-traveled roads or through housing developments. But as these barriers become more severe (interstates, large canals, double-tracked railroads, etc.), they become less permeable to most wildlife and may lead to genetic isolation of populations and/or decreased resilience of populations which become unable to migrate in response to disturbance, and in some cases, form population sinks.

In addition, increasing human populations will bring increased recreational pressures to the State. Arizona's mild winter climate and open spaces favor outdoor recreation and draw people from all over the world. As a result, many of these activities may require creative and proactive management to balance effects on wildlife and natural habitats while ensuring quality outdoor recreation opportunities for Arizona's citizens. Changes in land status on state and federal lands and access restrictions onto, and across, private lands also add to the challenges of: sustaining viable populations of wildlife; conserving natural habitats; and accommodating increased outdoor recreation, economic prosperity, and urban/rural growth across Arizona. Compounding this situation is the demographic trend of Arizona's residents shifting from primarily rural populations that are often more aware of local environmental issues, to an urbanized population that is often less informed about the needs of wildlife and wildlife habitat.

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 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 reduced pitch production in trees. These conditions allow insects to bore into, 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). 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 unusual stand and fuel conditions, making forest and woodland habitat types increasingly susceptible to stand-replacing catastrophic wildfires. The overall impact converts late-successional mixed conifer forests to early-successional grasslands, shrublands, and recovering forests. 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).

Many of the factors discussed below coincide geographically. Given the synergistic effects of multiple factors, it is difficult to understand the overall impact these factors will have on Arizona landscapes, habitats, or SGCN. In addition, it is difficult to predict which habitats may have higher risk of being altered by multiple factors. Development of the HabiMap™ Arizona, allows the Department and its partners to see the relationships among stressors on the ground and species affected by those stressors, and begin to analyze the cumulative effects of multiple stressors on those species.

Figure 18 shows how such an analysis can be completed using HabiMap™ Arizona. Panel A of figure 18 shows the modeled distribution of the relative stress of unnatural fire regimes on the landscape. As in all of the stressor models, red indicates a high relative stress while blue indicates less stress. Panel B displays the overlay of unnatural fire regime with the stress of insect infestations. Panel C shows the same layers but zoomed into the area of interest, which in this example is, the Santa Catalina Mountains near Tucson, Arizona. Panel D shows the results of querying the SGCN in the area of interest. Currently, queries are accomplished by drawing in an area of interest and returning the list of SGCN that potentially occur in the area. In the future, users will also be able to query for other species and/or stressors.

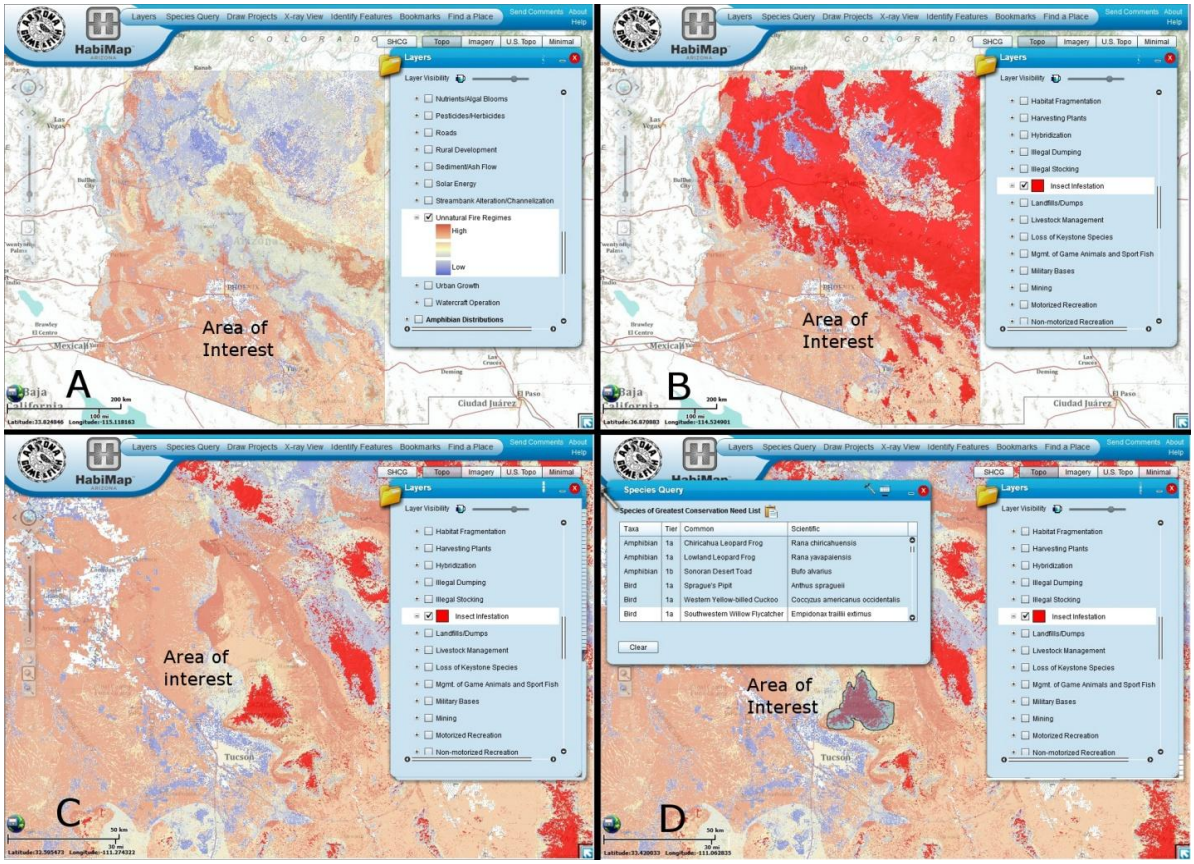


Figure 18. Stressor Analysis in HabiMap

DEVELOPMENT OF THE STRESSORS TO WILDLIFE AND WILDLIFE HABITAT MODELS

Important stressors to Arizona's wildlife and wildlife habitats were identified as part of the initial development of the 2005 CWCS, most of which followed stressor categories adopted from Salafsky et al. (2003). A complex threat assessment was performed in 2004, involving representatives from State and federal land management agencies, natural resource regulatory authorities and Native American tribes. At that time, 85 individual stressors were assessed for the magnitude and urgency of their impacts on Arizona's wildlife and wildlife habitats. Of those 85 stressors, 70 were considered to have a high level of urgency and/or magnitude in one or more vegetation types (See CWCS appendix O). Development of the stressors for the 2005 CWCS was completed at a coarse landscape scale using Brown and Lowe (1974) vegetation classes as the basis for mapping the distribution of the stressor. While the mapping for the previous assessment was an important first step, the coarseness of the data has limited the Department's ability to perform meaningful risk and cumulative effects analyses. It was recognized that a finer-scale analysis was needed in order to fulfill the intent of the Department's planning effort, which is to evaluate landscapes as they exist today and develop strategies on how best to take meaningful conservation actions that will benefit SGCN. By creating geospatial datasets that show the potential distribution of each specific stressor, as opposed to assigning each stressor to

coarse-scale vegetation classes, the Department was able to refine our understanding of where stressors occur and how they interact with each other and the SGCN (see Figure 4 and Figure 18 for examples).

To accomplish this, the Department formed a team to create spatially explicit models of stressor distributions across the landscape. The team developed a conceptual model of where each stressor occurred and its relative magnitude across the landscape. The best available data were used. Where there were no data, the Department relied on expert advice and the data need was noted. Thus, the stressor distribution models should be considered a first approximation of where stressors occur. Also, the Department is fully aware of the dynamic nature of Arizona's landscapes, and each of these models is a snapshot in time. The Department is committed to refining the models as better information becomes available and to reflect ongoing changes to the landscape. To that end, under each stressor, below, we discuss the methods by which each particular stressor was modeled, thus providing the information necessary for our partners to contribute data or methods that could potentially improve the models. Finally, although the magnitude and urgency of any one stressor depends on the species under consideration and its location on the landscape, we made a coarse effort to depict the relative strength of the stressor, and ranked them as high, medium, and minor, in terms of our current understanding of their *individual levels* of "importance" to wildlife and habitat in Arizona. However, as discussed above, stressors might affect wildlife communities and their habitats individually, additively or synergistically such that stressors that are categorized as "minor" might be exceedingly important when coupled with one or more additional stressors.

During this process, the Department realized that some stressors, although analyzed separately in the original stressor assessment, occur in the same places on the landscape. Those stressors were subsequently combined into a single distribution. Nine stressors are treated as ubiquitous, i.e., as occurring throughout the state or nearly so. Those stressors were either too difficult to map at this time, or are considered to occur uniformly throughout the state and, therefore, were not mapped. A description of the effects of those stressors and the existing state of knowledge for each are included below. The effects of some stressors are actually produced by a combination of other stressors, and therefore were not modeled separately; their effects are noted under the other model descriptions. For example, light pollution is caused by many things such as border activities, roads for motorized vehicles, urban growth, etc., and its effects are considered under those other stressors. To be consistent with the species distributions and other models, a 30 meter pixel was selected as the mapping unit.

Finally, it is important to emphasize that almost any activity or process can act as a stressor to wildlife, depending on context. Many of the stressors discussed below are, in the proper context, neutral or even beneficial to wildlife. Therefore, one should not interpret each stressor completely negatively. For example, fire can be a stressor to wildlife and is included below under "unnatural fire regimes." However, fire is a critically important tool for wildlife and land management when used correctly, and under certain circumstances naturally occurring wildfires are beneficial. In both cases, individual plants and animals might be stressed, injured, or even die as a result of a fire, but the population benefits typically outweigh the individual losses. The effects of unnatural fire regimes, however, typically result in catastrophic population losses and often result in changes to the entire biological community.

A brief description of the effects of each stressor and methods used to map it (model) follow. Please note that each stressor is mapped individually and independent of the other stressors. Weighting schemes are only meant to describe the relative strength of a single stressor across the landscape and not to be used to compare among stressors. For ease of organization, stressors are listed alphabetically within the high, medium and minor categories.

HIGH IMPORTANCE

Altered Surface Hydrology

In Arizona, many aquatic and riparian habitats have been altered, degraded, fragmented or completely lost as a result of groundwater pumping, dams, channelization projects and water diversions. Agricultural and urban areas increasingly depend on wells, water diversion structures and reservoirs to meet their water needs. Use of these tools alters ecosystem hydrology by diverting water out of natural channels, changing the natural variability of stream flow quantity, timing, and frequency across both time and space (hourly, daily, monthly, seasonally or yearly and at a site-specific, local or regional basis). Variability within these historic patterns is critical to maintaining long-term river and riparian health. Quantity and timing of stream flow directly impact other important aspects of riverine systems such as physical habitat structure, energy dissipation, sediment transport, temperature and water quality which, ultimately, results in affects to plant and animal species habitats and survival. Surface flow regimes might experience severe alterations from upstream dams, reservoirs, and impoundments, which are often cited as the most serious and continuing stressor to the ecological sustainability of rivers (Bunn and Arthington 2002). Altered flows (quantity, quality or timing) change the physical parameters of rivers and streams and often facilitate invasion of nonnative aquatic or riparian species of plants and animals or impact native riparian species richness and cover (Jansson et al. 2000; Brock 1994). The mere presence of a dam may have less influence on subsequent flood regimes than how the dam is operated per its operational guidelines. Reduced scouring frequency may allow increased sedimentation and accumulation of salts in the floodplain terrace soils, reducing riparian habitat health, growth and re-generation necessary for viability of SGCN and other species. Nutrient cycling and other parameters such as temperature, dissolved oxygen and pH, within reservoirs alter water quality downstream, and downstream aquatic and riparian communities can be significantly affected. Unnaturally large pulsed flow events discharged from reservoirs may cause severe scouring of channels and floodplains, causing direct mortality of plant and animal community elements, and sometimes resetting the successional scheme over vast extents of river and stream channels (Friedman et al. 1998, Johnson 1998, Stevens et al. 2001).

Loss of the natural hydrograph due to upstream regulation also affects floodplain processes such as leaching of salts; deposition of sediments and nutrients; rearrangement of structures and zones along rivers; and establishment of seedbeds for riparian plants (Stevens et al. 1995). Reservoirs act as sediment traps and disrupt or alter the sediment budgets of downstream reaches (Leopold et al. 1964; Stevens et al. 2001). Decreases in sediment inputs alter natural channel dynamics of mesohabitat creation and maintenance (Williams and Wolman, 1984; Petts 1979). Dams also fragment species ranges, preventing upstream and downstream movement of fishes and other aquatic species and affecting riparian plant dispersal.

Model: The upstream effect of altered surface hydrology was mapped by extracting the footprints of the reservoirs behind dams, using an existing data layer representing lake footprints statewide. Dam locations were identified by combining datasets from the National Inventory of Dams and the Arizona Department of Water Resources. The data were checked to make sure that only dams on a watercourse were included and reservoirs were added as necessary, using topographic maps as background. Downstream stressors were modeled by assessing the impact of the drainage area from the dam. The downstream stressor from dams and reservoirs was based upon the impact on the size of the drainage to the dam. If the drainage area above the dam was greater than 50 square miles, the stressor was assumed to continue from the dam to the Colorado River delta (at the U.S. /México border). If the drainage area to the dam was less than 50 square miles, the stressor continued downstream to the first confluence with another watercourse. The existing azhydro shapefile was used to map the extent of downstream stressors. Perennial, intermittent, and ephemeral watercourses were included. The use of stock tanks for agricultural use is recognized as a potential stressor, but a comprehensive dataset does not exist, so it was not included in the final model. Also, most diversions on all streams have likely been missed because there is not an accurate GIS layer available that depicts operational and certificated surface water right diversions, including volume of the diversion or its return flows.

Border Effects

Arizona shares over 350 miles of border with Mexico. Many wildlife populations have annual migrations or movement patterns that cross these borderlands. The Department works closely with Mexican authorities and other partners through various committees, teams, and workgroups to ensure the continued conservation of many borderland species. However, the volume of illegal immigration, drug smuggling, and law enforcement activity along the border has increased dramatically in recent years resulting in increased impact to habitats. Border security measures are being stepped up throughout the Arizona/Mexico borderlands region to address this increased border traffic (Roberts et al. 2010). The effects of associated road and barrier construction, along with enforcement patrols and pursuits in the borderlands region include: habitat loss and fragmentation, less usable habitat for wildlife populations, and increased road kill. Stressors associated with illegal immigration traffic include but aren't limited to: dispersed camping, altered fire regimes, decreased water quality from pollutants, unauthorized roads and trails, illegal dumping and littering, increased poaching, illegal collecting of wildlife, and general habitat destruction (Forman et al. 2003). In addition, the dense human population of Mexican residents along the shared border with Arizona increases the threat of disease to wildlife in this state. Pet or feral dogs and cats may transmit rabies, distemper, or other diseases to SGCN and other species, and livestock may transmit diseases to native ungulates, particularly bighorn sheep. Activities associated with expansion of urban centers, trade, commerce, and transportation as a result of the North American Free Trade Agreement (NAFTA) increase air, soil, and water pollution.

Model: The various border effects are assumed to occur in roughly the same areas and overlap with each other. Effects are most intense along the Arizona/México border and along major roads, and decrease with distance away from the border. We used expert opinion to determine how far from the border these impacts are occurring and created a linear gradient of intensity decreasing with distance from the border and falling to "0" or no effect north of I-10 and I-8. Also included was an area along the Colorado River to the Imperial National Wildlife Refuge.

Climate Change
This stressor can cause wildlife effects statewide in all habitats depending on habitat and species vulnerability and the spatial variability inherent in climate. However, information on the magnitude and spatial distribution of those effects is only now being explored. Nonetheless, the Department is currently engaged in a number of efforts to address the information needs associated with and the effects of climate change. See Climate Change for a full discussion of the impacts of climate change and how the Department is engaged in efforts to address those impacts.

Model: Ubiquitous. Due to its complexity, the decision was made not to model climate change until more information is available.

Disease/Pathogens/Parasites
This stressor is complex and can come from many different sources. It includes introduced pathogens and exotic parasites that affect native or game species and/or humans. Examples include West Nile Virus, Chronic Wasting Disease, diseases causing bighorn sheep die-offs such as pneumonia (*Pasteurella* spp. and *M. ovipeumoniae*), whirling disease (*Myxobolus cerebralis*), rabies, white-nose syndrome (*G. destructans*), hantavirus, ranaviruses (including *Ambystoma tigrinum* virus), amphibian chytrid fungus, various avian diseases (e.g. trichomoniasis in doves), plague, and foreign animal diseases. The stressor includes spreading respiratory disease to desert tortoises from adopted tortoises, threats to fish from hatcheries (state, federal and private), aquaculture threats, and domestic wolves as a disease threat to wild wolves.

The growing wildland-urban interface increases the possibility of wildlife exposure to potentially-infected domestic and feral pets and may contribute to the spread of these diseases. Whirling disease in salmonids has led Arizona to adopt a "no tolerance" policy that bans the stocking or importation of fish infected with whirling disease, although the potential for accidental introduction still exists. Native frog populations have been decimated by the introduction of the fungal disease, chytridiomycosis (Bd), whose ultimate origin still remains unknown. Introduced species such as bullfrogs, African clawed frogs, and barred tiger salamanders (introduced for the bait trade) are known to harbor Bd, yet they experience few symptoms of the disease (Bradley et al. 2002).

Model: Ubiquitous. This stressor is complex and can come from many different sources. It includes introduced pathogens and exotic parasites that affect native or game species and/or humans. Lack of comprehensive spatial data for the spread of disease complicates modeling this stressor. Thus, this stressor is treated as a statewide issue and not mapped.

Drought
Periodic drought (an extended period of abnormally dry weather) is a normal component of the climate system in the Southwest (Clark and Cobb 2003). However, it can still affect wildlife and wildlife habitat through various means: it places additional stress on species for limited water resources (Sprigg et al. 2000), increases susceptibility of forests to insect outbreaks and pathogens (Dale et al. 2001); favors the spread of unwanted introduced species (Allen and Breshears 1998); alters ecosystem function (Franklin et al. 1992, Dale et al. 2001); and increases

the possibility of large-scale wildfires (Sprigg et al. 2000). Drought 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 thereby altering the distribution and vigor of some plant communities (Griffin 1977, Pigott and Pigott 1993, Klopatek et al. 1997). In the future, the effects of recurrent drought may be further exacerbated by climate change (see Climate Change).

Model: Ubiquitous. This stressor is statewide, in all habitats and was not modeled.

Grazing by Ungulates

The following text is taken largely from Heffelfinger et al. (2006). Large herds of grazers have been absent from the deserts of the Southwest since the mass extinctions at end of the Pleistocene Epoch about 10,000 years ago (Martin and Klein 1984). Most wild grazing ungulates expanded throughout the Southwest only after the disappearance of these large grazers.

The first livestock (cattle, sheep, and horses) were brought into the American Southwest by the Spanish in the mid-1500s (Holechek et al. 1998). Many of those livestock escaped and proliferated in feral herds throughout New Mexico, Arizona, Texas, and northern México. As human settlement progressed, the numbers of domestic livestock increased on most available rangelands by the late 1800s. By the time a multiyear drought hit the Southwest in the 1890s it was obvious the arid southwestern ranges could not be stocked as heavily as more mesic grasslands to the east and north (Bahre 1991). The chronic overuse of vegetation by an inappropriately high number of livestock set in motion landscape-scale changes to southwestern rangelands. In more recent years (1980–1994) the number of cattle decreased by 9% in the U.S., but increased (11%) in México (Holechek et al. 1998). During that same period, the number of sheep decreased by 24% in the U.S. and 9% in México.

There is much confusion about the interchangeability of terms such as grazing, over-grazing, and overuse. A discussion of the effects of livestock on vegetation must be based on a consistent use of terminology. "Grazing" is neither good nor bad, it is simply consumption of available forage by an herbivore. Grazing the annual production of herbage at inappropriately high intensities is termed "overuse". "Overgrazing" describes a condition where the range is chronically overused for a multi-year period resulting in degeneration in plant species composition and soil quality (Severson and Urness 1994). There are different levels of overgrazing; range can be slightly overgrazed or severely overgrazed (Severson and Medina 1983).

Grazing, either by livestock, wild ungulates, or feral equines has the potential to change both food and cover. Although precipitation is the most important factor affecting ungulate nutrition and young survival, habitat conditions as influenced by ungulate density determines how much of that nutrition and cover remains available to wildlife. Livestock grazing can cause both short- and long-term changes to habitat (Peek and Krausman 1996, Bleich et al. 2005). Grazing at light to moderate levels has little influence on most wildlife, but overuse in arid environments removes much of the herbaceous cover that is crucial for nutrition and cover (Loft et al. 1987, Galindo-Leal et al. 1994). Long-term changes resulting from overgrazing include undesirable changes in the plant community, decreased mulch cover, decreased water infiltration, compacted soil, increased water runoff, decreased plant vigor and production, and a drier microclimate at

ground level (Severson and Medina 1983). Overgrazing also removes browse leaves and twigs, further exacerbating poor nutritional conditions created by removal of forbs (Hanson and McCulloch 1955). Livestock sometimes browse important shrubs excessively (Swank 1958, Knipe 1977). Jones (2000) reviewed the literature from arid rangelands in western North America and found that overuse and overgrazing had significant detrimental effects on 11 of 16 variables measured (mostly soil and vegetation characteristics). Decades of experience and, more recently, research has shown that general rules and range management practices from more mesic ranges cannot be applied successfully to southwestern rangelands. The range manager's axiom of "take half and leave half" is excessive for arid desert ranges (Holechek et al. 1999, Lyons and Wright 2003). Reducing the intensity of grazing generally results in improvements in range condition, but there is a misconception that removing cattle will always result in the range recovering to a climax state or pristine condition (Pieper 1994, Briske et al. 2003). In reality, southwestern rangeland is not resilient to overgrazing. Long-term deferments from grazing in arid and semiarid regions may not result in any significant improvement in range condition (Laycock 1991, Laycock 1994, Holechek et al. 1998), or improvements may take 40–50 years (Valone et al. 2002, Guo 2004). Although overgrazing has influenced the arid southwestern U.S. more than other rangeland types (Pieper 1994), grazing is sustainable in this region if stocking rates are at appropriate levels and season of use is considered (Holechek et al. 1999).

Model: This stressor can occur anywhere that elk, buffalo or domestic cattle graze and includes all grazing allotments, private parcels inside allotment boundaries and elk range outside of allotments. Only elk range outside allotment boundaries was included because cattle preference calculations on allotments compensates for elk use. Private parcels were included based on the assumption that these lands are also grazed. Information available to the team indicated that grazing by other ungulates (e.g. deer, pronghorn) does not rise to the level of a stressor. Buffalo ranges are not included, because data collected has shown that buffalo grazing on buffalo ranges is negligible.

Although the Department recognizes the value of different management practices by different agencies, we chose not to include those differences in this model due to lack of rigorous data. However, the difference in impacts resulting from different climatic regimes and the presence of sensitive landscape elements such as riparian areas was recognized and used to weight the data accordingly. The PRISM (Parameter-elevation Regressions on Independent Slopes Model) group's 1971 – 2000 average precipitation data (see http://www.prism.oregonstate.edu/) were used to weight the grazing allotments by the inverse of precipitation. In other words, the lower the precipitation, the higher the weight of this stressor. In addition, the impact to riparian areas was weighted twice that of upland areas.

Note: Due to lack of data, the impact to wet meadows could not be modeled but is recognized by the Department.

Groundwater Depletion and Springhead Use

Groundwater levels in Arizona have dropped considerably due to pumping for agricultural and urban needs. The loss of surface water habitat resulting from the historic water withdrawal and dewatering necessary to support anthropocentric water uses, exacerbated by drought conditions, has, and likely will continue to affect aquatic, riparian and wetland habitats in Arizona. Lowered

water tables affect all of Arizona's habitats, but can have considerable affects on small cienegas, springs, seeps, marshes, alluvial valley riparian areas and their associated SGCN. Spring "improvement," that is, capturing spring output in collection structures and either exporting the water or making it available to human determined uses, has significantly affected a large proportion of the springs around Arizona. Cienegas and other marshland habitats decreased greatly in Arizona in the preceding century (Hendrickson and Minckley 1984). Loss of these habitats as a result of groundwater depletion limits the extent of the wetted zone in the cienega or around the spring, the associated riparian plant community, and the associated fish and wildlife community. Wildlife could be affected either through diminishing surface water availability or degradation of habitat due to the effect of the lowering water table on hydrophytes and phreatophytes. These effects to vegetation become more pronounced during the summer growing season and following cessation of spring run-off. The disappearance of surface water in perennial or intermittent stream channels is assumed to result in the immediate and total loss of fish populations.

Model: After numerous discussions, the Department recognized its lack of expertise necessary to model the dependence of surface water on underlying ground water. As a result, the Department decided to use the simplest model possible and assume that all surface water is dependent to a certain extent on ground water saturated alluvial aquifers. Therefore all streams, springs and washes could be affected by ground water pumping. The influence of diminishing surface water in perennial and intermittent streams and springs was assumed to affect wildlife up to three miles away since this is the distance large ungulates have been shown to travel to water. The effect of ground water pumping on xeric-riparian washes was assumed to affect wildlife up to a distance of one mile.

The model was built by placing a point every 30 meters along perennial and intermittent streams. That point layer was merged with the springs layer and a kernel density was run with a search radius of 4828 m (approximately 3 miles). The same procedure was done for large desert washes with a search radius of 1609 m (approximately 1 mile). The two resulting layers were combined by normalizing each to 0 – 1, adding them together and dividing by 2.

Note: At the time of this writing, TNC has completed an analysis of Arizona's ground water (Marshall et al. 2010). The Department is currently partnering with TNC to update this stressor.

Illegal Stocking

Aquatic systems and riparian species in Arizona are negatively affected by nonnative invasive species which have been released into the environment intentionally. Effects to SGCN species can include the direct and indirect effects of predation, competition for resources, hybridization, and introduction of parasites and disease. For example, crayfish were introduced through recreational fishing activities and now threaten the persistence of many species of aquatic wildlife (Fernandez and Rosen 1996, Hensley et al. 2010). Illegal stocking of nonnative fish or bullfrogs can have pronounced impacts on native aquatic species. Also, release of nonnative tiger salamanders for use in the bait trade threatens native salamander populations, and tiger salamanders can carry diseases to other amphibian species.

Model: This stressor is mapped as occurring in all of Arizona's intermittent streams, perennial streams, lakes, and reservoirs—these areas were given a background score of 1. However, the Department recognizes that illegal stockings are more likely to occur near urban areas where recreational and aquarium hobby release pressures are high, and created an inverse distance weighted gradient of 15 miles around all cities and towns. The gradient around urban areas was rescaled between 0 and 1. Known illegal stocking locations, identified by regional personnel, were given a score of 2. All weights were considered additive such that the highest level of stressor occurs in waterbodies that are nearest to urban areas and are known to be illegally stocked.

Insect Infestations

Phytophagous (plant-eating) insect outbreaks cause tree mortality and reduced growth in Arizona's forests and woodlands (Negrón et al. 2009). 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 Arizona 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). 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). 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 (USFS 2003, 2004, 2005). 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).

Model: This stressor occurs in coniferous forests, including pinyon-juniper woodlands, primarily due to the impacts of bark beetles and other conifer-damaging insects which have the potential to

have significant ecosystem-wide impacts. This stressor can occur in the following SWReGAP vegetation classes:

- Colorado Plateau Pinyon-Juniper Woodland
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Juniper Savanna
- Madrean Juniper Savanna
- Madrean Pine-Oak Forest and Woodland
- Madrean Upper Montane Conifer-Oak Forest and Woodland
- Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Ponderosa Pine Woodland
- Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
- Southern Rocky Mountain Pinyon-Juniper Woodland

Invasive Animal Species

Invasive animal species in Arizona have a variety of impacts on native biodiversity, and can affect native species through competition, predation, introduction of disease and parasites, hybridization, etc. (Tellman 2002). In particular, invasive aquatic species, including but not limited to quagga mussels, crayfish, bullfrogs and some nonnative fishes, can have considerable effects on all native aquatic wildlife in Arizona. The impacts resulting from quagga mussels on native aquatic wildlife are yet to be understood, but might be catastrophic. Crayfish have been implicated in losses and in the decline of native gartersnake species, Sonoran mud turtles, and are suspected to have caused declines in native mollusks and fishes (Fernandez and Rosen 1996, Holycross et al. 2006, Hensley et al. 2010). Fernandez and Rosen (1996) also reported wholesale alteration of a stream community in the White Mountains, including plants, invertebrates and vertebrates. American bullfrogs directly affect wildlife populations through predation, including but not limited to Sonoran tiger salamanders, Arizona treefrogs, native ranid frogs, Sonoran mud turtles and Mexican gartersnakes (Rosen and Schwalbe 1996, 2002, Jones and Timmons 2011, Akins and Jones 2010,) and possibly through competition with native ranid frogs (Kiesecker et al. 2001, Pearl et al. 2005). Bullfrogs also carry the fungal disease chytridiomycosis, the effects of which can be devastating to Arizona's native anurans (Bradley et al. 2002, Sredl et al. 2002). In terrestrial habitats near urban areas and other areas modified by human activities, starlings can displace native birds, particularly cavity nesters (Kerpetz 1986). Nonnative bees are also replacing native pollinators and potentially impacting native plant communities (Schaffer et al. 1983).

Model: Ubiquitous. After much discussion, the Department decided that the most significant threats to wildlife were from crayfish, bullfrogs, and quagga mussels. There is not a complete database of where these threats occur, and in fact, these species threaten all waters at some level, even stock tanks which are so numerous that they cannot be mapped. Therefore, this stressor is treated as ubiquitous for now and mapped statewide.

Note: The Arizona Invasive Species Advisory Council (AISAC) may be developing a database (iMapInvasives) for terrestrial and aquatic species that can give future direction to better map this stressor. However, the Department's Aquatic Invasive Species Program Team is currently addressing various invasive species issues through development of State Risk Assessments and future Director's Orders.

Invasive Plant Species

Invasive plant species can include but are not limited to several exotic grasses (including bufflegrass, red brome, cheat grass, fountain grass, etc.), Sahara mustard, *Oncosiphon piluliferum*, sweet resin bush, Russian thistle, tamarisk, giant salvinia, hydrilla, Eurasian watermilfoil, etc. These and other invasive species can cause serious ecological impacts on plant and animal communities, vegetation structure, etc. (Van Devender et al. 1997, Crawford et al. 2001, Wilson et al. 2002, Landrum et al. 2005, Trader et al. 2006). Attributes that contribute to their "invasiveness" include altered phenology, prolific seed production, seed dormancy, resistance to or dependency on fire, and moderate to high rates of dispersal and establishment. These species are usually widely distributed both among and within ecosystems/communities (Northam et al. 2005, Bowers et al. 2006, Trader et al. 2006).

Model: Ubiquitous. The team searched for the most current data on nuisance plants. Northam et al. (2005) identified 19 species as the highest threats to Arizona. However this study did not provide data on where those species occur. Another study (Thomas and Guertin 2007) provided a database of known records of invasive species. The team reviewed these data and realized that the distributions were highly biased by where sampling occurred (along roads) and did not accurately represent where the threats occur. The invasive Species Council is currently working on assembling more comprehensive data. Until those data become available, this stressor is treated as statewide.

Note: The Arizona Invasive Species Advisory Council (AISAC) may be working on assembling more comprehensive data through iMapInvasive, but until those data become available, this stressor is treated as statewide. In addition, the Department's Aquatic Invasive Species Program Team is currently addressing various invasive species issues through development of State Risk Assessments and future Director's Orders.

Management for Game Animals and Sport fish

Game animals and sport fish are actively managed through fish hatchery and stocking programs, upland, riparian and wetland habitat restoration, development of wildlife water sources, and regulation of hunting, angling and collection activities. Game animals and fishes typically managed through mechanisms of this type include, but are not limited to, pronghorn, bighorn sheep, mule deer, waterfowl, rainbow and Apache trout, largemouth bass, etc. Management techniques and practices are applied to promote persistence of recreationally important species that can displace, compete or hybridize with, or prey on native species. Management actions and practices can also influence species assemblages and populations through additional habitat modifications. While the Department recognizes that some management activities may negatively influence some native species, most activities are benign or even beneficial to many species.

The Department evaluated various game and sport fish species distributions, management related activities and interspecific relations to determine where the effects of game and sport fish management may exist and have the potential to stress wildlife populations. The following species-specific discussions provide rationale supporting this evaluation.

Abert's squirrels: In the 1940s, Abert's squirrels were introduced into the Pinaleño, Catalina, Pinal, Bradshaw, Granite and Hualapai mountains, Mingus Mountain and onto the Hualapai Indian Reservation. Abert's squirrels might compete with Mt. Graham red squirrels in the Pinaleños, and possibly with Arizona gray squirrels in the Catalina and Rincon mountains.

Elk: High elk populations can create stress and competition in winter ranges and in transitional areas between winter and summer ranges for pronghorn and mule deer. Elk can compete with other ungulates for the same browse, and forbs in these areas. The Department uses forage monitoring protocols to inform management of elk populations and balance the needs of elk with forage production.

Fish and Native Aquatic Wildlife: Arizona's native fish and other native aquatic wildlife are threatened by the presence of nonnative fish, including sport fish, in sites where their presence is incompatible with management goals, in areas that are managed principally for native aquatic wildlife, or where they occur problematically with native fish.

Ring-necked Pheasant: Pheasants are an exotic species in Arizona, but are not considered a threat to native wildlife. The reasons for this are that this particular exotic species mainly exists in managed agricultural fields and has not shown the ability or propensity to survive or persist in wild upland areas given its susceptibility to predation and comparatively harsh weather and range conditions.

Chukar: Chukar present in Arizona are introduced and occur mostly in habitat types dominated by cheatgrass that primarily occur in areas on the Arizona Strip, north of the Grand Canyon. The Department actively manages these game birds through annual hunting seasons. Chukars occur in other portions of Arizona in significantly lower numbers/distribution, with corresponding hunter harvest being very low statewide. There is no evidence that chukar negatively impact or compete with native upland game birds in Arizona, therefore the Department has not modeled chukars as a threat.

Rio Grande Turkey: Absent any relocation or migration of this species into historical ranges of the native Merriam's or Gould's turkey, the introduction of this species into Arizona is not expected to threaten other species through competition or through any associated habitat impact or alteration.

Model: The game and sport fish management stressor was modeled using the distribution of Mt. Graham red squirrel (Pinaleño Mountains), Arizona gray squirrel (Catalina and Rincon Mountains), statewide sport fish distributions (all perennial and intermittent waters that have not been renovated or managed specifically for native fish), and areas where elk distributions overlap winter range for pronghorn and mule deer.

Motorized Recreation Off-Road

Recreational off-road vehicle use can be found across the entire state. All Terrain Vehicle (ATV) and Off Highway Vehicle (OHV) use in the state is predominantly comprised of independent constituent riders operating on roads and trails in established riding areas and/or on designated roads and trails established within Arizona's public lands (various land management agencies). The growth of ATV/OHV ownership and use in Arizona has also resulted in the gradual expansion and use of "maverick" trails and roads in some parts of the state. The popularity of this recreational activity is reflected through the establishment of a number of large organized events which are held annually that can have substantial club and structured group rides occurring statewide.

The specific effects of ATV/OHV use on Arizona habitats are not completely inventoried or understood, as impact and damage assessment information and processes have not been fully established. However, it is known that off-road vehicle travel can cause damage to soils and vegetation (Holechek et al. 1998), which can lead to corresponding impacts to wildlife by destroying and fragmenting habitat, causing direct mortality of wildlife, or creating altered behavior through stress and disturbance (Busack and Bury 1974, Brattstrom and Bondello 1983, Brooks and Lair 2005).

Model: This stressor includes the impacts of any motorized travel off-trail including but not limited to the use of ATV and OHV. There are 4 main components to this stressor and they are all of equal weight in the model:

1. Land ownerships that are open to public OHV travel

All lands protected from motorized off-trail recreation, or so highly managed as to preclude trail proliferation and unmanaged volumes of traffic, are not included in this stressor and are categorized below:

- Roadless areas
- Nature Conservancy properties
- Federal Designated Wilderness
- Designated portions of Arizona Game and Fish Commission-owned properties
- BLM Natural Conservation Areas (NCA)
- Military Lands (excluding Barry M. Goldwater range)
- National Monuments
- National Wildlife Refuges*
- National Historic Sites and Parks
- Private Lands
- Indian Reservations
- Local or State Parks

*Except Kofa, Buenos Aires, Cibola, and Imperial where ATV/OHV travel is permitted on designated roads and trails only.

2. Influence of urban encroachment and proximity to existing roadways

The greatest amount of OHV activity is found in close proximity to urban areas, where OHV users can quickly access public lands via paved and dirt roads. Therefore, a 5 mile inverse distance weighted gradient was included around towns and a 15 mile inverse distance weighted gradient was included around cities. Gradients were rescaled from 0 to 1.

Class 1 roads (interstates) are weighted as 4, class 2 roads (highways) are weighted as 2, and smaller roads are weighted as 1. Road density was calculated using a 5 mile search radius and re-scaled from 0 – 1.

3. OHV hot spots (includes perennial/intermittent riparian areas and long term visitor areas)
OHV hotspots are defined as areas where excessive levels of trail proliferation and traffic volume can present notable stressors to the extent that impacts to wildlife and habitat extend beyond the footprint of the trail. Impacts can include habitat destruction, fragmentation, and accompanying wildlife disturbance. Perennial and intermittent stream locations have been identified as hotspots at specific locales given the ecological significant of these riparian habitats. The Department has identified and mapped these hotspots based on expert opinion of Regional management staff. Some identified hot spots are designated and managed for OHV recreational use while others are not. Hot spots also include a few private land parcels and BLM Long-Term Visitor Areas. These were given a weight of 1.

4. Xeric riparian (washes) areas
Xeric riparian areas are included in the model as threatened areas. These areas are typically broad sandy washes that provide important desert/upland habitat features for various species, which can also attract high levels of use for off-trail recreation. Riparian areas with intermittent and/or perennial flows are not included unless they have been designated as an OHV hotspot. The impacts of OHV travel in these important areas are considered of the highest stressor level.

Data Mapping: The map components were considered additive, rather than weighted. Roads, xeric riparian, towns, and cities were added together and additive to land ownership. Hotspots are weighted equal to all four of the previous components combined. Lands not accessible to ATV/OHV use were masked out. This stressor includes all noise or light pollution associated with motorized recreation off-trail.

Note: BLM and Forest Service are currently in the process of developing motorized road plans across the state. After these planning processes are completed, more accurate data on designated areas for motorized recreation will become available and will, accordingly, better inform and reflect this analysis.

Nutrients/Algal Blooms
Sources leading to eutrophication (nutrient enrichment) of aquatic ecosystems typically include impacts from application of fertilizers for landscaping and agriculture (runoff), atmospheric deposition of nutrients, leakage from sewage and septic systems, and livestock waste (see Mason 2002 for an overview). Algal blooms are typically supported by and associated with nutrient rich waters, which serve to decrease water quality, adversely alter water chemistry, and deplete available oxygen. Declines in these water quality characteristics combined with accompanying

shifts in available nutrients can also lead to changes in vegetation structure over time to the detriment of SGCN.

Model: This stressor is mapped as all lakes and streams (intermittent and perennial). Although algal blooms typically occur less often in moving water, streams have been included because they transport nutrients and algae from one body of water to another. Streams are weighted as 1, lakes as 10, and lakes with previous algal blooms as 20.

Roads for Motorized Vehicles

Road and highway corridors have been identified as features that fragment habitats and landscapes (Saunders et al. 1991, Reed et al. 1996) because they serve to divide large landscapes into smaller patches and convert interior habitats into edge habitats. Studies in other states have demonstrated negative correlations between increasing road densities and wildlife populations (Lee et al. 1997, Wisdom et al. 2000). Development of a 16 foot-wide roadway removes approximately two acres of native habitat per mile of road. In addition, roadways can present direct source of wildlife mortality (and risks to human safety) due to vehicle collisions where corresponding wildlife movement corridors or foraging areas exist. The Department documented over 400 vehicle wildlife collisions along a 30 km stretch of highway in central Arizona from 1992 – 2004 alone (Dodd et al. 2006). In addition to introducing potential habitat fragmentation and wildlife/vehicle collisions, roadways can further facilitate increased levels of legal and illegal killing and collection of many species, including big game as well as sensitive reptiles and birds.

Roadways and associated infrastructure can also directly influence stream characteristics, such as channel and floodplain configuration, substrate embeddedness, riparian condition, relative prevalence of woody debris, stream flow rate, and temperature regime (Furniss et al. 1991). The timing, quantity, quality and location of surface water runoff can change as roadways and related drainage structures and development configurations act to intercept, collect, and/or divert water. These factors can accelerate water delivery and surface flow, thereby increasing the potential for higher magnitude of runoff in watersheds having roadway developments as compared to those not having such developments (Wemple et al. 1996). Road, trail and highway corridors can further serve as a means of dispersal for many nonnative and invasive plant species. Ground disturbance associated with the creation and maintenance of authorized roadways and trails provides additional opportunities for establishment of nonnative species (Parendes and Jones 2000).

Model: The U.S. Census Bureau's TIGER/Line® road layer is the basis for mapping this stressor. The layer was cleaned by removing class 5 (primitive) roads that were completely contained within wilderness areas. Many of those roads were known to be trails. Of the remaining roads, interstates were given a weight of 10, highways a weight of 5, and smaller roads a weight of 1. Road density was calculated with a search radius of 600 m which is the average distance roads were found to impact wildlife in at least one study (Foreman and Deblinger 2000).

Rural Development

Prior to the recession that began in 2007, population growth in Arizona was among the highest in the nation. The population of Arizona grew 40%, from 3.6 million to 5.1 million, between 1990 and 2000 (U.S. Census Bureau 2000). More recent estimates indicate an additional 28% growth in population between 2000 and 2009 (U.S. Census Bureau 2010). While Phoenix and Tucson continue to grow as the predominant desert urban centers, rural development continues to proceed steadily throughout the balance of the State. This growth is accompanied by habitat alterations that present a number of challenges to wildlife conservation including but not limited to: habitat loss due to development (including all related infrastructure development); habitat fragmentation; habitat degradation/damage; introduction and/or dispersion of nonnative, invasive and nuisance species (both plant and animal); and increased demand/competition over limited water resources.

Model: The stressor of rural development is present for all private and state trust lands, and any land marked for disposal by BLM throughout the state, but is higher near existing population centers and travel corridors. The model is based on a layer of all developable lands with private land weighted ten times higher than state trust or BLM disposal lands. Towns with a 200 census of greater than 0 were given an inverse distance weighted gradient of 5 miles (8046. 5 m). Road density was calculated using interstate highways, State and County highways, and any arterial roadways within an 18 km search radius. U.S. interstate highways were weighted as 10, State and County highways were weighted as 5, and arterials were weighted as 1. All weights were considered additive (urban + road + ownership), thus the highest weighted areas are found near existing urban centers, near large travel corridors, and on private land. The "Urban Growth" model was used to mask urban growth from this model.

This stressor includes noise and light pollution associated with rural development.

Sediment/Ash Flow

The institution of anthropocentric fire suppression during the early 1900s and on-going land use practices (e.g., livestock grazing) have led to unnatural fire regimes and higher than normal fuel loads in woodlands and forests across Arizona. Altered river and stream flows carry and deposit sediment in ways that can harm SGCN and alter habitats. In the past, more natural (i.e., frequent, smaller scale, low-intensity fires) occasionally resulted in sediment/ash transport and deposition in aquatic systems, benefitting some wildlife species. However, altered timing of fires, higher fuel loads, broader geographic extent, and increased fire intensity can produce substantively greater quantities of sediment/ash and cause greater loss of vegetation; the resulting soil instability reduces infiltration and increases runoff. Run-off from burned areas carrying ash and sediment can have an immediate and detrimental effect to aquatic SGCN fish and amphibians. Accumulation of the increased sediment may also alter habitat, and reduce water quality, especially dissolved oxygen.

Model: The Department modeled the stress from Sediment/Ash Flow as occurring in the perennial and intermittent streams and lakes in areas where sediment and ash flow from forest fires could impact wildlife. The model is based on the statewide layer of streams and lakes in or near forested systems.

Shrub and Woodland Invasions

Gori and Enquist (2003) documented a substantial decline in the area of grasslands throughout the Apache Highlands. Approximately 37% of historical grasslands have undergone a cover-type conversion to shrublands including juniper, mesquite, and catclaw; an additional 32% will likely be converted to shrubland in the near future due to current land management practices. Conservation of grasslands is needed to maintain many grassland species, particularly wide-ranging species such as pronghorn. Habitat degradation and shrub invasions may cause habitat specialists to be extirpated or even to go extinct. Other SGCN may be forced to move and seek necessary resources in different locations.

Model: Includes habitats that have been invaded by juniper, mesquite, or catclaw over the last 100 years. These habitats include Madrean oak woodlands, most pinyon juniper woodlands, and grasslands.

The SWReGAP vegetation classes that include juniper, mesquite or catclaw include:

- Apacherian-Chihuahuan Mesquite Upland Scrub
- Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe
- Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub
- Chihuahuan Sandy Plains Semi-Desert Grassland
- Colorado Plateau Blackbrush-Mormon-tea Shrubland
- Colorado Plateau Mixed Low Sagebrush Shrubland
- Colorado Plateau Pinyon-Juniper Shrubland
- Colorado Plateau Pinyon-Juniper Woodland
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Active and Stabilized Dune
- Inter-Mountain Basins Mat Saltbush Shrubland
- Inter-Mountain Basins Semi-Desert Grassland
- Inter-Mountain Basins Semi-Desert Shrub Steppe
- Inter-Mountain Basins Shale Badland
- Inter-Mountain Basins Wash
- Invasive Annual and Biennial Forbland
- Invasive Annual Grassland
- Invasive Perennial Grassland
- Madrean Encinal
- Madrean Juniper Savanna
- Madrean Pinyon-Juniper Woodland
- Mojave Mid-Elevation Mixed Desert Scrub
- Rocky Mountain Alpine-Montane Wet Meadow
- Rocky Mountain Subalpine Mesic Meadow
- Southern Colorado Plateau Sand Shrubland
- Southern Rocky Mountain Montane-Subalpine Grassland
- Southern Rocky Mountain Pinyon-Juniper Woodland

Solar Energy Development

Solar energy development was not recognized as a major stressor in the 2005 CWCS (AGFD 2006). Since that time, however, there has been a large push to begin construction of large-scale solar facilities throughout the Western United States. The Department recognizes the need for such development but is also concerned for the negative impacts such development may have for wildlife. The Department published guidelines to minimize those impacts in 2010 (AGFD 2010).

Impacts from solar energy development can include habitat loss from the construction of large-scale facilities and new or expansion of existing substations, new transmission lines, and associated access roads. These structures will also increase habitat fragmentation and have the potential to negatively impact wildlife movement. In addition, utility-scale solar facilities generally have large impervious surface areas which block or reroute surface flows, and, may use significant amounts of groundwater if using wet-cooled systems for turbines. The resulting changes in drainage patterns, storm water runoff, and depth to groundwater could result in significant negative impacts to wildlife and their habitats.

Model: We used a map published by the National Renewable Energy Laboratory on the feasibility of placing solar panel fields in Arizona (see http://www.nrel.gov/solar/). That map showed all land with a slope less than 3% as suitable for solar energy development. We mapped all land in Arizona that met those guidelines, excluding wildlife refuges, state, local and national parks, AGFD properties, urban areas, and wilderness.

Unnatural Fire Regimes

Wildfires are an integral process in Arizona and southwestern forest and grassland ecosystems. Prior to 1900, naturally occurring wildfires were widespread in all western forests at all elevations (Swetnam 1990) and historically kept ponderosa pine, mixed conifer and spruce-fir stand densities and fuel loads relatively low. From an ecological perspective, fire may be the most important disturbance process for many western forests (Hessburg and Agee 2003). However, since the early 1900s the frequency, size, intensity, seasonality, and type of fires has changed throughout the American Southwest (Dale et al. 2001). Systematic fire suppression efforts led to the elimination of high-frequency, low-intensity wildfires across Arizona and the Southwest (Collier and Webb 2002). This 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). Those grazing practices further reduced grass competition, thereby increasing tree and shrub establishment (Archer 1994, Gottfried et al. 1995, Belsky and Blumenthal 1997), which further altered natural fire cycles through the development of ladder fuels and the accumulation of heavy fuel loads. The frequency of large-scale, high intensity fires is increasing throughout the region (Sprigg et al. 2000, Dale et al. 2001). Catastrophic, stand replacing crown fires are now the standard, rather than the exception as a result of these changes (Covington and Moore 1994; but see Crawford et al. 2001).

Desert ecosystems historically had very low wildfire frequencies. Although lightning occasionally ignites desert fires, low fuel volumes and sparsely distributed vegetation would ordinarily prevent fires from spreading significantly (McLaughlin and Bowers 1982, Brooks 1999). However, large scale invasion of desert scrub habitats by a variety of invasive grasses and other vegetation (e.g., bufflegrass, red brome, cheatgrass, etc.) has altered fuel loads

considerably, and in wet years exotic grasses can form continuous carpets of fine fuels. Since the 1970s and early 1980s, catastrophic wildfires in the Sonoran and Mohave deserts have become relatively common (Brooks 1999, Esque and Schwalbe 2002, Brooks and Matchett 2006). Desert scrub vegetation, including long-lived species such as saguaros and paloverdes that evolved in a fire-free setting, generally lack adaptations with which to survive fire. Exotic grasses, which typically respond well to fire, subsequently proliferate and wildfires often become stand-replacing such that native desert shrublands are converted to exotic annual grasslands (Brooks and Pyke 2001, Esque and Schwalbe 2002). The effects of catastrophic wildfires on wildlife in Arizona and surrounding areas vary and are incompletely understood, however negative impacts at the individual, population and community levels are clear (for example, Simons 1991, Cunningham et al. 2002, Esque et al. 2003, Monroe et al. 2004, Vamstada and Rotenberry, 2010).

Land management practices and fire suppression have had adverse effects on many Arizona 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).

Model: The LANDFIRE Fire Regime Condition Class (FRCC) Departure Index was the basis for this model. LANDFIRE FRCC is a database showing the percent departure from normal fire regimes for different habitats (see http://www.landfire.gov/index.php). Since neither the Sonoran nor Mohave deserts are considered to have a normal fire regime (i.e., fires are not considered part of the natural processes maintaining these systems), these data show them as being less that 10% departed from normal. Since the creation of this model, large desert fires have clearly demonstrated the ecosystem impacts of unnatural fires in deserts (usually resulting from combustion of invasive exotic plant species). Thus the model was modified to increase the departure for Sonoran and Mohave systems by 70%.

Urban Growth

Prior to the 2007 recession, population growth in the State was among the highest in the nation. The population of Arizona grew 40% from 3.6 to 5.1 million from 1990 – 2000 (US Census Bureau 2000). Current estimates indicate an additional 28% growth in population from 2000 to 2009 (US Census Bureau 2010). Urban growth presents a number of challenges to wildlife conservation including, but not limited to, habitat loss; fragmentation, and degradation from structures, roadways, utility corridors, etc.; as well as introduction of invasive plants and animals; increased demand for limited water resources, etc.

Model: The Maricopa Association of Governments population projection map is the model of Arizona urban growth that was adopted for this exercise. In the interest of conservation, the 2050 model was chosen, which included the best data available created by experts on this topic. This stressor includes any noise and light pollution associated with urban growth.

MEDIUM IMPORTANCE

Air Traffic Corridors/Overflights

While in some cases, low-level aircraft flights have no apparent affect on wildlife behavior or physiology (e.g., Krausman et al. 1998, Krausman et al. 2004), low-level flights can startle and change behavior in some mammal and bird species, and might result in a loss of reproductive fitness (Manci et al. 1988). Pepper et al. (2003) identified a critical need for further study on the effects of aircraft noise on wildlife, because previous studies were inconclusive or were based on small sample sizes.

The Federal Aviation Administration maintains a database of aircraft/wildlife strikes and documents over 100,000 that have occurred over the past 20 years around the country. Almost 2,000 aircraft/wildlife collisions having been reported for Arizona over that same time period. The vast majority of these reports involved birds, although other taxa have also been struck (FAA 2010). In addition to the direct stress imposed on wildlife by these aircraft/wildlife collisions, they represent a serious threat to human safety for both civilian and military aircraft.

Model: This stressor was modeled by buffering the locations of airports obtained from the Arizona Department of Transportation by 10,000 feet. Military airports were given the highest stressor value of 4. Primary airports were assigned scores of 3, 2, 1, or 0. 5, somewhat arbitrarily, according to their jet capacity and level of activity. The high-impact tourist areas at the Grand Canyon, from the ALRIS Land cover, and around Sedona, drawn by regional personnel and digitized, were also assigned a value of 4. Buffered military training routes, obtained from the Barry M. Goldwater Range, at or below 2,000 feet above ground level (87% of all reported strikes occur at or below 2000 ft above ground level [Dolbeer and Wright 2008]), were selected and given a weight of 8. Buffers are determined by the Department of Defense in their National Environmental Policy Act analysis of wildlife impacts.

Canals/Pipelines

The arterial network of canals and pipelines designed to move water and fuel throughout Arizona may negatively impact wildlife and wildlife habitat. Running through Arizona is a large network of inter/intrastate natural gas pipelines, crude oil pipelines, product pipelines, and related processing, metering or compression stations. Most pipeline systems are below ground after construction. Related infrastructure, maintenance roads, and construction activities are the primary stressor to wildlife once the above-ground areas have been revegetated. Closely associated with these structures is the development of utility roads providing access for maintenance activities. Arizona also has a vast network of water delivery systems including various irrigation district canal networks, the Salt River Project (SRP) delivery system in central Arizona, and the Central Arizona Project (CAP) that delivers water from the Colorado River to central Arizona. Small regional irrigation systems and canal systems such as SRP are less of a barrier to wildlife primarily due to their smaller size, lack of fencing, or urban locations. However, these systems still create movement conduits for invasive aquatic plants and animals. For example, the SRP system is hydrologically connected to the Salt and Verde watersheds at the Granite Reef Diversion Dam.

The resulting negative impacts of both canals and pipelines may include, but are not limited to: habitat fragmentation; habitat loss and/or degradation; changes in community composition; water diversion; and stream bank alteration or channelization. In addition to the stressors listed above, other stressors brought about by canals, such as the spread of contaminants, herbicides, pesticides, and unintended movement of invasive animal and plant species are included in this model but are discussed in more detail in their appropriate categories. Agricultural runoff is not included in this model, but is captured in the Pesticides/Herbicides stressor category.

Model: This stressor was mapped from: 1) large water delivery systems such as the CAP, Welton-Mohawk, and Dome canals in southwestern Arizona, and CAP laterals to the Tohono O'odham Reservation; 2) the SRP delivery system throughout the Phoenix metropolitan area and outlying communities; 3) irrigation delivery systems along the Upper Verde River, including irrigation delivery laterals and ditches that are mapped by Northern Arizona University researchers; 4) statewide data from Arizona Department of Water Resources on small delivery systems that include canals and ditches; and 5) large proposed pipelines such as the West-wide Energy Corridor proposed by BLM, Transwestern's Phoenix Lateral, and El Paso's parallel project from San Simon to Tucson.

These canals, pipelines, and ditches were buffered by 30 meters. Transwestern and El Paso pipelines are weighted 1, the West-wide Corridor was weighted 5, and canal and ditches were weighted 10. The team recognizes that not all canals and ditches have the same affects due to varying sizes. However, lack of data at this time constrained the use of a more realistic weighting scheme.

Note: At the time of this writing, at least one of the large pipelines was recently completed and this model should be re-run with additional data, including all irrigation delivery systems for the state and pipeline data from the Department of Transportation Office of Pipeline Safety National Pipeline Mapping System.

Contaminants from Mine Tailings, Waste Water, and Runoff

Aquatic systems and species can be contaminated from sources such as waste water treatment plant effluent, leach pits, evaporation ponds, mine tailings, roadways, gas stations, storm drains, septic systems, industrial runoff, agriculture "tail water," livestock operations and others. Wildlife may be negatively affected directly through ingestion or absorption (for example, amphibians have highly permeable skin through which such materials may readily flow) or indirectly through bioaccumulation and transmission up the food chain. Contaminants affect water quality and alter water chemistry, which may increase physiological stress resulting in reduced fecundity, poor health or mortality of SGCN or other species. Contaminants may also increase the susceptibility of species to disease, pathogens, or parasites as a result of poor condition. Ultimately, accumulation of contaminants may lead to severe habitat degradation or loss, and may eventually result in changes in biological community composition (Clements et al. 2000).

Model: This stressor has the potential of occurring statewide within the streams, rivers, and other bodies of water. Impaired waters data from 2004 were obtained from the Arizona Department of Environmental Quality (ADEQ). ADEQ assessed water quality based on all readily available,

credible, and scientifically defensible monitoring data and information pertaining to possible numeric and narrative standards violations. Any stream with more than one exceedance of these measures was assessed as "impaired". One exceedance was assessed as "inconclusive", and zero exceedances was "attaining". These assessments were applied to each designated use of the water. Only the uses that affected wildlife were considered: Aquatic and Wildlife Uses, and Fish Consumption. If there were different assessments for each use, the assessment with more exceedances was used to classify the stream. The assessments were weighted as follows: 1 for attaining, 2 for inconclusive and 4 for impaired. These weights were applied to the section of stream identified by ADEQ. For those sections not assessed and all other perennial and intermittent streams not assessed, they were given a weight of 2 due to their potential of becoming impaired. The effects of endocrine disruptors in wastewater were not assessed due to lack of data.

Feral Animals

Escaped, unlawfully released or abandoned domesticated pets (including farm stock and equines) are severely impacting native wildlife and wildlife habitats. All nonnative animals have the potential to spread disease, and to become established and prey upon, harass or compete with native wildlife (see Jansen et al. 2006 for an example). Horses, burros, goats, domestic sheep, and hogs might overgraze or trample native plant species, thus increasing erosion, compacting soil through frequent trail usage, and polluting aquatic systems through waste accumulation. Feral and outdoor domestic cats are responsible for the death of millions of birds and other native wildlife across the U.S. each year (Winter and Wallace 2006), and feral and domestic dogs have been known to attack Sonoran desert tortoises (Jones 2008).

Model: Three methods were used to model the distribution of feral animals:

a. Department personnel mapped "hot spots", as places where known feral animal populations are threatening wildlife. Places where the feral animal hot spots are identified as hogs, goats, sheep, burros or horses were assigned a score of 2. Places where known hot spots were identified as cats or dogs were assigned a score of 1.
b. A 10 mile gradient around the polygons of current cities and around points of towns was assigned a score of 1 to represent the presence of feral cats and dogs.
c. The inside of city polygons was given a value of 0. 5 because there is a threat to wildlife inside the cities from feral animals, but not as much of a threat as outside of the cities.

Fishing Line

Discarded or lost fishing line and tackle represent a stressor to wildlife in Arizona. Most wildlife encounters with monofilament occur when riparian birds collect it for nest material (Hunt et al. 1992, Beatty et al. 1998); bald eagles and osprey might also catch dead fish that have fishing material attached. However animals can also become entangled while swimming or visiting lake shorelines and they can ingest material while feeding on dead fish. Anglers can snag submerged riparian vegetation leaving fishing tackle exposed to wildlife later when water levels recede. Fishing line pollution is associated with water bodies and all places where angling occurs, and the threat increases with the number of angler use days.

Model: The stressor was mapped along all shorelines in the state where angling occurs (including all sport fish and apache trout habitats). Angler use data show that fishing occurs 2.3 times more

often on lakes and reservoirs, so lakes and reservoirs were given 2.3 times more weight than rivers and streams.

Forest and Woodland Management

Forest management and fire suppression over the past 100 years has resulted in overly dense forests that, while favoring some species, discourage others. Significant efforts have been made in the ponderosa pine ecosystem, especially near towns and cities, to reduce this density and thereby reduce fire risk.

Removal of timber products can have adverse effects on wildlife if it is not implemented in a manner that leaves resulting structure that meets wildlife habitat needs. In addition, any management that removes old growth structure is particularly detrimental to forest and woodland species. Over the last century, species composition and structure of Arizona's forests have been altered by the combined effects of commercial logging, fire suppression, and improper grazing practices (USFS 1993, Covington and Moore 1994). In addition, more traditional silviculture practices aimed at growing trees efficiently have left some structurally homogenous forest patches, which have reduced habitat quality for most forest wildlife. Restoration of fire adapted ecosystems (through fuels reduction and prescribed fire) is a focus of current forest management efforts, with millions of dollars directed at thinning small diameter trees and the reintroduction of prescribed fires to reduce the potential for widespread catastrophic wildfires (Bogan et al. 1998). If managed with wildlife in mind, i.e., a mosaic of varying structure and age classes, the benefits of forest and woodland restoration typically outweigh the costs for wildlife.

In addition to the removal of overstory vegetation, a secondary impact of timber harvest has been the significant transportation system established to harvest and haul the product. Most of this road system is open to public use on a year-round basis except at the highest elevations in Arizona. This increased access for vehicular traffic has increased the disturbance to resident and migratory wildlife. Off-highway vehicle traffic is also increased by roadways developed in otherwise inaccessible areas, and growing impacts from OHV use are a concern on many public lands. Another indirect effect of forest and woodland management has been the introduction and proliferation of invasive plants (e.g., Crawford et al. 2001) which have reduced overall vegetation diversity and altered fire regimes in some areas.

This stressor refers mostly to forest and woodland management carried out in a way that is not beneficial to wildlife. Some examples would be even-aged management, old growth removal, mistletoe sanitation treatments, and any other treatment that leaves the forest in a non-mosaic, homogenous state.

Model: This model included all pinyon-juniper and other coniferous woodlands and forests, excluding wilderness lands.

The SWReGAP classes that were included are:

- Colorado Plateau Pinyon-Juniper Woodland,
- Great Basin Pinyon-Juniper Woodland
- Inter-Mountain Basins Juniper Savanna
- Invasive Southwest Riparian Woodland and Shrubland

- Madrean Encinal
- Madrean Juniper Savanna
- Madrean Pine-Oak Forest and Woodland
- Madrean Pinyon-Juniper Woodland
- Madrean Upper Montane Conifer-Oak Forest and Woodland
- Mesquite
- Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
- North American Warm Desert Riparian Mesquite Bosque
- North American Warm Desert Riparian Woodland and Shrubland, Riparian
- Rocky Mountain Aspen Forest and Woodland
- Rocky Mountain Gambel Oak-Mixed Montane Shrubland
- Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
- Rocky Mountain Ponderosa Pine Woodland
- Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland, Rocky
- Southern Rocky Mountain Pinyon-Juniper Woodland

Hybridization

Hybridization threatens the genetic integrity of native species, particularly those inhabiting aquatic ecosystems, through interbreeding with nonnative related species.

The Department considers the most important threat to Apache and Gila trout is hybridization with nonnative rainbow trout (*Oncorhynchus mykiss*) and cutthroat trout (*Oncorhynchus clarkii*) occupying the same habitats (Carmichael et al. 1993). Department experts believe there is a low level threat to flannelmouth and bluehead suckers due to the potential for introduction of the exotic white sucker (*Catostomus commersoni*). The white sucker currently does not occur in Arizona or is in extremely low numbers (not established yet).

Hybridization with non-native tiger salamanders, particularly barred tiger salamanders (*Ambystoma mavortium mavortium*), often imported for use in the bait trade, has been identified as a serious threat to endangered Sonoran tiger salamanders (Collins et al. 1988, USFWS 2002, Storfer et al. 2004). Department species experts do not believe there is a significant threat of hybridization among native leopard frog species, although some distributional overlap exists and hybridization undoubtedly occurs; those situations continue to be monitored. However, continued invasion of exotic Rio Grande leopard frogs (*Rana berlandieri*) could pose a serious threat of hybridization with native lowland leopard frogs (Rorabaugh et al. 2002).

All wild turkeys in Arizona are at risk of hybridization with escaped domestic turkeys. Although the Department has introduced the Rio Grande turkey to only one isolated area in Arizona that is not in native turkey range, experts believe the threat of hybridization from these transplants is lower than the threat of hybridization from unregulated domestic turkeys and from Rio Grande turkeys in neighboring states. Also, Indian tribes might make management decisions in which they relocate Merriam's turkeys in proximity to reintroduced Gould's turkeys, which also poses a hybridization risk.

Some experts believe there is a stressor of Rocky Mountain bighorn sheep populations meeting and hybridizing with desert bighorn sheep. Rocky Mountain bighorn sheep transplants and subsequent movements of transplanted animals bring them within range of some desert populations. Indian tribes might also make management decisions in which they relocate bighorn sheep in proximity to other bighorn sheep populations from a different subspecies, thus posing a potential hybridization risk. Finally, Department experts believe that the Mexican wolf is threatened with hybridization from domestic wolf mixes. Although the possibility has been suggested, Department experts believe there are no significant concerns about hybridization for pronghorn.

Model: This stressor was mapped as, 1) streams where Apache and Gila trout occur in close proximity to non-native trout; 2) the upper Colorado River where native suckers occur; 3) the distribution of the Sonoran tiger salamander; 4) the northern margin of the current distribution of *R. berlandieri*; 5) the entire range of wild turkey in Arizona; 6); bighorn sheep habitat in areas where the subspecies overlap concern exists; and 7) the Blue Range Wolf Recovery Area plus a 30 mile buffer.

All hybridization stressors were weighted the same and modeled as presence or absence. Additive effects were not considered.

Lead Contamination

Due to human activities, lead has become available to wildlife at higher levels than prior to industrialization (Pain et al. 1994). Lead poisoning in birds and mammals has been linked to several sources, including ingestion of spent lead gunshot (Pain et al. 1994, Ma 1996), consumption of lead sinkers (Sears 1988), secondary consumption of lead contaminated prey (DeMent et al. 1986, Frenzel and Anthony 1989), mining and smelting activities (Beyer et al. 1997, Henny et al. 2000), and firearms training facilities (Lewis et al. 2001).

In Arizona, lead as a stressor is very high for some wildlife species such as the California condor, and essentially zero for some others; hence it is categorized here as "medium."

Model: Ubiquitous although recognized to be locally concentrated. After consulting with eagle and condor experts in the Department, we determined that lead contamination is a statewide stressor to those populations.

Livestock Management Infrastructure

Ranching and livestock management have a long heritage in Arizona that has benefited wildlife in some instances. Managed rangelands often provide water and access to areas, and land eliminated from grazing may become developed for other purposes such as housing or energy. However, the infrastructure associated with livestock management, including ranch roads, corrals, livestock waters, and fences can also act as a stressor on wildlife.

Model: Livestock management is modeled as present on all Bureau of Land Management (BLM), US Forest Service (USFS) and ASLD grazing allotments and private property within allotments.

Loss of Keystone Species

Keystone species are species whose impact on a community or ecosystem is large, and disproportionately large relative to its abundance (Paine 1969, Power et al. 1996). If a keystone species is removed from a community other species that are closely associated with the keystone species will also be affected and perhaps disappear. Keystone species can include top predators, such as wolves, studies of which have shown that wolf reintroduction affects the behavior of other species and subsequently effects riparian and scavenger communities (e.g., Ripple and Beschta 2003, Wilmers and Getz 2004). Other keystone species are less obvious and their effects often more complex, such as red-naped woodpeckers in high elevation forests (Daily et al. 1993). Ecological guilds (i.e., multiple ecologically similar organisms that occur in the same area) can also play a keystone role. For example, a guild of three species of kangaroo rats has been shown to determine the transition between Chihuahuan Desert and semidesert grassland in southeastern Arizona (Brown and Heske 1990). Finally, some keystone species are categorized as "ecosystem engineers," because their activities directly or indirectly create, modify and maintain the physical condition of habitats (Jones et al. 1994, Wright and Jones 2006). Examples of these include prairie dogs (Power et al. 1996, Smith and Lomolino 2004), pocket gophers (Huntly and Inouye 1988), and beavers (Naiman et al. 1986).

In Arizona, some keystone species have either been completely removed or have experienced significant population reductions in their historical range, including Mexican grey wolf, black-tailed and Gunnison's prairie dogs, and American beavers.

Model: This stressor is considered present over the cumulative range of the Mexican grey wolf Blue Range Wolf Recovery Area, black-tailed and Gunnison's prairie dogs, and American beaver.

Mining

Mining occurs throughout Arizona and can influence ecosystem function, resilience, and sustainability. There are many types of mining in Arizona, including large-scale, open pit copper mines; sand and gravel mines; and small, abandoned hard rock mines. Impacts to wildlife vary depending on the type of mine and scale of operation. Activities associated with mines, may result in habitat fragmentation and loss through associated land clearing, road building, and disturbance from traffic, hauling, noise, lighting, and maintenance activities. Associated point-source pollution causes heavy metal and highly acidic water pollution (Drabkowski 1993, Starnes and Gasper 1996, Reece 1995), groundwater pollution (Miller et al. 1996), air pollution, noise, and habitat conversion (Dinerstein et al. 2000).

Mines typically require large quantities of water, and operations can impact highly sensitive resources such as riparian areas through modifications to watersheds (Dickens et al. 1989). 69% of all industrial water use in the Tucson Active Management Area is due to mining activities (ADWR 2010). Tailings displace existing habitat and are typically incapable of sustaining natural vegetation communities.

Smelter facilities have been implicated as causes of acid precipitation, mercury pollution, and other air and water pollution. Changes in Sonoran Desert vegetation composition and abundance

have been documented near mine facilities including smelters (Wood and Nash 1976), thus reducing wildlife habitat value.

Mitigation measures and adjustments to mine operations may reduce negative impacts to wildlife and sensitive habitats. Reclamation might restore habitats to conditions suitable for some wildlife (Jansen et al. 2006). However, long periods of operation and abandoned operations with no reclamation still pose a significant impact. Once a subterranean mine feature is established, it may provide important wildlife habitat. Abandoned mines provide roosts for many species of bats (Tuttle and Taylor 1994, Altenbach and Milford 1995). Managing mines (abandoned and active) for bats across landscapes has become an important conservation tool for many bat species (Sherwin et al. 2009, Navo 2001), however, mining activity can pose a hazard to bats and other wildlife when activity is renewed after a period of inactivity if that mine feature has become important wildlife habitat.

Model: Mine locations were obtained from the Arizona Department of Mines and Mineral Resources and mineral district data obtained from the Arizona Geological Survey. Mineral district polygons were converted to 30 m raster and then to points. Those points were merged with the mine point locations. A kernel density with a search radius of 1 mile was run, resulting in a linearly decreasing gradient of stressor intensity from the center of a mine to 1 mile away.

Note: All mines were treated equally whether active or inactive, including past, present, and future open pit and underground. Future iterations should consider different levels of impacts from different mining activities.

Power Lines/Telephone Lines/Cellular Towers

Lighted communications and transmission towers, which attract a variety of insect species, have the potential to attract and kill night-flying migratory birds and bats (Longcore et al. 2008). Lighting of towers in both urban and rural settings increases the density of birds at the hazard (glass barriers or lethal guy wires). Bird kills at lighted towers have been documented for at least 50 years (Longcore et al. 2008). Effects of utility corridors include habitat fragmentation and disturbance from authorized and unauthorized use of access roads and pads, the increased incidence of direct illegal take, and the introduction of nonnative plant species due to the disturbance of soil and native vegetation during construction and maintenance (Parendes and Jones 2000). In addition, power lines are known to cause direct mortality to birds. Between 1997 and 2003, 473 birds, the majority raptors, were reported as electrocuted (AGFD internal data)

Model: Ubiquitous. This stressor can cause wildlife effects statewide in all habitats and is generally associated with other threats already identified. It was not modeled.

Soil Erosion

Soil erosion can result from grazing, deforestation, fires, or any other disturbance or degradation of the topsoil. Resulting hydrological changes will cause shifts in vegetative cover necessary for maintaining intact ecosystems. Erosion due to wind and water action will increase siltation, decrease water quality, and lead to loss of riparian habitat diversity and complexity. Soil erosion is considered more thoroughly under other stressors.

Model: Ubiquitous. This stressor can cause wildlife effects statewide in all habitats and is generally associated with other threats already identified. It was not modeled.

Wind Energy Development

Wind energy facilities are not yet widespread in Arizona. However, as demand for alternative sources of energy increases and the technology improves, there is potential for more wind-energy sites to be developed within the state. Wind-generated electrical energy is considered to be more environmentally friendly because it does not create air-polluting and climate-modifying emissions. However, wind turbines and their construction can adversely affect wildlife and wildlife habitats. Wind turbine towers in particular have been directly associated with killing large numbers of bats and birds (particularly raptors) that strike moving blades (Baden and James 2004).

Effects of utility corridors, including wind turbine farm access routes, include habitat fragmentation and disturbance from authorized and unauthorized use of access roads and pads, creation of new electrical transmission corridors, and the introduction of nonnative plant species due to the disturbance of soil and native vegetation during construction and maintenance (Parendes and Jones 2000). These effects are covered under other stressors and are not covered in this model.

Model: This stressor includes any noise or light pollution associated with wind harvesting. Wind-harvesting was mapped using wind energy resources (i.e., areas of consistent wind) mapped by Northern Arizona University in combination with areas where wind facilities have been proposed. A scale of 1 to 10 was assessed. The wind resources were already rated from 1 to 7 on potential wind resources. The footprint of proposed wind facilities were given higher ranks, 8 through 10, depending on where they were in the assessment of the wind resource, with 10 being the most promising, 9 just started but believed to be promising, and 8 is proposed facilities or meteorological towers.

MINOR IMPORTANCE

Agricultural Conversion

Agricultural conversion is the process by which a portion of a natural landscape is altered to the point it is suitable for agricultural use. Due to the high value of Arizona's land for business and community development, this activity has dropped sharply and little natural land is currently being converted to agriculture. However, crop changes on existing agricultural lands can still impact wildlife species. This stressor does not include the effects from raising livestock (see Grazing by ungulates).

Model: This stressor was modeled as present on all existing agricultural fields using the Agriculture classification from the SWReGAP vegetation layer. All agricultural lands were ranked equally with no attempt to discern among different crops or other uses.

Dispersed Camping

The Department recognizes the value of camping, as a necessary and desirable tool for achieving wildlife population management objectives. However, dispersed camping and the routine human

activities typically associated with it can have direct influences on wildlife through disturbance and induced behavioral changes, as well as indirect affects including trampled vegetation, soil compaction, removal of woody material, discarded food and litter, human waste pollution and other physical disturbance at the campsite and surrounding area (Boyle and Samson 1985, Leung and Marion 2000, Steidl and Powell 2006). Influences to individual species have been documented for some activities, e.g., hiking (Swarthout and Steidl 2001, 2003), but the overall influence of activities surrounding dispersed camping is not fully understood, nor is it clear how much dispersed camping can be tolerated before there is an adverse effect on wildlife or wildlife habitat (Newman et al. 2006). However, dispersed camping is increasing along with other outdoor recreational activities, and its potential effects on habitats and species should be considered in conservation planning (Conner et al. 1990, also see Knight & Gutzwiller 1995 for a more comprehensive review of outdoor recreation).

Model: Dispersed camping occurs statewide on State Trust Land and public lands (forest, BLM, some military, national refuges, park service, etc.), primarily along roadsides. We modeled the influences with 200 foot buffers along rural and primitive roads on public lands, and then applied an inverse distance weighted gradient to 0. 25 miles from the buffer. This stressor includes all noise and light pollution associated with dispersed camping.

Domestication of Wildlife/Game Farming

Wildlife maintained within game farms pose risks to native wildlife species should they escape or be intentionally released. They may hybridize with native species, thus reducing genetic integrity. They may also introduce harmful disease, pathogens, or parasites to wildlife. This stressor includes the influences from escaped domesticated wildlife as a result of game farming and keeping native wildlife as pets but does not include keeping exotic species as pets.

Model: Some of the concerns about domestication of wildlife are covered under other stressor models such as hybridization or disease. Two game farms in Arizona, however, are permitted to keep native cervids. A 5-mile sphere of influence around each of them was used to define the location of this stressor. Game farms were located as points as close to the center of the farm as possible. A kernel density was run on the point locations with a search radius of approximately five miles (8045 meters) resulting in a gradient of influence that is strongest at the point location and falls to 0 at five miles away.

Dredging

Water sources are valuable for agriculture as well as recreational activities in Arizona. To ensure their persistence, earthen water storage tanks may occasionally be dredged to remove excess sediment or vegetation. Reservoirs may also be dredged to facilitate watercraft access or to improve water storage capacity. These activities mix sediments into the water column, potentially reduce water quality, and thus displace aquatic species. Machinery used for dredging can also trample surrounding riparian vegetation or wildlife species. Mercury and other toxins can accumulate in lake sediments, and dredging for other purposes could mobilize those accumulated toxins into the water column making them available to aquatic wildlife.

Model: Regional experts developed a list of lakes that are dredged or have the potential to be dredged. These were then mapped. Although stock tanks are often dredged, we are not mapping

stock tanks due to lack of a complete dataset. Urban lakes are typically not dredged and therefore are not considered in this stressor.

Drilling for Fuels

Extractive resource uses such as oil and gas development occur throughout Arizona and can influence ecosystem function, resilience and sustainability. Extractive resource uses may result in habitat fragmentation and loss through associated land clearing, road building, and disturbance from traffic, hauling and maintenance activities. Any of these activities and their adverse outcomes may ultimately lead to the reduction of wildlife populations.

Model: Point data on oil, natural gas, helium, and carbon dioxide wells were obtained from the Arizona Geological Survey. The data include all wells permitted within the state of Arizona and were last updated in January of 2005. The stressor from the wells was distributed by running a density kernel over the points with a 2 mile (3218. 6 m) search radius. This method effectively places the highest stressor in areas with a high density of wells and gradually diminishes to 0 at two miles from an existing well.

Note: All wells, including test and other non-producing wells, were weighted equally and are treated as a "high" stressor designation. A review of individual wells should be conducted to determine which wells actually pose a stressor to wildlife.

Harvesting/Collecting Animals

Hunting, trapping and fishing are some of the methods by which wildlife species are harvested and collected in Arizona. Overharvesting may occur when more animals are collected from specific areas or during timeframes than is sustainable for the affected species. The often unique qualities of species residing in this state enhance their desirability as targets of both legal harvest/collection for national and international hobbyists and in some cases for illegal trade. The influences to SGCN resulting from these activities may include, but are not limited to, changes in community composition, range contraction or eventual eradication/extinction. Because the Department manages wildlife resources in the state in a manner consistent with the North American Model for Wildlife Management, regulated, traditionally consumptive uses have not had a negative influence on those species. Department experts concluded that overharvest/collection of wildlife is a threat to only a few species of amphibians and reptiles: lowland burrowing treefrog, box turtle, Sonoran desert tortoise, Arizona and Bezy's night lizards, rosy boas, ridge-nosed rattlesnake, banded rock rattlesnake, twin-spotted rattlesnake, massasauga, green rat snake, brown vine snake, New Mexico milk snake.

Model: The stressor to green rat snake, milk snakes and massasauga, is mainly from road hunting, so the stressor for these species was limited to the small roads (class 3-5 in ALRIS transportation layer) with a 100 meter inverse distance weighted gradient and rescaled from 0 - 1. For all other species the stressor was modeled as present throughout the distribution of the range for the species. All species were given a weight of 1. The stressor was not weighted more if species ranges overlapped, but effects of roads were considered additive.

Harvesting/Collecting Plants
Harvest and collection of native plant species may pose risks to vegetation communities across Arizona. Plants, especially succulents (including yuccas, ocotillo, saguaros, other cactus species, etc.), are illegally collected for use in landscaping or for illicit trade. Overharvest of long lived species can lead to local or widespread extirpations. Not only do these activities degrade habitat quality, they may also cause changes in native fauna community composition and favor encroachment by nonnative species. Overharvest and collection of native plants may also affect critical food resources and habitat components necessary for SGCN (i.e., Lesser Long-nosed Bat, Cactus Ferruginous Pygmy Owl, etc).

Model: This stressor includes illegal collecting and poaching, as well as overharvest through legal take in specific areas and or particular time frames. The stressor was modeled as all desert vegetation in the Sonoran and Mohave deserts.

Highway/Roadway De-Icing
Even though most of Arizona experiences relatively mild winters, higher elevations in the state (for example, White Mountains, Mogollon Rim) experience significant snowfalls on average. In order to reduce vehicle collisions and accidents, the Arizona Department of Transportation (ADOT) de-ices roadways and highways soon after snowfalls. Salt build-up along the edges of roads attracts wildlife species, such as deer and elk, and increases the likelihood for wildlife/vehicle collisions. Accumulated deicing material (for example salt) changes soil composition and chemistry, becoming less suitable for native plant species. Additionally, spring runoff containing de-icing matter (including chloride) pollutes water sources and may cause decreased fecundity or increased mortality rates of wildlife species inhabiting those aquatic systems (Kaushal et al. 2005).

Model: This stressor occurs along and adjacent to roads that are treated with de-icing chemicals. Impacts leading to plant damage as well as plant mortality and degraded aquatic systems are the primary concern. ADOT provided information, which was then digitized, regarding which roads and road segments are subject to the application of deicing chemicals. We did not include the application of de-icing chemicals by ADOT on isolated underpasses and overpasses in the southern portion of the state, nor the limited chemical deicing activities conducted by the cities and counties. The zone of impact includes the deicer splash zone due to snow plow and passing vehicular traffic along the roadways as well as aerial drift. Literature indicates that the zone of impact can vary significantly based on such things as local topography, highway travel speeds, and wind speed and direction. In order to account for the variability in the size of the potential impact zone throughout the treated areas, we decided to use a 100 meter gradient from the road centerline as the zone of impact.

Illegal Dumping/Littering
The induction of non-biodegradable and other harmful materials through illegal dumping and littering may negatively impact SGCN and their habitat. Wildlife may alter their foraging behavior or experience mortality as the result of ingesting the disposed materials. This stressor includes trash that is thrown out or blown out of vehicles, large illegal dumping sites around cities, trash left by recreationists, illegal dumping and littering at off-range shooting sites, trash

that ends up in lakes and streams from recreationists or from rainfall events and floats downstream, etc.

Model: We mapped this stressor as follows:

- Existing cities, towns, and BLM long-term visitor areas were given a five mile inverse distance weighted gradient with a maximum weight of 10.
- Major roads (interstates, highways, and major arterials) were given a one mile inverse distance gradient with an additional weight of 10.
- Minor roads (small, rural, and primitive roads) were given a width of 2 pixels (60 m) and a weight of 1.
- Lakes and major rivers (Colorado from Hoover Dam down, Salt from Stewart Mountain Dam down, Verde from Horseshoe Lake down) were buffered with a single pixel (30 m per side) and a weight of 5.
- Minor streams were buffered with a single pixel (30 m per side) and given a weight of 1.

All weights are additive. Trash associated with illegal border crossings is treated under border effects.

Landfills/Dumps

The increasing influx of new residents to Arizona results in generation of large quantities of waste material which is then disposed of in landfills or dumps. The development and operation of these facilities may harm SGCN and their habitat. Landfills and dumps are often large (sometimes more than 1 mile^2 in size), thus resulting in habitat loss, and if not managed properly could lead to contamination and pollution in the surrounding environment. Densities of predators, such as scavenging dogs and corvids, may increase around disposal sites and result in harm to native species (Kristan and Boarman 2002). Additionally, increased heavy truck traffic on rural roads leading to these facilities may negatively impact wildlife through wildlife/vehicle collisions or by fragmenting their habitat through the development of new roads.

Model: Data containing the point locations of municipal solid waste landfills were obtained from the Arizona Department of Environmental Quality. Landfills are various sizes, and there are no data regarding the size of the landfills. Thus, an arbitrary radius of influence of 5 miles (8046. 5 meters) around each point was chosen as the distance to which a landfill had the potential to impact wildlife. The stressor is modeled with an inverse distance weight from the center point over a 5 mile radius.

Military Activities

The Department of Defense (DoD) manages 3. 9% of the land in Arizona. Military activities include research, development, testing, and evaluation of weapon and space systems, subsystems, and components; 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. The Department recognizes DoD as an important conservation partner and realizes that military lands provide substantial benefit to wildlife. However, the potential of negative impacts of military activities on wildlife must also be addressed.

Model: Due to lack of data on the location of specific activities on military lands, all SCGN occurring on military lands were considered to have the potential of being equally stressed by all military activities. Military lands were then buffered with an inverse distance weighted gradient up to two miles because the impacts (e.g. noise and light pollution) can occur outside of the military land itself. The model will be revised as appropriate data becomes available.

Non-Motorized Recreation Off-Trail

The SWAP defines this stressor as influences from foot, bike, and equine trailing in fragile habitats; trespassing in restricted natural areas; or the effects on wildlife and wildlife habitat from authorized paved and dirt trails intended for foot, bike or equine use, that currently exist or are planned.

Model: This map was constructed using regional expertise to identify localized areas where non-motorized influences were substantial such as within urban parks. Polygons were hand drawn around these areas and converted to a shapefile.

Pesticides and Herbicides

Pesticide and herbicide use may influence ecosystem function, resilience and sustainability. The application of these materials for agriculture, landscaping (including golf courses) and disease vector control (e.g., mosquitoes) may result in decreased water quality, altered water chemistry, and reduction in forage for prey species (e.g., insects, aquatic species). Wildlife species may gain exposure to the contaminants through ingestion or transmission across the skin (e.g., amphibians have highly permeable skin). Bioaccumulation of pesticides and herbicides may increase susceptibility to pathogens and parasites and reduce fitness due to reproductive effects (Relyea 2005).

Model: This stressor was mapped in agricultural fields, as identified in SWReGAP vegetation layer.

Railroads

The influences of railroads are similar to those from "Roads for Motorized Vehicles." Railroads fragment the landscape, cause direct mortality, and cause behavioral changes from light and noise pollution.

Model: The influence of railroads was modeled with a 600 m radius kernel density. The effect of this is to create a gradient that is highest at the railroad and declines linearly with distance from the railroad. The assumption of this model is that the influence of railroads is very similar to roads.

Recreational Sites and Facilities

Pressure from the state's growing population to build new recreational sites and facilities and maintain existing ones may result in habitat loss and fragmentation. Ski resorts, marinas, golf courses, campgrounds, RV parks, race tracks, and designated OHV use areas are interconnected by a series of roads that bisect the landscape, thus increasing the difficulty for wildlife to disperse or access necessary resources.

Model: Ubiquitous. Currently there is no centralized data source from which to map this stressor at the statewide level. In 2007, The Department formed a partnership where Arizona State Parks (ASP) agreed to gather statewide data on open space and recreation areas. Since that time, limited resources have forced ASP to abandon that effort and the data appear to be lost. For now, the stressor is considered to be low level and statewide.

Scientific Research and Collection

Scientific research is often necessary in order to gain a better understanding of wildlife behavior and their associated habitat needs. It offers important information to wildlife managers as well. However, scientific research and collection may negatively influence SGCN and their habitats. High levels of habitat disturbance may result from frequent visits to study sites. Frequent or inappropriate handling of wildlife may induce stress or inadvertently spread disease. Consumptive sampling techniques have the potential to negatively influence communities by altering reproductive and mortality rates.

Model: Ubiquitous. This stressor is considered to be general, statewide, low intensity, and random. There is a concern for potential of this stressor in some high diversity areas, e.g., in southeastern Arizona, however the Department reviews Scientific Collecting Permit applications and can reduce collecting in potential high use areas through that permit process. Not modeled.

Streambank Alteration/Channelization

Human presence on the Arizona landscape has always required water sources to be modified to their use. Diversion of streams for agriculture occurred at least as early as the Hohokam and other early agriculturalists. In early settlement times, many wet meadows and cienegas were drained to create farms and pastures, or to use the water elsewhere. Reduction to risk from flooding has likewise been a concern, causing the human community to seek methods to restrict watercourses to pre-determined paths. Both of these trends have continued to modern times, sometimes being implemented on truly landscape scales, such as along the Colorado River in western Arizona. Historic flood-control efforts have reduced some once vital riparian systems to concrete-lined ditches without significant biotic components. Humans have thus changed the natural flow regimes of rivers and runoff. The results of these changes include loss of riparian habitat, drying of natural springs and seeps, modification of springheads, and depletion of groundwater supplies. Both wildlife and plant species experience severe habitat degradation and loss and may be unable to reproduce or persist. These altered ecosystems may promote nonnative species invasions or encroachment by non-riparian species. More recently, some softer approaches incorporate a desire to preserve biotic resource values, but often the constraints imposed to control flooding inherently limit the outcomes to levels of quality and quantity far below the historic values.

This stressor occurs where stream/river banks have been altered (e.g. rip-rap, soil cement, dredging) in an effort to confine a natural drainage to a particular channel to alleviate overbank flooding. Examples include the Rillito River and the Santa Cruz River through Tucson, or the Salt River through Phoenix.

Model: The stressor includes places where channelization has already occurred and where it likely could occur in the future. There is no existing state database but good data are available for

Pima County. The entire lower Colorado River is assumed to be channelized from Hoover Dam down, except for one unchannelized reach. Expert opinion was used to map other known areas of channelization of rivers and streams. In addition, all streams and rivers within 30 miles of the center of Phoenix and large washes within the Phoenix metropolitan area were considered to be channelized or altered. Linear channel features were buffered by 30 meters and appended to any polygon features. The resulting layer was rasterized with all affected areas given a value of 1.

Watercraft Operation

Arizona diverse waterways provide recreational boating enthusiasts with significant opportunities to operate both motorized and non-motorized watercraft. The attraction of Arizona's unique waterways consistently results in some of the highest boater use densities in the country, and boaters have access to some high quality wildlife riparian, reservoir and riverine areas. In addition, enhanced public access to previously inaccessible areas results in loss of undisturbed habitat for SGCN. Oily exhaust and fuel discharged from motorized watercraft decreases water quality and alters water chemistry. Wake and prop disturbance may alter habitat structure or physical characteristics to the detriment of SGCN. Noise and air pollution resulting from use of watercraft may also negatively influence fauna in surrounding ecosystems. Some watercraft operations may force wildlife to change behavioral and reproductive patterns. Further, both motorized and non-motorized watercraft represent significant vector opportunities for aquatic invasive species transportation and introduction.

Model: This stressor can occur in any lake or river where watercraft is used. Lakes and rivers that allow motorized watercraft were weighted 10 times the influence of non-motorized waters. This stressor includes any noise or light pollution associated with watercraft operation.

CLIMATE CHANGE

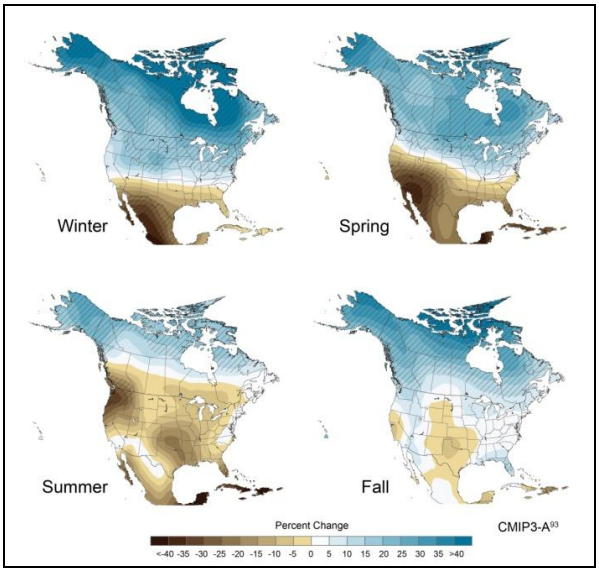


Figure 19. Projected seasonal changes in precipitation from 1961-1979 levels to 2080-2099 levels based on 15 climate change models. Image courtesy of U.S. Global Change Research Program (www. globalchange. gov)

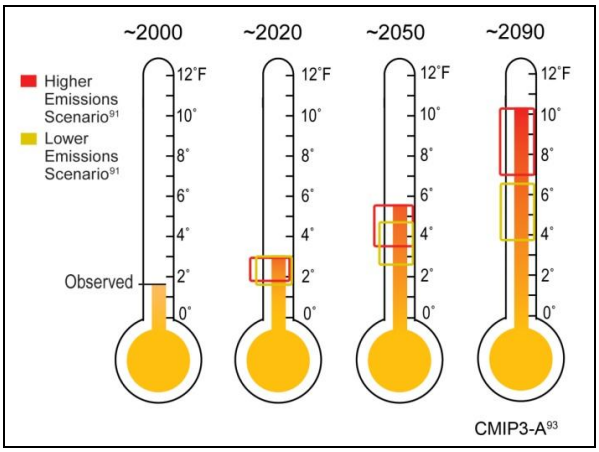


Figure 20. Projected temperature changes for the Southwest. The brackets on the thermometers represent the likely range of model predictions for two emission scenarios.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) published the fourth assessment report, Climate Change 2007, outlining the widespread consensus among the scientific community that global climate change is occurring; is driving observable changes on the landscape; and will bring even greater changes in the future (IPCC 2007c). The report states that global warming is unequivocal, and it contains detailed observational evidence from every continent and most oceans of measureable trends in air and water temperatures, sea levels, water cycles, severe weather events, and snow and ice cover on global and regional scales (IPCC 2007a).

Impacts to natural systems from climate change are well documented on a global scale but will vary regionally and are not as well defined at that scale. However, evidence is mounting that climate change in the western portion of North America, and particularly in the American Southwest, is proceeding at a faster rate than most of the continent (Figure 19) and see Overpeck and Udall 2010 for a review). Indeed, some areas have already experienced an increase in mean temperature of over 1 ^{o}C (1. 8 ^{o}F). This warming trend is expected to continue and accelerate into the next century with temperatures predicted to rise 4-5 °F by 2030 and 7-12 °F by 2090 (Figure 20, Sprigg et al. 2000).

This increase in temperature, coupled with a projected decrease in precipitation (Figure 21), will result in an even drier climate in southwestern North America (Archer and Predick 2008, Cayan et al. 2010, Seager and Vecchi 2010, Woodhouse et al. 2010,). These trends have already been shown to be driving a reduction in snow pack in the headwaters of the Colorado River, with a correspondingly lowered river flow (Pierce et al. 2008, Cayan et al. 2010). If this trend continues, there will be a decrease in water availability in a region where

water is already limited and is a vital resource for both aquatic and terrestrial species.

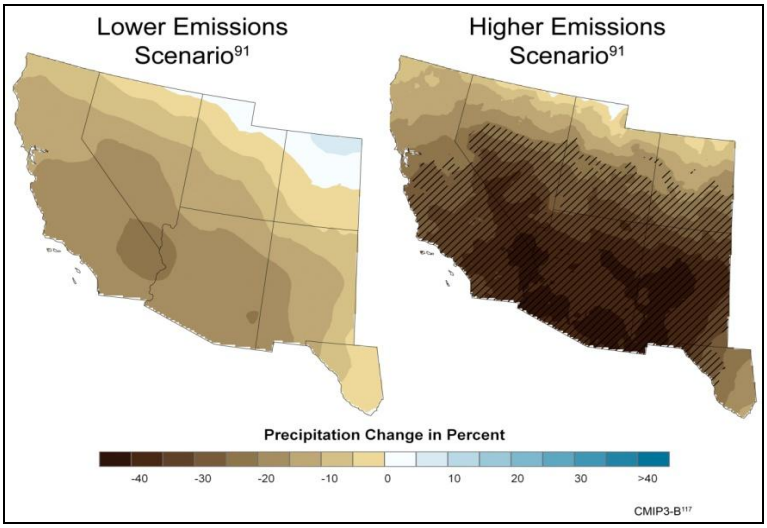


Figure 21. Projected precipitation changes for the Southwest from 1961-1979 levels to 2080-2099 levels under two emissions scenarios. Confidence in the projected changes is highest in the hatched areas. Image coutesy of U.S. Global Change Research Program (www.globalchange.gov)

Predicted changes in the seasonality of precipitation (Figure 19) may lead to a decoupling of biological processes such as food availability and reproductive timing. It may also lead to large scale ecosystem disruptions by affecting vegetation at the individual, population, or community levels (Weltzin and McPherson 1995, Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson et al. 1993). For example, in the arid Southwest, the distribution of plant communities are often driven by soil moisture gradients (Griffin 1977, Pigott and Pigott 1993, Klopatek et al. 1997). When periods of drought are exacerbated by the drying affects associated with climate change, vegetation communities throughout the region and in Arizona in particular, can be significantly affected. Recent research has shown that considerable vegetation changes have occurred in the past in relation to climate change and can be expected in Arizona's future (Betancourt 1990, Brown et al. 1997, Allen and Breshears 1998, Sprigg et al. 2000). In addition to direct effects of climate change, widespread mortality can also occur due to secondary effects such as altered fire regimes or precipitated insect infestations (Dale et al. 2001).

In addition, changes in seasonality can alter competitive interactions between species, thus changing community composition. For example, increases in winter precipitation favor tree establishment and growth at the expense of grasses (Bolin et al. 1986). Increased winter precipitation has also been shown to favor shrub expansion in areas of southeastern Arizona (Brown et al. 1997). These same authors documented major changes in population dynamics and community composition of animals on the study site—from local extinctions (including one keystone species) to decreases in formerly abundant species while other species increased in numbers. Increases in temperature and summer precipitation favor grasslands expanding into woodlands (Bolin et al. 1986). Recent research has linked the following to climate change in Arizona: changes in the phenology of flowering and distributional ranges of annuals species in the Santa Catalina Mountains; rapid and widespread mortality of pinyon pine and desert shrubs; and bark beetle eruptions (Crimmins et al. 2009, 2010, Breshears et al. 2005, McAuliffe and Hamerlynck 2010, Raffa et al. 2008, Williams et al. 2010). All of these indicate that large scale alterations to Arizona's habitats are already occurring, all of which can have serious consequences for wildlife.

The effects of climate change on animal populations and their habitats are expected to take many forms. The IPCC stated with "very high confidence" that both plant and wildlife species' ranges are projected to shift poleward and toward higher elevations (IPCC 2007b). However, migration of species ranges is only feasible if suitable habitat is both available and accessible. Many species will be unable to migrate due to landscape habitat fragmentation, loss of suitable habitat, lack of mobility, and/or because they are already at the extreme of some environmental gradient (e.g., they already live at the highest available elevation). In order to reduce their risk of extinction, species will need to have the ability to adjust their home ranges and distributions in a manner that allows them to keep up with the pace and scale of projected climate change (SCBD 2010). Indeed, the Secretariat of the Convention on Biological Diversity identified climate change as one of the five principle pressures driving the loss of biodiversity globally (SCBD 2010). Other changes we are likely to see include: changes in the timing of breeding seasons and migrations; disassembly of current ecosystems and biological communities, and formation of new ones; and altered occurrence of wildlife disease pathogens and invasive species (IPCC 2007b). "Adaptation" has been defined by the IPCC (2001) as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. And, in general, climate change will exacerbate many of the already existing stressors on ecosystems and their capacity for "adaptation" will be greatly affected by the intensity of other pressures that continue to be imposed (SCBD 2010).

Ironically, some of the strategies that society is adopting to address climate change may themselves put further stress on wildlife. The push for renewable energy development has resulted in over one million acres of land in Arizona being proposed for solar and/or wind energy development. The Department recognizes the need for generating electricity in a way that reduces carbon emissions and the release of other pollutants associated with fossil fuel generation, as well as the Nation's dependence on foreign oil. The Department supports the development of renewable energy facilities in Arizona, and is aware of significant benefits to Arizona's economy, the country, and the environment that building such facilities can provide.

However, the Department also recognizes that those same activities may have localized negative impacts on wildlife and the habitats on which they depend, and may affect the opportunity for activities such as hunting, fishing and wildlife viewing. These impacts may include, but are not limited to, the following:

- Wildlife mortality – from bird and bat collisions with wind turbine blades and meteorological towers, and as a direct result of construction
- Habitat loss and fragmentation – from the construction of large-scale utility solar facilities, new or expanded substations, new transmission lines and access roads
- Hydrologic impacts – from the construction of large impervious surface areas which block or reroute surface flows and the use of significant amounts of groundwater if using wet-cooled systems for turbines placed in already water-stressed systems

The complexity and number of uncertainties associated with climate change pose an unprecedented challenge to wildlife management agencies in planning for and addressing impacts to wildlife. A recent publication by the Association of Fish and Wildlife Agencies (AFWA 2009), recommends using an "adaptive" approach to deal with these issues. AFWA's recommended adaptive approach involves assessing existing conservation actions for their

effectiveness under both current and future climates. Further, in the national climate change strategy the USFWS discussed adaptation as planned, science-based management actions that can be taken to help reduce the impacts of climate change on fish, wildlife, and their habitats (USFWS 2010). The Department realizes that under current resource limitations the best strategy may be to increase resilience of species by reducing the impact of non-climate change stressors as resources and opportunities allow. The Department continues to be committed to conserving, enhancing, and restoring Arizona's wildlife and the habitats upon which they depend through aggressive protection and management programs, and to working with our partners to achieve those goals. That commitment extends to conserving wildlife and habitats by addressing direct ecological impacts of climate change and from the impacts of societal adaptations for climate change, including renewable energy generation, all of which is consistent with the USFWS' primary adaptation strategy: conservation of habitats necessary to conserve target populations and landscape-level ecological functions (USFWS 2010).

In order to achieve that commitment, the Department is engaged in many "no regrets" activities that although they address other specific conservation or management goals can also maintain healthy biological communities and landscapes, and therefore address climate change issues (AFWA 2009). Examples of these include: connecting landscapes to allow for wildlife movement; reducing the pressures from non-climate change stressors; restoring habitats and wildlife populations where appropriate; engaging in large scale watershed planning; surveying and monitoring wildlife populations to ensure population health and resilience; working towards endangered species recovery; providing information to be used in the development planning process to minimize impacts on wildlife; and educating the public about the importance of considering wildlife needs in all planning activities. In addition, this plan includes numerous actions designed to address climate change and its effects, both directly and indirectly, many of which can best be accomplished by our partners and the public (see Actions to Address Stressors).

The Department is also developing a series of planning tools, all of which are available at http://www.azgfd.gov/wildlifeplanning, including:

- Wildlife Friendly Guidelines (AGFD 2009a)
- Wind Energy Guidelines (AGFD 2008a)
- Solar Energy Guidelines (AGFD 2009b)
- Fencing, Culvert, and Bridge Guidelines
- The State Wildlife Action Plan System for Arizona
- Online Environmental Review Tool

The Online Environmental Review Tool (http://www.azgfd.gov/hgis/) provides information on known locations and status of Arizona's special status plant and wildlife species, and provides information and guideline links for incorporating wildlife conservation into project planning. This information can be used to guide preliminary decisions and assessments of proposed land and water development, management, and conservation projects. This tool provides a special status species list for Phase I Environmental Compliance and NEPA documents.

Despite all of these efforts, the Department is fully aware that there is far more work to be done, especially by filling in information gaps so that better decisions can be made. Specifically, research is needed to:

- Downscale global circulation models to a scale that is appropriate for making predictions at a regional and/or local level.
- Identify species and habitats that are most vulnerable to climate change and isolation.
- Develop monitoring protocols to capture the effects of climate change as they occur.
- Identify and protect important wildlife movement corridors.

However, we also recognize that availability of resources severely limit what we as an agency can accomplish alone. Hence, we rely on collaboration with our partners to undertake much of the work that is needed. The Department is actively engaged in a number of multi-partnered initiatives working to address climate change as outlined below, and will continue to engage with new initiatives as resources allow.

Arizona Wildlife Linkages Workgroup **–** Partnership of state, federal, and private organizations focusing on collaborating to identify and promote wildlife habitat connectivity opportunities for people and wildlife in Arizona and neighboring states.

Arizona Wildlife Connectivity Assessment – Multi-scale approach to wildlife corridor mapping that identifies and categorizes linkages around Arizona to promote a network of interconnected landscapes allowing for wildlife movement between crucial areas. Stakeholder and expert input is obtained for each county in Arizona and will be used to supplement corridor modeling.

Association of Fish & Wildlife Agencies – Climate Change Workgroup **-** Objective is to focus on improving the interaction and coordination between states in the adaptation planning process involved in creating practical wildlife management strategies for climate change.

Association of Fish & Wildlife Agencies – Climate Change Guidance **-** Provides voluntary guidance for state fish and wildlife agencies wanting to better incorporate the impacts of climate change on wildlife and their habitats in the SWAPs.

Department of the Interior – Landscape Conservation Cooperatives, Desert and Western Rockies – Management/science partnerships that inform integrated resource management actions addressing climate change and other stressors within and across landscapes. They will link science and conservation delivery. Landscape Conservation Cooperatives are designed to be true cooperatives, formed and directed by land, water, wildlife and cultural resource managers, and interested public and private organizations.

Department of the Interior – Southwest Climate Science Center **–** Based at the University of Arizona, the Southwest Climate Science Center will synthesize existing climate-change-impact data and management strategies, help resource managers put them into action on the ground, and engage the public through education initiatives.

Heinz Center, Bureau of Land Management and Arizona Game and Fish Department – Performance Measures for Western Wildlife Workshop – Objective was to design more effective

monitoring programs for the Department and its partners with a specific emphasis on monitoring the impacts of climate change.

The Nature Conservancy – Southwest Climate Change Initiative - Provides guidance to conservation practitioners and land managers in climate change adaptation planning and implementation on more local scales.

NatureServe (Doris Duke Charitable Foundation funded SWAP/Climate Change proposals) – Project has three components implemented through an overarching theme of climate change, including the integration of connectivity into SWAP revisions. Offer expertise to assist states in developing connectivity plans.

Northern Arizona University – Assessing the utility of existing corridor models through genetic analysis of population viability using habitat suitability and corridor design models developed by Dr. Paul Beier to provide implementation level recommendations for linkages based on species habitat suitability.

Sky Island Alliance – Climate Change Adaptation Project – Goal is to build a network (The Arizona Climate Change Network) of natural resource professionals, conservation organizations, landowners, and scientists that share a common interest in addressing the impacts of climate change by developing adaptation strategies at the local and regional level.

University of Arizona – Climate Assessment for the Southwest – Conducts research on the nature, causes, and consequences of climate change and variability in the southwestern United States.

USA National Phenology Network – Brings together citizen scientists, government agencies, non-profit groups, educators and students to monitor the impacts of climate change on plants and animals in the United States.

Western Association of Fish and Wildlife Agencies – Climate Change Committee – functions as WAFWA's principal forum for discussion, gathering information and/or identifying actions relative to all aspects of climate change as it related to fish and wildlife.

Western Governors Association – Climate Adaptation Group - Purpose is to 1) determine appropriate uses of climate adaptation modeling in informing natural resource and economic infrastructure planning and policies, and 2) to identify and fill existing gaps in climate adaptation efforts within Western Governors Association.

Western Regional Partnership – Provides a proactive and collaborative framework for senior-policy level Federal, State, and Tribal leadership to identify common goals and emerging issues. They have an indirect role in mitigating for climate change by addressing renewable energy implementation and wildlife corridors.

CONSERVATION ACTIONS

Active management to benefit species may be targeted towards individual species or at the habitats that they use. The Department developed priority conservation actions with the assumption that restoration of ecosystem structure, processes, and functions would have the most benefit for the most species. The primary mechanism to restore ecosystems is through removing or otherwise addressing the stressors to those systems. Hence, the Department developed numerous conservation actions that are specifically aimed at removing or alleviating the effect of stressors on the landscape and benefitting all species that inhabit that landscape.

All conservation activities include survey, monitoring, research, and other site and species management actions, as well as administrative, planning, and evaluation functions. Effective project administration requires the commitment of professional and administrative staff, who are responsible for conservation planning, project and budget management and supervision of staff. Therefore, in addition to performing general coordination and administrative duties, staff are responsible for data collection, analysis and management, they assist in the Department's three-tiered planning process, and develop and revise planning documents, permits, and annual performance reports relevant to SGCN management. To summarize SWAP-related activities and communicate that information to the public and scientific communities, staff attend or make presentations at conferences, training workshops, and other meetings, and produce technical reports, peer-reviewed and popular publications, etc.

It is also critically important to engage and provide technical assistance to internal and external partners, including environmental review, project evaluations, writing or revising recovery plans and addenda, status reviews, etc. This partner engagement also includes capacity building and professional training; the development of conservation strategies, assessments, and agreements to address the needs of non-listed species of concern; and recommendations and guidelines for the management of populations and their habitats. All of these activities involve participation on recovery teams, recovery implementation teams, advisory teams, habitat conservation planning teams, conservation teams, management oversight groups, technical advisory committees, and other entities convened to address conservation of federally-listed species and other species of concern to Arizona and México, and involve coordination with Canada, México, and other Latin American countries.

The following conservation actions that address stressors or address species and/or other taxa were developed by Department staff and cooperators to help meet recovery goals for ESA-listed species, conservation and research needs, to maintain habitat and populations, and to reduce or remove threats. Many of the actions identified under each of the stressors were either paraphrased from species recovery plans, conservation agreements, area management plans, conservation and outdoor education programs, or envisioned by staff, cooperators, experts, and the public. The actions identified under each stressor were considered feasible to implement, at least at some scale on the landscape or site of interest, and that most of these actions are intended to be implemented by Department cooperators, landowners, municipalities, and businesses. Many of these actions also appear in the Department's Online Environmental Review Tool as recommended actions to mitigate impacts due to project-specific stressors.

Among the SGCN in Arizona (listed in Appendix E:), the conservation actions for species and/or other taxa were developed by Department staff and prioritized for Tier 1A and 1B species, either as individual species or groups of related species projects. These projects and associated actions are identified in Department annual work plans and operational plans, developed in coordination with USFWS species leads. The actions that address species and/or other taxa are intended to be implemented by Department staff with assistance from agency cooperators and volunteers.

ACTIONS TO ADDRESS STRESSORS

Agricultural conversion

Acquire land or conservation easements to protect key conservation areas.
Assess the impacts of this activity on wildlife species.
Collaborate on public outreach, education, and incentive programs to encourage erosion control techniques on private lands.
Encourage low water use agriculture.
Encourage modification of water laws to incorporate groundwater with surface flow in quantifying water rights and use.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Increase public awareness on alternative methods to using fertilizers, pesticides, and other contaminants.
Increase public awareness on impacts of fertilizers, pesticides, and other contaminants on wildlife and their habitat.
Mitigate habitat loss from agricultural conversion and/or urban/rural development.
Promote organic agriculture and gardening practices that do not rely on chemical treatments.
Promote self-containing designs for high fertilizer use areas or filtration of nutrients.
Promote water conservation methods for business, agriculture, and residential use.
Protect and restore riparian areas.
Research the scope and magnitude of the impacts to wildlife.
Use alternative means for pest control (biocontrol, genetic control, management practices).
Use appropriate concentrations and types of pesticides, herbicides, or alternatives to control undesirable species, especially near sensitive habitat and watercourses.
Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.
Work with county agricultural extension agents and the NRCS to encourage wildlife-friendly buffers and habitat enhancements surrounding agricultural fields.

Air traffic corridors/overflights

Establish proper wildlife deterrent methods.
Establish, where necessary, advisory distances for air traffic corridors/overflights in critical wildlife habitats.
Inform and educate the public on potential negative impacts of low level overflights to wildlife.
Work with FAA to establish regulations limiting minimum height of private aircraft in natural areas.
Work with urban planners to ensure areas surrounding airfields do not attract large birds.

Altered Surface Hydrology

Create and maintain habitat improvement features for aquatic species.

Determine if adjusting dam operations to adjust water temperatures downstream is a benefit to native species.

Determine if modifying dam operations can simulate natural sediment transport and improve wildlife habitat.

Develop contingency plans for rapid salvage of wildlife populations threatened with extirpation in situations of imminent habitat loss.

Develop off-channel wetlands and backwaters along rivers to increase wildlife habitat.

Establish new wild and/or captive populations of SGCN wildlife.

Establish or revise laws and agency policies that protect instream flows to benefit wildlife and riparian habitat.

Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.

Incorporate stream morphology and wildlife habitat features in canals and flood control drainages.

Increase public awareness of water cycles, water tables, instream flow, proper stream morphology, and ecosystem functions.

Manage watersheds to maintain hydrological integrity and incorporate wildlife values.

Prevent or minimize recreational impacts in sensitive habitats.

Promote water conservation methods for business, agriculture, and residential use.

Promote water conservation methods in growth planning to develop sustainable water use.

Protect and restore springheads.

Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.

Protect sensitive habitats from excessive grazing.

Remove artificial stream barriers where appropriate.

Remove or modify unnecessary or inoperative dams or diversions.

Renovate/restore suppressed or extirpated native wildlife communities, habitats, and connectivity.

Survey for areas of suitable habitat for reestablishment of species.

Work with city and county planners to limit or prevent development in flood plains and areas that impact watershed integrity.

Work with land managers to develop and implement management plans that incorporate wildlife values.

Border Effects

Design lighting projects along the borderlands that minimize disturbance to wildlife, but meet the needs of the Department of Homeland Security.

Develop cooperative cleanup efforts along the border for the benefit of wildlife.

Encourage revegetation and restoration of existing unauthorized roads and trails.

Establish new wild and/or captive populations of SGCN wildlife.

Identify and protect key wildlife corridors for landscape connectivity.

Incorporate wildlife values in the design of road and trail networks in and around natural areas.

Increase enforcement of existing laws pertaining to the illegal harvest of wildlife.

Manage for vegetation types that reduce fuel loads and provide better wildlife habitat.

Restore natural fire regimes (frequency, intensity, and mosaic distribution) to improve wildlife habitat.

Retain and secure old mine adits and shafts for wildlife habitat (primarily for bats).

Use controlled burning to limit and reduce fuel loads and shrub invasion.
Use fencing and/or increased law enforcement presence to reduce unauthorized use and access to sensitive habitats.
Work with borderland agencies and landowners to minimize vandalism to livestock and wildlife water sources.
Work with Department of Homeland Security agencies to identify sensitive habitats, incorporate wildlife values, and mitigation actions for borderland management activities.
Work with land managers to develop and implement management plans that incorporate wildlife values.
Work with the Department of Homeland Security to design and construct wildlife-friendly border barriers.

Canals/pipelines

Advocate for and create new urban fishing opportunities.
Create barriers between susceptible native species and non-natives to reduce hybridization, predation, competition, and transmission of diseases, pathogens, and parasites.
Develop contingency plans for rapid salvage of wildlife populations threatened with extirpation in situations of imminent habitat loss.
Encourage proper maintenance and functioning of current pipelines.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Identify wildlife core habitats and corridors to avoid when installing new pipelines and canals.
Incorporate stream morphology and wildlife habitat features in canals and flood control drainages.
Manage so as to sustain or enhance native fish and sport fish populations.
Remove or modify unnecessary or inoperative dams or diversions.
Revegetate disturbed areas with native plants.
Use wetlands to buffer and filter contaminants from storm runoff and irrigation return water in and around urban/rural areas.

Climate change

Develop plans to conserve species of greatest conservation need that are not sufficiently addressed under existing plans.
Encourage research into mechanisms by which species are likely to respond to climate change.
Establish long-term species and native habitat monitoring.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Increase public awareness of the importance of energy conservation and efficiency.
Promote the use of rooftop solar or other alternative energy generation technologies that utilize previously disturbed and developed lands.
Support alternative energy and recycling efforts to reduce toxic by-products and wastes from traditional fuels and mineral extraction.
Support efforts to reduce emission of greenhouse gases.
Work with city and county planners to promote in-fill development and limit urban/rural sprawl.

Contaminants from mine tailings, waste water and runoff

Assess the impacts of this activity on wildlife species.
Cooperate with municipalities to develop waste management plans that incorporate wildlife values.
Ensure new and existing landfills are properly lined and sealed to prevent contaminating surrounding habitat and water resources.

Establish new wild and/or captive populations of SGCN wildlife.
Increase public awareness on alternative methods to using fertilizers, pesticides, and other contaminants.
Increase public awareness on impacts of fertilizers, pesticides, and other contaminants on wildlife and their habitat.
Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
Regulate and enforce use of containment measures for commercial operations to prevent toxins from polluting surrounding habitat.
Research the scope and magnitude of the impacts to wildlife.
Support alternative energy and recycling efforts to reduce toxic by-products and wastes from traditional fuels and mineral extraction.
Use wetlands to buffer and filter contaminants from storm runoff and irrigation return water in and around urban/rural areas.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.

Disease/pathogens/parasites

Adopt national standards and efforts to reduce and control invasive species.
Collaborate with partners on disease/pathogen/parasite issues to protect wildlife.
Establish new wild and/or captive populations of SGCN wildlife.
Evaluate regulations and policies for game farms/domestication of wildlife to ensure wild populations and habitats are protected.
Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.
Pursue projects to limit spread of disease/pathogens/parasites to sensitive wildlife populations.
Survey for diseases/pathogens/parasites in native wildlife populations.
Use appropriate measures to prevent transfer of diseases/pathogens/parasites during wildlife management activities.

Dispersed camping

Encourage responsible outdoor recreation through education (for example: "Stay on the Trails," "Leave No Trace," "Be Bear Aware," "Stop Aquatic Hitchhikers").
Increase enforcement for laws governing recreational activities.
Increase public awareness of dumping and littering impacts to wildlife and their habitat.
Increase public awareness of responsible camping practices (low impact camping).
Prevent or minimize recreational impacts in sensitive habitats.
Protect and restore riparian areas.
Protect and restore springheads.
Revegetate disturbed areas with native plants.

Domestication of wildlife/game farming

Adopt national standards and efforts to reduce and control invasive species.
Evaluate regulations and policies for game farms/domestication of wildlife to ensure wild populations and habitats are protected.
Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.
Manage so as to sustain or enhance native fish and sport fish populations.

Dredging

Evaluate the use of dredge material for use in establishing artificial wildlife habitat (islands, backwaters).

Drilling for fuels

Encourage design of extractive operations that minimizes disturbance to wildlife.

Drought

Continue with drought response planning relative to wildlife populations to ensure sustainability.

Design forest/woodland harvesting and management strategies that promote wildlife habitat diversity and connectivity.

Encourage development of water recycling systems/programs (effluent, storm water run-off) to increase the amount of water available to wildlife.

Encourage development of water use plans that protect instream flow.

Encourage proper functioning riparian areas and aquatic habitats as buffers against drought effects.

Encourage the utilization of native and low water use plants in landscaping.

Establish new wild and/or captive populations of SGCN wildlife.

Establish or revise laws and agency policies that protect instream flows to benefit wildlife and riparian habitat.

Increase public awareness of water cycles, water tables, instream flow, proper stream morphology, and ecosystem functions.

Manage upland watersheds to retain vegetation as a buffer against drought effects.

Manage watersheds to maintain hydrological integrity and incorporate wildlife values.

Promote adjustment of livestock management practices during droughts to ensure sufficient forage for wildlife.

Promote rainwater harvesting (i.e., rain barrels) for garden and landscape irrigation in urban settings.

Promote water conservation methods for business, agriculture, and residential use.

Promote water conservation methods in growth planning to develop sustainable water use.

Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.

Survey for areas of suitable habitat for reestablishment of species.

Work with city and county planners to limit or prevent development in flood plains and areas that impact watershed integrity.

Feral animals

Evaluate regulations and policies for game farms/domestication of wildlife to ensure wild populations and habitats are protected.

Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.

Increase public awareness on the impacts of releasing exotic species, pets, or livestock on wildlife and wildlife habitat.

Increase public awareness on the need to control feral animals.

Increase public education and enforcement of existing laws and promote more stringent laws prohibiting the release of domestic or exotic animals into the wild.

Reduce/eliminate the effects of feral animal populations in sensitive wildlife habitats or near wildlife populations of concern.

Work with city and county planners to incorporate wildlife values in urban/rural development plans.

Fishing line

Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.

Increase public awareness on the effects of improper disposal of fishing line.

Provide more wildlife proof waste receptacles in areas of public recreation.

Forest and woodland management

Design forest/woodland harvesting and management strategies that promote wildlife habitat diversity and connectivity.

Encourage design of extractive operations that minimizes disturbance to wildlife.

Establish new wild and/or captive populations of SGCN wildlife.

Implement watershed based approaches aimed at preventing excessive soil erosion.

Manage for vegetation types that reduce fuel loads and provide better wildlife habitat.

Promote guidelines for timber harvesting and associated road building that positively affect wildlife.

Reduce the density of undesirable trees and shrubs (selective thinning and eradication of tamarisk) to prevent crown fires and wildfires in riparian areas.

Restore natural fire regimes (frequency, intensity, and mosaic distribution) to improve wildlife habitat.

Use controlled burning to limit and reduce fuel loads and shrub invasion.

Use integrated management activities in concert to address invasive species.

Use integrated management activities in concert to address nuisance species.

Work with fire fighting services to develop fire management plans that minimize effects of fire retardants and water drawing on wildlife and wildlife habitats.

Grazing by ungulates

Develop and implement livestock and big game management guidelines that minimize habitat degradation while maintaining stock ponds where appropriate.

Disseminate information to partners on effects of grazing on resources.

Encourage proper functioning riparian areas and aquatic habitats as buffers against drought effects.

Encourage the use of livestock/wildlife drinkers to provide clean water and eliminate need for stock tanks that can support aquatic invasive species.

Encourage use of wildlife compatible fences.

Establish new wild and/or captive populations of SGCN wildlife.

Implement watershed based approaches aimed at preventing excessive soil erosion.

Manage upland watersheds to retain vegetation as a buffer against drought effects.

Modify grazing practices of grasslands to allow for natural fire regimes and reduction in undesirable vegetation.

Promote adjustment of livestock management practices during droughts to ensure sufficient forage for wildlife.

Protect and restore riparian areas.

Protect and restore springheads.

Protect sensitive habitats from excessive grazing.

Remove unnecessary fences and barriers to wildlife movement.

Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.

Work with land managers to develop and implement management plans that incorporate wildlife values.

Work with land managers to reduce or prevent high sedimentation of aquatic systems where appropriate.

Groundwater depletion and springhead use

Encourage gray water use.

Encourage low water use agriculture.

Encourage modification of water laws to incorporate groundwater with surface flow in quantifying water rights and use.
Encourage the utilization of native and low water use plants in landscaping.
Establish new wild and/or captive populations of SGCN wildlife.
Increase public awareness on the importance of conserving groundwater and springs for the benefit of wildlife.
Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
Promote legislation to increase water conservation.
Promote the use of rooftop solar or other alternative energy generation technologies that utilize previously disturbed and developed lands.
Promote water conservation methods for business, agriculture, and residential use.
Promote water conservation methods in growth planning to develop sustainable water use.
Protect and restore springheads.
Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.

Habitat degradation/shrub invasions

Develop and implement livestock and big game management guidelines that minimize habitat degradation while maintaining stock ponds where appropriate.
Establish new wild and/or captive populations of SGCN wildlife.
Modify grazing practices of grasslands to allow for natural fire regimes and reduction in undesirable vegetation.
Restore natural fire regimes (frequency, intensity, and mosaic distribution) to improve wildlife habitat.
Revegetate disturbed areas with native plants.
Use integrated management activities in concert to address invasive species.
Use integrated management activities in concert to address nuisance species.

Harvesting/collecting animals

Increase enforcement of existing laws pertaining to the illegal harvest of wildlife.
Increase public awareness of regulations pertaining to illegal harvest.

Highway/roadway de-icing

Use inert or non-polluting materials for roadway de-icing.

Hybridization

Address hybridization and replication of rare populations in watershed planning efforts.
Create barriers between susceptible native species and non-natives to reduce hybridization, predation, competition, and transmission of diseases, pathogens, and parasites.
Establish new wild and/or captive populations of SGCN wildlife.
Evaluate and modify Department regulations where appropriate.
Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.
Increase public awareness on the impacts of releasing exotic species, pets, or livestock on wildlife and wildlife habitat.
Increase public education and enforcement of rules and regulations on introducing and spreading invasive species.
Regulate or prohibit movement of species with high risk of hybridization with native species.
Remove species with high risk of hybridization with native species.
Renovate/restore suppressed or extirpated native wildlife communities, habitats, and connectivity.

Illegal dumping/littering

Cooperate with municipalities to develop waste management plans that incorporate wildlife values.

Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.

Increase public awareness of dumping and littering impacts to wildlife and their habitat.

Promote recycling to reduce contamination from landfills and mine operations.

Illegal stocking

Establish new wild and/or captive populations of SGCN wildlife.

Evaluate additional regional guidelines for use of different fishing baits and risks of bait-bucket dumping.

Evaluate and modify Department regulations where appropriate.

Increase public awareness on the impacts of releasing exotic species, pets, or livestock on wildlife and wildlife habitat.

Increase public education and enforcement of rules and regulations on introducing and spreading invasive species.

Renovate aquatic systems to remove undesirable species.

Insect Infestation

Design forest/woodland harvesting and management strategies that promote wildlife habitat diversity and connectivity.

Pursue projects to limit spread of disease/pathogens/parasites to sensitive wildlife populations.

Restore natural fire regimes (frequency, intensity, and mosaic distribution) to improve wildlife habitat.

Work with land managers to develop and implement management plans that incorporate wildlife values.

Invasive animal species

Adopt national standards and efforts to reduce and control invasive species.

Build a central database that identifies the distribution of aquatic invasive species in relation to sensitive habitats and wildlife of concern.

Conduct inspections at state borders to detect and prevent the spread of invasive plants and animals.

Create barriers between susceptible native species and non-natives to reduce hybridization, predation, competition, and transmission of diseases, pathogens, and parasites.

Develop guidelines for the elimination of invasive species and re-establishment of native assemblages.

Develop mechanisms to control or eliminate crayfish.

Develop strict guidelines which carefully evaluate native wildlife impacts before approval of exotic species introduction.

Eliminate bullfrogs where appropriate.

Encourage the use of livestock/wildlife drinkers to provide clean water and eliminate need for stock tanks that can support aquatic invasive species.

Establish new wild and/or captive populations of SGCN wildlife.

Evaluate and modify Department regulations where appropriate.

Evaluate, modify and ensure regulatory mechanisms are updated where appropriate (for example: restrictive live wildlife under Article 4 (ARS R12-4-406).

Identify watersheds and other conservation areas to prioritize renovation activities.

Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.

Increase public education and enforcement of rules and regulations on introducing and spreading invasive species.
Limit recreational and commercial use of crayfish and bullfrogs as fishing bait.
Manage so as to sustain or enhance native fish and sport fish populations.
Renovate aquatic systems to remove undesirable species.
Renovate/restore suppressed or extirpated native wildlife communities, habitats, and connectivity.
Support and participate in the multi-agency Governor's Invasive Species Task Force.
Survey for areas of suitable habitat for reestablishment of species.
Use integrated management activities in concert to address invasive species.

Invasive plant species

Adopt national standards and efforts to reduce and control invasive species.
Conduct inspections at state borders to detect and prevent the spread of invasive plants and animals.
Develop regulations on the sale and use of potentially invasive plants for landscaping, aquariums, and backyard ponds.
Develop strict guidelines which carefully evaluate native wildlife impacts before approval of exotic species introduction.
Eliminate invasive plant species (e.g., bufflegrass, fountain grass, etc.) from highway rights-of-way.
Encourage the utilization of native and low water use plants in landscaping.
Encourage volunteer groups to participate in invasive plant control projects.
Increase public education and enforcement of rules and regulations on introducing and spreading invasive species.
Limit extent and level of disturbance that promotes invasion and spread of invasive plants.
Revegetate disturbed areas with native plants.
Support and participate in the multi-agency Governor's Invasive Species Task Force.
Use certified weed-free straw or native vegetation for roadside erosion control.
Use integrated management activities in concert to address invasive species.

Landfills/dumps

Ensure new and existing landfills are properly lined and sealed to prevent contaminating surrounding habitat and water resources.
Improve public access and use of landfills to reduce illegal dumping.
Locate new landfills in appropriate locations that reduce impacts to wildlife and water sources.
Minimize wildlife access to landfills to discourage use as a source of food.
Promote recycling to reduce contamination from landfills and mine operations.
Regulate and enforce regulations that ensure allowable materials are disposed of properly based on landfill type (industrial waste, municipal waste, hazardous materials).
Use old pit mines as landfills, where appropriate.
Work with manufacturing and commercial industries to modify products and packaging to reduce disposable material and need for additional landfills.

Lead ammunition

Develop a self assessment for research needs and priorities.
Develop information and outreach materials on "other" messages associated with the ingested lead and wildlife issue.
Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.
Encourage proper disposal of animal and animal parts taken with the use of lead ammunition and establish regulations as appropriate.

Expand voluntary efforts to reduce the use of the lead ammunition condor efforts beyond big game.
Increase outreach to encouraging the use of non-lead ammunition.
Work with industry to develop standardized product labeling for non-lead ammunition, and to increase the development of less costly forms of nonlead ammunition.

Light pollution

Identify sites where light pollution affects wildlife.

Livestock management

Acquire land or conservation easements on portions of rangeland critical to wildlife.
Collaborate with partners on disease/pathogen/parasite issues to protect wildlife.
Develop and implement livestock and big game management guidelines that minimize habitat degradation while maintaining stock ponds where appropriate.
Encourage the use of livestock/wildlife drinkers to provide clean water and eliminate need for stock tanks that can support aquatic invasive species.
Encourage use of wildlife compatible fences.
Establish new wild and/or captive populations of SGCN wildlife.
Identify sensitive habitats and associated stressors in watershed planning efforts to prioritize conservation needs.
Protect and restore riparian areas.
Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.
Protect sensitive habitats from excessive grazing.
Pursue projects to limit spread of disease/pathogens/parasites to sensitive wildlife populations.
Remove unnecessary fences and barriers to wildlife movement.
Revegetate disturbed areas with native plants.
Use integrated management activities in concert to address invasive species.
Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.

Loss of keystone species

Develop and implement livestock and big game management guidelines that minimize habitat degradation while maintaining stock ponds where appropriate.
Develop plans to conserve species of greatest conservation need that are not sufficiently addressed under existing plans.
Implement recovery plans, habitat conservation plans, and other cooperative agreements for sustaining wildlife resources.
Manage habitat to maximize biodiversity by keeping common species common and protecting imperiled species.
Manage so as to sustain or enhance native fish and sport fish populations.
Protect and restore riparian areas.
Renovate aquatic systems to remove undesirable species.
Renovate/restore suppressed or extirpated native wildlife communities, habitats, and connectivity.
Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.

Management for game animals and sport fish

Develop and implement integrated fisheries management plans for watersheds (for native and sport fish).

Develop guidelines for the elimination of invasive species and re-establishment of native assemblages.
Develop guidelines to limit excessive habitat degradation or loss by managed game species.
Establish new wild and/or captive populations of SGCN wildlife.
Expand hatchery capabilities to propagate native species.
Incorporate ecosystem and community level concerns into operational plans.
Incorporate management needs for gartersnakes and other aquatic wildlife when planning sport fish management actions.
Manage so as to sustain or enhance native fish and sport fish populations.

Military activities

Work with military during on project evaluation.
Apply for military and related grants.

Mining

Establish new wild and/or captive populations of SGCN wildlife.
Incorporate wildlife values in planning and locations for new mines, associated structures, and leach fields.
Increase public awareness of wildlife impacts and benefits of mining operations.
Promote recycling to reduce contamination from landfills and mine operations.
Retain and secure old mine adits and shafts for wildlife habitat (primarily for bats).
Revegetate disturbed areas with native plants.

Motorized recreation off-trail

Encourage responsible outdoor recreation through education (for example: "Stay on the Trails," "Leave No Trace," "Be Bear Aware," "Stop Aquatic Hitchhikers").
Encourage revegetation and restoration of existing unauthorized roads and trails.
Incorporate wildlife values in the design of road and trail networks in and around natural areas.
Increase enforcement for laws governing recreational activities.
Increase public awareness of responsible OHV use and laws.
Increase public awareness on the negative effects of creation and use of unauthorized roads and trails for recreation.
Prevent or minimize recreational impacts in sensitive habitats.
Work with land managers to develop and implement management plans that incorporate wildlife values.

Non-motorized recreation off-trail

Clearly mark designated roads and trails for recreational users.
Encourage revegetation and restoration of existing unauthorized roads and trails.
Increase public awareness on the negative effects of creation and use of unauthorized roads and trails for recreation.
Prevent or minimize recreational impacts in sensitive habitats.
Seasonally close areas to recreational and commercial use when sensitive breeding wildlife are present.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.

Nutrients/algal blooms

Chemical and biological treatment of lakes (copper compounds, microbes, hay) to prevent and reduce algal blooms.
Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.

Encourage the utilization of native and low water use plants in landscaping.
Establish new wild and/or captive populations of SGCN wildlife.
Increase public awareness on impacts of fertilizers, pesticides, and other contaminants on wildlife and their habitat.
Promote self-containing designs for high fertilizer use areas or filtration of nutrients.
Use appropriate measures to prevent transfer of diseases/pathogens/parasites during wildlife management activities.
Use wetlands to buffer and filter contaminants from storm runoff and irrigation return water in and around urban/rural areas.

Pesticides/herbicides

Establish new wild and/or captive populations of SGCN wildlife.
Identify and use pesticides and herbicides that have limited negative impact to wildlife (a wildlife-safe label).
Increase public awareness on alternative methods to using fertilizers, pesticides, and other contaminants.
Promote organic agriculture and gardening practices that do not rely on chemical treatments.
Use alternative means for pest control (biocontrol, genetic control, management practices).
Use appropriate concentrations and types of pesticides, herbicides, or alternatives to control undesirable species, especially near sensitive habitat and watercourses.
Use wetlands to buffer and filter contaminants from storm runoff and irrigation return water in and around urban/rural areas.

Power/Telephone lines/cellular towers

Assess and implement current recommendations for power lines/wind-harnessing turbines/ telephone lines/cell phone towers/radio towers to minimize impacts to wildlife.
Develop guidelines for location and design of new infrastructure installations to minimize effects on wildlife and habitats.
Encourage use of underground power and telephone lines where feasible.
Prevent or minimize recreational impacts in sensitive habitats.

Railroads

Identify and protect key wildlife corridors for landscape connectivity.

Recreational sites/facilities

Benchmark and evaluate successful recreational management efforts in various parks, forests, rangelands, and private lands.
Conduct boat inspections at marina and boat launch ramps to detect and prevent the spread of aquatic invasive species.
Design recreation site management plans and policies that minimize impacts to wildlife and habitats.
Educate the public about maintaining sensitive habitat for wildlife.
Encourage gray water use.
Establish new wild and/or captive populations of SGCN wildlife.
Increase enforcement for laws governing recreational activities.
Increase public awareness on the impacts of releasing exotic species, pets, or livestock on wildlife and wildlife habitat.
Increase public awareness on the risks of wildlife transmitted diseases.
Manage watercraft recreation to reduce impacts to shoreline habitats and minimize disturbance to wildlife.

Support prevention of human-caused fire through enforcement of appropriate fire use regulations and education.
Use environmentally-friendly materials, landscaping, and structure designs for recreational sites.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.

Roads for motorized vehicles

Develop species-specific wildlife compatible fencing guidelines.
Eliminate invasive plant species (e.g., bufflegrass, fountain grass, etc.) from highway rights-of-way.
Encourage cooperative clean up efforts along highways through existing and new programs.
Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.
Encourage increased partnering and communication with transportation officials on projects that affect wildlife and their habitat.
Encourage maintenance of paved and unpaved roads in a manner that minimizes impacts on wildlife and wildlife habitats.
Encourage use of wildlife compatible fences.
Encourage wildlife friendly design for all road building.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Increase public awareness on the negative effects of feeding wildlife.
Promote design and construction of overpasses, underpasses or culverts to increase permeability of existing or planned roads.
Reduce sedimentation effects from road and trail construction.
Remove unnecessary fences and barriers to wildlife movement.
Support prevention of human-caused fire through enforcement of appropriate fire use regulations and education.
Use appropriate concentrations and types of pesticides, herbicides, or alternatives to control undesirable species, especially near sensitive habitat and watercourses.
Use certified weed-free straw or native vegetation for roadside erosion control.
Use exclusion fencing and other design features to funnel wildlife movement to existing underpasses, overpasses or culverts.
Use native plants for roadway landscaping and urban/rural developed areas.
Use seed traps along forest/woodland roads to prevent the spread of invasive plants.

Rural development

Acquire land or conservation easements to protect key conservation areas.
Encourage the utilization of native and low water use plants in landscaping.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Identify key conservation areas to protect from development.
Increase enforcement for laws governing recreational activities.
Increase public awareness of the importance of energy conservation and efficiency.
Increase public awareness of water cycles, water tables, instream flow, proper stream morphology, and ecosystem functions.
Increase public education and enforcement of existing laws and promote more stringent laws prohibiting the release of domestic or exotic animals into the wild.
Mitigate habitat loss from agricultural conversion and/or urban/rural development.

Promote establishment and protection of green belts and other preserves including terrestrial and aquatic corridors.
Promote legislation to increase water conservation.
Promote the use of rooftop solar or other alternative energy generation technologies that utilize previously disturbed and developed lands.
Promote urban growth planning initiatives that protect instream flow or acquire water rights (through purchase, conservation agreement, etc.).
Protect and restore riparian areas.
Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.
Renovate aquatic systems to remove undesirable species.
Use environmentally-friendly materials, landscaping, and structure designs for rural development.
Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.
Work with city and county planners to promote in-fill development and limit urban/rural sprawl.

Scientific research and collection

Collaborate with partners to evaluate effects of capture and sampling techniques on wildlife.
Evaluate and modify Department regulations where appropriate.
Work through Scientific Collecting Permit process to reduce unintended cumulative effects on wildlife.

Sediment/ash flows

Determine if modifying dam operations can simulate natural sediment transport and improve wildlife habitat.
Develop contingency plans for rapid salvage of wildlife populations threatened with extirpation in situations of imminent habitat loss.
Develop plan to repatriate native species on an opportunistic basis (e.g. after catastrophic event flushes system).
Establish new wild and/or captive populations of SGCN wildlife.
Manage for vegetation types that reduce fuel loads and provide better wildlife habitat.
Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
Protect and restore riparian areas.
Revegetate disturbed areas with native plants.
Work with land managers to develop and implement management plans that incorporate wildlife values.
Work with land managers to reduce or prevent high sedimentation of aquatic systems where appropriate.

Soil erosion

Establish new wild and/or captive populations of SGCN wildlife.
Implement 'Best Management Practices' when building roads or other infrastructure (dams, mines, developments, etc.).
Implement watershed based approaches aimed at preventing excessive soil erosion.
Install streambank stabilization structures or habitat features to reduce erosion and loss of sediment.
Manage for vegetation types that reduce fuel loads and provide better wildlife habitat.
Promote guidelines for timber harvesting and associated road building that positively affect wildlife.
Protect and restore riparian areas.

Revegetate disturbed areas with native plants.
Survey for areas of suitable habitat for reestablishment of species.
Train resource managers, developers, and private landowners in ways to minimize soil erosion and improve habitat.
Work with land managers to develop and implement management plans that incorporate wildlife values.

Solar energy development

Develop or implement existing guidelines for location and design of new infrastructure installations to minimize effects on wildlife and habitats.
Enforce regulatory mandates on the loss of native wildlife and their habitats.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Identify problem areas and retrofit existing problem structures to minimize affects on wildlife.
Increase public awareness of the importance of energy conservation and efficiency.
Limit access and use of utility maintenance roads for official use when other adequate access exists or is not desirable.
Promote the use of rooftop solar or other alternative energy generation technologies that utilize previously disturbed and developed lands.

Streambank alteration/channelization

Establish new wild and/or captive populations of SGCN wildlife.
Establish or revise laws and agency policies that protect instream flows to benefit wildlife and riparian habitat.
Incorporate stream morphology and wildlife habitat features in canals and flood control drainages.
Increase public awareness of water cycles, water tables, instream flow, proper stream morphology, and ecosystem functions.
Manage watersheds to maintain hydrological integrity and incorporate wildlife values.
Prevent or minimize recreational impacts in sensitive habitats.
Promote water conservation methods for business, agriculture, and residential use.
Promote water conservation methods in growth planning to develop sustainable water use.
Protect and restore riparian areas.
Protect sensitive habitats from excessive grazing.
Renovate/restore suppressed or extirpated native wildlife communities, habitats, and connectivity.
Survey for areas of suitable habitat for reestablishment of species.
Work with city and county planners to limit or prevent development in flood plains and areas that impact watershed integrity.
Work with other agencies to employ new techniques in lieu of traditional stream bank armoring and flood control measures.

Unauthorized roads & trails

Encourage responsible outdoor recreation through education (for example: "Stay on the Trails," "Leave No Trace", "Be Bear Aware", "Stop Aquatic Hitchhikers").
Encourage revegetation and restoration of existing unauthorized roads and trails.
Establish new wild and/or captive populations of SGCN wildlife.
Incorporate wildlife values in the design of road and trail networks in and around natural areas.
Increase enforcement for laws governing recreational activities.
Increase public awareness of responsible OHV use and laws.

Increase public awareness on the negative effects of creation and use of unauthorized roads and trails for recreation.
Use fencing and/or increased law enforcement presence to reduce unauthorized use and access to sensitive habitats.

Unnatural fire regimes

Design fire management plans and wildland/urban interface policies that consider wildlife values.
Develop contingency plans for rapid salvage of wildlife populations threatened with extirpation in situations of imminent habitat loss.
Eliminate invasive plant species (e.g., bufflegrass, fountain grass, etc.) from highway rights-of-way.
Encourage the utilization of native and low water use plants in landscaping.
Establish new wild and/or captive populations of SGCN wildlife.
Incorporate wildlife values in the design of road and trail networks in and around natural areas.
Manage for vegetation types that reduce fuel loads and provide better wildlife habitat.
Modify grazing practices of grasslands to allow for natural fire regimes and reduction in undesirable vegetation.
Reduce salt cedar and exotic grasses to improve recolonization of native vegetation.
Reduce the density of undesirable trees and shrubs (selective thinning and eradication of tamarisk) to prevent crown fires and wildfires in riparian areas.
Support prevention of human-caused fire through enforcement of appropriate fire use regulations and education.
Use certified weed-free straw or native vegetation for roadside erosion control.
Use controlled burning to limit and reduce fuel loads and shrub invasion.
Use integrated management activities in concert to address invasive species.
Work with land managers to develop and implement management plans that incorporate wildlife values.

Urban growth

Acquire land or conservation easements to protect key conservation areas.
Assess the impacts of this activity on wildlife species.
Create and maintain habitat improvement features for aquatic species.
Encourage the utilization of native and low water use plants in landscaping.
Establish new wild and/or captive populations of SGCN wildlife.
Identify and protect key wildlife corridors for landscape connectivity.
Identify key conservation areas to protect from development.
Increase enforcement for laws governing recreational activities.
Increase public awareness of the effects of human activities and infrastructure on wildlife habitat fragmentation.
Increase public awareness of the importance of energy conservation and efficiency.
Increase public awareness of water cycles, water tables, instream flow, proper stream morphology, and ecosystem functions.
Increase public education and enforcement of existing laws and promote more stringent laws prohibiting the release of domestic or exotic animals into the wild.
Promote establishment and protection of green belts and other preserves including terrestrial and aquatic corridors.
Promote legislation to increase water conservation.
Promote the use of rooftop solar or other alternative energy generation technologies that utilize previously disturbed and developed lands.

Promote urban growth planning initiatives that protect instream flow or acquire water rights (through purchase, conservation agreement, etc.).
Protect and restore riparian areas.
Protect instream flow or acquire water rights (through purchase, conservation agreement, etc.) to benefit wildlife habitat.
Renovate aquatic systems to remove undesirable species.
Research the scope and magnitude of the impacts to wildlife.
Work cooperatively with landowners/permittees and NRCS by providing financial and technical assistance (thru incentive programs) to conservation projects.
Work with city and county planners to incorporate wildlife values in urban/rural development plans.
Work with city and county planners to promote in-fill development and limit urban/rural sprawl.

Watercraft operation

Conduct boat inspections at marina and boat launch ramps to detect and prevent the spread of aquatic invasive species.
Cooperate with municipalities to develop waste management plans that incorporate wildlife values.
Encourage cooperative clean up efforts of aquatic and terrestrial wildlife habitats through existing and new programs.
Incorporate wildlife needs in aquatic vegetation removal efforts.
Increase enforcement for laws governing recreational activities.
Increase public awareness of dumping and littering impacts to wildlife and their habitat.
Increase public awareness on the impacts of watercraft and watercraft operating practices to wildlife and wildlife habitat.
Increase public education and enforcement of rules and regulations on introducing and spreading invasive species.
Install designated, concrete watercraft launch ramps to minimize shoreline habitat degradation.
Install washdown stations to prevent spread of aquatic invasive species.
Manage watercraft recreation to reduce impacts to shoreline habitats and minimize disturbance to wildlife.
Prevent or minimize recreational impacts in sensitive habitats.
Promote integrated aquatic plant management strategies.
Promote the "Boating Access Grant Program" to help fund development of launch ramps, information kiosks, and restrooms.
Promote the "Clean Vessel Act Grant Program" to develop sanitary waste pump-out and dump stations.
Require use of established launch ramps for watercraft put in/take out.

Wind energy development

Assess and implement current recommendations for power lines/wind-harnessing turbines/ telephone lines/cell phone towers/radio towers to minimize impacts to wildlife.
Develop guidelines for location and design of new infrastructure installations to minimize effects on wildlife and habitats.
Encourage use of underground power and telephone lines where feasible.
Identify problem areas and retrofit existing problem structures to minimize affects on wildlife.
Limit access and use of utility maintenance roads for official use when other adequate access exists or is not desirable.

EXAMPLES OF ACTIONS TO ADDRESS SELECT SPECIES AND/OR OTHER TAXA*

*These are provided as examples only and are not intended to be all inclusive. The absence of information below should not restrict otherwise eligible work from SWG grants.

Nongame Crustacean and Mollusk Species/Project Information

California Floater

Project Description: Administration, planning and implementation of conservation actions for Arizona's only native freshwater mussel, the California floater.

Project activities include:

- Provide input on species status reviews.
- Coordinate efforts with partners.
- Develop funding proposals, write briefings.
- Monitor wild populations.
- Survey potential and historic habitat.
- Control and eradicate invasive exotic competitors and predators.
- Conduct research into genetics and taxonomy.
- Conduct research into captive propagation and rearing.
- Review feasibility of reintroducing wild caught or captive progeny back into suitable habitat or refugia.

Kanab Ambersnail and Niobrara Ambersnail

Project Description: Administration, planning and implementation of conservation actions for Kanab ambersnail (ESA-listed endangered) and Niobrara ambersnail in Grand Canyon and vicinity.

Project activities include:

- Provide input on species status reviews.
- Revise and implement the 2002 Interim Conservation Plan and species management objectives for the Glen Canyon Dam Adaptive Management Program.
- Coordinate efforts with partners.
- Develop funding proposals.
- Monitor wild and translocated populations.
- Survey potential habitat.
- Salvage habitat and populations at risk.
- Reintroduce ambersnails into historic range to establish new wild and captive populations.
- Augment stock of translocated populations to maintain genetic variability.

Page Springsnail

Project Description: Administration, planning and implementation of conservation actions for Page Springsnail (ESA candidate) in the Verde Valley area.

Project activities include:

- Provide input on species status reviews.
- Implement the CCAA.
- Coordinate efforts with partners.
- Develop funding proposals.
- Monitor wild populations.
- Survey potential habitat.
- Support research on genetics/taxonomy and captive propagation.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Reintroduce springsnails into historic range to repatriate extirpated sites and establish new wild and captive populations. Augment stock of translocated populations to maintain genetic variability.

San Bernardino Springsnail

Project Description: Administration, planning and implementation of conservation actions for San Bernardino springsnail (ESA candidate) in southeastern Arizona.

Project activities include:

- Provide input on species status reviews.
- Coordinate efforts with partners.
- Develop funding proposals, write briefings.
- Survey potential and historic habitat.
- Conduct research into genetics and taxonomy.
- Review feasibility of reintroducing wild stock from Sonora, México, back into suitable habitat or refugia in Arizona.

San Xavier Talussnail

Project Description: Administration, planning and implementation of conservation actions for San Xavier talussnail at White Hill, southwest of Tucson.

Project activities include:

- Provide input on species status reviews.
- Revise and implement the conservation agreement.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild populations.
- Survey potential habitat.

Three Forks Springsnail

Project Description: Administration, planning and implementation of conservation actions for Three Forks Springsnail (ESA candidate).

Project activities include:

- Provide input on species status reviews.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild populations.
- Survey potential habitat.
- Support research on genetics/taxonomy and captive propagation.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Review the feasibility of reintroducing springsnails into historic range to repatriate extirpated sites and establish new wild and captive populations.

Wet Canyon Talussnail (and other landsnails of the Pinaleno Mountains)

Project Description: Administration, planning and implementation of conservation actions for Wet Canyon talussnail and other landsnails of the Pinaleno Mountains.

Project activities include:

- Provide input on species status reviews.
- Revise and implement the conservation agreement.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild populations.
- Survey potential habitat.

Remaining SGCN Mollusks in Arizona

Project Description: Administration, planning and implementation of conservation actions for various mollusks statewide that are SGCN (Tier 1A and 1B).

Project activities include:

- Provide input on species status reviews.
- Coordinate efforts with partners.
- Develop funding proposals, write briefings.
- Inventory to collect baseline information on status and distribution.
- Monitor wild populations.
- Survey potential habitat.

Nongame Native Fish Species/Project Information

Gila chub

Project Description: Administration, planning and implementation of recovery actions for Gila chub (ESA endangered).

Project activities include:

- Input on species status review.
- Create recovery plan.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and captive populations.
- Survey potential habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild populations.
- Augment stock of translocated populations to maintain genetic variability.

Little Colorado Spinedace

Project Description: Administration, planning and implementation of recovery actions for Little Colorado spinedace (ESA threatened).

Project activities include:

- Provide input on species status reviews.
- Revise recovery plan.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and captive populations.
- Survey potential habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild populations.
- Augment stock of translocated populations to maintain genetic variability.

Loach Minnow and Spikedace

Project Description: Administration, planning and implementation of recovery actions for loach minnow and spikedace (ESA endangered).

Project activities include:

- Provide input on species status reviews.

- Revise recovery plans.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and captive populations.
- Survey potential habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild populations
- Augment stock of translocated populations to maintain genetic variability.

Topminnow and Pupfish

Project Description: Administration, planning and implementation of recovery actions for Gila topminnow, Yaqui topminnow, desert pupfish, and Quitobaquito (Río Sonoyta) pupfish (all ESA endangered).

Project activities include:

- Provide input on species status reviews.
- Revise recovery plans.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and captive populations.
- Survey potential habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat of fish for translocation.
- Reintroduce fish into historic range to establish new wild and captive populations.
- Augment stock of translocated populations to maintain genetic variability.

Virgin River Fishes

*Project Description***:** Administration, planning and implementation of recovery actions for Virgin chub (ESA endangered), woundfin (ESA endangered), Virgin River spinedace (ESA candidate, protected under a signed conservation agreement), and other SGCN native fishes in the Virgin River drainage.

Project activities include:

- Provide input on species status reviews.
- Revise recovery plans.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild populations.
- Survey habitat.

- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild populations.
- Augment stock of translocated populations to maintain genetic variability.

Yaqui Drainage Fishes and Sonora Chub

Project Description: Administration, planning and implementation of recovery actions for fishes native to the Río Yaqui drainage, including Yaqui chub and Yaqui topminnow (ESA endangered), Yaqui catfish and beautiful shiner (ESA threatened), Mexican stoneroller, and other native fishes endemic to the drainage; and Sonora chub (ESA threatened) endemic to the Río de la Concepción drainage.

Project activities include:

- Provide input on species status reviews.
- Revise recovery plans and review safe harbor agreements.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild populations.
- Survey habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild populations.
- Augment stock of translocated populations to maintain genetic variability.

Big River Native Fishes

Project Description: Administration, planning and implementation of conservation actions for the following big river native fishes: humpback chub, bonytail, razorback sucker, and Colorado pikeminnow (all ESA endangered).

Project activities include: Implement the Lower Colorado River Multi-Species Conservation Program, Glen Canyon Dam Adaptive Management Program, and Central Arizona Project Gila River Basin Native Fishes Conservation Program research and management goals for these species,

- Provide input on species status reviews.
- Revise species recovery plans.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and translocated populations.
- Survey potential habitat.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.

- Review the feasibility of reintroducing into historic range to establish new wild and captive populations.
- Augment stock of translocated populations to maintain genetic variability.

Statewide Conservation Agreement and Strategy 6-Species of Suckers and Chubs

Project Description: Administration, planning and implementation of conservation actions under the Statewide Conservation Agreement and Strategy for roundtail chub, headwater chub, Zuni bluehead sucker (all ESA candidates), and bluehead sucker, flannelmouth sucker, and Little Colorado sucker.

Project activities include:

- Provide input on species status reviews.
- Revise conservation agreements.
- Coordinate efforts with partners.
- Develop funding proposals, write technical reports and briefings.
- Monitor wild and captive populations.
- Survey potential habitat.
- Control and eradicate invasive exotic competitors and predators.
- Salvage populations at risk.
- Quarantine and disease treat fish for translocation.
- Reintroduce fish into historic range to establish new wild and captive populations.
- Augment stock of translocated populations to maintain genetic variability.

Remaining SGCN Native Fishes

Project Description: Administration, planning and implementation of conservation actions for various native fishes statewide that are SGCN Tier 1B.

Project activities include:

- Provide input on species status reviews.
- Coordinate efforts with partners.
- Develop funding proposals, write briefings.
- Inventory to collect baseline information on status and distribution.
- Monitor wild populations.
- Survey potential habitat.

Nongame Amphibian and Reptile Species/Project Information

Arizona Treefrog (Huachuca-Canelo Hills DPS) Conservation

Project Description: Administration, planning and implementation of priority conservation activities for the Arizona treefrog Huachuca-Canelo Hills Distinct Population Segment (DPS) (ESA candidate). The Department is committed to coordinate and implement conservation

activities, and staff work with partners to develop work plans, and coordinate and implement priority conservation activities as appropriate and feasible.

Project activities include: Coordinate with partners to achieve conservation goals for Arizona treefrogs in the Canelo Hills and Huachuca Mountains area. Document the current status of Arizona treefrogs in the Huachuca Mountains and Canelo Hills, by gathering information on historical and present distributions, population and metapopulation dynamics, disease, causes of declines, ecology and general natural history. Using this information, develop and implement recommendations on land-use practices and policies to halt or slow further population declines.

- Survey extant populations or historical localities for Arizona treefrogs in the Huachuca Mountains, Canelo Hills and vicinity to determine status or to identify conservation opportunities.
- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from Arizona treefrog breeding sites and nearby habitats as needed for conservation. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.
- Continue to monitor the current distribution of chytrid fungus in populations of Arizona treefrogs. Opportunistically collect skin swabs for disease analysis from animals in the wild.

Chiricahua Leopard Frog Recovery

Project Description: Administration, planning and implementation of priority recovery activities for Chiricahua leopard frogs (ESA threatened), designed to document progress in meeting Recovery Goals and achieving the de-listing criteria.

Actions are designed to meet the following recovery criteria identified in the recovery plan: 1) Establish at least two metapopulations and one isolated and robust population in each of seven Arizona Recovery Units (RU) which are defined by geography, hydrography, land management and ownership, and threats; 2) Protect and manage aquatic breeding habitats; 3) Protect and manage additional habitat needed for population connectivity, recolonization, and dispersal; 4) Reduce or eliminate threats and causes of decline, and ensure commitments are in place for long-term management in each RU.

The Department is the lead or co-lead for the Chiricahua leopard frog Recovery Team, two Chiricahua leopard frog recovery steering committees (Mogollon Rim and Southeastern Arizona-Southwestern New Mexico), and several local recovery groups. We staff, organize, and lead meetings; and work with partners to develop and implement work plans, etc.

Project activities include: Implement activities outlined in the recovery plan. Meet with Recovery Team, steering committees, and local recovery groups to develop work plans to implement activities outlined in the recovery plan.

- Engage landowners to enroll high priority properties in the Safe Harbor Agreement (includes site evaluation).
- Establish Safe Harbor populations and Certificates of Inclusion when deemed appropriate.

- Survey sites to identify recovery opportunities, threats, and new Chiricahua leopard frog populations.
- Monitor actively managed recovery areas to determine status and evaluate success.
- Continue collaborative efforts to maintain existing and establish new captive colonies and facilities to rear or headstart Chiricahua leopard frogs.
- Establish or augment populations at one or more sites, which includes: site selection, evaluation, renovation (if necessary), and collection, propagation and release of frogs, eggs or tadpoles.
- Implement and assist cooperators in invasive bullfrog eradication and control efforts at selected high priority Chiricahua leopard frog recovery sites, monitor effectiveness of bullfrog removal efforts, and train Department staff and cooperators in bullfrog removal methods.
- Continue to monitor the current distribution of amphibian chytrid fungus. Opportunistically collect skin swabs for PCR to detect chytrid fungus from animals in the wild and in captive populations.
- Provide professional training to individuals who will conduct certified surveys for Chiricahua leopard frogs

Northern Leopard Frog Conservation

Project Description: Administration, planning and implementation of priority conservation activities for northern leopard frog. This species was petitioned for listing under ESA in 16 western U.S. states, but the USFWS determined listing was not warranted; analyses are ongoing. Nonetheless, this species has experienced serious declines in Arizona and the Department is committed to its conservation.

Project activities include: Coordinate with partners to achieve conservation goals for northern leopard frogs. Staff organize and lead meetings, work with partners to develop work plans, implement work plans, etc. Document the current status of Northern leopard frogs in Arizona, by gathering information on historical and present distributions, population and metapopulation dynamics, disease, causes of declines, ecology and general natural history. Using this information, develop and implement recommendations on land-use practices and policies to halt or slow further population declines.

- Survey sites to identify new northern leopard frog populations, threats, and conservation opportunities.
- Monitor populations of northern leopard frogs to determine status and to evaluate success of management actions.
- Evaluate sites for stocking or augmentation on Apache-Sitgreaves, Coconino, and Kaibab national forests, BLM, Arizona State Land Department, Department properties, and private lands.
- Develop refugia and rearing facilities as needed.
- Establish or augment northern leopard frog populations at one or more sites, which includes: site selection, evaluation, and site renovation (if necessary), and collection, propagation and release of frogs, eggs or tadpoles.

- Implement and assist cooperators in invasive bullfrog eradication and control efforts at selected high priority northern leopard frog conservation sites, monitor effectiveness of bullfrog removal efforts, and train Department staff and cooperators in bullfrog removal methods.
- Continue to monitor the current distribution of amphibian chytrid fungus. Opportunistically collect skin swabs for disease analysis from animals in the wild and in captive populations.

Relict Leopard Frog Conservation

Project Description: Administration, planning and implementation of priority conservation activities for relict leopard frog (ESA candidate). Department staff provide leadership on the Relict Leopard Frog Conservation Team, organize and lead meetings, work with partners to develop work plans, and coordinate and implement priority conservation activities, etc.

Project activities include: Coordinate with partners to achieve conservation goals for relict leopard frogs. Coordinate and meet twice a year with Relict Leopard Frog Conservation Team, and implement activities and achieve goals outlined in the Conservation Agreement and Rangewide Conservation Assessment and Strategy.

- Survey sites to identify threats, new relict leopard frog populations, and conservation opportunities.
- Establish relict leopard frogs in the Black Mountains and on the Arizona Strip, which includes possible habitat renovation, collecting frogs, tadpoles or eggs, propagation, and translocation.
- Monitor re-established populations 2-4 times per year to determine status and trends, and to evaluate success of management actions.
- Evaluate additional sites for stocking or augmentation.
- Document progress in meeting the goals of the Conservation Agreement and Rangewide Conservation Assessment and Strategy.
- Where necessary, implement and assist cooperators in invasive bullfrog eradication and control efforts at selected high priority relict leopard frog conservation sites, monitor effectiveness of bullfrog removal efforts, and train Department staff and cooperators in bullfrog removal methods.
- Continue to monitor the current distribution of amphibian chytrid fungus. Opportunistically collect skin swabs for disease analysis from animals in the wild and in captive populations.

Sonora Tiger Salamander Recovery

Project Description: Administration, planning and implementation of priority recovery activities for Sonora tiger salamander (ESA endangered), designed to document progress in meeting Recovery Goals and achieving the down-listing, and eventually, de-listing criteria.

Actions are designed to meet the following down-listing criteria identified in the recovery plan: 1) Approximately 90% of salamander's currently-occupied range and approximately 90% of current breeding ponds are protected and maintained to prevent habitat loss and degradation, are

free from introduced fish and crayfish, and protected from barred tiger salamander introductions, and collection of salamanders for bait; 2) Monitoring over a five year period must indicate that the number of Sonora tiger salamander populations is not in decline and that there are no new factors that threaten the persistence of Sonora tiger salamanders.

The Department is the co-lead for the Sonora Tiger Salamander Participation Team; staff help to organize and lead meetings, work with partners to develop work plans, etc.

Project activities include: Meet with Recovery Team to develop work plans to implement activities outlined in the recovery plan (once per-year). Implement activities outlined in the recovery plan.

- Continue to monitor extant and potential breeding sites for the 10-year occupancy protocol, and to document occurrence and reproductive success (including metamorphosis), and to identify presence of disease.
- Implement or assist outside cooperators in studies of demography, dispersal, conservation genetics, disease, distribution, natural history, etc.
- Implement management strategies including, habitat enhancement and renovation.
- Collect salamanders exhibiting disease symptoms for examination. Collect water and substrate samples as needed for analysis. Analyze dead or moribund animals for disease factors.
- Continue to monitor the current distribution of amphibian chytrid fungus and ranavirus in populations of Sonoran tiger salamanders. Opportunistically collect skin swabs for disease analysis from animals in the wild and in captive populations.
- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from Sonoran tiger salamander breeding sites and nearby habitats as needed for conservation. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.

Tarahumara Frog Conservation

Project Description: Administration, planning and implementation of priority conservation activities for Tarahumara frogs. This species was extirpated from Arizona in the late 1970s – early 1980s, and reintroduced into historical range in Arizona in 2004. The Department is the co-lead for the Tarahumara Conservation Team. Staff organize and lead meetings, work with partners to develop work plans and coordinate and implement priority conservation activities, etc.

Project activities include: Coordinate and meet with the Tarahumara Conservation Team twice a year. Develop work plans, coordinate and implement activities that will achieve conservation goals outlined in the Tarahumara frog 12-Step Re-establishment Procedure, and document progress in meeting the goals of the 12-step Re-establishment Proposal.

- Monitor extant populations of Tarahumara frogs to determine status and trends, and to evaluate success of management efforts.
- Evaluate additional sites in which to reestablish Tarahumara frogs.
- Continue collaborative efforts with partners to maintain critically needed existing colonies, refugia and head start facilities.

- Supplement existing reintroduction sites when appropriate.
- Establish populations at one or more additional sites, which includes site renovation (if necessary), and collection, propagation and release of frogs, eggs or tadpoles.
- Where necessary, implement and assist cooperators in invasive bullfrog eradication and control efforts at selected potential reestablishment sites, monitor effectiveness of bullfrog removal efforts, and train Department staff and cooperators in bullfrog removal methods.
- Continue to monitor the current distribution of amphibian chytrid fungus. Opportunistically collect skin swabs for disease analysis from animals in the wild and in captive populations.

Remaining SGCN Amphibian Conservation

Project Description: Arizona has 25 species of native amphibian species, 15 of which have been identified in the Arizona SWAP as SGCN (Tier 1A and 1B), including one ESA-listed endangered species, one threatened species, two candidates and one species petitioned for listing. Surprisingly little is known about most of Arizona's amphibians, including their status and distribution. Some of the native amphibians are rare or at risk from numerous threats such as loss or degradation of habitat, groundwater use, catastrophic wildfires, climate change and invasive exotic species. One exotic amphibian (American bullfrog) is a serious threat to other aquatic wildlife, and is a primary impediment to the recovery of declining native amphibians and reptiles.

To address these information needs, document the current status of SGCN amphibian species by gathering information on historical and present distributions, population and metapopulation dynamics, possible causes of declines, and general natural history and ecology. Conduct surveys, monitor populations and habitats, and identify management potential for specific sites. Collect a limited number of specimens from historical and newly identified locations for taxonomic analysis, genetics, research, health assessments, propagation, and/or to establish new wild or captive populations. Identify essential habitats, research needs, and other management recommendations.

Project activities include: Coordinate with partners to achieve information needs for SGCN amphibians. Staff organize and lead meetings, work with partners to develop work plans, implement work plans, etc.

- Opportunistically survey extant populations and historical localities for SGCN amphibian species as needed to determine status or identify conservation opportunities.
- Establish long-term monitoring programs to track changes in amphibian community composition and distribution that might result from climate change or other ecological perturbations.
- Collect a limited number of specimens from historical and newly identified locations for taxonomic analysis, genetics, research, health assessments.
- Continue to monitor the current distribution of amphibian chytrid fungus and ranavirus in populations of Arizona amphibians. Opportunistically collect skin swabs for disease analysis from animals in the wild and in captive populations.

- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from wildlife habitats as needed for conservation. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.

Flat-tailed Horned Lizard Conservation

Project Description: Administration, planning and implementation of conservation actions for flat-tailed horned lizards (FTHL). Although flat-tailed horned lizards (FTHL) have no ESA status, they have been considered for listing as a threatened species under the ESA on four separate occasions since 1996. On each occasion, the FWS withdrew its proposed listing rule, largely because of protections afforded to the species by the 1996 FTHL Conservation Agreement, to which the Department is a signatory, and the 2003 Rangewide Management Strategy (RMS). The Department serves on the FTHL Interagency Coordinating Committee (ICC) and the Management Oversight Group, both of which provide guidance to signatory agencies regarding implementation of the RMS, and monitor and report on implementation progress. The RMS is a long-term plan of action among signatory agencies to ensure persistence of the species, and it is implemented by the Department in the Yuma Desert Management Area and surrounding habitat.

Project activities include: Continue to cooperate with other agencies signatory to the FTHL Conservation Agreement, to ensure that actions identified in the agreement, and the Rangewide Management Strategy on which it is based, are implemented in the United States and México.

- Implement management recommendations and guidelines (including surveying and monitoring) for the species and its habitats.
- Continue to conduct annual demographic monitoring surveys to determine population size, trends, recruitment, survival, and effects of environmental variables.
- Continue to conduct annual occupancy monitoring surveys to determine changes in distribution as well as habitat use.
- Collect life history, movement, demographic and habitat selection data through radio-telemetry studies and/or standard mark-recapture techniques at one or more sites for use in population viability and occupancy analyses.
- Recover mortalities in Arizona for necropsy, disease testing, museum specimens, or genetic analyses.
- Coordinate the analysis of rangewide monitoring data to determine regional population densities, trends, and occupancy throughout the species' range in Arizona and California.
- Conduct research and monitoring to determine the population size, density, survival rate, recruitment, and population growth rate of flat-tailed horned lizards within the Yuma Desert Management Area.

Mud Turtle Conservation

Project Description: Administration, planning and implementation to document the current status of Arizona, Sonora and yellow mud turtle by gathering information on historical and present distributions, population and metapopulation dynamics, proximate and ultimate causes of declines, and general natural history and ecology. Using this information, develop and implement recommendations on management actions, land-use practices and policies to halt or

slow further population declines. Identify priority information needs, gather information, and coordinate and implement priority conservation activities for Arizona, Sonora, Sonoyta (ESA candidate), and yellow mud turtle populations in Arizona. Work with partners to develop work plans, implement work plans, etc.

The Department is the lead for the Quitobaquito/Rio Sonoyta Working Group which identifies conservation priorities and opportunities for the Sonoyta mud turtle, Sonoyta pupfish (ESA endangered), Quitobaquito springsnail (petitioned for listing), and longfin dace and their habitat. Staff organize and lead meetings, work with partners to develop work plans, etc.

Project activities include: Continue to meet with partners twice a year and collaborate to finalize Quitobaquito/Rio Sonoyta Working Group Candidate Conservation Agreement for the Sonoyta mud turtle, Sonoyta pupfish, and Quitobaquito springsnail and the longfin dace within Quitobaquito Pond, Organ Pipe Cactus National Monument, Arizona and the Rio Sonoyta, Sonora, México.

- Salvage Sonoyta mud turtles from Quitobaquito Pond when necessary.
- With partners, continue annually to monitor Sonoyta mud turtles at Quitobaquito pond.
- Repatriate previously salvaged Sonoyta mud turtles to Quitobaquito Pond.
- Establish a permanent Sonoyta mud turtle refuge population.
- Form a mud turtle working group including agencies, academics, and private sector partners to explore conservation opportunities for Arizona, Sonora and yellow mud turtles.
- Conduct literature and museum searches for historical localities of Arizona, Sonora, Sonoyta and yellow mud turtles.
- Survey extant populations, historical localities, or other sites to determine status or to identify conservation opportunities.
- Collaborate with partners to implement recommendations and guidelines for management (including monitoring, research, etc.) of each species and its habitats.
- Monitor wild populations of Sonora mud turtles.
- Work with partners when planning and implementing native fish renovation projects to ensure thorough consideration of Sonora mud turtle management needs.
- Monitor effects of native fish restoration projects (e.g., Bonita Creek) on Sonora mud turtle populations.
- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from selected high priority mud turtle conservation sites. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.
- Salvage populations at risk.

Narrow-headed Gartersnake Conservation

Project Description: Administration, planning and implementation of conservation actions for narrow-headed gartersnake, which is being considered for listing under the ESA by the USFWS. The Department is co-lead (with USFWS) on the Gartersnake Conservation Working Group, and organizes and leads meetings, works with partners to develop work plans, and coordinates and

implements priority conservation activities. The group includes partners representing several agencies, academia, and the private sector.

Project activities include: Coordinate with partners in Gartersnake Conservation Working Group to achieve conservation goals for narrow-headed gartersnakes. Using this information, develop and implement recommendations on land-use practices and policies to halt or slow further population declines.

- Survey extant populations and historical localities, or other sites as needed, for narrow-headed gartersnakes to determine status or to identify conservation opportunities.
- Implement management recommendations and guidelines (including survey, monitoring, research, etc.) for the species and its habitats.
- Conduct surveys to compare areas of apparent decline with apparently more stable populations, to investigate likely mechanisms of decline.
- Continue to collect tissue samples from narrow-headed gartersnakes for genetic analyses.
- Recover mortalities in Arizona for necropsy, disease testing, museum specimens, or genetic analyses.
- Collect life history (e.g. survival, behavior, etc.) and habitat selection data through radio-telemetry studies at one or more sites in Arizona.
- Conduct detailed population study at one or more sites, using standard mark-recapture techniques.
- Investigate and test experimental translocation as a technique for augmenting existing, or reestablishing wild populations of narrow-headed gartersnakes.
- Test and evaluate implementation of conservation and management strategies such as release of captive bred/head-started narrow-headed gartersnakes and habitat enhancement for the species.
- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from narrow-headed gartersnake and nearby habitats as needed for conservation. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.
- Secure existing or establish new wild populations of narrow-headed gartersnakes.

Northern Mexican Gartersnake Conservation

Project Description: Administration, planning and implementation of conservation actions for northern Mexican gartersnake (ESA candidate). The Department is co-lead (with USFWS) on the Gartersnake Conservation Working Group, and organizes and leads meetings, works with partners to develop work plans, and coordinates and implements priority conservation activities. The group includes partners representing several agencies, academia, and the private sector.

Project activities include: Coordinate with partners in Gartersnake Conservation Working Group to achieve conservation goals for northern Mexican gartersnakes. Using this information, develop and implement recommendations on land-use practices and policies to halt or slow further population declines.

- Survey extant populations and historical localities, or other sites as needed, for northern Mexican gartersnakes to determine status or to identify conservation opportunities.

- Implement management recommendations and guidelines (including survey, monitoring, research, etc.) for the species and its habitats.
- Conduct surveys to compare areas of apparent decline with apparently more stable populations, to investigate likely mechanisms of decline.
- Continue to collect tissue samples from northern Mexican gartersnakes for genetic analyses.
- Recover mortalities in Arizona for necropsy, disease testing, museum specimens, or genetic analyses.
- Continue to monitor northern Mexican gartersnakes at Page Springs and Bubbling Ponds hatcheries to obtain demographic data and data that might explain how gartersnakes persist in the presence of invasive exotic predators and to guide habitat management recommendations for the hatcheries.
- Continue to collect natural history and habitat selection data through radio-telemetry studies of northern Mexican gartersnakes at Bubbling Ponds and Page Springs fish hatcheries.
- Conduct detailed population study at one or more sites, using standard mark-recapture techniques, including the upper Santa Cruz River in San Rafael Ranch State Park.
- Test and evaluate implementation of conservation and management strategies such as release of captive bred/head-started northern Mexican gartersnakes and habitat enhancement for the species.
- Investigate and test experimental translocation as a technique for augmenting existing, or reestablishing wild populations of northern Mexican gartersnakes.
- Remove invasive exotic species (e.g., bullfrogs, crayfish, fishes, etc.) from northern Mexican gartersnake and nearby habitats as needed for conservation. Monitor effectiveness of removal efforts, and train Department staff and cooperators in removal methods.

Ornate Box Turtle Conservation

Project Description: Administration, planning and implementation to document the current status of ornate (desert) box turtles by gathering information on historical and present distributions, population and metapopulation dynamics, proximate and ultimate causes of declines, and general natural history and ecology. Using this information, develop and implement recommendations on management actions, land-use practices and policies to halt or slow further population declines. Identify priority information needs, gather information, and coordinate and implement priority conservation activities for desert box turtle populations in Arizona. Work with partners to develop work plans, implement work plans, etc.

Project activities include: Coordinate and manage the Ornate Box Turtle Watch, a citizen science project which engages the public to gather and submit data on box turtle observations in southeastern Arizona. Form an Ornate Box Turtle Working Group including agencies, NGOs, academics, and private sector partners that will explore conservation opportunities for box turtles and their habitats as well as develop a monitoring strategy for ornate (desert) box turtles.

- Conduct and continue to support appropriate management and monitoring activities to collect natural history and habitat selection data including capture-recapture using visual surveys, trapping, and radio-telemetry.
- Conduct blood sampling and analyses to determine population genetics and presence/absence of disease.
- Continue to monitor for disease and evaluate each desert box turtle encountered (captive or wild) for signs of upper respiratory tract disease (URTD), shell disease, herpes virus, Rana virus, or other potential pathogens.
- Recover mortalities for necropsy, disease testing, museum specimens, or genetic analyses.
- Continue to work with the public through the "Ornate Box Turtle Watch" to obtain information on box turtle distribution, and to refine citizen science survey techniques.

Sonoran Desert Tortoise Conservation

Project Description: Administration, planning and implementation of priority conservation activities for Sonoran desert tortoises (ESA candidate). Staff co-lead (with USFWS) the Arizona Interagency Desert Tortoise Team (AIDTT) to set conservation priorities Sonoran desert tortoises. Staff also coordinate and implement annual monitoring efforts, field research, and the Department's Tortoise Adoption Program (TAP).

Project activities include: Coordinate with partners to achieve conservation and research goals, ensuring geographically and ecologically broad coverage of Sonoran desert tortoises in Arizona. Complete and implement the State Conservation Agreement, Assessment and Strategy for the Sonoran Desert Tortoise (SCA) with AIDTT partners.

- Coordinate annual tortoise monitoring on up to 5 BLM, 2 NPS, and 1 NF long-term desert tortoise monitoring plots (LTMPs), including complete coverage surveys of up to five LTMPs and up to 52 3-ha occupancy sites within each of three study areas for use in population viability and occupancy analyses.
- Monitor desert tortoise population at Sugarloaf Mountain, Tonto National Forest.
- Continue to collect natural history and habitat selection data through radio-telemetry study on juvenile desert tortoises at Sugarloaf Mountain, Tonto National Forest.
- Work with partners (BLM, USFS, NPS) to apply state-of-the-art range-wide monitoring strategies on long-term monitoring plots.
- Continue to monitor for disease and evaluate each tortoise encountered (captive or wild) for signs of Upper Respiratory Tract Disease (URTD), shell disease, and other health problems. If necessary, collect blood samples and conduct appropriate analyses to determine population genetics, assess contaminants levels, and exposure to *Mycoplasma* (URTD) or other potential pathogens.
- Study the effectiveness of fencing and crossing structures for desert tortoises along Arizona highways as necessary.
- Administer the tortoise adoption program and coordinate activities with external partners.
- Conduct and continue to support population monitoring, and habitat surveys in cooperation with other agencies and organizations involved in the AIDTT.

- Develop and implement recommendations and guidelines for management (including survey, monitoring, research, etc.) of the species and its habitats.

Tucson Shovel-nosed Snake

Project Description: Administration, planning and implementation to identify priority information needs, gather information, and coordinate and implement priority conservation activities for Tucson shovel-nosed snake (ESA candidate). The Department works with partners to develop work plans, implement work plans, etc.

Project activities include: Document the current status of Tucson shovel-nosed snakes by gathering information on historical and present distributions, collecting tissue samples to describe genetic variability, and conduct field surveys to determine relative or absolute abundance, distribution, population status, and management needs. Using this information, develop and implement recommendations on land-use practices and policies to halt or slow further population declines.

- Conduct road surveys to delineate the distribution of Tucson shovel-nosed snakes and other shovel-nosed snake subspecies.
- Work with internal and external collaborators to obtain ecological information on the species and to survey additional sites.
- Conduct studies to compare areas of apparent decline with apparently more stable populations, to investigate likely mechanisms of decline.
- Implement recommendations and guidelines for management (including survey, monitoring, research, etc.) the species and its habitats.
- Continue to collect tissue samples from shovel-nosed snakes for genetic analyses.
- Recover mortalities in Arizona for necropsy, disease testing, or museum specimens.
- Conduct detailed population study at one or more sites, using standard mark-recapture techniques, and experiment with techniques to improve capture success.

Remaining SGCN Reptile Conservation

Project Description: Arizona has 107 species of native reptile species, more than 20 of which have been identified in the Arizona SWAP as SGCN (Tier 1A and 1B), including one ESA-listed endangered species, two threatened species, three candidates, and three species being considered for listing. Surprisingly little is known about most of Arizona's reptiles, including their status and distribution. Some of the native reptiles are rare or at risk from numerous threats such as loss or degradation of habitat, catastrophic wildfires, climate change and invasive exotic species. One exotic amphibian (American bullfrog) is a serious threat to other aquatic wildlife, and is a primary impediment to the recovery of declining native amphibians and reptiles.

To address these information needs, document the current status of SGCN reptile species by gathering information on historical and present distributions, population and metapopulation dynamics, proximate and ultimate causes of declines, and general natural history and ecology. Conduct surveys, monitor populations and habitats, and identify management potential for specific sites. Collect a limited number of specimens from historical and newly identified locations for taxonomic analysis, genetics, research, health assessments, propagation, and/or to

establish new wild or captive populations. Identify essential habitats, research needs, and other management recommendations.

Project activities include: Coordinate with partners to achieve information needs for SGCN reptiles. Staff organize and lead meetings, work with partners to develop work plans, implement work plans, etc.

- Opportunistically survey extant populations and historical localities for SGCN reptile species as needed to determine status or identify conservation opportunities.
- Establish long-term monitoring programs to track changes in reptile community composition and distribution that might result from climate change or other ecological perturbations.
- Collect a limited number of specimens from historical and newly identified locations for taxonomic analysis, genetics, research, health assessments.
- Monitor the current distribution of ranavirus in populations of Arizona turtles. Collect tissue samples for disease analysis from living or recently dead animals in the wild and in captive populations.
- Remove invasive exotic species from wildlife habitats as needed for conservation and restoration efforts.

Nongame Birds and Mammals Species/Project Information

Arizona Bird Conservation Initiative

Project Description: The Arizona Bird Conservation Initiative (ABCI) is a department led voluntary coalition of government agencies, conservation groups, academic institutions, private businesses, and citizens dedicated to "keeping common birds common" and reversing the downward trends of declining species. ABCI coordinates planning and implementation efforts to conserve, monitor and enhance bird populations and their habitats as identified by the SWAP and promote management recommendations outlined in the Arizona Partners in Flight (PIF) Bird Conservation Plan.

Project activities include:

- Develop and maintain a diverse partnership dedicated to the conservation of birds and their habitats through conservation planning and coordination.
- Collaborate to identify and prioritize bird conservation opportunities and needs.
- Promote landscape-oriented multi-species population monitoring and conservation efforts.
- Support and promote existing training workshops that will assist in the implementation of the Arizona Coordinated Bird Monitoring (AZCBM) Program.
- Hold annual state and regional meetings to serve as a forum for information sharing and AZCBM implementation coordination with local bird conservation partners and volunteers.
- Active participation in Sonoran and Intermountain West Joint Ventures, PIF Western Working Group, Southern Wings and other similar partnerships.

- Support the Important Bird Areas (IBA) Program. A partnership of Audubon and the Department, engaged in IBA identification, conservation planning, and on-the-ground conservation actions at priority bird habitats.
- Administer conservation projects funded to implement recommendations for the conservation of high priority bird species or habitats as identified by the SWAP, Arizona PIF Bird Conservation Plan or any of the 4 national bird initiatives through the ABCI Grants Program (depending on availability of funds).
- Promote bird conservation among the general public through support of International Migratory Bird Day and other similar activities.
- Pursue development of a web portal for a Citizen Science Program to implement wildlife projects that rely on data reporting and gathering by citizen scientists.
- Seek opportunities to move forward in planning for the development of an AZ Avian Data Center.

Arizona Coordinated Bird Monitoring Program

Program Description: Of approximately 150 bird SGCN, roughly 20 are monitored sufficiently to determine population trend. This program plans and coordinates multi-entity efforts to implement various statewide bird population monitoring projects to determine long-term population trends for breeding and wintering birds in Arizona, including many SGCN. These data are used to assist the Department and cooperating entities to determine species status, distribution and population trends, to evaluate/predict effects of habitat change, determine effects of land management actions, and assist in establishing management and conservation priorities.

Project Activities include:

- North American Marsh Bird Surveys – following national protocol, conduct annual call playback surveys at established points.
- Western (U.S.) Colonial Aquatic Bird Nest Inventory – Following protocol, annually visit known nesting colonies and viewing from and observation point at an unobtrusive distance obtain an actual or estimated count of active nests and adults.
- Winter Aquatic Bird Surveys
    - Phoenix Area Survey – Coordinated effort on a single mid-January day from visual observation point survey and count all wild aquatic birds at urban ponds, lakes and canals in the Greater Phoenix Area.
    - Reservoir Survey – Boat-based visual observation point survey in mid- to late January to count all wild aquatic birds utilizing various river reservoirs.
- North American Breeding Bird Surveys – Following national protocol, annually conduct single-morning auditory and visual observation point surveys along established road routes.
- Nightjar Surveys – Following national protocol, annually conduct single-evening auditory and visual observation point surveys along established road routes.
- Riparian, Sonoran Desert, and Grassland Breeding Bird Surveys – Using both auditory and visual survey techniques, conduct morning area search and point-count surveys within an established plot to determine diversity and density of breeding avian species.

- National Audubon Christmas Bird Counts – Using both auditory and visual techniques conduct annual, area search survey within a section of an established 15 mi. diameter count.
- Other SGCN Bird Species - Opportunistically survey extant populations and historical localities for SGCN bird species as needed to determine status or identify conservation opportunities.

Bald and Golden Eagle Management Program

Project Description: This is a cooperative effort among multiple federal, state, tribal, and private organizations collaborating on the conservation of the bald and golden eagles in Arizona. Since 1991, the AGFD has been the lead planning and implementation agency for bald eagle management activities statewide. In 2010, the AGFD assumed a lead role in planning and implementation of golden eagle conservation and management actions. Through these conservation and management actions, the AGFD can inform the USFWS on the population status of bald and golden eagles in Arizona which will be necessary for the implementation of the new Bald and Golden Eagle Act permitting process.

Project activities include:

- Meet in July and January with the Southwestern Bald Eagle Management Committee and project cooperators to discuss progress, modify field and data protocols, set work schedules for the following field season, develop and implement recommendations and guidelines for management (including survey, monitoring, research, etc.) of the species and its habitats.
- Coordinate seasonal breeding area closures.
- Conduct nest surveys, winter count, and occupancy-reproductive assessment flights via aerial, ground, and boat surveys.
- Conduct appropriate management and monitoring activities including rescue, rehabilitation, nest rebuilding, pest control, and fostering.
- Conduct demographic studies including adult identification, trapping, transmitter deployment, banding, and blood sampling and analyses to determine population genetics and to assess contaminants levels.
- Coordinate the Arizona Bald Eagle Nestwatch Program.
- Salvage/collect addled eggs, eggshells, carcasses, bone, feathers, and other parts, for contaminants analyses and subsequent transfer to the National Eagle Repository.
- Implement public relations and outreach techniques and media events and documentaries at selected nest sites under the supervision of a permitted biologist.

California Condor Reintroduction Program

Project Description: This is a cooperative program among multiple federal, state, tribal, and private organizations to reestablish the condor (ESA endangered; non-essential experimental 10(j) population) within its historic habitat in northern Arizona and southern Utah. The Arizona/Utah reintroduction program, initiated in 1996, has resulted in just under 80 free-flying condors. Wild breeding has also been successful in Arizona, with 12 wild-hatched chicks.

Project activities include:

- Communicate project information to public and cooperating partners through popular and technical publications, media news releases, and personal presentations at scientific conferences, workshops, and public events.
- Coordinate and implement voluntary lead reduction efforts within condor range, including hunter outreach efforts and non-lead ammunition incentive programs when feasible.
- Meet with members of the Southwest Condor Working Group and Condor Field Crew Working Group to discuss condor program progress, modify field and data protocols, and develop and implement recommendations and guidelines for management of the species and its habitat.
- Continue with all activities associated with repatriation of California condors to Arizona.
- Participate as a member of the field team in monitoring, feeding, and management of released condors and additional release efforts.
- Participate in and implement appropriate condor related research and planning when feasible.

Raptor Management Program

Project Description: The Raptor Management Program was developed to address the management and monitoring needs of all raptor species. In addition to addressing the threats to population abundance and species occurrence, the program assists with the incorporation of raptor conservation measures in development projects, urban expansion, and regulates Sport Falconry.

Project activities include:

- Monitoring raptor breeding populations and their habitats, migration corridors, and winter and summer stop-over areas.
- Identify, coordinate, conduct, and participate in interagency surveys, research, demographic studies, habitat and population monitoring, and other field studies on raptor species.
- Trap, climb and otherwise capture and mark individual raptor species for mark-recapture studies.
- Deploy transmitters for long-term mortality studies.
- Take measurements on nestling raptors to assess the gender and health of the individuals.
- Recapture individuals by trapping or otherwise capture or viewing from spotting scopes.
- Collect samples for genetics and disease testing including biological samples from live and dead individuals.
- Assess impacts of projects on all aspects of raptor ecology.
- Assist New Mexico and The Peregrine Fund northern aplomado falcon (Falco femoralis septentrionalis) re-establishment efforts by investigating sighting reports of aplomado falcons in Arizona.
- Continue to implement the 5-year post-delisting monitoring protocol for peregrine falcon for the statewide non-urban breeding population.

- Monitor urban population trends in metropolitan areas using observation point surveys.
- Collect addle eggs and analyze eggshell thickness for possible contaminant effects from selected eyries.
- Conduct habitat sampling at recent sites of occurrence and at random sites within known, suspected, and potential habitats of occurrence.
- Develop and implement a ferruginous pygmy-owl captive propagation program using owls captured in southern Arizona and Mexico, develop a habitat model to identify potential release areas for hacking captive bred offspring.
- Rebuild and relocate nests for increased productivity and management purposes.
- Establish artificial nest boxes for certain speciesin suitable habitat, in cooperation with private property owners and government agencies.
- Create and monitor artificial nest sites for productivity and nest site fidelity when feasible.

Remaining SGCN Bird Conservation

Project Description: Approximately 545 species of birds have been documented in Arizona, including roughly 300 species which nest annually in the state. Of the 145 species that are currently considered SGCN in Arizona, only 20 species are monitored sufficiently to determine population trend. This fact is further exemplified when only six of the twelve species of federally listed and candidate bird species in the state are sufficiently monitored. Some of the native bird are rare or at risk from numerous threats such as loss or degradation of habitat, groundwater use, catastrophic wildfires, and invasive exotic species.

Project activities include:

- Opportunistically survey populations and historical localities for SGCN bird species as needed to determine status or identify conservation opportunities.
- Following established yellow-billed cuckoo survey protocol, participate in coordinated statewide conservation and recovery efforts, including conducting noninvasive call playback techniques.
- Participate in coordinated least tern conservation and recovery efforts, including monitoring breeding populations at an unobtrusive distance when appropriate and feasible to determine nesting success.
- Conduct, coordinate, or otherwise participate in Yuma clapper rail call playback surveys using established national protocol (i.e. Standardized North American Marsh Bird Monitoring Protocol) documenting multiple marsh bird species.
- When feasible, use Yuma clapper rail call playback surveys in areas subject to channel maintenance during the breeding season, to document occupancy and to monitor changes associated with river management activities.
- Following the USFWS-AGFD sanctioned southwestern willow flycatcher protocol, participate in coordinated statewide willow flycatcher conservation and recovery efforts, including conducting noninvasive call playback surveys when appropriate and feasible.
- Conduct masked bobwhite auditory and call playback surveys, inventories, and monitoring research actions in Arizona as permitted by the Department's 10(a)(1)(A) permit.

- Assist with masked bobwhite surveys, inventories, and monitoring research and habitat enhancement actions for masked bobwhite in Arizona and Mexico.
- Assist the Buenos Aires National Wildlife Refuge with implementation of masked bobwhite recovery activities on the BANWR, as permitted by the Department's 10(a)(1)(A) permit, and assist México with similar activities in Sonora.

Bat Conservation

Project Description: Administration, planning and implementation to document and monitor significant roost sites in mines, bridges, buildings, trees, and caves for Arizona's 28 bat species, with special emphasis on special status species: lesser long-nosed bat (ESA endangered), Mexican long-tongued bat, California leaf-nosed bat, Allen's lappet browed bat, Townsend's big-eared bat, and other species of interest. Surveillance and monitoring of Arizona's bat species is important for recognizing population declines to allow for appropriate management actions and avoid the need to list species. Recovery of the endangered lesser long-nosed bat populations should prevent their local extirpation, impacts to the global population and to the plants that they pollinate.

Project activities include:

- Survey and monitor populations and their habitat when appropriate and feasible.
- Implement recommendations and guidelines for management (including survey, monitoring, research, etc.) of bat species and their habitats.
- Survey or monitor potential and known roosting locations in Arizona.
- Document and monitor significant roost sites in mines, caves, trees, bridges, and buildings.
- Using standard scientific techniques, continue monitoring bat species and develop specific recommendations for their management. As appropriate to survey results, propose Candidate species for listing or Conservation Agreements.
- Identify and tabulate roost characteristics and bat species composition for all sites occupied by sensitive bat species being surveyed.
- Estimate colony size by species and identify potential threats and management needs at each roost site.
- Continue to work with AGFD regional offices and external partners towards a more coordinated bat monitoring effort; emphasize long-term population trend data collection; evaluate the effects of management actions. Species to focus on for monitoring and surveys include: lesser long-nosed bat roost surveys; Townsend's big-eared bat; California leaf nosed bat winter vs. summer roosts; resurvey historical Mexican free-tailed roosts; red bat surveys; *Eumops underwoodi*; bat hibernacula; bat migration routes.
- Identify and monitor winter hibernacula; develop a surveillance effort for white nose syndrome.

Black-footed Ferret Recovery

Project Description: Administration, planning and implementation of recovery actions for the black-footed ferret (ESA endangered; non-essential experimental 10(j) population), to maintain a

free-ranging, self-sustaining population of black-footed ferrets in the Aubrey Valley. Recovery of the species should help to prevent extinction and reverse local extirpation. Success in the Aubrey Valley has allowed us to partially augment the Espee Ranch site with additional ferrets. In the future we hope to do more captive breeding/preconditioning to help establish other populations.

Project activities include:

- Monitor wild populations at the two reintroduction sites in Arizona.
- Survey and map potential habitat.
- Coordinate extensive bi-annual spotlighting events to monitor populations (dispersal and over-winter survival).
- Process and vaccinate captured animals at spotlighting events.
- Annually map both reintroduction sites to determine density of Gunnison's prairie dogs.
- Augment reintroduced populations if and when necessary.
- Monitor and mitigate for disease (specifically plague, canine distemper virus, and tularemia).
- Outreach to and educate the local community about black-footed ferret reintroduction and prairie dog biology.

Black-tailed Prairie Dog and Gunnison's Prairie Dog Conservation

Project Description: Administration, planning and implementation of conservation actions for black-tailed prairie dogs (BTPD) and Gunnison's prairie dogs (GUPD). Conservation actions for these prairie dogs should prevent further declines of GUPD and re-establish BTPD, an extirpated species. Actions accomplished now should preclude the need to list the species under the ESA.

Project activities for BTPD include:

- Re-establish the species within its historic range.
- Monitor reintroduced populations.
- Survey potential habitat for additional reintroductions.
- Educate the public to encourage support for reintroduction efforts.
- Identify and promote landowner incentives.
- Monitor plague.
- Identify, prioritize, and implement research needs.

Project activities for GUPD include:

- Use occupancy surveys to monitor and to assess population viability.
- Maintain populations across 75% of historic range.
- Use occupancy surveys to monitor and address plague outbreaks.
- Implement corrective measures if populations decline.
- Identify potential habitat and promote conservation of these areas.
- Monitor take by hunters and implement hunting closure.
- Review and recommend changes to state statutes and regulations pertaining to prairie dog poisoning.

- Educate the public regarding prairie dog biology and their importance in ecological communities.
- Identify and promote landowner incentives.
- Identify, prioritize, and implement research needs.

Mexican Wolf Reintroduction

Project Description: Administration, planning and implementation of reintroduction activities for the Mexican Wolf (ESA endangered; non-essential experimental 10(j) population). The current goal of establishing a wild population of at least 100 wolves is the initial effort in recovering Mexican wolves and preventing their extinction. The successful establishment of this initial self sufficient population in the wild will assist in preserving the genetic diversity of this wolf subspecies and allow for the preservation of wild characteristics necessary for this species to survive without human assistance in the wild.

Project activities include:

- Conduct initial releases and translocations.
- Monitor wolf populations.
- Capture and radio telemetry collaring.
- Handle captured wolves according to specific protocols.
- Coordinate efforts with cooperating agencies.
- Developing proactive projects with local stakeholders.
- Collect and process biological samples.
- Contact with specific stakeholders regarding wolf information.
- Conduct aerial population count and capture actions.
- Develop specific management recommendations.

Mount Graham Red Squirrel Conservation

Project Description: Administration, planning and implementation of conservation actions for the Mount Graham red squirrel (ESA endangered). Information gathered provides updates to species status reviews and site-specific locality information to the Mount Graham red squirrel midden database which assists implementation of management activities identified in the Mount Graham red squirrel species Recovery Plan.

Project activities include:

- Conduct annual surveys.
- Monitor populations and habitats.
- Identify management potential for specific sites.

Sonoran Pronghorn Recovery

Project Description: Administration, planning and implementation of recovery actions for Sonoran pronghorn (ESA endangered; non-essential experimental 10(j) population). Recovery of Sonoran pronghorn should prevent their extinction in the United States. Downlisting and

delisting Sonoran pronghorn should reduce the restrictions on land use activities (i.e., military training, recreational use and access, etc.).

Project activities include:

- Implement recovery actions such as habitat enhancements.
- Manage the captive breeding program.
- Monitor the wild population.
- Establish additional populations within suitable historic habitat.
- Conduct rangewide surveys in Arizona.
- Conduct rangewide surveys and aerial telemetry monitoring of the populations in Sonora, México.

Jaguar and Ocelot Conservation

Project Description: Administration, planning and implementation of conservation actions for jaguar and ocelot (both ESA endangered). Information gathered provides updates to Recovery Plans, species status reviews and site-specific locality information to the Service's jaguar monitoring project.

Project activities include:

- Conduct survey and detection projects to locate and monitor free-ranging jaguars/ocelots in the borderlands by using trail cameras or other remote-sensing technologies, hair snares, track counts, scat-sniffing dogs and other standard non-invasive field techniques.
- Cooperate in genetic research to clarify taxonomic questions regarding jaguars/ocelots in the American Southwest and northwestern México.
- Follow up on reported jaguar/ocelot sightings by conducting field assessments and interviews to ascertain validity of each reasonably-credible report.
- Participate in development of a species Recovery Plan for jaguar.

Statewide SGCN Mammal Survey and Routine Monitoring

Project Description: Arizona has 154 species of native mammal species, 35 of which have been identified in the Arizona SWAP as SGCN (Tier 1A and 1B). Surprisingly little is known about most of Arizona's small mammals, including their status, natural history and distribution information. Some of the native mammals are rare or at risk from threats such as loss or degradation of habitat, groundwater use, catastrophic wildfires, and invasive exotic species. Also, when it is completed the Small Mammal Conservation Plan will identify additional management and conservation needs.

To address these information needs, document the current status of SGCN mammals by gathering information on historical and present distributions, population and metapopulation dynamics, proximate and ultimate causes of declines, and general natural history and ecology. Conduct surveys, monitor populations and habitats, and identify management potential for specific sites. Collect a limited number of specimens from historical and newly identified locations for taxonomic analysis, genetics, research, health assessments, propagation, and/or to

establish new wild or captive populations. Identify essential habitats, research needs, and other management recommendations.

Project activities include:

- Implement recommendations on research and conservation of high priority mammal species or habitats as identified by the Small Mammal Conservation Plan, or Conservation Agreements.
- Coordinate and conduct statewide monitoring and inventory surveys/counts, and habitat identification for mammals.
- Monitor and sample (as necessary) Hualapai Mexican vole populations from Navajo Mountain, Aubrey Cliffs, Bradshaw Mountains, Juniper Mountains, Music Mountains, Cerbat Mountains, Mount Floyd, Sierra Prieta Mountains, Prescott Basin, Prospect Valley, and Hualapai Mountains.
- Freeze Hualapai Mexican vole tissues and prepare skulls and museum study skins from dead specimens, to be used for genetic, taxonomic, or disease research, etc.

MONITORING

MONITORING AND ADAPTIVE MANAGEMENT

Monitoring is a critical element in any conservation effort and forms a keystone of the Arizona SWAP and the Department's Mission to "conserve, enhance and restore Arizona's diverse wildlife resources and habitats." However, defining what monitoring is can be problematic. For example, in the monitoring literature, terms are often defined in multiple ways and discussed at scales ranging from local to global. Stem et al. (2005) used monitoring and evaluation ("M&E") together and seemingly interchangeably (see also Atkinson et al. 2004). Most simply, Elzinga et al. (2001) defined monitoring as the systematic and repetitive collection and analysis of information to evaluate changes in condition and progress toward meeting a management objective. The objective, or desired future condition, determines what is measured, how well and how often it is measured (Elzinga et al. 2001).

The Heinz Center (2009) discussed monitoring specifically in the context of SWAPs and assessing their success, and defined **monitoring** as the "repeated measurement of an environmental variable, either at regular intervals, or before and after an intervention" (e.g., a management action), a definition much like that in Elzinga et al. (2001). This definition encompasses the "status assessment" of Stem et al. (2005). Population monitoring is a type of status assessment that over time may be used to determine status and potential threats, however population monitoring is often time consuming and expensive (Stem et al. 2005). The Heinz Center (2009) defined **evaluation** as a "study specifically designed to determine whether a particular management intervention achieved the desired effect." Stem et al. (2005) discussed evaluation under the heading of "measuring effectiveness." Like Elzinga et al. (2001), The Heinz Center (2009) acknowledged the subtle but important difference between monitoring and evaluation, and clearly placed monitoring for SWAPs in the context of management or conservation actions. Therefore, most importantly, monitoring is not only a systematic and repeated activity, but it is often associated with a management action and therefore is coupled with evaluation, which is specifically designed to assess the effects of an action in a scientifically rigorous manner.

The Heinz Center also provided a framework for monitoring that was designed to be applied to SWAPs. In September 2010, several Department staff participated in a workshop cosponsored by the Department, The Heinz Center and BLM in which this framework was discussed and applied in the context of monitoring programs that the Department currently conducts or supports, or for monitoring programs in which partners might engage. This framework, which is discussed in detail in The Heinz Center (2009), includes a sequence of six logical steps to develop and implement a monitoring program:

1. Identify the conservation target, whether it is a population, species, community, etc.
2. Develop a conceptual model to illustrate how threats and management actions might affect the conservation target.
3. Use the model to identify indicators for the actions.
4. Develop the monitoring program to track those indicators.
5. Implement the actions and measure (i.e., monitor) the indicators.

6. Use "adaptive management" to evaluate and if necessary modify the actions.

The Department may use this framework to develop new monitoring programs or to reevaluate existing programs for internal consistency and rigor. The latter can be a particularly useful exercise to examine logical assumptions and goals for existing programs. Partners are encouraged to consider this framework when establishing new monitoring programs and to work across agencies and other entities to achieve common monitoring goals, particularly with respect to questions dealing with climate change.

Modern approaches to wildlife management and conservation biology acknowledge the need for monitoring in the context of "adaptive management" (Salafsky et al. 2001). **Adaptive management** is a scientific approach that: 1) recognizes uncertainty that is inherent in natural systems (for example, how ecological systems function, or how they might respond to management actions), 2) capitalizes upon change and improvement in data gathering and analysis techniques, and 3) treats actions in an experimental framework in which learning becomes an inherent objective and alternative hypotheses are evaluated. Simply put, adaptive management is a mechanism for continuous improvement based on what has been learned through monitoring and evaluation of management actions.

Science-based adaptive management generally includes four steps (Elliott et al. 2003):

1. Set management goals, and identify assumptions within those goals.
2. Implement management actions.
3. Monitor and analyze responses of species and habitats to management.
4. Revise management actions, goals or monitoring strategies as necessary.

Importantly, the process is then repeated, such that testing and revision become a standard management approach and there is a pattern of cyclical feedback that informs the management process. Perhaps the most critical realization of the adaptive management paradigm is that management is not simply an objective, but it is a process, and as the Department gathers information and tests hypotheses, it can adapt its management strategies and policies accordingly (Johnson 1999, Salafsky et al. 2001, Schoonmaker and Luscombe 2005). Therefore, monitoring programs are basically research tools designed to address specific management action questions (Schoonmaker and Luscombe 2005), the protocols, time frames and study design of which are determined by the characteristics of the species under study (life history characteristics, habitat preferences, etc.).

Finally, Atkinson et al. (2004) described targeted studies (also called evaluation for basic research by Stem et al. 2005) as a research mechanism of monitoring through which one might improve basic knowledge of biological systems, stressors or management techniques. This is achieved either by gathering information that can resolve uncertainties (for example, the effects of wind turbines on bat populations) or by applying experimental management techniques (for example, stocking topminnows in various habitats). Whether the data are gathered through observation and measurement, or by experimental manipulation of a system, targeted studies can address specific questions, either in the long term or short term. Although research in the context of wildlife conservation activities is often considered separately from monitoring, monitoring

typically comprises a large component of targeted studies (i.e., repeated measures) and therefore research and monitoring are inextricably linked.

MONITORING HABITAT CONDITION

One of the primary goals of the Arizona SWAP is to "keep common species common" in addition to the immediate, critical conservation needs that must be addressed. It is also clear that wildlife management cannot be considered or practiced without considering the health and welfare of the habitats in which animals live. Thus, monitoring must have several interconnected components, including habitat evaluation coupled with multiple-species and single-species efforts.

Monitoring can be conducted at various hierarchical scales, depending on the particular questions being addressed. Ideally, the Department would engage in a comprehensive program that involved monitoring at several levels, including species, landscape and ecoregion. Many current plans might approach monitoring from either a habitat level or from a more fine-grained species level; for reference, these correspond fairly closely with TNC "course-filter" and "fine-filter" biodiversity conservation targets (TNC 1982). One desirable outcome of implementing the SWAP is the development of a landscape level of habitat assessment through coordination of multiple partners. To this end the Department has begun to inventory and assess landscape level information through the SHCG, a model encompassing data on habitats, biodiversity, economic and recreational values, and large unfragmented landscapes (see Modeling Areas of Wildlife Conservation Potential: the Species and Habitat Conservation Guide (SHCG)). The next step will be to assess the utility of that model with respect to identifying conservation opportunities and needs, statewide.

The Department maps and models habitat characteristics to a large degree as part of individual species management or recovery efforts, and the SHCG will contribute towards comprehensive efforts for long term assessment and monitoring of habitats across the state. Public land management agencies (e.g., USFWS, USFS, BLM) and non-governmental organizations monitor wildlife habitats on lands over which they have management authority, or they have been developing ecological assessments of large landscapes in which conservation priorities are identified and from which monitoring programs might be developed (or are suggested), or organize and participate in national efforts towards wildlife monitoring. Examples of the first include, USFS Forest Health Monitoring program (Rogers et al. 2001) and the nationwide Multiple Species Inventory and Monitoring protocol intended to provide a "consistent and efficient method for obtaining basic presence/absence data and associated habitat condition data for a large number of individual species" at representative sites (Manley et al. 2004, Manley et al. 2006). Examples of ecological assessments include TNC grassland assessment (Gori and Enquist 2003), Apache Highlands ecological analysis (Marshall et al. 2004), an ecological analysis of Sonoran Desert (Marshall et al. 2000), etc. And, well known examples of NGO activities include Audubon Christmas Bird Counts and Important Bird Area monitoring. Finally, one clear outcome of the monitoring workshop; co-sponsored by the Department, the Heinz Center, and BLM; was the need for multiple members of the conservation community to work towards building monitoring efforts that address landscape level needs, including the effects of climate change on plant and animal communities.

Certain guilds and taxonomic groups of animals are particularly suited to habitat or landscape level monitoring, for example, grassland herbivores, riparian passerine birds, etc. However, other animals, for reasons of biology or legal status, require more narrowly focused, species level monitoring, for example, Kanab ambersnail (highly restricted distribution) or Gila topminnow (monitoring success of stocking program and Safe Harbor Agreement [SHA] sites).

However, under certain circumstances, a fine-scaled, single-species approach can accomplish the goals of habitat based monitoring, and provide important information regarding habitat condition. Because resource limitations often preclude complete species inventories, there have been many attempts to estimate species richness or habitat condition by using surrogate measurements (Mac Nally and Fleishman 2002) and therefore maximize information return while minimizing resource expenditures. Species that are most strongly associated with specific habitats might act as "umbrella" species (Schoonmaker and Luscombe 2005) or "indicator" species (Landres et al. 1988) for other species in the community and for the habitat (although see critique and cautions in Landres et al. 1988, and Niemi et al. 1997). Umbrella species are not necessarily linked functionally with a particular habitat or to other species, as are keystone species (Paine 1966), but their widespread distribution within a habitat or ties to particular habitat characteristics that are ordinarily associated with overall habitat health can make them convenient monitoring subjects.

In high elevation mixed conifer habitat, for example, the presence of northern goshawks might suggest that conditions are excellent for other birds that use similar habitat components or respond positively to management for northern goshawks (e.g., wild turkey, flammulated owl, Williamson's sapsucker, solitary vireo, Grace's warbler, western tanager, red crossbill) (Latta et al., 1999), as well as for some mammals (e.g., Mexican vole, dusky shrew, long-tailed weasel), despite the obvious differences in specific ecological requirements of the various taxa. In this particular example, monitoring strategies for northern goshawks outlined in Arizona PIF Conservation Plan (Latta et al. 1999) might accomplish habitat monitoring goals at the landscape level. For a practical application, see Sitko and Hurteau (2010). Also in mixed conifer, monitoring tiger salamanders in natural wetlands might serve as an indicator of presence/absence of western chorus frogs, Arizona treefrogs, wandering gartersnakes, montane or Mexican voles, and other species associated with the wetlands or their surroundings. In this context, several SGCN species might serve as indicators of habitat quality for more common animals and habitats.

However, several authors caution that indicators can only be used to predict diversity within taxonomic limits, e.g., an indicator bird species might not be useful to predict vegetation condition or mammal diversity (e.g., Mac Nally and Fleishman 2002). In light of these cautions, discussions with partners during the 2010 Heinz Center monitoring workshop made it clear that when using indicator species, the environmental targets must be clearly measureable (modeling their use beforehand is strongly advised), the indicators must be able to be sampled in a repeatable and statistically rigorous fashion, and their use must generate testable predictions. Finally, it is critical to recognize that if the predictions are not borne out, then a new and testable approach is necessary.

MONITORING WILDLIFE

The Department's monitoring priorities are often driven by commitments to threatened and endangered species conservation or by funding constraints, e.g., game or sport fish funding. Multispecies planning efforts such as the Arizona Bird Conservation Initiative and the Arizona Bat Plan are efforts that aim to document guilds in addition to individual species, and common species in addition to rare elements of our natural heritage. In addition, these multispecies efforts all tier off of national and/or regional planning efforts that provide standards for monitoring measures and metrics. All multispecies planning currently underway with the Department requires conservation and monitoring of SGCN identified by Arizona's SWAP.

The Department has a long history of establishing and implementing research and population monitoring activities that withstand scientific scrutiny. Statewide population monitoring protocols and research projects for many SGCN have already been established. The Department has Contracts, Research and Nongame branches with personnel dedicated to many of these activities. Additional efforts are contracted to external partners. Many high priority research and monitoring efforts are conducted by wildlife biologists employed by the Department for their expertise in specific taxon groups. As part of their regular duties, these expert biologists conduct routine survey and monitoring activities, as well as provide training and establish monitoring protocols for other biologists to follow (for example, Chiricahua leopard frog workshop, HDMS, Department School training sessions, etc.). In addition, Wildlife Managers and other biologists located in six regional offices across the state are trained to note the presence or absence of certain SGCN (or invasive exotic species) and report relevant information to appropriate personnel in the Department, and those data are incorporated into existing repositories (HDMS, riparian herpetofauna database, native fishes database, crayfish database, etc.). Additional data are collected through the Department's administration of scientific collecting permits and from the general public.

The section below provides examples as an overview of monitoring approaches and mechanisms currently used by the Department or in development. Table 4 is an attempt at a more inclusive list of Department and partner-led monitoring efforts underway or planned for the near future. While not all monitoring programs have explicit adaptive management goals written into them, many plans incorporate adaptive management philosophy and discuss the need to reevaluate results at certain intervals and to adjust management protocols accordingly. Other plans have adaptive management clearly built into them. The examples are presented along taxonomic lines, and are meant to illustrate single species and multispecies monitoring (for both target and non-target species), habitat monitoring, as well as the incorporation of adaptive management into Departmental protocols. Where practical, the Department will continue to develop or adjust existing monitoring and data collection protocols to gather data on all SGCN species, and to work with our partners to achieve common conservation goals.

EXAMPLES OF EXISTING MONITORING PROGRAMS

Crustaceans and Mollusks

Crustacean and mollusk monitoring is still in its formative stages in Arizona, and efforts are concentrated on a variety of species of snails, including springsnails, ambersnails, and

talussnails. Monitoring is usually single-species based and typically includes a habitat monitoring component. For most SGCN crustaceans and mollusks, monitoring programs will be put in place as resources become available. The most well developed monitoring protocols have been established for ambersnails, for which a fair amount of baseline ecological research has already been done (Stevens et al. 1997; Sorensen and Nelson 2002). Monitoring at three sites in Arizona comprises timed presence-absence counts and standardized plot-based sampling with associated habitat components.

Invasive exotic invertebrates have become a huge problem in Arizona, and a GIS-linked database has been developed to track the distribution of invasive exotic crayfish in the White Mountains of Arizona. Crayfish have been implicated in the decline of nongame and sport fishes, as well as mollusks, ranid frogs, gartersnakes and mud turtles (Fernandez and Rosen 1996, Akins and Jones, 2010). This database is managed by the Department, but data have been contributed largely by private citizens and conservation groups (including TNC and Trout Unlimited Zane Gray Chapter), as well as USFS personnel. The Department plans to expand the database to include the entire state.

Crustacean and mollusk monitoring may also be extended to shared watersheds between Arizona and Sonora, México. Recent inventory efforts by partners in Sonora have indicated the presence of existing populations of species that have experienced drastic declines in Arizona (e.g., San Bernardino springsnail), and represent conservation opportunities for both sides of the border (Varela-Romero and Myers 2010).

Fishes

Monitoring of fishes is often single-species focused, primarily because of funding source restrictions or recovery needs. Information is often collected with respect to downlisting/ delisting goals as outlined in recovery plans (or drafts). Examples of this approach include Gila topminnow, desert pupfish, Apache trout, Gila trout, and Little Colorado spinedace monitoring protocols (table 4). In many cases, despite the necessity of a single species approach, Department biologists often make an effort to gather incidental information on non-target species of fishes and amphibians.

Desert pupfish and Gila topminnows, both short lived and inhabitants of variably isolated habitats, require annual monitoring because habitat conditions can change quickly. The Draft - Gila Topminnow Recovery Plan calls for stocking topminnows into suitable habitat within their former range. At every site, the plan requires monitoring at 1 month, 6 months and 1 year post-stocking (Weedman 1999). The practical reasons behind such a schedule are the evaluation and measure of success of the project: short-term to verify survival from the stocking effort, and long-term to verify persistence and recruitment at a level that will ensure a self-sustaining population. The success of the effort is evaluated and subject to adaptive management, the details of which are provided in the statewide SHA for topminnow and pupfish (AGFD 2007). Examples of altered circumstances that could lead to modifications in management protocols include drought, invasion by nonnative organisms, and population failure. The draft recovery plan outlines potential management alternatives for each circumstance. Other single species fish surveys (e.g., Little Colorado spinedace) result in community level data that are incorporated into the monitoring protocols.

Multiple-species protocols include the Muleshoe Cooperative Management Area surveys, which specifically target five species of federally listed native fishes, and involve collaborative efforts among the Department and Federal and private partners. This particular project is designed to reintroduce and manage five species of critically threatened and endangered fishes into shared jurisdictional waters that are tributary to the San Pedro River in southern Arizona, and to monitor their subsequent success. Data collected for "non-target" native and non-native species provide a more complete picture of the system. This gives managers an effective means of tracking trends in the native aquatic communities, and allowing the identification and timely response to threats (e.g., non-native aquatic species) that may appear during the life of the project.

Amphibians

The 10-year Sonoran tiger salamander occupancy monitoring project is also a single species effort in which incidental information is gathered on other species. This effort is designed to provide spatial and temporal data from which to design recovery actions for this endangered species. The resulting multispecies dataset derived from a single species work plan has resulted in the development of a GIS database that not only allows the Department to examine changes, spatially and temporally, in distribution of salamanders, but it also allows tracking of federally listed Chiricahua leopard frogs and invasive exotic species such as bullfrogs and crayfish. This has become a powerful tool for management of aquatic habitats in the San Rafael Valley where these animals occur, and provides the potential for rapid adaptive adjustments to recovery efforts. For the past several years the Department has been incorporating information about Mexican gartersnakes into the database, which increases its utility for community-wide monitoring and conservation.

Conservation action questions have been incorporated into monitoring protocols for several species, including the Tarahumara frog reintroduction program. The success of Tarahumara frog repatriation is measured according to five stages in the frog's life history and ecology, all of which are necessary for success and all of which can be measured objectively (and relatively easily): survival of release, survival over winter, long-term survival, reproduction, and recruitment. Adaptive management was built into the plan at 1-year, 2-year and 5-year intervals, at which times the project success is evaluated and necessary modifications incorporated.

The Department has reintroduced Chiricahua leopard frogs to several sites within its historical range, and has stocked them in a number of Safe Harbor sites. Reintroduction sites are monitored annually under an adaptive management regime that requires reevaluation of stocking to determine if the stocking has been a success, if the site continues to be suitable, if additional animals need to be repatriated, etc. The Chiricahua leopard frog statewide SHA also calls for annual monitoring of SHA sites, which is often accomplished with help from partners.

With partners in USFWS and USFS (Coronado NF), the Department is developing a 10-year monitoring program (implemention began in spring 2011) to evaluate the success of the Peña Blanca area bullfrog removal effort. Bullfrog removal was accomplished through a multipartner, agency and private sector effort that can be a model for future projects to eliminate exotic species. The new multispecies monitoring program will include presence/absence monitoring for bullfrogs, particularly in Peña Blanca Lake as well as in stock tanks associated with the Peña

Blanca watershed, and regions to the east that are presumably most vulnerable to bullfrog reinvasion. The plan will also focus on presence/absence monitoring of Chiricahua and lowland leopard frogs, both of which have benefitted directly from bullfrog removal. The plan will include actions necessary to address reinvasions of bullfrogs, should they occur.

Reptiles

Averill-Murray (2000) outlined a quantitative protocol for monitoring Sonoran desert tortoises using capture-recapture methods on 17, 1km^2 or 1mi^2 plots randomly assigned on BLM lands throughout the Arizona distribution of the tortoise. Later advancements in population estimation techniques suggested distance sampling might be more efficient and more accurate, and initial attempts at evaluating distance sampling were positive (Averill-Murray and Averill-Murray 2005, Swann et al. 2002). The Department then contracted a 2-year study to evaluate the technique more fully, the results of which suggested that Sonoran desert tortoise habitat was too complex for distance sampling methods to be efficient (Zylstra et al. 2010). Further, additional demographic characteristics (i.e., adult survival) cannot be estimated with distance sampling methods (Zylstra and Steidl 2009). Zylstra and Steidl (2009) also suggested that a monitoring program based on occupancy would be more efficient and have greater power to detect linear population trends than a program based on distance sampling. In 2010, the Department implemented a pilot study using occupancy methods, while continuing capture-recapture methods on the plots, to provide information on distribution, density and survival estimates of Sonoran desert tortoises.

The Department instituted a Mexican gartersnake monitoring project at the Department's Bubbling Ponds and Page Springs fish hatcheries. This project combines capture/recapture and radio telemetry to determine population dynamics and habitat use. This site is heavily infested with invasive bullfrogs and the project was designed to understand how these two species manage to coexist, whereas they do not seem to do so elsewhere in the snake's historical range. This effort will also inform hatchery improvements and operations, and suggest ways in which those can be managed to minimize impacts to Mexican gartersnakes and perhaps to improve their situation. In addition, the Department is working with a variety of partners through the Gartersnake Conservation Working Group (co-led by the Department and USFWS) to obtain additional distribution and abundance data for Mexican gartersnakes throughout their Arizona range.

Tucson shovel-nosed snakes are candidates for listing under the ESA (USFWS 2008b). Efforts to evaluate population status have proven exceedingly difficult, and to date most information on distribution and abundance of shovel-nosed snakes has been gathered from road-riding surveys in which living or dead animals are surveyed on highways (Wood et al. 2008, Mixan and Lowery 2008, Jones et al. 2011). Mixan and Lowery (2008) found that road-kill data suggested a much more robust population than did their extensive trapping efforts, while trapping by Rosen (2008) failed to produce any shovel-nosed snakes at all. Because of uncertainty as to whether or not "standard" trapping techniques accurately assess populations, the Department is testing modified trapping techniques to identify appropriate methods to monitor these snakes.

Finally, in 2009 the Department instituted a "citizen science" survey protocol to evaluate the status of ornate box turtles in southeastern Arizona. This closed season species has apparently

declined considerably in the last two decades, but evidence has been largely anecdotal. Because box turtles are typically active for a relatively short time of year during the summer monsoon season and occur over a broad geographical expanse, it seemed more practical to enlist the help of ordinary citizens (local residents, birders, tourists, etc.) to document presence of box turtles, rather than expend limited resources using Department biologists to monitor these turtles. Data sheets are distributed at a number of Department outreach events and through partners, e.g., TNC. Distributional data obtained through this project will enable the Department to focus efforts on understanding box turtle declines and conservation needs.

Birds

The Arizona Bird Conservation Initiative (ABCI) continues to obtain key stakeholder support to implement and expand an integrated and coordinated approach to statewide bird monitoring through the Arizona Coordinated Bird Monitoring Program(AZCBM). ABCI is coordinated by the Department and consists of participants from state, federal and tribal entities, as well as universities and non-governmental organizations. The AZCBM approach closely parallels the four general monitoring goals outlined in the 2007 North American Bird Conservation Initiative (NABCI) Monitoring Subcommittee document, "Opportunities for Improving Avian Monitoring": 1) Integrate monitoring into bird management and conservation practices, 2) Coordinate and integrate monitoring projects among organizations and across spatial scales, 3) Improve statistical design, and 4) maintain a modern data management system (NABCI-U.S. 2007). The objectives of the AZCBM Program is to coordinate statewide efforts to monitor bird populations of most species in Arizona to provide long-term population trends and population estimates, as well as to identify SGCN, determine research needs and evaluate land management actions. Further, bird monitoring efforts in Arizona, as elsewhere, benefit greatly from the input of citizen science. As Schoonmaker and Luscombe (2005) pointed out, "properly trained citizens not only reduce the cost of data collection and ground-truthing, they can also become engaged supporters of fish and wildlife conservation."

With stakeholder support and as a result of specific regulatory and monitoring needs, the Department has developed a Raptor Management Program to conserve raptor species and manage the threats to improve population numbers. The Raptor Management Program encapsulates long-term monitoring programs such as the Arizona Bald Eagle Management Program and the California Condor Reintroduction Program. It also has begun long-term monitoring programs to address specific regulatory and monitoring needs like the Golden Eagle Management Program, and has implemented management actions to address specific population threats like the Burrowing Owl Clearance Protocol and Training. With a goal to conserve Arizona's birds of prey and their habitats through aggressive protection and management programs, the Department's Raptor Management Program will continue to provide the monitoring needs, data, and conservation programs necessary to improve the status of this specific group of birds.

Mammals

The Department's Mammals Program has developed the Arizona Bat Conservation Strategic Plan (Hinman and Snow 2003) which helps guide our monitoring efforts and programs. Like the Arizona PIF Bird Conservation Plan implementation strategy, the Bat Conservation Plan calls for statewide species and habitat monitoring. Although some species recovery plans, for example,

lesser long-nosed bat, require single species monitoring protocols, the vast majority of bat monitoring efforts target multiple species, through mist net and roost surveys. This plan highlights the ability to monitor species regardless of priority, such that rare and common species can be assessed equally. Significant roost sites in mines, bridges, buildings, trees, and caves for Arizona's 28 bat species are documented and monitored, with special emphasis on special status species and SGCN, including lesser long-nosed bat (endangered), Mexican long-tongued bat, California leaf-nosed bat, Allen's lappet-browed bat, Townsend's big-eared bat, and other species of interest. The Department consults with multiple agencies on bat management activities to develop recommendations and guidelines for management of bat species and their habitats. The Department promotes and distributes the Arizona Bat Conservation Strategic Plan, which sets goals and priorities for management, research, education, inventory and monitoring. The program also maintains an information network among biologists and works with partners to identify and secure sites with bat friendly gates. Information and outreach about bat conservation is provided to the public along with assistance on nuisance bat issues.

Another strategic plan, the Small Mammal Conservation Plan, is being developed. With direction from the Arizona SWAP, this ambitious document will incorporate the goals of adaptive management into plans for monitoring multiple species across multiple landscapes and ecoregions. Developing and implementing the small mammal plan for Arizona will help identify management and conservation needs. The plan is intended to define specific areas of concern for management, research, inventory, monitoring, and education that should be addressed in Arizona by land managers, wildlife managers, scientists, and concerned citizens. This will include efforts for all SCGN mammal species.

The Black-tailed Prairie Dog Re-establishment Project is a long-term monitoring program that will direct adaptive management practices and aid in restoration of a keystone (ecosystem engineer) species. Monitoring is an intensive part of this project with daily monitoring occurring immediately following a release, weekly monitoring for three months post-release, and then monthly monitoring for the remainder of the year. Also, the Gunnison's Prairie Dog (GUPD) Occupancy Surveys will establish a long-term data set across the entire range of GUPD which will provide critical information for conservation and management, as well as provide up-to-date information for the USFWS that they can use to determine whether listing under the ESA is appropriate. GUPD monitoring is not as intensive as for black-tailed prairie dogs, but still critical to determine the stability of the population (including the goal of maintaining populations across 75% of the historic range), the presence of disease, and the potential for future black-footed ferret release sites. Incidental monitoring is a part of many surveys as well, and SGCN such as golden eagles, ferruginous hawks and burrowing owls are documented if observed while biologists conduct prairie dog surveys.

Mammal monitoring extends to our partnerships with colleagues in México with whom the Department collaborates on projects that are relevant to cross border conservation efforts. Examples of this include biannual aerial surveys of Sonoran pronghorn populations in Sonora, and annual roost surveys of lesser long-nosed bats.

Unknown Status Species and Monitoring Needs

A continuing critical challenge facing the Department concerns the appropriate mechanisms for accumulating information on the status and distribution of Unknown status species (Appendix E:). In part, responsibilities for conservation agreements, recovery plans, draft recovery plans, etc., consume many of the resources available to the Department for conservation of Arizona's wildlife. Nonetheless, the Department is committed to gathering data on Unknown status species and to working with our partners to do the same. Many of the monitoring efforts in which the Department is currently involved, or plans for the near future, have built into them mechanisms either explicitly designed for monitoring multiple species, or for including "non-target" species into the protocols (table 4). These monitoring programs will continue to accumulate significant amounts of data on many Unknown status species. Also, the International and Borderlands Program collaborates with partners in México to gather information on species listed in the United States and on various SGCN species relevant to other Arizona conservation efforts.

Excellent examples of these kinds of programs include: the AZCBM that provides long-term population trend data on entire suites of birds through projects like Colonial Nest Surveys, Secretive Marsh Bird Surveys, Riparian Bird Surveys, Forest Bird Surveys (with USFS partners) and IBA monitoring (with Audubon partners) among others; AGFD Regional fish and riparian herpetofauna surveys in which data are collected on a variety of non-target species; Chiricahua Leopard Frog Visual Encounter Surveys that collect information on all species of non-target amphibians and reptiles in addition to Chiricahua leopard frogs.

Finally, in addition to programs highlighted above and in table 4, depending on resource availability the Department has solicited proposals from outside cooperators through the "Bird and Bat Grants" program to initiate or continue surveys/monitoring for entire suites of animals for which there is no other mechanism for gathering data. Since its inception, these grants have resulted in the implementation of over 70 bird and 36 bat conservation projects all over the State, with a targeted effort at addressing conservation priorities identified in the Bird Plan (Latta et al. 1999) and the Bat Plan (Hinman and Snow 2003) (priorities tiered to the SWAP broad strategies). This relatively small grants program has contributed immensely to strengthening or developing our bird and bat conservation partnerships with the USFS, BLM, USFWS, Audubon Society chapters, Wild at Heart, state universities, and many others. This program maintains flexibility for which priorities (in the conservation plans) get funded annually, allowing for increased partners' participation, rapid focus on emerging conservation needs, and greater opportunity for partnership building. In the area of bird monitoring, these grants have supported the Hummingbird Monitoring Network (HMN) to target a group of birds that presents more challenges than those common to monitoring other landbird species. Hummingbird numbers are difficult to estimate and are best counted and identified (i.e., females and juveniles) by banding efforts at hummingbird concentration sites, the approach used by the HMN. Bird grants to the USFS have also served as a catalyst for forest birds monitoring across Arizona's northern forests. This effort is now contributing to NABCI Bird Conservation Region level population estimates and trends.

In order to fill gaps in existing monitoring projects and to implement best monitoring practices, the Department will coordinate monitoring projects with external, existing programs such as: PARC (www.parcplace.org), NABCI (www.nabci-us.org), The Wildlands Project

(www.twp.org), Pima County's Sonoran Desert Conservation Plan (www.pima.gov/sdcp), and the Central Arizona-Phoenix Long-Term Ecological Research project (caplter.asu.edu). Many of these initiatives have been further developed for application in Arizona (Latta et al. 1999; Foreman et al. 2000, Pima County 2002, Hinman and Snow 2003, Grand Canyon Wildlands Council 2004).

MONITORING EFFECTIVENESS AND TRACKING PROGRESS

Perhaps the most difficult aspect of adaptive management is developing the appropriate mechanisms for tracking the success or failure of management protocols, especially when those protocols cover the multitude of species found in Arizona. As indicated above, successful monitoring begins with identifying the conservation target and the indicator(s) that will be tracked, and ultimately the success of the project is evaluated in the context of adaptive management (The Heinz Center 2009). The 2010 Monitoring Workshop resulted in extensive discussions regarding appropriate targets and indicators, and included exercises in brainstorming monitoring approaches in model habitats, like the Sonoran Desert and high elevation spruce-fir forests. These example-based discussions helped participants think more carefully about ways in which to focus the development of monitoring projects, and therefore ensure their success.

For most species and projects listed in table 4 there are recovery plans, conservation agreements and management plans that provide clear conservation targets, with monitoring programs to measure success in achieving agreement or recovery goals (see Appendix G:). While it would be impractical to list targets for all of those species/projects here, examples of how projects monitor conservation goals include the following:

1. The Muleshoe Ecosystem Management Plan (BLM 1998), a partnership among the Department, BLM, USFS and TNC, outlined goals and objectives for native fish reintroduction and conservation in tributaries to the San Pedro River within the Muleshoe Ranch Conservation Management Area (CMA) (see discussion above). Through additional partnerships with U.S. Bureau of Reclamation and USFWS, native fishes were repatriated to sites on the CMA beginning in 2007 (including Gila topminnow, desert pupfish, loach minnow, spikedace, and Gila chub). The goal of the repatriations was to establish self-sustaining populations of each of these species. After stocking, repatriated populations were monitored annually for five years, except for topminnow and pupfish which were monitored more frequently: one month post-stocking, six months post-stocking, and then annually, as per generalized monitoring protocols for these two species. The measures or indicators of population establishment were species abundance and evidence of reproduction and recruitment. Annually, and after monitoring, Department staff meet with all partners to evaluate progress and successes and to determine future direction. Adaptive management principles are used, and if evidence suggests that a few individuals of a species are present but a population is not yet established, then an augmentation stocking occurs. If a population is determined to be established, then no further augmentations are necessary. If the species is not captured after several successive monitoring events, then the multi-agency team may also determine that the habitat is not sufficient to sustain the species, and discontinue stocking at that site. After five years, the multi-agency team will meet to evaluate all stocking and monitoring data and plan future direction of management actions.

2. The Chiricahua Leopard Frog Recovery Plan (USFWS 2007) outlines clear goals for recovery in the eight Chiricahua leopard frog Recovery Units (RU), parts of seven of which are in Arizona. The recovery indicators include, in part, establishing two metapopulations and one isolated robust population in each RU. As management efforts (including repatriations, habitat improvement, invasive species control, etc.) and monitoring proceed, the complexity of endangered species recovery in general, and metapopulation dynamics in particular, continue to require evaluation of project progress. Department biologists work with partners and stakeholders in regional Steering Committee Meetings and Local Recovery Group Meetings to discuss progress and to consider adjustments in an adaptive management context.

3. The AZCBM, discussed briefly above, was developed when biologists evaluating the need for a coordinated monitoring program for priority bird species, discovered that there were good data available for as few as 12 species of Arizona birds. Consequently, monitoring for status assessment (Stem et al. 2005) was identified as the fundamental need, before appropriate management actions could be designed. The program includes several projects for which the main goals are to provide long-term statewide population trend data for species where this information is limited and evaluate the effects of management actions and stressors, or from which management objectives can be derived. These projects involve many partners and numerous dedicated volunteers to collect data. One of those projects, the Arizona Riparian Bird Surveys project was developed with external partners, uses a rigorous, randomized design with multi-year sampling. As monitoring proceeds biologists will accumulate the necessary data from which to detect those trends, establish population estimates, and evaluate management actions.

Other monitoring efforts have tracking measures built into them, whether or not monitoring is linked to a formal recovery plan or conservation agreement. The Department is committed to evaluating new monitoring projects to ensure that appropriate tracking mechanisms and conservation targets are built into the plans.

Finally, successful monitoring programs depend on successful partnerships. Table 4 summarizes many Department monitoring efforts, and the degree to which those efforts depend on partnerships is evident in the column for agency or organization leads. This list is by no means comprehensive for Arizona, and there are many other ongoing monitoring efforts with which the Department is not directly involved, whether through academia, tribes, agencies or NGOs. Our partners are encouraged to work with the Department to fill existing gaps in SGCN monitoring.

Further, although monitoring efforts in table 4 are characterized as single species or multi-species, most single species projects collect data on many non-target species, including other SGCN. And as explained elsewhere, the Department collects survey data opportunistically for a variety of SGCN and other species, such that when resources become available we will prioritize additional monitoring efforts for SGCN not otherwise covered by existing monitoring efforts.

Table 4: Summary of ongoing and planned monitoring efforts currently carried out by the Department and cooperators.

All monitoring efforts explicitly target SGCN or they include larger communities of which SGCN are a part, and include their habitats or threats. Where appropriate, details are described in Planning Documents referenced under "Document # (see Appendix G).

Project	Document #	Single species	Multi-species	Habitat	Long-term	Geographic Scope	Agency or Organization Leads (work units)
Crustaceans and Mollusks							
Kanab ambersnail	26, 27		X	X	X	rangewide	AGFD WMNG
Page springsnail	214, 215	X		X	X	local	AGFD (WMNG)
Quitobaquito tryonia	215, 241		X	X	X	local	NPS, AGFD (WMNG)
San Xavier talussnail	28	X		X	X	local	AGFD (WMNG/FOR5), El Paso Corp., SW Transmission Coop
Three Forks springsnail	212, 215	X		X	X	local	AGFD (WMNG), USFS
Wet Canyon talussnail	29		X	X	X	local	AGFD (WMNG), USFS
Fishes							
Apache trout	82, 87, 230	X		X	X	rangewide	AGFD (FOR1, WMFS), USFWS-AZFWCO
Bonytail	246	X			X	statewide	AGFD (FOR3), USFWS, USBR
Colorado pikeminnow	250	X			X	statewide	AGFD (FOR6)
Desert pupfish	34, 145, 235, 237	X		X	X	basin	AGFD (WMNG), BLM, USFWS
Gila topminnow	35, 145, 235, 237, 249	X		X	X	basin	AGFD (WMNG), BLM, USFWS
Gila trout	36	X		X	X	statewide	AGFD (WMFS), FWS-AZFWCO
Humpback chub	248	X			X	local	USFWS, NPS, AGFD (WMRS,WMNG)
Little Colorado spinedace	42, 107, 115, 116	X		X	X	rangewide	AGFD (WMNG, FOR1, FOR2)
Loach minnow	43	X			X	statewide	AGFD (WMNG)
Quitobaquito (Rio Sonoyta) pupfish	241		X		X	rangewide	NPS, AGFD (WMNG)
Razorback sucker	251	X			X	statewide	AGFD (WMNG, FOR3, FOR4, FOR6), USFWS, USBR
Sonora chub	45	X			X	local	AGFD (FOR5)
Spikedace	46, 129	X			X	statewide	AGFD (WMNG)
Virgin River fishes	47		X		X	rangewide	AGFD (FOR2,WMNG), USFWS, BLM
Virgin spinedace	247	X			X	local	AGFD (FOR2,WMNG)
Yaqui fishes	31		X		X	rangewide	USFWS, AGFD (FOR5)
CAP Monitoring	270		X		X	basin	AGFD (WMNG), USBR, USFWS
Draft Lower Colorado River National Wildlife Mgmt Plan	70		X			local	USFWS

Project	Document #	Single species	Multi-species	Habitat	Long-term	Geographic Scope	Agency or Organization Leads (work units)
El Coronado Ranch monitoring	21, 274		X		X	local	AGFD (FOR5), USFWS
Horseshoe Lake and Bartlett Lake monitoring	76		X		X	local	SRP, (AGFD WMHB,WMRS)
Lower Colorado River Multispecies Conservation Plan	32, 33, 41, 44, 231, 246, 248, 250, 251		X		X	local	AGFD (WMHB, FOR4), USFWS
Muleshoe Ranch monitoring	147		X		X	local	AGFD (WMNG), BLM, USFWS, TNC
Packard Ranch/Tavasci Marsh monitoring	129		X		X	local	AGFD (FOR3), NPS
Regional Fish Surveys	none		X	X	X	local	AGFD Regional offices
Sipe Wildlife Area fish monitoring	115		X		X	local	AGFD (FOR1)
Statewide Conservation Agreement and Strategy for 6 fish species	239		X		X	statewide	AGFD (WMNG)
Amphibians							
American bullfrog monitoring, Peña Blanca Lake area	draft		X		X	local	AGFD (WMNG, FOR5), USFS
American bullfrog monitoring, Scotia Canyon area	273		X		X	local	USFS, AGFD (WMNG)
Chiricahua leopard frog monitoring in RU 1, 2, 3, 4	219, 256	X			X	local	AGFD (FOR6)
Chiricahua leopard frog monitoring in RU 5	256	X			X	local	AGFD (FOR2, FOR6)
Chiricahua leopard frog monitoring in Recovery Unit (RU) 6 and 7	256	X				local	AGFD (FOR1)
Chiricahua leopard frog Safe Harbor Agreement monitoring	222	X			X	rangewide	AGFD (WMNG, FOR1, FOR2, FOR5, FOR6)
Chiricahua Leopard Frog Visual Encounter Surveys	256		X		X	rangewide	AGFD (WMNG)
Lowland and Plains leopard frogs	none		X			statewide	AGFD Regional offices
Northern leopard frog	none	X			X	rangewide	AGFD (FOR2)
Relict leopard frog	218	X			X	rangewide	Relict Leopard Frog Conservation Team, AGFD (FOR3)
Sonora tiger salamander 10-year monitoring protocol	53		X	X	X	local	AGFD (WMNG,FOR5)
Tarahumara frog reintroduction	234	X		X	X	local	AGFD (WMNG, FOR5), USFS, USFWS
Chytridiomycosis surveys	256		X		X	statewide	AGFD (WMNG)
Reptiles							
Flat-tailed horned lizard	48	X		X	X	local	AGFD (WMRS, FOR4, WMNG)

Project	Document #	Single species	Multi-species	Habitat	Long-term	Geographic Scope	Agency or Organization Leads (work units)
Mexican gartersnake	none	X				rangewide	AGFD (WMNG, FOR2, FOR5, FOR6)
Narrow-headed gartersnake	none	X				rangewide	AGFD (WMNG, FOR2, FOR6)
New Mexico ridge-nosed rattlesnake	51	X				local	AGFD (WMNG)
Ornate box turtle watch	266	X			X	statewide	AGFD (WMNG)
Sonoran desert tortoise disease monitoring	49, 240, 259	X			X	rangewide	AGFD (WMNG)
Sonoran desert tortoise juvenile size-class monitoring	49, 240, 259	X				local	AGFD (WMNG)
Sonoran desert tortoise monitoring, Florence Military Reservation	259, 264, 265	X			X	local	AGFD (WMRS)
Sonoran desert tortoise permanent plots & occupancy sites	49, 240, 259, 264	X			X	rangewide	AGFD (WMNG), BLM
Sonoran mud turtle monitoring, Bonita Creek	none	X				local	AGFD (WMNG)
Sonoyta mud turtle	241		X		X	local	AGFD (WMNG), NPS, CEDES
Tucson shovel-nosed snake	none	X				rangewide	AGFD (WMRS,FOR6, WMNG)
Nonnative turtle monitoring, Phoenix Zoo	none		X		X	local	AGFD (WMNG)
Mammals							
Black-footed ferret	58	X			X	local	AGFD (WMNG, FOR3)
Black-footed ferret and Gunnison's prairie dog disease monitoring	58		X		X	local	AGFD (WMNG, FOR3)
Black-footed ferret management and prairie dog monitoring	58	X			X	local	AGFD (WMNG)
Black-tailed prairie dog	163	X			X	statewide	AGFD (WMNG)
Desert bighorn sheep	none	X				local	Gila River Indian Community, AGFD (WMRS)
Gunnison's prairie dog	253, 267, 268	X			X	statewide	AGFD Regional offices
Jaguar	55	X			X	borderlands	AGFD (WMNG)
Lesser long-nosed bat roost monitoring	54, 161	X		X	X	rangewide	AGFD (WMNG, FOR5), many partners
Mexican wolf	57	X			X	local	AGFD (FOR1)
Mt. Graham red squirrel	160	X			X	local	AGFD (FOR5), USFS, UA
Sonoran pronghorn	162	X			X	rangewide	AGFD (FOR4), CEDES
Arizona Bat Conservation Strategic Plan	54		X	X	X	statewide	AGFD (WMNG, Regional offices)
Fort Huachuca bat monitoring	54, 78		X		X	local	DOD

Project	Document #	Single species	Multi-species	Habitat	Long-term	Geographic Scope	Agency or Organization Leads (work units)
Long-term bat monitoring	54		X	X	X	statewide	AGFD (WMNG, Regional offices)
Mammal track surveys	none		X		X	local	Sky Island Alliance
White-nose Syndrome disease monitoring	269	X	X	X		statewide	AGFD, USFS, BLM, many partners
Birds							
Bald eagle (breeding and winter)	211	X			X	statewide	AGFD (WMNG), numerous federal, state, tribal, local and NGO partners
Burrowing owl	168	X			X	statewide	AGFD (WMRS,WMNG), Wild At Heart
California condor	170, 171, 172, 262	X			X	local	AGFD (FOR2), Peregrine Fund
Golden eagle nesting surveys	none	X				statewide	AGFD (WMNG), numerous federal, state, tribal, local and NGO partners
Masked (Northern) bobwhite	72	X			X	local	USFWS
Mexican spotted owl	204	X			X	rangewide	USFS
Peregrine falcon	263	X			X	statewide	AGFD, USFWS
Southwestern willow flycatcher	165, 203	X			X	local	USFWS, USBR
Christmas Bird Count	169		X		X	statewide	National Audubon Society, local Audubon chapters
Hummingbird Monitoring Network	169		X		X	local	Hummingbird Monitoring Network
Important bird area (IBA) monitoring	169		X		X	local	Audubon AZ, Tucson Audubon Society, AGFD (WMNG)
Nightjar surveys (U.S.)	169		X		X	statewide	U.S. Nightjar Survey Network, USFWS, AGFD (WMNG)
North American Breeding Bird Survey	169		X		X	statewide	USGS (Laurel, MD), AGFD (WMNG)
North American Marsh Bird surveys, including Yuma Clapper Rail	210		X		X	rangewide	AGFD (FOR4,FOR6)
Phoenix area and reservoir winter aquatic bird survey	none		X		X	local	AGFD (WMNG)
Riparian bird surveys	169, 272		X		X	statewide	AGFD (WMNG)
Sonoran Desert and grassland bird surveys	169		X		X	statewide	AGFD (WMNG), DOD, BLM
Tucson bird count	169		X		X	local	UA
Western (U.S.) Colonial Aquatic Bird Nest Surveys	169		X			local	AGFD (WMNG)

LITERATURE CITED

ACERP (Arizona Comprehensive Environmental Risk Project). 1995. The Arizona Comprehensive Environmental Risk Project Report. ACERP Steering Committee, Phoenix, Arizona. [http://earthvision.asu.edu/acerp/].

Arizona Department of Commerce. 2007. Arizona State and County Economic Base Studies. Arizona Department of Commerce. Phoenix, Arizona.

ADEQ (Arizona Department of Environmental Quality). 2004. Arizona's 2004 303(d) List and Other Impaired Waters. ADEQ, Phoenix, Arizona.

ADWR (Arizona Department of Water Resources). 1994. Arizona Riparian Protection Program Legislative Report: A Report to the Governor, President of the Senate and Speaker of the House. ADWR, Phoenix, Arizona.

ADWR (Arizona Department of Water Resources). 2010. Arizona Water Atlas: Volume 8 Active Management Area Planning Area. ADWR, Phoenix, Arizona. 467 pp.

AFWA (Association of Fish and Wildlife Agencies). 2009. Voluntary guidance for states to incorporate climate change into state wildlife action plans and other management plans. 42 pp.

Arizona Game and Fish Commission. 1988. Threatened Native Wildlife in Arizona. Approved by the Arizona Game and Fish Commission in public meeting on July 21, 1988.

AGFD (Arizona Game and Fish Department). 1996. Wildlife of Special Concern in Arizona. Approved by the Arizona Game and Fish Commission in public meeting on March 16, 1996. Arizona Game and Fish Department, Phoenix, Arizona. 32 pp.

AGFD (Arizona Game and Fish Department). 2006. Arizona's Comprehensive Wildlife Conservation strategy: 2005-2015. Arizona Game and Fish Department, Phoenix, Arizona. 835 pp.

AGFD (Arizona Game and Fish Department). 2007. Safe Harbor Agreement for Topminnows and Pupfish in Arizona. Arizona Game and Fish Department, Phoenix, Arizona. 36 pp.

AGFD (Arizona Game and Fish Department). 2008a. Guidelines for Reducing Impacts to Wildlife from Wind Energy Development in Arizona. 68 pp.

AGFD (Arizona Game and Fish Department). 2008b. Hunt Arizona: Survey, Harvest and Hunt Data for Big and Small Game. 179 pp.

AGFD (Arizona Game and Fish Department). 2009a. Wildlife Friendly Guidelines: City and Project Planning. 43 pp.

AGFD (Arizona Game and Fish Department). 2010 Guidelines for Solar Development in Arizona. 33 pp.

Akins, C. M. and T. R. Jones. 2010. *Kinosternon sonoriense* (Sonoran mud turtle). Predation. Herpetological Review 41:485-486

Allen, C. D. and D. D. Breshears. 1998. Drought-induced shift of a forest-woodland ecotone: rapid landscape response to climate variation. Proceedings of the National Academy of Sciences 95: 14839-14842.

Archer, S. 1994. Woody plant encroachment into southwestern grasslands and savannas: rates, patterns and proximate causes. Pages 13-68 *in* M. Vavra, W. A. Laycock, and R. D. Pieper (eds.). Ecological Implications of Livestock Herbivory in the West. Society for Range Management, Denver, Colorado.

Archer, S. R. and K. I. Predick. 2008. Climate change and ecosystems of the southwestern United States. Rangelands 30:23-28.

Altenbach, J. S. and H. E. Milford. 1995. Evaluation and management of bats in abandoned mines in New Mexico. Pages 326-330 *in* D. Pate (ed.). Proceedings of the 1993 Cave Management Symposium. Carlsbad, New Mexico.

Atkinson, A. J., P. C. Trenham, R. N. Fisher, S. A. Hathaway, B. S. Johnson, S. G. Torres and Y. C. Moore. 2004. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. U.S. Geological Survey Technical Report. USGS Western Ecological Research Center, Sacramento, California. 69 pp.

Averill-Murray, R. C. 2000. Survey protocol for Sonoran desert tortoise monitoring plots: Reviewed and revised. Arizona Interagency Desert Tortoise Team. Arizona Game and Fish Department, Phoenix, Arizona. 41 pp.

Averill-Murray, R. C. and A. Averill-Murray. 2005. Regional-scale estimation of density and habitat use of the desert tortoise (*Gopherus agassizii*) in Arizona. Journal of Herpetology 39: 65-72.

Baden, S. A. and James, M. A. 2004. Wind energy development and avian effects in northern Arizona: A review of the state of current knowledge and recommendations for minimizing impacts. Arizona: Grand Canyon Trust.

Bahre, C. J. 1991. A legacy of change: Historic human impact on vegetation in the Arizona borderlands. University of Arizona Press, Tucson, Arizona.

Bahre, C. J. and M. L. Shelton. 1993. Historic vegetation change, mesquite increases, and climate in southeastern Arizona. Journal of Biogeography 20: 489-504.

Bazzaz, F. A. and R. W. Carlson. 1984. The response of plants to elevated CO_2 (carbon dioxide): Competition among an assemblage of annuals at two levels of soil moisture (*Amaranthus retroflexus, Polygonum pensylvanicum, Ambrosia artemisiifolia, Abutilon theophrasti*). Oecologia 62: 196-198.

Beatty, G. L., J. T. Driscoll, and J. G. Koloszar. 1998. Arizona bald eagle nestwatch program: 1997 summary report. Nongame and Endangered Wildlife Program Technical Report 131. Arizona Game and Fish Department, Phoenix, Arizona.

Belsky, A. J. and D. M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior West. Conservation Biology 11: 315-327.

Beschta, R. L., J. J. Rhodes, J. B. Kauffman, R. E. Gresswell, G. W. Minshall, J. R. Karr, D. A. Perry, F. R. Hauer, and C. A. Frissell. 2004. Postfire management on forested public lands of the western United States. Conservation Biology 18: 957-967.

Betancourt, J. L. 1990. Late Quaternary biogeography of the Colorado Plateau. Pages 259-293 *in* J.L. Betancourt, T. R. Van Devender, and P. S. Martin (eds). Packrat Middens: The Last 40,000 Years of Biotic Change. University of Arizona Press, Tucson, Arizona.

Beyer, W. N., L. J. Blus, C. J. Henny and D. Audet. 1997. The role of sediment ingestion in exposing wood ducks to lead. Ecotoxicology 6: 181-186.

Bleich, V. C., J. G. Kie, T. R. Stephenson, M. W. Oehler, Sr. and A. L. Medina. 2005. Managing rangelands for wildlife. Pages 873–897 *in* C. E. Braun (ed.). The wildlife techniques manual. The Wildlife Society, Bethesda, Maryland.

Bogan, M. A., C. D. Allen, E. H. Muldavin, S. P. Platania, J. N. Stuart, G. H. Farley, P. Mehlhop, and J. Belnap. 1998. Southwest. Pages 543-592 *in* M. J. Mac, P. A. Opler, C. E. Puckett Haecker, and P. D. Doran (eds.). Status and Trends of the Nation's Biological Resources. 2 vols. U.S. Geological Survey, Reston, Virginia.

Bolin, B., B. R. Doos, J. Jager, and R. A. Warrick. 1986. The Greenhouse Effect, Climate Change, and Ecosystems. John Wiley and Sons, New York, New York.

Bowers, J. E., T. M. Bean and R. M. Turner. 2006. Two decades of change in distribution of exotic plants at the Desert Laboratory, Tucson, Arizona. Madroño: 53:252-263.

Bowman, W. D., D. M. Cairns, J. S. Baron, and T. R. Seastedt. 2002. Islands in the sky: Alpine and treeline ecosystems of the Rockies. Pages 183-202 *in* J.S. Baron (ed.). Rocky Mountain Futures: An Ecological Perspective. Island Press, Washington, DC.

Boykin, K. G., B. C. Thompson, R. A. Deitner, D. Schrupp, D. Bradford, L. O'Brien, C. Drost, S. Propeck-Gray, W. Rieth, K. A. Thomas, W. Kepner, J. Lowry, C. Cross, B. Jones, T. Hamer, C. Mettenbrink, K. J. Oakes, J. Prior-Magee, K. Schulz, J. J. Wynne, C. King, J. Puttere, S. Schrader, and Z. Schwenke. 2007. Predicted animal habitat distributions and

species richness. Pages 39-78 *in* J. S. Prior-Magee, K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and B.C. Thompson (eds.). Southwest Regional Gap Analysis Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, Idaho.

Boyle, S. A. and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: A review. Wildlife Society Bulletin 13: 110-116.

Bradley, G. A., P. C. Rosen, M. J. Sredl, T. R. Jones and J. E. Longcore. 2002. Chytridiomycosis in native Arizona frogs. Journal of Wildlife Diseases 38:206-212.

Brattstrom, B. H. and M. C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 *in* R. H. Webb and H. G. Wilshire (eds). Environmental Effects of Off-Road Vehicles: Impacts and Management in Arid Regions. Springer-Verlag, New York, New York.

Brennan, T. C. and A. T. Holycross. 2007. A field guide to amphibians and reptiles in Arizona. Arizona Game and Fish Department, Phoenix, Arizona. 150 pp.

Breshears, D. D., N. S. Cobb, P. M. Rich, K. P. Price, C. D. Allen, R. G. Balice, W. H. Romme, J. H. Kastensf, M. L. Floyd, J. Belnap, J. J. Anderson, O. B. Myers, and C. W. Meyer. 2005. Regional vegetation die-off in response to global-change-type drought. Proceedings of the National Academy of Sciences 102: 15144-15148.

Briske, D. D., S. D. Fuhlendorf and F. E. Smeins. 2003. Vegetation dynamics on rangelands: A critique of the current paradigm. Journal of Applied Ecology 40: 601–614.

Brock, J. H. 1994. *Tamarix* spp. (salt cedar), an invasive exotic woody plant in arid and semi-arid riparian habitats of western USA. Pages 27-44 *in* L. C. de Waal, L. E. Child, P. M. Wade, and J. H. Brook (ed.). Ecology and management of invasive riverside plants. John Wiley and Sons, Chichester, United Kingdom.

Brooks, M. L. 1999. Alien annual grasses and fire in the Mojave Desert. Madroño 46:13-19.

Brooks, M. L. and B. Lair. 2005. Ecological effects of vehicular routes in a desert ecosystem. Report of USGS Recoverability and Vulnerability of Desert Ecosystems Program. [http://www.dmg.gov/documents/Desert_Road_Ecology_report.pdf].

Brooks, M. L. and J. R. Matchett. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980–2004. Journal of Arid Environments 67: 148-164.

Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. Pages 1-14 *in* K. E. M. Galley and T. P. Wilson (eds.). Proceedings of the invasive species workshop: The role of fire in the control and spread of invasive species. Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and

Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, Florida.

Brown, D. E. (ed). 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City, Utah. 342 pp. Originally published 1982 as Desert Plants 4 (1-4).

Brown, D. E., N. B. Carmony, and R. M. Turner. 1981. Drainage map of Arizona showing perennial streams and some important wetlands. Arizona Game and Fish Department, Phoenix, Arizona. 1 sheet (1:1,000,000).

Brown, D. E., and C. H. Lowe. 1974. A digitized computer-compatible classification for natural and potential vegetation in the Southwest with particular reference to Arizona. Journal Arizona Academy Science 9, Supplement 2: 1-11.

Brown, J. H. and E. J. Heske. 1990. Control of a desert-grassland transition by a keystone rodent guild. Science 250: 1705-1707.

Brown, J. H., T. J. Valone, and C. G. Curtin. 1997. Reorganization of an arid ecosystem in response to recent climate change. Proceedings of the National Academy of Sciences. 94: 9729-9733.

Bunn, S. E. and A. H. Arthington. 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. Environmental Management 30: 492-507.

BLM (Bureau of Land Management) 1998. Muleshoe Ecosystem Management Plan and Environmental Assessment. 206 pp.

BLM (Bureau of Land Management) 2005. Updated BLM sensitive species list for Arizona. Instruction Memorandum No. AZ-2006-002, Change 1. Phoenix: Arizona State Office, Bureau of Land Management. November 4.

Busack, S. D. and R. B. Bury. 1974. Some effects of off-road vehicles and sheep grazing on lizard populations in the Mohave Desert. Biological Conservation 6: 179-183.

Carmichael, G. J., J. N. Hanson, M. E. Schmidt and D. C. Morizot. 1993. Introgression among Apache, cutthroat and rainbow trout in Arizona. Transactions of the American Fisheries Society 122: 121-130.

Cayan, D. R., T. Das, D. W. Pierce, T. P. Barnett, M. Tyree and A. Gershunov. 2010. Future dryness in the southwest U.S. and the hydrology of the early 21st century drought. Proceedings of the National Academy of Sciences 107: 21271-21276.

Center for the Future of Arizona, 2009. A Citizens' Agenda for Arizona's Second Century: The Arizona We Want. [http://www.thearizonawewant.org].

Clark, E. and N. Cobb (compilers). 2003. 2003 Southwest Drought Summit Summary Report. [http://watershed.nau.edu/2003DroughtSummit/index.htm].

Clements, W. H., D. M. Carlisle, J. M. Lazorchak, P. C. Johnson. 2000. Heavy metals structure benthic communities in Colorado mountain streams. Ecological Applications 10: 626-638.

Collier, M. and R. H. Webb. 2002. Floods, Droughts, and Climate Change. The University of Arizona Press, Tucson, Arizona. 154 pp.

Collins, J. P., T. R. Jones, and H. A. Berna. 1988. Conserving genetically distinctive populations: the case of the Huachuca tiger salamander (*Ambystoma tigrinum stebbinsi*), Pages 45-53 *in* R. C. Szaro, K. C. Severson, and D. R. Patton (eds.). Management of amphibians, reptiles, and small mammals in North America. USDA Forest Service GTR-RM-166, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Conner, R. C., J. D. Born, A. W. Green, and R. A. O'Brien. 1990. Forest Resources of Arizona. U.S. Forest Service Resource Bulletin INT-69. U.S. Dept of Agriculture, Forest Service, Ogden, Utah.

Cooke, R. U. and R. W. Reeves. 1976. Arroyos and environmental change in the American South-West. Clarenden Press, Oxford, England. 213 pp.

Cooper, C. F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecological Monographs 30:129-164.

Corman, T. E. and C. Wise-Gervais, editors. 2005. Arizona Breeding Bird Atlas. University of New Mexico Press, Albuquerque, New Mexico. 635 pp

Covington, W. W. and M. M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. Journal of Forestry 92: 39-47.

Crawford, J. A., C. -H. A. Wahren, S. Kyle and W. H. Moir. 2001. Responses of exotic plant species to fires in *Pinus ponderosa* forests in northern Arizona. Journal of Vegetation Science 12: 261-268.

Crimmins, T. M., M. A. Crimmins and C. D. Bertelsen. 2009. Flowering range changes across an elevation gradient in response to warming summer temperatures. Global Change Biology 15: 1141-1152

Crimmins, T. M., M. A. Crimmins and C. D. Bertelsen. 2010. Complex responses to climate drivers in onset of spring flowering across a semi-arid elevation gradient. Journal of Ecology 98: 1042-1051.

Cunningham, S. C., R. D. Babb, T. R. Jones, B. D. Taubert and R. Vega. 2002. Reaction of lizard populations to a catastrophic wildfire in a central Arizona mountain range. Biological Conservation 107: 193-201.

Dahms, C. W., and B. W. Geils. 1997. An assessment of forest ecosystem health in the Southwest. General Technical Report RM-GTR-295. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Southwest Region, Fort Collins, Colorado.

Daily, G. C., P. R. Ehrlich and N. M. Haddad. 1993. Double keystone bird in a keystone species complex. Proceedings of the National Academy of Sciences 90: 592-594.

Dale, V. H., L. A. Joyce, S. McNulty, R. P. Nielson, M. P. Ayres, M. D. Flannigan, P. J. Hanson, L. C. Irland, A. E. Lugo, C. J. Peterson, D. Simberloff, F. J. Swanson, B. J. Stocks, and B. M. Wotton. 2001. Climate Change and Forest Disturbance. Bioscience. 51: 723-734.

DeMent, S. H., J. J. Chisolm, Jr., J. C. Barber and J. D. Strandberg. 1986. Lead exposure in an "urban" peregrine falcon and its avian prey. Journal of Wildlife Diseases 22: 238-244.

Dickens, P. S., R. A. Minear, and B. A. T. Schantz. 1989. Hydrologic arteration of mountain watersheds from surface mining. Journal of the Water Pollution Control Federation 7: 1249-1260.

Dinerstein, E., D. Olson, J. Atchley, C. Loucks, S. Contreras-Balderas, R. Abell, E. Inigo, E. Enkerlin, C. Williams, and G. Castilleja. 2000. Ecoregion-based conservation in the Chihuahuan Desert-a biological assessment. World Wildlife Fund, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), The Nature Conservancy, PRONATURA Noreste, and Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM).

Dodd, N. L., J. W. Gagnon, S. Boe, and R. E. Schweinsburg. 2006. Characteristics of elk-vehicle collisions and comparison to GPS-determined highway crossing patterns. Pages 461-477 *in* C. L. Irwin, P. Garrett, K. P. McDermott (eds.). Proceedings of the 2005 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina.

Dolbeer, R. A. and S. E. Wright. 2008. Wildlife strikes to civil aircraft in the United States: 1990 – 2007. Federal Aviation Administration National Wildlife Strike Database Serial Report Number 14. 57 pp.

Drabowski, E. F. 1993. Water quality impacts at abandoned hardrock mines. Natural Science Technology 28: 399-407.

Edwards, C. W., C. F. Fulhorst, and R. D. Bradley. 2001. Molecular phylogenetics of the *Neotoma albigula* species group: Further evidence of a paraphyletic assemblage. Journal of Mammalogy 82: 267-279.

Elliott, G., M. Chase, G. Geupel and E. Cohen. 2003. Developing and implementing an adaptive conservation strategy: A guide for improving adaptive management and sharing the learning among conservation practitioners. PRBO Conservation Science 2003. Website of PRBO Conservation Science [http://www.prbo.org/].

Elton, C. S. 1958. The ecology of invasions by animals and plants. University of Chicago Press, Chicago, Illinois.

Elzinga, C. L., D. W. Salzer, J. W. Willoughby, and J. P. Gibbs. 2001. Monitoring plant and animal populations. Blackwell Science, Inc., Malden, Massachusetts. 360 pp.

Esque, T. C., and C. R. Schwalbe. 2002. Alien annual grasses and their relationships to fire and biotic change in Sonoran Desertscrub. Pages 165-194 *in*: Tellman, B. (ed.). Invasive exotic species in the Sonoran Desert. Arizona-Sonora Desert Museum, University of Arizona Press, Tucson.

Esque, T. C., C. R. Schwalbe, L. A. Defalco, R. B. Duncan and T. J. Hughes. 2003. The Southwestern Naturalist 48:103-111.

Ewing, R., J. Kostyack, D. Chen, B. Stein, and M. Ernst. 2005. Endangered by sprawl: How runaway development threatens America's wildlife. National Wildlife Foundation, Smart Growth America, and NatureServe. Washington, DC. 53 pp.

FAA (Federal Aviation Administration). 2010. FAA wildlife strike database. [http://wildlife-mitigation.tc.faa.gov/wildlife/default.aspx].

Fernandez, P. J. and P. C. Rosen. 1996. Effects of the introduced crayfish *Orconectes virilis* on native aquatic herpetofauna in Arizona. Final report, IIPAM Project I94054. Arizona Game and Fish Department, Phoenix, Arizona.

Finch, D. M. (ed). 2004. Assessment of Grassland Ecosystem Conditions in the Southwestern United States, Volume 1. U.S. Forest Service General Technical Report RMRS-GTR-135. Rocky Mountain Research Station, Fort Collins, Colorado.

Forman, R. T. T. and R. D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 14: 36-46.

Foreman, D., K. Daly, B. Dugelby, R. Hanson, R. Howard, J. Humphrey, L. Linck, R. List, and K. Vacariu. 2000. Sky Islands Wildlands Network Conservation Plan. The Wildlands Project, Tucson, Arizona. 220 pp.

Foreman, D., K. Daly, R. Noss, M. Clark, K. Menke, D. R. Parsons, and R. Howard. 2003. New Mexico highlands wildlands network vision: Connecting the Sky Islands to the southern Rockies. The Wildlands Project. Richmond, Vermont.

Foreman, R. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, T. C. Winter. 2003. Road ecology: Science and solutions. Island Press. Washington, DC.

Franklin, J. F., F. J. Swanson, M. E. Harmon, D. A. Perry, T. A. Spies, V. H. Dale, A. McKee, W. K. Ferrell, J. E. Means, S. V. Gregory, J. D. Lattin, T. D. Schowalter and D. David. 1992. Effects of global climatic change on forests in northwestern North America. Pages 244-257 *in* R. L. Peters and T. E. Lovejoy (eds.). Global warming and biological diversity. Yale University Press: New Haven, Connecticut.

Frenzel, R. W. and R. G. Anthony. 1989. Relationships of diets and environmental contaminants in wintering bald eagles. Journal of Wildlife Management 53:792-802.

Friedman, J. M., W. R. Osterkamp, M. L. Scott, and G. T. Auble. 1998. Downstream effects of dams on channel geometry and bottomland vegetation: regional patterns in the Great Plains. Wetlands 18:619-633.

Frissel, C. A. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California. Conservation Biology 8: 629-644.

Furniss, M. J., T. D. Roeloffs, and CS Lee. 1991. Road construction and maintenance. Pages 297-323 *in* W. R. Meehan (ed.). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, Maryland.

Galindo-Leal, C., A. Morales and M. Weber. 1994. Utilizacion de habitat, abundancia y dispersion del venado de Coues: un experiment seminatural. Pages 315–332 *in* C. Vaughan and M. A. Rodriguez (eds.). Ecologia y manejo del venado cola blanca en México y Costa Rica. Editorial de la Universidad Nacional.

Goldman, E. A. 1937. The Colorado River as a barrier in mammalian distribution. Journal of Mammalogy. 18:427-435.

Gori, D. F., and C. A. F. Enquist. 2003. An assessment of the spatial extent and condition of grasslands in central and southern Arizona, southwestern New Mexico and northern Mexico. Prepared by The Nature Conservancy, Arizona Chapter. 28 pp.

Gottfried, G. J., P. F. Ffolliott, and L. F. DeBano. 1995. Forests and woodlands of the Sky Islands: stand characteristics and silvicultural prescriptions. Pages 152-164 *in* L. F. Debano, P. F. Ffolliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B. Edminster (tech. coords.), Biodiversity and management of the Madrean Archipelago: the Sky Islands of the southwestern United States and northwestern Mexico. 1994. Tucson, Arizona. U.S. Forest Service General Technical Report RM-264. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Grand Canyon Wildlands Council. 2004 (draft). Grand Canyon Wildlands Network: A proposal. Grand Canyon Wildlands Council, Flagstaff, Arizona.

Griffin, J. R. 1977. Oak woodland. Pages 383-416 *In* M. Barbour and J. Major (eds.). Terrestrial Vegetation of California. Wiley-Interscience, New York, New York.

Griffith, J. S. and T. R. Tiersch. 1989. Ecology of fishes in Redfield Canyon, Arizona, with emphasis on *Gila robusta intermedia.* Southwestern Naturalist 34: 131-134.

Grinnell, J. 1914. An account of the mammals and birds of the lower Colorado valley: With special reference to the distributional problems presented. University of California Press, Berkeley, California. 286 pp.

Gruell, G. E. 1999. Historical and modern roles of fire in pinyon-juniper. Pages 24-28 *in* S.B. Monsen and R. Stevens (eds.). Ecology and management of pinyon-juniper communities within the Interior West. Proceedings RMRS-P-9. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Guo, Q. 2004. Slow recovery in desert perennial vegetation following prolonged human disturbance. Journal of Vegetation Science 15: 757-762.

Haack, R. A. and J. W. Byler. 1993. Insects and pathogens: Regulators of forested ecosystems. Journal of Forestry 91: 32-37.

Hall, J. A., S. Weinstein, and C. L. McIntyre. 2005. The impacts of livestock grazing in the Sonoran Desert: A literature review and synthesis. The Nature Conservancy in Arizona, Tucson.

Hanson, W. R. and C. Y. McCulloch. 1955. Factors influencing mule deer on Arizona brushlands. Transactions of the North American Wildlife Conference 20: 568-588.

Heffelfinger, J. R., C. Brewer, C. H. Alcalá-Galván, B. Hale, D. L. Weybright, B. F. Wakeling, L. H. Carpenter and N. L. Dodd. 2006. Habitat guidelines for mule deer: Southwest Deserts Ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies. 48 pp.

Heinz Center. 2009. Measuring the Results of Wildlife Conservation Activities. Washington, DC. 122 pp.

Hendrickson, D. A., and W. L. Minckley. 1984. Cienegas - vanishing climax communities of the American Southwest. Desert Plants 6: 131-175.

Henny, C. J., L. J. Blus, D. J. Hoffman, L. Sileo, D. J. Audet and M. R. Snyder. 2000. Field evaluation of lead effects on Canada geese and mallards in the Coeur d'Alene River Basin, Idaho. Archives of Environmental Contamination and Toxicology 39: 97-112.

Hensley, F. R., T. R. Jones, M. S. Maxwell, L. J. Adams, N. S. Nedella. 2010. Demography, terrestrial behavior, and growth of Sonoran mud turtles (*Kinosternon sonoriense*) in an extreme habitat. Herpetological Monographs 24: 174-193.

Hessburg, P. F. and J. K. Agee. 2003. An environmental narrative of inland northwest United States forests, 1800-2000. Forest Ecology and Management 178: 23-59.

Hicks, Holly and W. E. Van Pelt. in lit. Interagency Management Plan for Black-tailed Prairie Dogs in Arizona: 2009 Revision. Nongame and Endangered Wildlife Program. Arizona Game and Fish Department, Phoenix, Arizona.

Hinman, K. E. and T. K. Snow, eds. 2003. Arizona Bat Conservation Strategic Plan. Nongame and Endangered Wildlife Program Technical Report 213. Arizona Game and Fish Department, Phoenix, Arizona.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press, Tucson. 602 pp.

Holechek, J. L., R. D. Pieper and C. H. Herbel. 1998. Range management principles and practices. Third Edition. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Holechek, J. L., M. Thomas, F. Molinar and D. Gault. 1999. Stocking desert rangelands: What we've learned. Rangelands 21: 8-12.

Holycross, A. T., W. P. Burger, E. J. Nigro and T. C. Brennan. 2006. Surveys for *Thamnophis eques* and *Thamnophis rufipunctatus* in the Gila River watershed of Arizona and New Mexico. Unpublished report submitted to the Arizona Game and Fish Department. 105 pp.

Hunt, W. G., D. E. Driscoll, E. W. Bianchi, and R. E. Jackman. 1992. Ecology of bald eagles in Arizona. Report to U.S. Bureau of Reclamation, Contract 6-CS-30-04470. BioSystems Analysis Incorporated, Santa Cruz, California.

Huntly, N. and R. Inouye. 1988. Pocket gophers in ecosystems: Patterns and mechanisms. BioScience 38: 786-793.

Hunter, A. F. and L. W. Aarssen. 1988. Plants helping plants. Bioscience 38: 34-40.

IPCC (International Panel on Climate Change). 2001. Climate Change 2001: Impacts, adaptation and vulnerability. IPCC Third Assessment Report. Cambridge University Press. Cambridge, United Kingdom. 1032 pp.

IPCC (International Panel on Climate Change). 2007a. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller, editors. Cambridge University Press, Cambridge, United Kingdom. 996 pp.

IPCC (International Panel on Climate Change). 2007b. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, editors., Cambridge University Press, Cambridge, United Kingdom. 976 pp.

IPCC (International Panel on Climate Change). 2007c. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R. K and Reisinger, A., editors. IPCC, Geneva, Switzerland. 104 pp.

Jansen, B. D., J. R. Hefflefinger, T. H. Noon, P. R. Krausman, and J. C. de Vos, Jr. 2006. Infectious keratoconjunctivitis in bighorn sheep, Silver Bell Mountains, Arizona, USA. Journal of Wildlife Disease 42: 407-411.

Jansson, R. C. Nilsson, M. Dynesius, E. Andersson. 2000. Effects of river regulation on river-margin vegetation: A comparison of eight boreal rivers. Ecological Applications 10: 203-224 .

Johnson, B. L. 1999. The role of adaptive management as an operational approach for resource management agencies. Conservation Ecology 3: 8. [http://www.consecol.org/vol3/iss2/art8/].

Johnson, H. B., H. W. Polley, and H. S. Mayeux. 1993. Increasing CO_2 and plant-plant interactions: Effects on natural vegetation. Vegetation 104/105: 157-170.

Johnson, W. C. 1998. Adjustment of riparian vegetation to river regulation in the Great Plains, USA. Wetlands 18: 608-618.

Jones, A. 2000. Effects of grazing on North American arid ecosystems: A quantitative review. Western North American Naturalist 60: 155-164.

Jones, C. A. 2008. *Mycoplasma agassizii* in the Sonoran population of the desert tortoise in Arizona. M.S. Thesis, University of Arizona, Tucson, Arizona, 126 pp.

Jones, C. G., J. H. Lawton, M. Shachak. 1994. Organisms as ecosystem engineers. Oikos 69: 373-386.

Jones, T. R. and R. J. Timmons. 2010. *Hyla wrightorum* (Arizona treefrog). Predation. Herpetological Review 41: 473-474.

Jones, T. R., R. D. Babb, F. R. Hensley, C. LiWanPo and B. K. Sullivan. 2011. Sonoran desert snake communities at two sites: Concordance and effects of increased road traffic. Herpetological Conservation and Biology 6: 61-71.

Kaushal, S. S. P. M. Groffman, G. E. Likens, K. T. Belt, W. P. Stack, V. R. Kelly, L. E. Band, and G. T. Fisher. 2005. Increased salinization of fresh water in the northeastern United States. Proceedings of the National Academy of Sciences 102: 13517-13520.

Kerpetz, A. 1986. Competition between European starlings and native woodpeckers for nest cavities in saguaros. M.Sc. Thesis. University of Arizona, Tucson.

Kiesecker, J. M., A. R. Blaustein and C. L. Miller. 2001. Potential mechanisms underlying the displacement of native red-legged frogs by introduced bullfrogs. Ecology 82: 1964-1970.

Klopatek, J. M., R. T. Conant, J. M. King, R. A. Malin, K. L. Murphy and C. C. Klopatek. 1997. Implications of patterns of carbon pools and fluxes across a semiarid environmental gradient. Landscape and Urban Planning 39: 313-321.

Knight, R. L. and K. J. Gutzwiller, eds. 1995. Wildlife and Recreationists: Coexistence through management and research. Island Press, Washington, DC. 372 pp.

Knipe, T. 1977. The Arizona whitetail deer. Special Report 6, Arizona Game and Fish Department, Phoenix, Arizona.

Krausman, P. R., L. K. Harris, C. L. Blasch, K. K. G. Koenen, J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs 157: 1-41.

Krausman, P. R., M. C. Wallace, C. L. Hayes and D. W. DeYoung. 1998. Effects of jet aircraft on mountain sheep. Journal of Wildlife Management 62: 1246-1254.

Kristan, W. B. and W. I. Boarman. 2002. Spatial pattern of risk of common raven predation on desert tortoises. Ecology 84: 2432-2443.

Lamb, T., T. R. Jones and P. J. Wettstein. 1997. Evolutionary genetics and phylogeography of tassel-eared squirrels (*Sciurus aberti*). Journal of Mammalogy 78: 117-133.

Landres, P. B., J. Verner and J. W. Thomas. 1988. Ecological uses of vertebrate indicator species: A critique. Conservation Biology 24: 316-328.

Landrum, L. R., L. Dugan, S. Whitcomb. 2005. Noteworthy collections, Arizona, *Oncosiphon piluliferum*. Madroño 52: 270-274.

Latta, M. J., C. J. Beardmore, and T. E. Corman. 1999. Arizona Partners in Flight Bird Conservation Plan. Version 1. 0. Nongame and Endangered Wildlife Program Technical Report 142. Arizona Game and Fish Department, Phoenix, Arizona.

Laycock, W. A. 1991. Stable states and thresholds of range condition on North American rangelands: A viewpoint. Journal of Range Management 44: 427–433.

Laycock, W. A. 1994. Implications of grazing vs. no grazing on today's rangelands. Pages 250-280 *in* M. Vavra, W. A. Laycock and R. D. Pieper (eds.). Ecological implications of livestock herbivory in the West. Society for Range Management, Denver, Colorado.

Lee, D. C., J. R. Sedell, B. R. Rieman, R. F. Thurow, and J. E. Williams. 1997. Broadscale assessment of aquatic species and habitats. Pages 1058-1496 *in* T. M. Quigley and S. J. Arbelbide (tech eds.). An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: Volume 3. U.S. Forest Service General Technical Report PNW-GTR-405. Pacific Northwest Research Station, Portland, Oregon.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial Processes in Geomorphology. W. H. Freeman, San Francisco, California.

Leung, Y. -F., and J. L. Marion. 2000. Recreation impacts and management in wilderness: A state-of-knowledge review. Pages 23-48 *in* Wilderness Science in a Time of Change Conference. Volume 5: Wilderness Ecosystems, Threats, and Management. D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin (comps.). USDA Forest Service Proceedings RMRS-P-15-VOL-5, Rocky Mountain Research Station, Ogden, Utah.

Lewis, L. A., R. J. Poppenga, W. R. Davidson, J. R. Fischer and K. A. Morgan. 2001. Lead toxicosis and trace element levels in wild birds and mammals at a firearms training facility. Archives of Environmental Contamination and Toxicology 41: 208-214.

Longcore, T., C. Rich and S. A. Gauthreaux, Jr. 2008. Height, guy wires, and steady-burning lights increase hazard of communication towers to nocturnal migrants: A review and meta-analysis. The Auk 125: 485-492.

Loft, E. R., J. W. Menke, J. G. Kie and R. C. Bertram. 1987. Influence of cattle stocking rate on the structural profile of deer hiding cover. Journal of Wildlife Management 51: 655-664.

Lovejoy, T. E., and L. Hannah, editors. 2005. Climate change and biodiversity. Yale University Press, New Haven, Connecticut.

Lowry, J. H, Jr., R. D. Ramsey, K. A. Thomas, D. L. Schrupp, W. G. Kepner, T. Sajwaj, J. Kirby, E. Waller, S. Schrader, S. Falzarano, L. Langs Stoner, G. Manis, C. Wallace, K. Schulz, P. Comer, K. Pohs, W. Rieth, C. Velasquez, B. Wolk, K. G. Boykin, L. O'Brien, J. Prior-Magee, D. Bradford and B. Thompson. 2007. Land cover classification and mapping. Pages 14-38 *in* J. S. Prior-Magee, K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and B.C. Thompson (eds.). Southwest Regional Gap Analysis Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, Idaho.

LCRMSCP (Lower Colorado River Multi-Species Conservation Program). 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Sacramento, California. 506 pp.

Lyons, R. K. and B. D. Wright. 2003. Using livestock to manage wildlife habitat. Publication B-6136 [http://wildlife.tamu.edu/publications/B6136_livestock_tool.pdf], Texas Cooperative Extension Service, Texas A&M University, College Station, Texas.

Ma, W. C. 1996. Lead in mammals. Pages 281-296 *in* W. N. Beyer, G. H. Heinz, A. W. Redmon-Norwood (eds.). Environmental Contaminants in Wildlife. Interpreting Tissue Concentrations. SETAC Special Publication Series, CRC Press, Boca Raton.

MacNally, R. and E. Fleishman. 2002. Using "indicator" species to model species richness: Model development and predictions. Ecological Applications 12: 79-92.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: A literature synthesis. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, Colorado, NERC-88/29. 88 pp.

Manley, P. N., W. J. Zielinski, M. D. Schlesinger, and S. R. Mori. 2004. Evaluation of a multiple-species approach to monitoring species at the ecoregional scale. Ecological Applications 14: 296-310.

Manley, P. N., B. Van Horne, J. K. Roth, W. J. Zielinski, M. M. McKenzie, T. J. Weller, F. W. Weckerly, and C. Vojta. 2006. Multiple species inventory and monitoring technical guide. Gen. Tech. Rep. WO-73. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 204 p.

Marshall, J. T. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Cooper Ornithological Society, Berkeley, California. Pacific Coast Avifauna. 125 pp.

Marshall, R. M., S. Anderson, M. Batcher, P. Comer, S. Cornelius, R. Cox, A. Gondor, D. Gori, J. Humke, R. Paredes Aguilar, I. E. Parra, S. Schwartz. 2000. An ecological analysis of conservation priorities in the Sonoran Desert ecoregion. Prepared by The Nature Conservancy Arizona Chapter, Sonoran Institute, and Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora with support from Department of Defense Legacy Program, Agency and Institutional partners. 146 pp.

Marshall, R. M., D. Turner, A. Gondor, D. Gori, C. Enquist, G. Luna, R. Paredes Aguilar, S. Anderson, S. Schwartz, C. Watts, E. Lopez, and P. Comer. 2004. An ecological analysis of conservation priorities in the Apache Highlands ecoregion. Prepared by The Nature Conservancy of Arizona, Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora, agency and institutional partners. 152 pp.

Marshall R. M., M. D. Robles, D. R. Majka, J. A. Haney. 2010. Sustainable Water Management in the Southwestern United States: Reality or Rhetoric. PLoS ONE 5(7): e11687. Doi:10. 1371/journal. pone. 0011687.

Martin, P. S. and R. G. Klein (editors). 1984. Quaternary Extinctions: A prehistoric revolution. University of Arizona Press. Tucson, Arizona.

Mason, C. F. 2002. Biology of Freshwater Pollution. 2002. 4th ed. Pearson Education Limited. England.

Mattson, W. J. and R. A. Haack. 1987. The role of drought in outbreaks of plant-eating insects. Bioscience 37: 110-118.

McAuliffe, J. R. and E. P. Hamerlynck. 2010. Perennial plant mortality in the Sonoran and Mojave deserts in response to severe, multi-year drought. Journal of Arid Environments 74: 885-896.

McCarty, K. M. and K. V. Jacobson. 2011. Arizona bald eagle management program 2011 summary report. Nongame and Endangered Wildlife Program Technical Report 266. Arizona Game and Fish Department, Phoenix, Arizona.

McIntosh, B. A., J. R. Sedell, J. E. Smith, R. C. Wissmar, S. E. Clarke, G. H. Reeves, and L. A. Brown. 1994. Management history of east-side ecosystems: Changes in fish habitats over 50 years, 1935-1992 *in* Eastside forest ecosystem health assessment, Volume III. U.S. Forest Service General Technical Report PNW-GTR-321. Portland, Oregon.

McLaughlin, S. P. and J. E. Bowers. 1982. Effects of wildfire on a Sonoran Desert plant community. Ecology 63: 246-248.

McPherson, G. R. 1992. Ecology of oak woodlands in Arizona. Pages 24-33 *in* P. F. Ffolliott, G. J. Gottfried, D. A. Bennett, V. M. Hernandez, A. Ortega-Rubio, and R. H. Hamre (tech. coords.), Ecology and management of oak and associated woodlands: perspectives in the southwestern United States and northern Mexico. U.S. Forest Service General Technical Report RM-218. Fort Collins, Colorado.

Miller, G. C., W. B. Lyons, and A. Davis. 1996. Understanding the water quality of pit lakes. Environmental Science and Technology 30: 118-123.

Mixan, R. J. and S. F. Lowery. 2008. Planning level surveys for Tucson shovel-nosed snake on the Florence Military Reservation 2008. Unpublished report submitted to Arizona Army National Guard, Facilities Management Office: Environmental, Phoenix, Arizona. 9 pp.

Monroe, L. M., S. C. Cunningham and L. B. Kirkendall. 2004. Small mammal community responses to a wildfire on a central Arizona sky island. Journal of the Arizona-Nevada Academy of Science 37: 56-61.

Monsen, S. B. and R. Stevens. 1999. Symposium on pinyon and juniper ecology, restoration, and management: introduction. Pages 3-4 *in* S.B. Monsen and R. Stevens. Ecology and management of pinyon-juniper communities within the Interior West. Proceedings

RMRS-P-9. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Morrison Institute for Public Policy. 2008. Megapolitan: Arizona's Sun Corridor, Arizona State University, 52 pages.

Mueller, G. A., and Marsh, P. C. 2002. Lost, a desert river and its native fishes: A historical perspective of the Lower Colorado River. U.S. Geological Survey USGS/BRD/ITR-2002-0010.

NABCI-U.S. (U.S. North American Bird Conservation Initiative Monitoring Subcommittee). 2007. Opportunities for improving avian monitoring. U.S. North American Bird Conservation Initiative Report. 50 pp.

Nabhan, G. P. and A. R. Holdsworth. 1999. State of the Desert Biome: Uniqueness, biodiversity, threats and the adequacy of protection in the Sonoran Bioregion. 2nd ed. Arizona-Sonora Desert Museum, Tucson, Arizona. 80pp.

Naiman R. J., Melillo J. M., Hobbie J. E. 1986. Alteration of North American streams by beaver (*Castor canadensis*). Ecology 67: 1254-1289.

NatureServe. 2010a. A Network Connecting Science with Conservation. http://www.natureserve.org/explorer/glossary/gloss_g.htm.

NatureServe. 2010b. NatureServe Explorer Glossary (website accessed November 16, 2010). http://www.natureserve.org/explorer/glossary/gloss_g.htm.

Navo, K. W. 2001. The survey and evaluation of abandoned mines for bat roosts in the West: Guidelines for natural resource managers. Proceedings of the Denver Museum of Nature and Science, Series 4, Number 2. Denver, Colorado. 12 pp.

Negrón, J. F., J. D. McMillan, J. A. Anhold, D. Coulson. 2009. Bark beetle-caused mortality in a drought-affected ponderosa pine landscape in Arizona, USA. Forest Ecology and Management 257: 1353-1362.

Nehlsen, W., J. E. Williams and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16: 4-21.

Newman, P., C. Monz, Y. -F. Leung, and D. M. Theobald. 2006. Monitoring campsite proliferation and conditions: Recent methodological considerations. The George Wright Forum 23: 28-35.

Niemi, G. J., J. M. Hanowski, A. R. Lima, T. Nicholls and N. Weiland. 1997. A critical analysis on the use of indicator species in management. Journal of Wildlife Management 61: 1240-1252.

Northam, F. E., D. M. Backer, and J. A. Hall. 2005. Development of a categorized list of invasive non-native plants that threaten wildlands in Arizona. Final report of the Arizona Wildlands Invasive Plant Working Group.

Ohmart, R. D., W. C. Hunter, and K. V. Rosenberg. 1991. Birds of the lower Colorado River. The University of Arizona Press, Tucson, Arizona. 416 p.

Osmond, C. B., M. Austin, J. Berry, W. Billings, J. Boyer, J. Dacey, P. Nobel, S. Smith, and W. Winner. 1987. Stress physiology and the distribution of plants. BioScience 37: 38-48.

Overpeck, J. and B. Udall. 2010. Dry times ahead. Science 328: 1642-1643.

Pain, D. J., J. Sears, and I. Newton. 1994. Lead concentrations in birds of prey in Britain. Environmental Pollution 87:173-180.

Pain, D. J. 1996. Lead in waterfowl. Pages 251-264 *in* W. N. Beyer, G. H. Heinz, A. W. Redmon-Norwood (eds.). Environmental Contaminants in Wildlife. Interpreting Tissue Concentrations. SETAC Special Publication Series, CRC Press, Boca Raton.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist 100: 65-75.

Paine, R. T. 1969. A note on trophic complexity and community stability. American Naturalist 103: 91-93.

Paine, R. T., M. J. Tegner, and E. A. Johnson. 1998. Compounded perturbations yield ecological surprises. Ecosystems 1: 535-545. New Mexico Environmental Department, Surface Water Quality Bureau, Santa Fe, New Mexico.

Parendes, L. A. and J. A. Jones. 2000. Light availability, dispersal, and exotic plant invasion along roads and streams in the H.J. Andrews Experimental Forest, Oregon. Conservation Biology 14: 64-75.

Pase, C. P. and D. E. Brown. 1994. Interior Chaparral. Pages 95-99 *in* D. E. Brown (ed.). Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press. Salt Lake City, Utah. 342 pp.

Patten, D. T. and J. C. Stromberg. 1995. Dynamics of the landscape patches in the old growth forest on Mt. Graham (Pinaleño Mountains), Arizona. Pages 174-179 *in* DeBano, L. F., P. F. Folliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B. Edminster, (eds.). Biodiversity and management of the Madrean Archipelago: The sky islands of southwestern United States and northwestern Mexico. General Technical Report RM-264, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Patterson, D. T. and E. P. Flint. 1990. Implications of increasing carbon dioxide and climate change for plant communities and competition in natural and managed ecosystems. Pages 83-110 *in* B. A. Kimball, N. J. Rosenberg, L. H. Allen, G. H. Heichel, C. W. Struber, D.

E. Kissel, S. Ernst (eds.). Impact of carbon dioxide, trace gases, and climate change on global agriculture. American Society of Agronomy Special Publication No. 53.

Pearl, C. A., M. P. Hayes, R. Haycock, J. D. Engler, J. Bowerman. 2005. Observations of interspecific amplexus between western North American ranid frogs and the introduced American bullfrog (*Rana catesbeiana*) and a hypothesis concerning breeding interference. American Midland Naturalist 154: 126-134.

Peek, J. M. and P. R. Krausman. 1996. Grazing and mule deer. Pages 183–192 *in* P. R. Krausman, (ed.) Rangeland Wildlife. Society for Range Management, Denver, Colorado.

Peet, R. K. 1988. Forests of the Rocky Mountains. *in* M. G. Barbour and W. D. Billings (eds.), North American vegetation. Cambridge University Press, New York, New York.

Pepper, C. B., M. A. Nascarella and R. J. Kendall. 2003. A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study. Environmental Management 32: 418-432.

Petts, G. E. 1979. Complex response of river channel morphology subsequent to reservoir construction. Progress in Physical Geography 3: 329-362.

Pieper, R. D. 1994. Ecological implications of livestock grazing. Pages 177-211 *in* M. Vavra, W. A. Laycock, and R. D. Pieper (eds.). Ecological implications of livestock herbivory in the West. Society for Range Management, Denver, Colorado.

Pierce, D. W. T. P. Barnett, H. G. Hidalgo, T. Das, C. Bonfils, B. D. Santer, G. Bala, M. D. Dettinger, D. R. Cayan, A. Mirin, A. W. Wood, and T. Nozawa. 2008. Attribution of declining western U.S. snowpack to human effects. Journal of Climate 21: 6425-6444.

Pigott, C. D. and S. Pigott. 1993. Water as a determinate of the distribution of trees at the boundary of the Mediterranean zone. Journal of Applied Ecology 81: 557-566.

Pima County. 2002. Priority Biological Resources of the Sonoran Desert Conservation Plan: providing urban development guidelines as adopted in the Environmental Element of the Comprehensive Plan. Pima County Administrator's Office, Tucson, Arizona.

Power, M. E., D. Tilman, J. A. Estes, B. A. Menge, W. J. Bond, L. S. Mills, G. Daily, J. C. Castilla, J. Lubchenco, and R. T. Paine. 1996. Challenges in the quest for keystones. BioScience 46: 609-620.

Prior-Magee, J. S., K. G. Boykin, D. F. Bradford, W. G. Kepner, J. H. Lowry, D. L. Schrupp, K. A. Thomas, and B. C. Thompson, Editors. 2007. Southwest Regional Gap Analysis Project Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, Idaho.

Raffa, K. F., B. H. Aukema, J. Bentz, A. L. Carroll, J. A. Hicke, M. G. Turner, and W. H. Romme. 2008. Cross-scale drivers of natural disturbances prone to anthropogenic amplification: The dynamics of bark beetle eruptions. BioScience 58: 501-517.

Reece, B. A. 1995. Perpetual pollution. Clementine, winter edition, 1995. Pages 3-6.

Reed, R. A., J. Johnson-Barnard, and W. L. Baker. 1996. Contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology 10: 1098-1106.

Relyea, R. A. 2005. Pesticides and amphibians: The importance of community context. Ecological Applications 14: 1125-1134.

Rieman, B. E., D. C. Lee, and R. F. Thurow. 1997. Distribution, status, and likely future trends of bull trout in the interior Columbia River and Klamath River basins. Transactions of the 46th North American Wildlife and Natural Resources Conference 117: 1111-1125.

Richard, S. M., ed. 2002. Database for mineral districts in the state of Arizona. Arizona Geological Survey, Digital Information Series 23. 22 pp.

Ripple, W. J. and R. L. Beschta. 2003. Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. Forest Ecology and Management 184: 299–313.

Roberts, B., G. Hanson, D. Cornwell, and S. Borger. 2010. An analysis of migrant smuggling costs along the southwest border. Office of Immigration Statistics, U.S. Department of Homeland Security.

Rogers, P., D. Atkins, M. Frank, and D. Parker. 2001. Forest health monitoring in the Interior West. General Technical Report RMRS-GTR-75. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 40 pp.

Rorabaugh, J. C., M. J. Sredl, V. Miera, and C. A. Drost. 2002. Continued invasion by an introduced frog (*Rana berlandieri*): Southwestern Arizona, southeastern California, and Río Colorado, México. The Southwestern Naturalist 47: 12-20.

Rosen, P. C. 2008. 2007 survey results for the Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*), with evidence for ecological change in south-central Arizona. Unpublished report to Arizona Game and Fish Department, Phoenix, Arizona. 30 pp.

Rosen, P. C. and C. R. Schwalbe. 1996. A critical interim evaluation of the effectiveness of bullfrog removal methods at San Bernardino National Wildlife Refuge. Final report, IIPAM Project I94040. Arizona Game and Fish Department, Phoenix, Arizona. 23 pp.

Rosen, P. C. and C. R. Schwalbe. 2002. Conservation of wetland herpetofauna in southeastern Arizona. Final report, IIPAM Project I99016. Arizona Game and Fish Department, Phoenix, Arizona. 95 pp.

Salafsky, N., D. Salzer, J. Ervin, T. Boucher, and W. Ostlie. 2003 (draft). Conventions for defining, naming, measuring, combing, and mapping threats in conservation: An initial proposal for a standard system. December 2003 version. Foundations of Success. Bethesda, Maryland. 33 pp.

Salafsky, N., R. Margoluis, and K. H. Redford. 2001. Adaptive management: A tool for conservation practitioners. Biodiversity Support Program, Washington, D. C.

Salafsky, N., R. Margoluis, K. H. Redford, and J. G. Robinson. 2002. Improving the practice of conservation: A conceptual framework and research agenda for conservation science. Conservation Biology 16: 1469-1479.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: A review. Conservation Biology 5: 18-32.

Savage, M. and T. W. Swetnam. 1990. Early and persistent fire decline in a Navajo ponderosa pine forest. Ecology 70: 2374-2378.

Sayre, N. 1999. The cattle boom in southern Arizona: Towards a critical political ecology. Journal of the Southwest 41: 239-271.

SCBD (Secretariat of the Convention on Biological Diversity). 2010. Global Biodiversity Outlook 3. Montreal. 94 pp.

Schaffer, W.M., D.W. Zeh, S.L. Buchmann, S. Kleinhaus, M.V. Schaffer, and J. Antrim. 1983. Competition for nectar between introduced honeybees and native North American bees and ants. Ecology 64: 564-577.

Schmidt, K. M., J. P. Menakis, C. C. Hardy, W. J. Hann, and D. L. Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. General Technical Report RMRS-GTR-87. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Schoonmaker, P., and W. Luscombe. 2005. Habitat monitoring: An approach for reporting status and trends for state Comprehensive Wildlife Conservation Strategies. Illahee, Portland, Oregon.

Schowalter, T. D. 1986. Ecological strategies of forest insects: The need for a community-level approach to reforestation. Ecology 62: 57-66.

Schowalter, T. D. 1994. An ecosystem-centered view of insect and disease effects on forest health. Pages 189-195 *in* W. W. Covington and L. F. DeBano (eds.). Sustainable ecological systems: Implementing an ecological approach to land management. U.S. Forest Service Technical Report RM-247. Fort Collins, Colorado.

Schowalter, T. D. and P. Turchin. 1993. Southern pine beetle infestation and development: interaction between pine and hardwood basal areas. Forest Science 39: 201-210.

Schulze, E. D., R. Robichaux, J. Grace, P. Rundel, and J. Ehleringer. 1987. Plant water balance. BioScience 37: 30-37.

Schussman, H. and D. Gori. 2004. An ecological assessment of the Bureau of Land Management's current fire management plans: Materials and recommendations for future fire planning. Report to Bureau of Land Management, Arizona State Office, Phoenix, Arizona. 101 pp.

Seager, R. and G. A. Vecchi. 2010. Greenhouse warming and the 21st century hydroclimate of southwestern North America. Proceedings of the National Academy of Sciences 107: 21277-21282.

Sears, J. 1988. Regional and seasonal variations in lead poisoning in the mute swan *Cygnus olor* in relation to the distribution of lead and lead weights in the Thames area, England. Biological Conservation 46: 115-134.

Severson, K. E. and A. L. Medina. 1983. Deer and elk habitat management in the southwest. Journal of Range Management Monograph 2: 1-64.

Severson, K. E. and P. J. Urness. 1994. Livestock grazing: A tool to improve wildlife habitat. Pages 232-249 *in* M. Vavra, W. A. Laycock, and R. D. Pieper (eds.). Ecological Implications of livestock herbivory in the West. Society of Range Management, Denver, Colorado.

Sheridan, T. E. 1995. Arizona: A History. University of Arizona Press, Tucson, Arizona.

Sherwin, R. E., J. S. Altenbach, and P. E. Brown. 2001. Characteristics of the mines of importance to bats. Pages 109-114 *in* K. C. Vories and D. Throgmorton (eds.). Proceedings of the Bat Conservation and Mining Technical Forum. The Office of Surface Mining, Bat Conservation International, and SIUC Coal Research Center. St. Louis, Missouri. November 2000.

Silberman, J. 2001. The economic importance of fishing and hunting for the State of Arizona. School of Management, Arizona State University, Tempe, Arizona.

Simons, L. H. 1991. Rodent dynamics in relation to fire in the Sonoran Desert. Journal of Mammalogy 72: 518-524.

Sinervo, B., F. Méndez-de-la-Cruz, D. B. Miles, B. Heulin, E. Bastiaans, M. Villagrán-Santa Cruz, R. Lara-Resendiz, N. Martínez-Méndez, M. Lucía Calderón-Espinosa, R. Nelsi Meza-Lázaro, H. Gadsden, L. Javier Avila, M. Morando, I. J. De la Riva, P. Victoriano Sepulveda, C. F. Duarte Rocha, N. Ibargüengoytía, C. Aguilar Puntriano, M. Massot, V. Lepetz, T. A. Oksanen, D. G. Chapple, A. M. Bauer, W. R. Branch, J. Clobert, J. W. Sites

Jr. 2010. Erosion of lizard diversity by climate change and altered thermal niches. Science 328: 894-899.

Sitko, S. and S. Hurteau. 2010. Evaluating the impacts of forest treatments: The first five years of the White Mountain Stewardship Project. The Nature Conservancy. Phoenix, Arizona. 110 pp.

Smith, G. A. and M. V. Lomolino. 2004. Black-tailed prairie dogs and the structure of avian communities on the shortgrass plains. Oecologia 38: 592-602.

Sorensen, J. A. and C. B. Nelson. 2002. Interim conservation plan for *Oxyloma (haydeni) kanabensis* complex and related ambersnails in Arizona and Utah. Nongame and Endangered Wildlife Technical Report 192. Arizona Game and Fish Department, Phoenix, Arizona.

Southwick Associates. 2003. Economic Impact Analysis of Nonconsumptive Wildlife-Related Recreation in Arizona. Conducted for the Arizona Game and Fish Department, in conjunction with the Responsive Management project, Arizona residents' attitudes toward nongame wildlife.

Sprigg, W., T. Hinkley, and the Southwest Regional Assessment Group. 2000. Preparing for a Changing Climate: the potential consequences of climate variability and change. Report for the U.S. Global Change Research Program. Institute for the Study of Planet Earth, University of Arizona, Tucson, Arizona. 60 pp.

Sredl, M. J., K. J. Field, and A. M. Peterson. 2002. Understanding and mitigating effects of chytrid fungus to amphibian populations in Arizona. Nongame and Endangered Wildlife Program Technical Report 208. Arizona Game and Fish Department, Phoenix, Arizona.

Starnes, L. B. and D. C. Gasper. 1996. Effects of surface mining on aquatic resources in North America. American fisheries society position statement. Fisheries 21: 24-26.

Steidl, R. J. and B. F. Powell. 2006. Assessing the effects of human activities on wildlife. The George Wright Forum 23: 50-58.

Stein, B. A., L. S. Kutner, and J. S. Adams (eds.). 2000. Precious heritage: The status of biodiversity in the United States. Oxford University Press. 416 pp.

Stephen, C. L., J. C. Devos, Jr., T. E. Lee, Jr., J. W. Bickham, J. R. Heffelfinger, O. E. Rhodes, Jr. 2005. Population genetic analysis of Sonoran pronghorn (*Antilocarpa americana sonoriensis*). Journal of Mammalogy 86: 782-792.

Stem, C., R. Margoulis, N. Salafsky, and M. Brown. 2005. Monitoring and evaluation in conservation: A review of trends and approaches. Conservation Biology 19: 295-309.

Stevens, L. E., T. J. Ayers, J. B. Bennett, K. Christensen, M. J. C. Kearsley, V. J. Meretsky, A. M. Phillips III, R. A. Parnell, J. Spence, M. K. Sogge, A. E. Springer, D. L. Wegner. 2001. Planned flooding and Colorado River riparian trade-offs downstream from Glen Canyon Dam, Arizona. Ecological Applications 11: 701-710.

Stevens, L. E., F. R. Protiva, D. M. Kubly, V. J. Meretsky, and J. R. Peterson. 1997. The ecology of Kanab ambersnail (Succineidae: *Oxyloma haydeni kanabensis* Pilsbry, 1948) at Vaseys Paradise, Grand Canyon, Arizona: Final Report. U.S. Bureau of Reclamation Glen Canyon Environmental Studies Program Report, Flagstaff, Arizona.

Stevens, L. E., J. C. Schmidt, T. J. Ayers, and B. T. Brown. 1995. Flow regulation, geomorphology, and Colorado River marsh development in the Grand Canyon, Arizona. Ecological Applications 5: 1025-1039.

Stevens, R. and S. B. Monson. 2004. Guidelines for restoration and rehabilitation of principal plant communities. Pages 199-294 *in* S.B. Monson, R. Stevens and N.L. Shaw (comps.). Restoring Western Ranges and Wildlands, USDA Forest Service Rocky Mountain Research Station RMRS-GTR 136 vol. 1. Available online: http://www.treesearch.fs.fed.us/pubs/31962.

Stevens, L. E. and A. E. Springer. 2004. A conceptual model of springs ecosystem ecology: Task 1b final report. NPS cooperative agreement number CA 1200-99-009. Report to the National Park Service.

Stone, P. A. 2001. Movements and demography of the Sonoran mud turtle, *Kinosternon sonoriense*. Southwestern Naturalist 46: 41-53.

Storfer, A., S. G. Mech, M. W. Reudink, R. E. Ziemba, J. Warren and J. P. Collins. 2004. Evidence for introgression in the endangered Sonora tiger salamander, *Ambystoma tigrinum stebbinsi* (Lowe). Copeia 2004: 783-796.

Swank, W. G. 1958. The mule deer in the Arizona Chaparral. Wildlife Bulletin 3, Arizona Game and Fish Department, Phoenix, Arizona.

Swann, D. E., R. C. Averill-Murray, and C. R. Schwalbe. 2002. Distance sampling for Sonoran desert tortoises. Journal of Wildlife Management 66: 969-975.

Swarthout, E., and R. J. Steidl. 2001. Flush responses of Mexican spotted owls to recreationists. Journal of Wildlife Management 65: 312-317.

Swarthout, E., and R. J. Steidl. 2003. Experimental effects of hiking on Mexican spotted owls. Conservation Biology 17: 307-315.

Swetnam, T. W. 1990. Fire history and climate in the southwestern United States. Pages 6-17 *in* J. S. Krammes (tech. coord.). Proceedings-Effects of Fire Management of Southwestern

Natural Resources, 1988. Tucson, Arizona. U.S. Forest Service General Technical Report RM-191.

Swetnam, T. W. and J. L. Betancourt. 1990. Fire-southern oscillation relations in the southwestern United States. Science 249: 1017-1021.

Swetnam, T. W. and C. H. Baisan. 1996. Historical fire regime patterns in southwestern United States since A.D. 1700. Pages 11-32 *in* C. D. Allen (tech. ed.). Fire effects in southwestern forests: proceedings of the Second La Mesa Fire Symposium. U.S. Forest Service General Technical Report RM-GTR 286. Fort Collins, Colorado.

Tausch, R. J. 1999. Historic pinyon and juniper woodland development. Pages 12-19 *in* Monsen, S. B., and R. Stevens (eds.). Ecology and management of pinyon-juniper communities within the Interior West. Proceedings RMRS-P-9. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Tellman, B. (ed.). 2002. Invasive exotic species in the Sonoran Desert region. University of Arizona Press, Tucson, Arizona.

Tellman, B., R. Yarde, M. G. Wallace. 1997. Arizona's changing rivers: How people have affected the rivers. Water Resources Research Center, College of Agriculture, The University of Arizona, Tucson, Arizona.

Thomas, K. A. and P. Guertin. 2007. Southwest exotic mapping program 2007: Occurrence summary and maps of select invasive, non-native plants in Arizona. U.S. Geological Survey Open-file report 2007-1277.

Thurow, R. F, D. C. Lee, and B. E. Rieman. 1997. Distribution and status of seven native salmonids in the interior Columbia basin and portions of the Klamath River and Great Basins. Transactions of the 46th North American Wildlife and Natural Resources Conference 117: 1094-1110.

TNC (The Nature Conservancy). 1982. Natural Heritage Program Operations Manual. The Nature Conservancy, Arlington, Virginia (Unpublished). 238pp.

TNC (The Nature Conservancy). 2004a. Arizona Forest Legacy Program: Assessment of need. Report to Arizona State Land Department, Fire Management Division, Phoenix, Arizona. 269 pp.

Trader, M. R., M. L. Brooks and J. V. Draper. 2006. Seed production by the non-native *Brassica tournefortii* (Sahara mustard) along desert roadsides. Madroño 53: 313-320.

Travis, S. E. and P. Keim. 1995. Differentiating individuals and populations of mule deer using DNA. The Journal of Wildlife Management 59: 824-831.

Tuhy, J. S., P. Comer, D. Dorfman, M. Lammert, J. Humke, B. Cholvin, G. Bell, B. Neely, S. Silbert, L. Whitham, and B. Baker. 2002. A conservation assessment of the Colorado Plateau ecoregion. The Nature Conservancy, Moab, Utah. 110 p. + appendices. Available online: www.azconservation.org.

Turner, R. M. 1994a. Great Basin Desertscrub. pp. 145-155. *in* D.E. Brown (ed.). Biotic Communities: Southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah. 342 pp.

Turner, R. M. 1994b. Mohave Desertscrub. pp. 157-168. *in* D.E. Brown (ed.). Biotic Communities: Southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah. 342 pp.

Turner, R. M. 1994c. Sonoran Desertscrub. pp. 181-221. *in* D.E. Brown (ed.). Biotic Communities: Southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah. 342 pp.

Turner, R. M., R. H. Webb, J. E. Bowers, and J. R. Hastings. 2003. The Changing Mile revisited: An ecological study of vegetation change with time in the lower mile of an arid and semiarid region. The University of Arizona Press, Tucson, Arizona. 334 pp.

Tuttle, M. D. and D. A. R. Taylor. 1994. Bats and Mines. Bat Conservation International. Austin, Texas.

TWW (Teaming With Wildlife Committee). 2003a. State Wildlife Grants: The Nation's core program for preventing wildlife from becoming endangered. International Association of Fish and Wildlife Agencies, Washington DC. [www.teaming.com].

TWW (Teaming With Wildlife Committee). 2003b. State Wildlife Conservation Strategies: Defining a vision for conservation success. International Association of Fish and Wildlife Agencies, Washington DC. [www.teaming.com].

TWW (Teaming With Wildlife Committee). 2003c. State Wildlife Conservation Strategies: Eight required elements. International Association of Fish and Wildlife Agencies, Washington DC. [www.teaming.com].

U.S. Census Bureau. 2000. Arizona County and State Statistics. [http://www.census.gov/census2000/states/az.html].

U.S. Census Bureau. 2010. Arizona County and State Statistics. [http://www.census.gov/census2005/states/az.html].

USFS (USDA Forest Service). 1993. Changing conditions in southwestern forests and implications on land stewardship. USDA Forest Service, Southwest Region, Albuquerque, New Mexico.

USFS (USDA Forest Service). 2000. Roadless area conservation summary. U.S. Forest Service, Washington, D. C.

USFS (USDA Forest Service). 2003. Forest insect and disease conditions in the Southwestern Region, 2002. Report R3-03-01, Southwestern Region Forestry and Forest Health, U.S. Department of Agriculture Forest Service, Albuquerque, New Mexico. [http://www.fs.fed.us/r3/publications/documents/fidc2003.pdf].

USFS (USDA Forest Service). 2004. Forest insect and disease conditions in the Southwestern Region, 2003. Report R3-04-02, Southwestern Region Forestry and Forest Health, U.S. Department of Agriculture Forest Service, Albuquerque, New Mexico. [http://www.fs.fed.us/r3/publications/documents/fidc2004.pdf].

USFS (USDA Forest Service). 2005. Forest insect and disease conditions in the Southwestern Region, 2004. Report R3-05-01, Southwestern Region Forestry and Forest Health, USDA Forest Service, Albuquerque, New Mexico. [http://www.fs.fed.us/r3/publications/documents/fidc2005.pdf].

USFS (USDA Forest Service). 2010. Regional Forester's Sensitive Species List. [http://www.fs.fed.us/r3/resources/tes/complete-animals.pdf].

USFWS (U.S. Fish and Wildlife Service). 2002. Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) recovery plan. U.S. Fish and Wildlife Service, Phoenix, Arizona. iv + 67 pp.

USFWS (U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau). 2006. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. 164 pp.

USFWS (U.S. Fish and Wildlife Service). 2007. Chiricahua leopard frog (*Rana chiricahuensis*) Recovery Plan. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico. 149 pp. + Appendices A-M.

USFWS (U.S. Fish and Wildlife Service). 2008a. Birds of conservation concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp.

USFWS (U.S. Fish and Wildlife Service). 2008b. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*) as threatened or endangered with critical habitat. Federal Register 75: 16050-16065.

USFWS (U.S. Fish and Wildlife Service). 2010. Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change. 32 pp.

USGS National Gap Analysis Program. 2007. Digital animal-habitat models for the southwestern United States. Version 1.0. Center for Applied Spatial Ecology, New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University.

Valencia, R. A. 1993. Arizona riparian inventory and mapping project, a report to the Governor, President of the Senate and Speaker of the House. Arizona Game and Fish Department, Phoenix, Arizona.

Valone, T. J., M. Meyer, J. H. Brown and R. M. Chew. 2002. Timescale of perennial grass recovery in desertified arid grasslands following livestock removal. Conservation Biology 16: 995-1002.

Van Devender, T. R., R. S. Felger and A. Búrquez M. 1997. Exotic plants in the Sonoran Desert region, Arizona and Sonora. Pages 1-6 *in* M. Kelley, E. Wagner and P. Warner (eds.). Proceedings of the California Exotic Pest Plant Council Symposium.

Vamstada, M. S. and J. T. Rotenberry. 2010. Effects of fire on vegetation and small mammal communities in a Mojave Desert Joshua tree woodland. Journal of Arid Environments 74: 1309-1318.

Varela-Romero, A. and T. L. Myers. 2010. Genetic evaluation of springsnails in the San Bernardino River watershed of Sonora, Mexico, in relation to *Pyrgulopsis bernardina* (Taylor, 1987). Arizona Heritage Fund contract report to Arizona Game and Fish Department, Phoenix, Arizona. 37 pp.

Waring, R. H., and G. B. Pittman. 1983. Physiological stress in lodgepole pine as a precursor for mountain pine beetle attack. Zeitschrift fur angewandte Enomologie 96: 265-270.

Weedman, D. A. 1999. Gila topminnow (*Poeciliopsis occidentalis occidentalis*) Revised Recovery Plan (DRAFT).

Weltzin, J. F. and G. R. McPherson. 1995. Potential effects of climate change on lower treelines in the southwestern United States. Pages 180-193 *in* L. F. Debano, P. F. Ffolliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B. Edminster (tech. coord.). Biodiversity and Management of the Madrean Archipelago: the Sky Islands of the southwestern United States and northwestern Mexico. 1995. Tucson, Arizona. US Forest Service General Technical Report RM-GTR-264. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Wemple, B.C., J.A. Jones, and G.E. Grant. 1996. Channel network extension by logging roads in two basins, Western Cascades, Oregon. Water Resources Bulletin 32: 1195-1207.

Williams, A. P., C. D. Allen, C. I. Millar, T. W. Swetnam, J. Michaelsen, C. J. Still and S. W. Leavitt. 2010. Forest responses to increasing aridity and warmth in the southwestern United States. Proceedings of the National Academy of Sciences 107: 21289-21294.

Williams, G. P. and M. G. Wolman. 1984. Downstream effects of dams on alluvial rivers. U.S. Geological Survey Professional Paper 1286.

Wilmers, C. C. and W. M. Getz, 2004. Simulating the effects of wolf-elk population dynamics on resource flow to scavengers. Ecological Modeling 177: 193-208.

Wilson, J. L. and B. M. Tkacz. 1994. Status of insects and diseases in the Southwest: implications for forest health. Pages 196-203. *in* W. W. Covington and L. F. DeBano (eds.). Sustainable ecological systems: implementing an ecological approach to land management. U.S. Forest Service Technical Report RM-247. USDA Forest Service, Fort Collins, Colorado.

Wilson, M. F., L. Leigh and R. S. Felger. 2002. Invasive exotic plants in the Sonoran Desert. Pages 81-90. *in* B. Tellman (ed.). Invasive exotic species in the Sonoran Desert. Arizona-Sonora Desert Museum, University of Arizona Press, Tucson.

Winter, L. and G. E. Wallace. 2006. Impacts of feral and free-ranging cats on bird species of conservation concern: A five-state review of New York, New Jersey, Florida, California, and Hawaii. American Bird Conservancy, The Plains, Virginia. 27 pp.

Wisdom, M. J., R. S. Holthausen, B. K. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia Basin: broad-scale trends and management implications. U.S. Forest Service General Technical Report PNW-GTR-485. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Whittier, J. B., C. P. Paukert, and K. Gido. 2006. Development of an aquatic GAP for the Lower Colorado River Basin. Gap Analysis Bulletin No. 14 USGS/BRD/Gap Analysis Program. Moscow, Idaho.

Wood, C. W., Jr. and T. N. Nash III. 1976. Copper smelter effluent effects on Sonoran Desert vegetation. Ecology 57: 1311-1316.

Wood, D. A., J. M. Meik, A. T. Holycross, R. N. Fisher and A. G. Vandergast. 2008. Molecular and phenotypic diversity in *Chionactis occipitalis* (western shovel-nosed snake), with emphasis on the status of *C.o. klauberi* (Tucson shovel-nosed snake). Conservation Genetics 9: 1489-1507.

Woodhouse, C. A., D. M. Meko, G. M. MacDonald, D. W. Stahle and E. R. Cook. 2010. A 1,200-year perspective of 21st century drought in southwestern North America. Proceedings of the National Academy of Sciences 107: 21283-21288.

Wright, J. P. and C. G. Jones. 2006. The concept of organisms as ecosystem engineers ten years on: Progress, limitations, and challenges. BioScience 56: 203-209.

Zeng, Z. and J. H. Brown. 1987. Population ecology of a desert rodent: *Dipodomys merriami* in the Chihuahuan Desert. Ecology 68: 1328-1340.

Zylstra, E. R., and R. J. Steidl. 2009b. Designing a framework for monitoring Sonoran desert tortoises (*Gopherus agassizii*) in Arizona. Final Report to the Arizona Game and Fish Department.

Zylstra, E. R., R. J. Steidl, and D. E. Swann. 2010. Evaluating survey methods for monitoring a rare vertebrate, the Sonoran desert tortoise. Journal of Wildlife Management 74: 1311-1318.

Appendix A: Acronyms Used in the SWAP

ABBA	Arizona Breeding Bird Atlas
ABCI	Arizona Bird Conservation Initiative
ADEQ	Arizona Dept of Environmental Quality
ADOT	Arizona Dept of Transportation
ADWR	Arizona Dept of Water Resources
AFWA	Association of Fish and Wildlife Agencies
AGFD	Arizona Game and Fish Department
AIDTT	Arizona Interagency Desert Tortoise Team
ASP	Arizona State Parks
ASLD	Arizona State Land Department
ATV	All-Terrain Vehicle
AUD	Angler Use Days
AZCBM	Arizona Coordinated Bird Monitoring Program
AZFWCO	USFWS Arizona Fish and Wildlife Conservation Office
BLM	Bureau of Land Management
CCA	Candidate Conservation Agreements
CCAA	Candidate Conservation Agreements with Assurances
CMA	Conservation Management Area
CWCS	Comprehensive Wildlife Conservation Strategy
DEM	Digital Elevation Model
DoD	Department of Defense
ESA	Endangered Species Act
FOR1	AGFD Field Operations Division, Region 1, Pinetop Office
FOR2	AGFD Field Operations Division, Region 2, Flagstaff Office
FOR3	AGFD Field Operations Division, Region 3, Kingman Office
FOR4	AGFD Field Operations Division, Region 4, Yuma Office
FOR5	AGFD Field Operations Division, Region 5, Tucson Office
FOR6	AGFD Field Operations Division, Region 6, Mesa Office
FTHL	Flat-tailed Horned Lizard
GIS	Geographic Information System
HDMS	Heritage Database Management System
HMN	Hummingbird Monitoring Network
HUC	Hydrologic Unit Code
IBA	Important Bird Area
IPCC	International Panel on Climate Change
LCRB	Lower Colorado River Basin
LTMP	Long Term Monitoring Plot
NABCI	North American Birds Conservation Initiative
NF	National Forest
NGO	Non-Government Organizations
NPS	National Park Service
NRCS	Natural Resource Conservation Service
OHV	Off Highway Vehicle

PARC	Partners in Amphibian and Reptile Conservation
PIF	Partners in Flight
SERI	Species of Economic and Recreational Importance
SGCN	Species of Greatest Conservation Need
SHA	Safe Harbor Agreements
SHCG	Species and Habitat Conservation Guide
SRP	Salt River Project
SW	Southwest
SWAP	State Wildlife Action Plan
SWAPSAZ	State Wildlife Action Plan System for Arizona
SWG	State Wildlife Grants
SWReGAP	Southwest Regional Gap Analysis Project
TNC	The Nature Conservancy
TWW	Teaming With Wildlife Committee
UA	University of Arizona
URTD	Upper Respiratory Track Disease
USBR	US Bureau of Reclamation
USDA	US Dept of Agriculture
USFWS	US Fish and Wildlife Service (also FWS)
USGS	US Geological Survey
WHR	Wildlife Habitat Relationship
WMFS	AGFD Wildlife Management Division, Fisheries Branch
WMHB	AGFD Wildlife Management Division, Habitat Branch
WMNG	AGFD Wildlife Management Division, Nongame Branch
WMRS	AGFD Wildlife Management Division, Research Branch
WSCA	Wildlife of Special Concern in Arizona

Appendix B: Acknowledgements

(in alphabetical order; all are Department staff unless noted otherwise)

Primary Authors: Francisco Abarca, Matthew Bullock, Laura Canaca, Joyce Francis, Eric Gardner, Thomas R. Jones, Julie Mikolajczyk, Jeff Sorensen, Dana Warnecke.

Technical, administrative, and editorial support: Josh Avey, Randy Babb, Pat Barber, Kevin Bergersen, Sue Boe, Valerie Boyarski, Mary Broniarczyk, Trevor Buhr, Bill Burger, Chris Cantrell, Cody D. Carter, Barbara Cook, Jon Cooley, Troy Corman, Daniel Cox, Marianne Cox, Mark Dahlberg, Mike Demlong, Locana de Souza, Dave Dorum, James Driscoll, Albert Eiden, Nicole Eiden, Russ Engel, Robert Fink, Jeff Gagnon, Ty Gray, Wolfgang Grunberg, Jon Hanna, Tom Hildebrandt, John Hervert, Cristina Jones, Edwin Juarez, Ann Justice-Allen, Abi King, Bill Knowles, Angie Lohse, Rod Lucas, Rob Marshall (TNC), Elroy Masters (BLM), Jonathan Mawdsley (The Heinz Center), Angela McIntyre, Tom McMahon, Richard Miller, Gloria Morales, Amber Munig, Daniel Nelson, Chantal O'Brien, Mark Ogonowski, Audrey Owens, Leonard Ordway, Sal Palazzolo, Jeff Pebworth, Matthew Pierce, Lin Piest, Bob Posey, Mike Rabe, Sara Reif, Marcos Robles (TNC), Ginger Ritter, Andi Rogers, Joan Sacco, Cecilia Schmidt, Sabra Schwartz, Ray Schweinsburg, Mike Senn, Ron Sieg, Jimmy Simmons, Joan Scott, Troy Smith, Mike Sredl, Janice Stroud, Gene Sturla, Reuben Teran, Ron Thompson, Ross Timmons, Jared Underwood, Bill Vanpelt, Raul Vega, Brian Wakeling, Dana Warnecke, Renee Wilcox, Dave Weedman, Danette Weiss, John Windes, Kelly Wolff - Krauter, Kirk Young.

The Department thanks the Heinz Center and BLM for their coordination and collaboration in hosting the Arizona Workshop for Performance Measures for Western Wildlife.

In addition, the Department extends a thank you to all of the representatives from other government agencies, tribes, nongovernmental organizations and the public who provided valuable expertise and input through participation in workshops and meetings and/or provided feedback and comments through the online survey or the Department's website.

Appendix C: Vegetation Classification Crosswalk

Brown and Lowe Description	SWReGAP Description	ABBA Description
Aspen	Rocky Mountain Aspen Forest and Woodland	Aspen Forest
Bristlecone Pine	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	Subalpine Scrub
Burn	Recently Burned	Burn
Chihuahuan Desert Scrub	Chihuahuan Succulent Desert Scrub	Chihuahuan Desertscrub
Chihuahuan Desert Scrub	Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	Chihuahuan Desertscrub
Chihuahuan Desert Scrub	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	Chihuahuan Desertscrub
Chihuahuan Desert Scrub	Chihuahuan Mixed Salt Desert Scrub	Chihuahuan Desertscrub
Great Basin Desertscrub	Inter-Mountain Basins Big Sagebrush Shrubland	Cold-temperate (Great Basin) Desertscrub
Great Basin Desertscrub	Colorado Plateau Blackbrush-Mormon-tea Shrubland	Cold-temperate (Great Basin) Desertscrub
Great Basin Desertscrub	Inter-Mountain Basins Mixed Salt Desert Scrub	Cold-temperate (Great Basin) Desertscrub
Great Basin Desertscrub	Inter-Mountain Basins Montane Sagebrush Steppe	Cold-temperate (Great Basin) Desertscrub
Great Basin Desertscrub	Inter-Mountain Basins Greasewood Flat	Cold-temperate (Great Basin) Desertscrub
Human Dominated	Inter-Mountain Basins Playa	Urban and Residential
Human Dominated	Developed, Open Space - Low Intensity	Urban and Residential
Human Dominated	Developed, Medium - High Intensity	Urban and Residential
Human Dominated	Barren Lands, Non-specific	Urban and Residential
Human Dominated	Agriculture	Agriculture
Interior Chaparral	Great Basin Semi-Desert Chaparral	Interior Chaparral
Interior Chaparral	Mogollon Chaparral	Interior Chaparral
Lowr Colo R. Sonoran Desertscrub	North American Warm Desert Active and Stabilized Dune	Sonoran Desertscrub: Lower Colorado River
Lowr Colo R. Sonoran Desertscrub	North American Warm Desert Wash	Sonoran Desertscrub: Lower Colorado River
Madrean Evergreen	Madrean Encinal	Mexican Evergreen Woodland
Mesquite	Mesquite	Mesquite
Mohave Desertscrub	Mojave Mid-Elevation Mixed Desert Scrub	Mohave Desertscrub
Mohave Desertscrub	Sonoran Mid-Elevation Desert Scrub	Mohave Desertscrub
Open-pit mine	Recently Mined or Quarried	Open-pit mine
Petran Montane Conifer Forest	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	Mixed-Conifer Forest
Petran Montane Conifer Forest	Rocky Mountain Ponderosa Pine Woodland	Ponderosa Pine Forest
Petran Subalpine Conifer Forest	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	Subalpine Spruce-Fir Forest
Petran Subalpine Conifer Forest	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	Subalpine Spruce-Fir Forest
Petran Subalpine Conifer Forest	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	Ponderosa Pine - Gambel's Oak Forest
Petran Subalpine Conifer Forest	Madrean Upper Montane Conifer-Oak Forest and Woodland	Mexican Evergreen Woodland
Pine-Oak	Madrean Pine-Oak Forest and Woodland	Madrean Pine-Oak Woodland
Pinyon-Juniper	Southern Rocky Mountain Pinyon-Juniper Woodland	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Colorado Plateau Pinyon-Juniper Woodland	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Great Basin Pinyon-Juniper Woodland	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	Pinyon Pine-Juniper Woodland

Pinyon-Juniper	Colorado Plateau Pinyon-Juniper Shrubland	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Inter-Mountain Basins Juniper Savanna	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Madrean Pinyon-Juniper Woodland	Pinyon Pine-Juniper Woodland
Pinyon-Juniper	Madrean Juniper Savanna	Pinyon Pine-Juniper Woodland
Plains, Great Basin Grassland	Inter-Mountain Basins Shale Badland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Inter-Mountain Basins Active and Stabilized Dune	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Inter-Mountain Basins Wash	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Inter-Mountain Basins Mat Saltbush Shrubland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Colorado Plateau Mixed Low Sagebrush Shrubland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Inter-Mountain Basins Semi-Desert Shrub Steppe	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Southern Rocky Mountain Montane-Subalpine Grassland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Inter-Mountain Basins Semi-Desert Grassland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Southern Colorado Plateau Sand Shrubland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Invasive Perennial Grassland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Invasive Annual Grassland	Cold-temperate(Great Basin)/Plains Grassland
Plains, Great Basin Grassland	Invasive Annual and Biennial Forbland	Cold-temperate(Great Basin)/Plains Grassland
Playa	North American Warm Desert Playa	Chihuahuan Desertscrub
Riparian	North American Warm Desert Riparian Woodland and Shrubland	Riparian
Riparian	North American Warm Desert Riparian Mesquite Bosque	Riparian
Riparian	Invasive Southwest Riparian Woodland and Shrubland	Riparian
Riparian - Modeled	Riparian	Riparian
Rock	Rocky Mountain Cliff and Canyon	Rock
Rock	Colorado Plateau Mixed Bedrock Canyon and Tableland	Rock
Rock	Inter-Mountain Basins Volcanic Rock and Cinder Land	Rock
Rock	North American Warm Desert Bedrock Cliff and Outcrop	Rock
Rock	North American Warm Desert Badland	Rock
Rock	North American Warm Desert Volcanic Rockland	Rock
Rock	North American Warm Desert Pavement	Rock
Semidesert Grassland	Apacherian-Chihuahuan Mesquite Upland Scrub	Semiarid/Sonoran Savannah Grassland
Semidesert Grassland	Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	Semiarid/Sonoran Savannah Grassland
Semidesert Grassland	Chihuahuan Sandy Plains Semi-Desert Grassland	Semiarid/Sonoran Savannah Grassland
Sonoran/Mohave Desertscrub	Sonora-Mojave Creosotebush-White Bursage Desert Scrub	Sonoran/Mohave Desertscrub
Sonoran/Mohave Desertscrub	Sonora-Mojave Mixed Salt Desert Scrub	Sonoran/Mohave Desertscrub
Subalpine Grassland	Rocky Mountain Subalpine Mesic Meadow	Montane Meadow/Subalpine Grassland
Subalpine Grassland	Rocky Mountain Alpine-Montane Wet Meadow	Montane Meadow/Subalpine Grassland
Tundra	Rocky Mountain Alpine Bedrock and Scree	Alpine Tundra
Upland Sonoran Desertscrub	Sonoran Paloverde-Mixed Cacti Desert Scrub	Sonoran Desertscrub: uplands
Water	Open Water	Riparian
Xeric Riparian	Wash	Wash
Xeric Riparian	North American Warm Desert Wash	Sonoran Desertscrub: Lower Colorado River

Appendix D: Masters Species List

CRUSTACEANS and MOLLUSKS			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Anodonta californiensis	California Floater	*Pyrgulopsis deserta*	Desert Springsnail
Artemia franciscana	San Francisco Brine Shrimp	*Pyrgulopsis glandulosa*	Verde Rim Springsnail
Ashmunella chiricahuana	Cave Creek Woodlandsnail	*Pyrgulopsis montezumensis*	Montezuma Well Springsnail
Ashmunella ferrissi	Reed's Mountain Woodlandsnail	*Pyrgulopsis morrisoni*	Page Springsnail
Ashmunella levettei	Huachuca Woodlandsnail	*Pyrgulopsis simplex*	Fossil Springsnail
Ashmunella mogollonensis	Mogollon Woodlandsnail	*Pyrgulopsis sola*	Brown Springsnail
Ashmunella pilsbryana	Blue Mountain Woodlandsnail	*Pyrgulopsis thompsoni*	Huachuca Springsnail
Ashmunella proxima	Chiricahua Woodlandsnail	*Pyrgulopsis trivialis*	Three Forks Springsnail
Branchinecta coloradensis	Colorado Fairy Shrimp	*Radiodiscus millecostatus*	Ribbed Pinwheel
Branchinecta kaibabensis	Kaibab Fairy Shrimp	*Sonorella allynsmithi*	Squaw Peak Talussnail
Branchinecta lindahli	Versitle Fairy Shrimp	*Sonorella ambigua*	Papago Talussnail
Branchinecta packardi	Rock Pool Fairy Shrimp	*Sonorella anchana*	Sierra Ancha Talussnail
Catinella avara	Suboval Ambersnail (1)	*Sonorella apache*	Apache Talussnail
Catinella vermeta	Suboval Ambersnail (2)	*Sonorella ashmuni*	Richinbar Talussnail
Chaenaxis tuba	Hollow Tuba	*Sonorella baboquivariensis*	Baboquivari Talussnail
Cionella lubrica	Glossy Pillar	*Sonorella bagnarai*	Rincon Talussnail
Columella columella	Mellow Column	*Sonorella bartschi*	Escabrosa Talussnail
Cyzicus mexicanus	Mexican Clam Shrimp	*Sonorella bequaerti*	Happy Valley Talussnail
Cyzicus setosa	Bristletail Clam Shrimp	*Sonorella bicipitis*	Dos Cabezas Talussnail
Deroceras laeve	Pond slug	*Sonorella binneyi*	Horseshoe Canyon Talussnail
Discus shimekii	Striate Disc	*Sonorella bowiensis*	Quartzite Hill Talussnail
Discus shimekii cockerelli	Cockerell's Striate Disc	*Sonorella bradshaveana*	Bradshaw Talussnail
Discus whitneyi	Forest Disc	*Sonorella caeruliflumini*s	Blue Talussnail
Eocyzicus digueti	Straightbacked Clam Shrimp	*Sonorella christenseni*	Clark Peak Talussnail
Eremarionta rowelli	Eastern Desertsnail	*Sonorella clappi*	Madera Talussnail
Eubranchipus bundyi	Knobbedlip Fairy Shrimp	*Sonorella coloradoensis*	Grand Canyon Talussnail
Eubranchipus serratus	Ethologist Fairy Shrimp	*Sonorella coltoniana*	Walnut Canyon Talussnail
Fossaria modicella	Rock Fossaria	*Sonorella compar*	Oak Creek Talussnail
Fossaria obrussa	Golden Fossaria	*Sonorella dalli*	Garden Canyon Talussnail

Fossaria parva	Pygmy Fossaria	*Sonorella danielsi*	Bear Canyon Talussnail
Fossaria techella	Freshwater Snail	*Sonorella delicata*	Tollhouse Canyon Talussnail
Gastrocopta ashmuni	Sluice Snaggletooth	*Sonorella dragoonensis*	Stronghold Canyon Talussnail
Gastrocopta cochisensis	Apache Snaggletooth	*Sonorella eremita*	San Xavier Talussnail
Gastrocopta cristata	Crested Snaggletooth	*Sonorella ferrissi*	Dragoon Talussnail
Gastrocopta dalliana	Shortneck Snaggletooth	*Sonorella franciscana*	St. Francis Talussnail
Gastrocopta pellucida	Slim Snaggletooth	*Sonorella galiurensis*	Galiuro Talussnail
Gastrocopta pilsbryana	Montane Snaggletooth	*Sonorella grahamensis*	Pinaleno Talussnail
Gastrocopta prototypus	Sonoran Snaggletooth	*Sonorella granulatissima*	Ramsey Canyon Talussnail
Gastrocopta quadridens	Cross Snaggletooth	*Sonorella huachucana*	Huachuca Talussnail
Glyphyalinia indentata	Carved Glyph	*Sonorella imitator*	Mimic Talussnail
Gyraulus circumstriatus	Disc Gyro	*Sonorella imperatrix*	Total Wreck Talussnail
Gyraulus parvus	Ash Gyro	*Sonorella imperialis*	Empire Mountain Talussnail
Hawaiia minuscula	Minute Gem	*Sonorella insignis*	Whetstone Talussnail
Helicodiscus eigenmanni	Mexican Coil	*Sonorella macrophallus*	Wet Canyon Talussnail
Helisoma anceps	Two-ridge Rams-horn	*Sonorella magdalenensis*	Sonoran Talussnail
Holospira arizonensis	Arizona Holospira	*Sonorella meadi*	Aqua Dulce Talussnail
Holospira campestris	Holospira (no common name)	*Sonorella micra*	Pygmy Sonorella
Holospira chiricahuana	Cave Creek Holospire	*Sonorella micromphala*	Milk Ranch Talussnail
Holospira cionella	Holospira (no common name)	*Sonorella milleri*	Table Top Talussnail
Holospira danielsi	Stongrib Holospira	*Sonorella mustang*	Mustang Talussnail
Holospira ferrissi	Stocky Holospira	*Sonorella neglecta*	Portal Talussnail
Holospira millestriata	Holospira (no common name)	*Sonorella odorata*	Pungent Talussnail
Holospira montivaga	Vagabond Holospira	*Sonorella optata*	Big Emigrant Talussnail
Holospira sherbrookei	Silver Creek Holospira	*Sonorella papagorum*	Papago Talussnail
Holospira tantalus	Teasing Holospira	*Sonorella parva*	Little Talussnail
Holospira whetstonensis	Whetstone Holospira	*Sonorella pedregosensis*	Leslie Canyon Talussnail
Hyalella azteca	amphipod	*Sonorella reederi*	Rampart Talussnail
Hyalella montezuma	Montezuma Well amphipod	*Sonorella rinconensis*	Posta Quemada Talussnail
Leptestheria compleximanus	Spineynose Clam Shrimp	*Sonorella rosemontensis*	Rosemont Talussnail
Lynceus brachyurus	Holarctic Clam Shrimp	*Sonorella russelli*	Black Mesa Talussnail
Lynceus brevifrons	Short Finger Clam Shrimp	*Sonorella sabinoensis*	Santa Catalina Talussnail
Microphysula ingersolli	Spruce Snail	*Sonorella santaritana*	Aqua Caliente Talussnail
Nesovitrea electrina	Amber Glass	*Sonorella simmonsi*	Picacho Talussnail
Oreohelix anchana	Ancha Mountainsnail	*Sonorella sitiens*	Las Guijas Talussnail
Oreohelix barbata	Bearded Mountainsnail	*Sonorella superstitionis*	Superstition Mountains Talussnail
Oreohelix concentrata	Huachuca Mountainsnail	*Sonorella tortillita*	Tortolita Talussnail
Oreohelix grahamensis	Pinaleno Mountainsnail	*Sonorella tryoniana*	Sanford Talussnail

Oreohelix houghi	Diablo Mountainsnail	*Sonorella vespertina*	Evening Talussnail
Oreohelix strigosa meridionalis	Rocky Mountainsnail	*Sonorella virilis*	Chiricahua Talussnail
Oreohelix subrudis	Subalpine Mountainsnail	*Sonorella walkeri*	Santa Rita Talussnail
Oreohelix yavapai	Yavapai Mountain Snail	*Sonorella waltoni*	Doubtful Canyon Talussnail
Oreohelix yavapai cummingsi	Cummings Mountainsnail	*Sonorella xanthenes*	Kitt Peak Talussnail
Otala lactea	Milk Snail	*Streptocephalus dorothae*	New Mexico Fairy Shrimp
Oxyloma haydeni haydeni	Niobrara Ambersnail	*Streptocephalus mackini*	Chihuahuan Desert Fairy Shrimp
Oxyloma haydeni kanabensis	Kanab Ambersnail	*Streptocephalus sealii*	Spinytail Fairy Shrimp
Pallifera pilsbryi	Arizona mantleslug	*Streptocephalus texanus*	Greater Plains Fairy Shrimp
Physella humerosa	Corkscrew Physa	*Stygobromus arizonensis*	Arizona Cave Amphipod
Physella osculans	Cayuse Physa	*Succinea grosvenori*	Santa Rita Ambersnail
Physella virgata	Protean Physa	*Succinea luteola*	Mexico Ambersnail
Pisidium casertanum	Ubiquitous Peaclam	*Thamnocephalus mexicanus*	Mexican Beavertail Fairy Shrimp
Pisidium insigne	Tiny Peaclam	*Thamnocephalus platyurus*	Beavertail Fairy Shrimp
Planorbella tenuis	Mexican Rams-horn	*Thysanophora hornii*	Southwestern Fringed-snail
Promenetus exacuous	Sharp Sprite (A Planorbid Snail)	*Triops longicaudatus*	Longtail Tadpole Shrimp
Punctum californicum	Ribbed Spot	*Triops newberryi*	Desert Tadpole Shrimp
Pupilla hebes	Crestless Column	*Tryonia gilae*	Gila Tryonia
Pupilla syngenes	Top-heavy Column	*Tryonia quitobaquitae*	Quitobaquito Tryonia
Pupoides hordaceus	Ribbed Dagger	*Vallonia cyclophorella*	Silky Vallonia
Pupoides nitidulus	Dagger (no common name)	*Vallonia perspectiva*	
Pyrgulopsis arizonae	Bylas Springsnail	*Valvata humeralis*	Glossy Valvata
Pyrgulopsis bacchus	Grand Wash Springsnail	*Vertigo berryi*	Rotund Vertigo
Pyrgulopsis bernardina	San Bernardino Springsnail	*Vitrina pellucida alaskana*	Western Glass Snail
Pyrgulopsis conica	Kingman Springsnail	*Zonitoides arboreus*	Quick Gloss
FISH			
Scientific Name	**Scientific Name**	**Scientific Name**	**Scientific Name**
Agosia chrysogaster	Longfin Dace	*Gila purpurea*	Yaqui Chub
Campostoma ornatum	Mexican Stoneroller	*Gila robusta*	Roundtail Chub
Catostomus bernardini	Yaqui Sucker	*Gila seminuda*	Virgin Chub
Catostomus clarki	Desert Sucker	*Ictalurus pricei*	Yaqui Catfish
Catostomus discobolus	Bluehead Sucker	*Lepidomeda mollispinis mollispinis*	Virgin Spinedace
Catostomus discobolus yarrowi	Zuni Bluehead Sucker	*Lepidomeda vittata*	Little Colorado Spinedace

Catostomus insignis	Sonora Sucker	*Meda fulgida*	Spikedace
Catostomus latipinnis	Flannelmouth Sucker	*Mugil cephalus*	Striped Mullet
Catostomus sp.	Little Colorado Sucker	*Oncorhynchus gilae apache*	Apache (Arizona) Trout
Cyprinella formosa	Beautiful Shiner	*Oncorhynchus gilae gilae*	Gila Trout
Cyprinodon eremus	Quitobaquito Pupfish	*Plagopterus argentissimus*	Woundfin
Cyprinodon macularius	Desert Pupfish	*Poeciliopsis occidentalis occidentalis*	Gila Topminnow
Elops affinis	Machete	*Poeciliopsis occidentalis sonoriensis*	Yaqui Topminnow
Gila cypha	Humpback Chub	*Ptychocheilus lucius*	Colorado Pikeminnow
Gila ditaenia	Sonora Chub	*Rhinichthys osculus*	Speckled Dace
Gila elegans	Bonytail	*Tiaroga cobitis*	Loach Minnow
Gila intermedia	Gila Chub	*Xyrauchen texanus*	Razorback Sucker
Gila nigra	Headwater Chub		

AMPHIBIANS			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Ambystoma mavortium nebulosum	Arizona Tiger Salamander	*Pseudacris hypochondriaca*	Desert Pacific Treefrog
Ambystoma mavortium stebbinsi	Sonoran Tiger Salamander	*Pseudacris triseriata*	Western Chorus Frog
Bufo [*Ollotis*] *alvarius*	Sonoran Desert Toad	*Rana* [*Lithobates*] *blairi*	Plains Leopard Frog
Bufo [*Anaxyrus*] *cognatus*	Great Plains Toad	*Rana* [*Lithobates*] *chiricahuensis*	Chiricahua Leopard Frog
Bufo [*Anaxyrus*] *debilis*	Green Toad	*Rana* [*Lithobates*] *onca*	Relict Leopard Frog
Bufo [*Anaxyrus*] *microscaphus*	Arizona Toad	*Rana* [*Lithobates*] *pipiens*	Northern Leopard Frog
Bufo [*Anaxyrus*] *punctatus*	Red-spotted Toad	*Rana* [*Lithobates*] *tarahumarae*	Tarahumara Frog
Bufo [*Anaxyrus*] *retiformis*	Sonoran Green Toad	*Rana* [*Lithobates*] *yavapaiensis*	Lowland Leopard Frog
Bufo [*Anaxyrus*] *woodhousii*	Woodhouse's Toad	*Scaphiopus couchii*	Couch's Spadefoot
Craugastor augusti	Barking Frog	*Smilisca fodiens*	Lowland Burrowing Treefrog
Gastrophryne olivacea	Great Plains Narrow-mouthed Toad	*Spea bombifrons*	Plains Spadefoot
Hyla arenicolor	Canyon Treefrog	*Spea intermontana*	Great Basin Spadefoot
Hyla wrightorum	Mountain Treefrog	*Spea multiplicata*	Mexican Spadefoot
Hyla wrightorum (Huachuca-Canelo Hills DPS)	Arizona Treefrog (Huachuca-Canelo Hills DPS)		

REPTILES			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Arizona elegans	Glossy Snake	*Leptotyphlops dissectus*	New Mexico Threadsnake
Aspidoscelis arizonae	Arizona Striped Whiptail	*Leptotyphlops humilis*	Western Threadsnake
Aspidoscelis burti	Canyon Spotted Whiptail	*Lichanura orcutti*	Northern Three-lined Boa (Desert Rosy Boa)
Aspidoscelis exsanguis	Chihuahuan Spotted Whiptail	*Lichanura trivirgata*	Rosy Boa (Mexican Rosy Boa)
Aspidoscelis flagellicauda	Gila Spotted Whiptail	*Masticophis bilineatus*	Sonoran Whipsnake
Aspidoscelis pai	Pai Striped Whiptail	*Masticophis flagellum*	Coachwhip
Aspidoscelis sonorae	Sonoran Spotted Whiptail	*Masticophis taeniatus*	Striped Whipsnake
Aspidoscelis tigris	Tiger Whiptail	*Micruroides euryxanthus*	Sonoran Coralsnake
Aspidoscelis uniparens	Desert Grassland Whiptail	*Oxybelis aeneus*	Brown Vinesnake
Aspidoscelis velox	Plateau Striped Whiptail	*Phrynosoma cornutum*	Texas Horned Lizard
Aspidoscelis xanthonota	Red-back Whiptail	*Phrynosoma goodei*	Goode's Horned Lizard
Callisaurus draconoides	Zebra-tailed Lizard	*Phrynosoma hernandesi*	Greater Short-horned Lizard
Chilomeniscus stramineus	Variable Sandsnake	*Phrynosoma mcallii*	Flat-tailed Horned Lizard
Chionactis occipitalis	Western Shovel-nosed Snake	*Phrynosoma modestum*	Round-tailed Horned Lizard
Chionactis occipitalis klauberi	Tucson Shovel-nosed Snake	*Phrynosoma platyrhinos*	Desert Horned Lizard
Chionactis palarostris	Sonoran Shovel-nosed Snake	*Phrynosoma solare*	Regal Horned Lizard
Chrysemys picta	Painted Turtle	*Phyllorhynchus browni*	Saddled Leaf-nosed Snake
Coleonyx variegatus	Banded Gecko	*Phyllorhynchus decurtatus*	Spotted Leaf-nosed Snake
Coluber constrictor flaviventris	Eastern Yellow-bellied Racer	*Pituophis catenifer*	Gophersnake
Cophosaurus texanus	Greater Earless Lizard	*Plestiodon callicephalus*	Mountain Skink
Crotalus atrox	Western Diamond-backed Rattlesnake	*Plestiodon gilberti arizonensis*	Arizona Skink
Crotalus cerastes	Sidewinder	*Plestiodon gilberti rubricaudata*	Western Red-tailed Skink
Crotalus cerberus	Arizona Black Rattlesnake	*Plestiodon multivirgatus*	Many-lined Skink
Crotalus lepidus	Rock Rattlesnake	*Plestiodon obsoletus*	Great Plains Skink
Crotalus mitchellii	Speckled Rattlesnake	*Plestiodon skiltonianus*	Western Skink
Crotalus molossus	Black-tailed Rattlesnake	*Rhinocheilus lecontei*	Long-nosed Snake
Crotalus oreganus	Western Rattlesnake	*Salvadora grahamiae*	Eastern Patch-nosed Snake
Crotalus pricei	Twin-spotted Rattlesnake	*Salvadora hexalepis*	Western Patch-nosed

			Snake
Crotalus scutulatus	Mohave Rattlesnake	*Sauromalus ater*	Common Chuckwalla
Crotalus tigris	Tiger Rattlesnake	*Sceloporus clarkii*	Clark's Spiny Lizard
Crotalus viridis	Prairie Rattlesnake	*Sceloporus graciosus*	Common Sagebrush Lizard
Crotalus willardi	Ridge-nosed Rattlesnake	*Sceloporus jarrovii*	Yarrow's Spiny Lizard
Crotalus willardi obscurus	New Mexico Ridge-nosed Rattlesnake	*Sceloporus magister*	Desert Spiny Lizard
Crotaphytus bicinctores	Great Basin Collared Lizard	*Sceloporus slevini*	Slevin's Bunchgrass Lizard
Crotaphytus collaris	Eastern Collared Lizard	*Sceloporus tristichus*	Plateau Lizard
Crotaphytus nebrius	Sonoran Collared Lizard	*Sceloporus virgatus*	Striped Plateau Lizard
Diadophis punctatus	Ring-necked Snake	*Senticolis triaspis*	Green Ratsnake
Dipsosaurus dorsalis	Desert Iguana	*Sistrurus catenatus*	Massasauga
Elgaria kingii	Madrean Alligator Lizard	*Sonora semiannulata*	Groundsnake
Gambelia wislizenii	Long-nosed Leopard Lizard	*Tantilla hobartsmithi*	Smith's Black-headed Snake
Gopherus agassizii	Mojave Desert Tortoise	*Tantilla nigriceps*	Plains Black-headed Snake
Gopherus morafkai	Sonoran Desert Tortoise	*Tantilla wilcoxi*	Chihuahuan Black-headed Snake
Gyalopion canum	Chihuahuan Hook-nosed Snake	*Tantilla yaquia*	Yaqui Black-headed Snake
Gyalopion quadrangulare	Thornscrub Hook-nosed Snake	*Terrapene ornata*	Ornate Box Turtle
Heloderma suspectum	Gila Monster	*Thamnophis cyrtopsis*	Black-necked Gartersnake
Heterodon nasicus	Western Hog-nosed Snake	*Thamnophis elegans*	Terrestrial Gartersnake
Holbrookia elegans	Elegant Earless Lizard	*Thamnophis eques megalops*	Northern Mexican Gartersnake
Holbrookia maculata	Lesser Earless Lizard	*Thamnophis marcianus*	Checkered Gartersnake
Hypsiglena chlorophaea	Desert Nightsnake	*Thamnophis rufipunctatus*	Narrow-headed Gartersnake
Hypsiglena jani	Chihuahuan Nightsnake	*Trimorphodon biscutatus*	Western Lyresnake
Hypsiglena species novum	Hooded Nightsnake	*Uma rufopunctata*	Yuman Desert Fringe-toed Lizard
Kinosternon flavescens	Yellow Mud Turtle	*Uma scoparia*	Mohave Fringe-toed Lizard
Kinosternon arizonense	Arizona Mud Turtle	*Urosaurus graciosus*	Long-tailed Brush Lizard
Kinosternon sonoriense longifemorale	Sonoyta Mud Turtle	*Urosaurus ornatus*	Ornate Tree Lizard
Kinosternon sonoriense sonoriense	Sonora Mud Turtle	*Uta stansburiana*	Common Side-blotched Lizard
Lampropeltis getula californiae	California Kingsnake	*Xantusia arizonae*	Arizona Night Lizard
Lampropeltis getula nigrita	Western Black Kingsnake	*Xantusia bezyi*	Bezy's Night Lizard
Lampropeltis getula splendida	Desert Kingsnake	*Xantusia vigilis*	Desert Night Lizard

Lampropeltis pyromelana	Sonoran Mountain Kingsnake		
Lampropeltis triangulum	Milksnake		
Lampropeltis triangulum (Cochise County)	Milksnake		
BIRDS			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Dendrocygna autumnalis	Black-bellied Whistling-Duck	*Sayornis nigricans*	Black Phoebe
Chen caerulescens	Snow Goose	*Sayornis saya*	Say's Phoebe
Chen rossii	Ross's Goose	*Pyrocephalus rubinus*	Vermilion Flycatcher
Branta canadensis	Canada Goose	*Myiarchus tuberculifer*	Dusky-capped Flycatcher
Aix sponsa	Wood Duck	*Myiarchus cinerascens*	Ash-throated Flycatcher
Anas strepera	Gadwall	*Myiarchus tyrannulus*	Brown-crested Flycatcher
Anas americana	American Wigeon	*Myiodynastes luteiventris*	Sulphur-bellied Flycatcher
Anas platyrhynchos	Mallard	*Tyrannus melancholicus*	Tropical Kingbird
Anas discors	Blue-winged Teal	*Tyrannus vociferans*	Cassin's Kingbird
Anas cyanoptera	Cinnamon Teal	*Tyrannus crassirostris*	Thick-billed Kingbird
Anas clypeata	Northern Shoveler	*Tyrannus verticalis*	Western Kingbird
Anas acuta	Northern Pintail	*Pachyramphus aglaiae*	Rose-throated Becard
Anas crecca	Green-winged Teal	*Lanius ludovicianus*	Loggerhead Shrike
Aythya valisineria	Canvasback	*Vireo bellii arizonae*	Arizona Bell's Vireo
Aythya americana	Redhead	*Vireo vicinior*	Gray Vireo
Aythya collaris	Ring-necked Duck	*Vireo plumbeus*	Plumbeous Vireo
Aythya affinis	Lesser Scaup	*Vireo huttoni*	Hutton's Vireo
Mergus merganser	Common Merganser	*Vireo gilvus*	Warbling Vireo
Oxyura jamaicensis	Ruddy Duck	*Perisoreus canadensis*	Gray Jay
Callipepla squamata	Scaled Quail	*Gymnorhinus cyanocephalus*	Pinyon Jay
Callipepla gambelii	Gambel's Quail	*Cyanocitta stelleri*	Steller's Jay
Colinus virginianus ridgwayi	Masked Bobwhite	*Aphelocoma californica*	Western Scrub-Jay
Cyrtonyx montezumae	Montezuma Quail	*Aphelocoma ultramarina*	Mexican Jay
Dendragapus obscurus	Dusky Grouse	*Nucifraga columbiana*	Clark's Nutcracker
Meleagris gallopavo merriami	Merriam's Turkey	*Pica hudsonia*	Black-billed Magpie
Meleagris gallopavo mexicana	Gould's Turkey	*Corvus brachyrhynchos*	American Crow
Podilymbus podiceps	Pied-billed Grebe	*Corvus cryptoleucus*	Chihuahuan Raven
Podiceps nigricollis	Eared Grebe	*Corvus corax*	Common Raven
Aechmophorus occidentalis	Western Grebe	*Eremophila alpestris*	Horned Lark

Aechmophorus clarkii	Clark's Grebe	*Progne subis arboricola*	Western Purple Martin
Phalacrocorax brasilianus	Neotropic Cormorant	*Progne subis hesperia*	Desert Purple Martin
Phalacrocorax auritus	Double-crested Cormorant	*Tachycineta bicolor*	Tree Swallow
Pelecanus erythrorhynchos	American White Pelican	*Tachycineta thalassina*	Violet-green Swallow
Botaurus lentiginosus	American Bittern	*Stelgidopteryx serripennis*	Northern Rough-winged Swallow
Ixobrychus exilis hesperis	Western Least Bittern	*Petrochelidon pyrrhonota*	Cliff Swallow
Ardea herodias	Great Blue Heron	*Hirundo rustica*	Barn Swallow
Ardea alba	Great Egret	*Poecile gambeli*	Mountain Chickadee
Egretta thula	Snowy Egret	*Poecile sclateri*	Mexican Chickadee
Bubulcus ibis	Cattle Egret	*Baeolophus wollweberi*	Bridled Titmouse
Butorides virescens	Green Heron	*Baeolophus ridgwayi*	Juniper Titmouse
Nycticorax nycticorax	Black-crowned Night-Heron	*Auriparus flaviceps*	Verdin
Plegadis chihi	White-faced Ibis	*Psaltriparus minimus*	Bushtit
Coragyps atratus	Black Vulture	*Sitta canadensis*	Red-breasted Nuthatch
Cathartes aura	Turkey Vulture	*Sitta carolinensis*	White-breasted Nuthatch
Gymnogyps californianus	California Condor	*Sitta pygmaea*	Pygmy Nuthatch
Pandion haliaetus	Osprey	*Certhia americana*	Brown Creeper
Ictinia mississippiensis	Mississippi Kite	*Campylorhynchus brunneicapillus*	Cactus Wren
Haliaeetus leucocephalus	Bald Eagle	*Salpinctes obsoletus*	Rock Wren
Circus cyaneus	Northern Harrier	*Catherpes mexicanus*	Canyon Wren
Accipiter striatus	Sharp-shinned Hawk	*Thryomanes bewickii*	Bewick's Wren
Accipiter cooperii	Cooper's Hawk	*Troglodytes aedon*	House Wren
Accipiter gentilis atricapillus	Northern Goshawk	*Troglodytes pacificus*	Pacific Wren
Buteogallus anthracinus	Common Black-Hawk	*Cistothorus palustris*	Marsh Wren
Parabuteo unicinctus	Harris's Hawk	*Polioptila caerulea*	Blue-gray Gnatcatcher
Buteo nitida	Gray Hawk	*Polioptila melanura*	Black-tailed Gnatcatcher
Buteo brachyurus	Short-tailed hawk	*Polioptila nigriceps*	Black-capped Gnatcatcher
Buteo swainsoni	Swainson's Hawk	*Cinclus mexicanus*	American Dipper
Buteo albonotatus	Zone-tailed Hawk	*Regulus satrapa*	Golden-crowned Kinglet
Buteo jamaicensis	Red-tailed Hawk	*Regulus calendula*	Ruby-crowned Kinglet
Buteo regalis	Ferruginous Hawk	*Sialia sialis fulva*	Azure Bluebird
Aquila chrysaetos	Golden Eagle	*Sialia mexicana*	Western Bluebird
Caracara cheriway	Crested Caracara	*Sialia currucoides*	Mountain Bluebird
Falco sparverius	American Kestrel	*Myadestes townsendi*	Townsend's Solitaire
Falco femoralis septentrionalis	Northern Aplomado Falcon	*Catharus ustulatus*	Swainson's Thrush
Falco peregrinus anatum	American Peregrine Falcon	*Catharus guttatus*	Hermit Thrush
Falco mexicanus	Prairie Falcon	*Turdus migratorius*	American Robin
Laterallus jamaicensis	California Black Rail	*Dumetella carolinensis*	Gray Catbird

coturniculus			
Rallus longirostris yumanensis	Yuma Clapper Rail	*Mimus polyglottos*	Northern Mockingbird
Rallus limicola	Virginia Rail	*Oreoscoptes montanus*	Sage Thrasher
Porzana carolina	Sora	*Toxostoma bendirei*	Bendire's Thrasher
Gallinula chloropus	Common Moorhen	*Toxostoma curvirostre*	Curve-billed Thrasher
Fulica americana	American Coot	*Toxostoma crissale*	Crissal Thrasher
Grus canadensis	Sandhill Crane	*Toxostoma lecontei*	Le Conte's Thrasher
Charadrius alexandrinus nivosus	Western Snowy Plover	*Anthus rubescens*	American Pipit
Charadrius vociferus	Killdeer	*Anthus spragueii*	Sprague's Pipit
Charadrius montanus	Mountain Plover	*Phainopepla nitens*	Phainopepla
Himantopus mexicanus	Black-necked Stilt	*Peucedramus taeniatus*	Olive Warbler
Recurvirostra americana	American Avocet	*Calcarius ornatus*	Chestnut-collared Longspur
Actitis macularius	Spotted Sandpiper	*Rhynchophanes mccownii*	McCown's Longspur
Tringa melanoleuca	Greater Yellowlegs	*Oreothlypis celata*	Orange-crowned Warbler
Numenius americanus	Long-billed Curlew	*Oreothlypis virginiae*	Virginia's Warbler
Calidris minutilla	Least Sandpiper	*Oreothlypis luciae*	Lucy's Warbler
Limnodromus scolopaceus	Long-billed Dowitcher	*Dendroica petechia*	Yellow Warbler
Gallinago delicata	Wilson's Snipe	*Dendroica coronata*	Yellow-rumped Warbler
Sternula antillarum browni	California Least Tern	*Dendroica nigrescens*	Black-throated Gray Warbler
Patagioenas fasciata	Band-tailed Pigeon	*Dendroica graciae*	Grace's Warbler
Zenaida asiatica	White-winged Dove	*Oporornis tolmiei*	MacGillivray's Warbler
Zenaida macroura	Mourning Dove	*Geothlypis trichas*	Common Yellowthroat
Columbina inca	Inca Dove	*Cardellina rubrifrons*	Red-faced Warbler
Columbina passerina	Common Ground-Dove	*Myioborus pictus*	Painted Redstart
Rhynchopsitta pachyrhyncha	Thick-billed Parrot	*Icteria virens*	Yellow-breasted Chat
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	*Piranga flava*	Hepatic Tanager
Geococcyx californianus	Greater Roadrunner	*Piranga rubra*	Summer Tanager
Tyto alba	Barn Owl	*Piranga ludoviciana*	Western Tanager
Otus flammeolus	Flammulated Owl	*Pipilo chlorurus*	Green-tailed Towhee
Megascops kennicottii	Western Screech-Owl	*Pipilo maculatus*	Spotted Towhee
Megascops trichopsis	Whiskered Screech-Owl	*Aimophila ruficeps*	Rufous-crowned Sparrow
Bubo virginianus	Great Horned Owl	*Melozone fuscus*	Canyon Towhee
Glaucidium gnoma californicum	Northern Pygmy-0wl	*Melozone aberti*	Abert's Towhee
Glaucidium gnoma gnoma	Mountain Pygmy-Owl	*Peucaea carpalis*	Rufous-winged Sparrow
Glaucidium brasilianum cactorum	Cactus Ferruginous Pygmy-Owl	*Peucaea botterii arizonae*	Arizona Botteri's Sparrow

Micrathene whitneyi	Elf Owl	*Peucaea cassinii*	Cassin's Sparrow
Athene cunicularia hypugaea	Western Burrowing Owl	*Spizella passerina*	Chipping Sparrow
Strix occidentalis lucida	Mexican Spotted Owl	*Spizella breweri*	Brewer's Sparrow
Asio otus	Long-eared Owl	*Spizella atrogularis*	Black-chinned Sparrow
Aegolius acadicus	Northern Saw-whet Owl	*Pooecetes gramineus*	Vesper Sparrow
Chordeiles acutipennis	Lesser Nighthawk	*Chondestes grammacus*	Lark Sparrow
Chordeiles minor	Common Nighthawk	*Amphispiza quinquestriata*	Five-striped Sparrow
Phalaenoptilus nuttallii	Common Poorwill	*Amphispiza bilineata*	Black-throated Sparrow
Caprimulgus ridgwayi	Buff-collared Nightjar	*Amphispiza belli*	Sage Sparrow
Caprimulgus arizonae	Mexican Whip-poor-will	*Calamospiza melanocorys*	Lark Bunting
Aeronautes saxatalis	White-throated Swift	*Passerculus sandwichensis*	Savannah Sparrow
Cynanthus latirostris	Broad-billed Hummingbird	*Ammodramus savannarum ammolegus*	Arizona Grasshopper Sparrow
Amazilia violiceps	Violet-crowned Hummingbird	*Ammodramus savannarum perpallidus*	Western Grasshopper Sparrow
Lampornis clemenciae	Blue-throated Hummingbird	*Ammodramus bairdii*	Baird's Sparrow
Eugenes fulgens	Magnificent Hummingbird	*Melospiza melodia*	Song Sparrow
Calothorax lucifer	Lucifer Hummingbird	*Melospiza lincolnii*	Lincoln's Sparrow
Archilochus alexandri	Black-chinned Hummingbird	*Zonotrichia leucophrys*	White-crowned Sparrow
Calypte anna	Anna's Hummingbird	*Junco hyemalis*	Dark-eyed Junco
Calypte costae	Costa's Hummingbird	*Junco phaeonotus*	Yellow-eyed Junco
Selasphorus platycercus	Broad-tailed Hummingbird	*Cardinalis cardinalis*	Northern Cardinal
Trogon elegans	Elegant Trogon	*Cardinalis sinuatus*	Pyrrhuloxia
Ceryle alcyon	Belted Kingfisher	*Pheucticus melanocephalus*	Black-headed Grosbeak
Chloroceryle americana	Green Kingfisher	*Passerina caerulea*	Blue Grosbeak
Melanerpes lewis	Lewis's Woodpecker	*Passerina amoena*	Lazuli Bunting
Melanerpes formicivorus	Acorn Woodpecker	*Passerina cyanea*	Indigo Bunting
Melanerpes uropygialis	Gila Woodpecker	*Passerina versicolor*	Varied Bunting
Sphyrapicus thyroideus	Williamson's Sapsucker	*Agelaius phoeniceus*	Red-winged Blackbird
Sphyrapicus nuchalis	Red-naped Sapsucker	*Sturnella magna*	Eastern Meadowlark
Picoides scalaris	Ladder-backed Woodpecker	*Sturnella neglecta*	Western Meadowlark
Picoides pubescens	Downy Woodpecker	*Xanthocephalus xanthocephalus*	Yellow-headed Blackbird
Picoides villosus	Hairy Woodpecker	*Euphagus cyanocephalus*	Brewer's Blackbird
Picoides arizonae	Arizona Woodpecker	*Quiscalus mexicanus*	Great-tailed Grackle
Picoides dorsalis	American Three-toed Woodpecker	*Molothrus aeneus*	Bronzed Cowbird

Colaptes auratus	Northern Flicker	*Molothrus ater*	Brown-headed Cowbird
Colaptes chrysoides	Gilded Flicker	*Icterus cucullatus*	Hooded Oriole
Camptostoma imberbe	Northern Beardless-Tyrannulet	*Icterus bullockii*	Bullock's Oriole
Contopus cooperi	Olive-sided Flycatcher	*Icterus parisorum*	Scott's Oriole
Contopus pertinax	Greater Pewee	*Pinicola enucleator*	Pine Grosbeak
Contopus sordidulus	Western Wood-Pewee	*Carpodacus cassinii*	Cassin's Finch
Empidonax traillii extimus	Southwestern Willow Flycatcher	*Carpodacus mexicanus*	House Finch
Empidonax wrightii	Gray Flycatcher	*Loxia curvirostra*	Red Crossbill
Empidonax oberholseri	Dusky Flycatcher	*Spinus pinus*	Pine Siskin
Empidonax occidentalis	Cordilleran Flycatcher	*Spinus psaltria*	Lesser Goldfinch
Empidonax fulvifrons pygmaeus	Northern Buff-breasted Flycatcher	*Coccothraustes vespertinus*	Evening Grosbeak

MAMMALS			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Ammospermophilus harrisii	Harris' Antelope Squirrel	*Odocoileus hemionus hemionous*	Rocky Mountain Mule Deer
Ammospermophilus leucurus	White-tailed Antelope Squirrel	*Odocoileus virginianus couesi*	Coues whitetail deer
Ammospermophilus leucurus tersus	Prospect Valley White-tailed Antelope Squirrel	*Ondatra zibethicus*	Common Muskrat
Antilocapra americana americana	America Pronghorn	*Onychomys leucogaster*	Northern Grasshopper Mouse
Antilocapra americana sonoriensis	Sonoran Pronghorn	*Onychomys torridus*	Southern Grasshopper Mouse
Antrozous pallidus	Pallid Bat	*Ovis canadensis canadensis*	Rocky Mountain Bighorn Sheep
Baiomys taylori	Northern Pygmy Mouse	*Ovis canadensis mexicana*	Desert Bighorn Sheep
Bassariscus astutus	Ringtail	*Ovis canadensis nelsoni*	Desert Bighorn Sheep
Canis latrans	Coyote	*Panthera onca*	Jaguar
Canis lupus baileyi	Mexican Gray Wolf	*Parastrellus hesperus*	Western Pipistrelle
Castor canadensis	American Beaver	*Perognathus amplus*	Arizona Pocket Mouse
Cervus elaphus nelsoni	Rocky Mountain Elk	*Perognathus amplus cineris*	Wupatki Arizona Pocket Mouse
Chaetodipus baileyi	Bailey's Pocket Mouse	*Perognathus apache*	Apache Pocket Mouse
Chaetodipus formosus	Long-tailed Pocket Mouse	*Perognathus apache melanotis*	Apache Pocket Mouse
Chaetodipus hispidus	Hispid Pocket Mouse	*Perognathus flavus*	Silky Pocket Mouse
Chaetodipus intermedius	Rock Pocket Mouse	*Perognathus flavus goodpasteri*	Springerville Pocket Mouse

Chaetodipus penicillatus	Sonoran Desert Pocket Mouse	*Perognathus longimembris*	Little Pocket Mouse
Choeronycteris mexicana	Mexican Long-tongued Bat	*Perognathus parvus*	Great Basin Pocket Mouse
Clethrionomys gapperi	Southern Red-backed Vole	*Peromyscus boylii*	Brush Mouse
Conepatus leuconotus	Hog-nosed Skunk	*Peromyscus crinitus*	Canyon Mouse
Corynorhinus townsendii pallescens	Pale Townsend's Big-eared Bat	*Peromyscus eremicus*	Cactus Mouse
Cynomys gunnisoni	Gunnison's Prairie Dog	*Peromyscus leucopus*	White-footed Mouse
Cynomys ludovicianus	Black-tailed Prairie Dog	*Peromyscus maniculatus*	Deer Mouse
Didelphis virginiana californica	Mexican Oppossum	*Peromyscus merriami*	Mesquite Mouse
Dipodomys deserti	Desert Kangaroo Rat	*Peromyscus nasutus* (*difficilis*)	Rock Mouse
Dipodomys merriami	Merriam's Kangaroo Rat	*Peromyscus truei*	Pinon Mouse
Dipodomys microps celsus	Chisel-toothed Kangaroo Rat	*Procyon lotor*	Raccoon
Dipodomys microps leucotis	Houserock Valley Chisel-toothed Kangaroo Rat	*Puma concolor*	Mountain Lion
Dipodomys ordii	Ord's Kangaroo Rat	*Reithrodontomys fulvescens*	Fulvous Harvest Mouse
Dipodomys spectabilis	Banner-tailed Kangaroo Rat	*Reithrodontomys megalotis*	Western Harvest Mouse
Eptesicus fuscus	Big Brown Bat	*Reithrodontomys montanus*	Plains Harvest Mouse
Erethizon dorsatum	North American Porcupine	*Sciurus aberti*	Abert's Squirrel
Euderma maculatum	Spotted Bat	*Sciurus aberti chuscensis*	Abert's Chuska Squirrel
Eumops perotis californicus	Greater Western Mastiff Bat	*Sciurus aberti kaibabensis*	Kaibab Squirrel
Eumops underwoodi	Underwood's Mastiff Bat	*Sciurus arizonensis*	Arizona Gray Squirrel
Idionycteris phyllotis	Allen's Big-eared Bat	*Sciurus nayaritensis chiricahuae*	Chiricahua Fox Squirrel
Lasionycteris noctivagans	Silver-haired Bat	*Sigmodon arizonae cienegae*	Arizona Cotton Rat
Lasiurus blossevillii	Western Red Bat	*Sigmodon arizonae jacksoni*	Yavapai Arizona Cotton Rat
Lasiurus cinereus	Hoary Bat	*Sigmodon arizonae plenus*	Colorado River Cotton Rat
Lasiurus xanthinus	Western Yellow Bat	*Sigmodon fulviventer*	Tawny-bellied Cotton Rat
Leopardus pardalis	Ocelot	*Sigmodon hispidus*	Hispid Cotton Rat
Leptonycteris yerbabuenae	Lesser Long-nosed Bat	*Sigmodon hispidus eremicus*	Yuma Hispid Cotton Rat
Lepus alleni	Antelope Jackrabbit	*Sigmodon ochrognathus*	Yellow-nosed Cotton Rat
Lepus californicus	Black-tailed Jackrabbit	*Sorex arizonae*	Arizona Shrew
Lontra canadensis	Southeastern River Otter	*Sorex merriami*	Merriam's Shrew

lataxina			
Lontra canadensis sonora	Southwestern River Otter	*Sorex monticolus*	Dusky Shrew
Lynx rufus	Bobcat	*Sorex nanus*	Dwarf Shrew
Macrotus californicus	California Leaf-nosed Bat	*Sorex palustris*	Water Shrew
Mephitis macroura	Hooded Skunk	*Spermophilus lateralis*	Golden-mantled Ground Squirrel
Mephitis mephitis	Striped Skunk	*Spermophilus spilosoma*	Spotted Ground Squirrel
Microtus longicaudus	Long-tailed Vole	*Spermophilus tereticaudus*	Round-tailed Ground Squirrel
Microtus longicaudus leucophaeus	White-bellied Long-tailed Vole	*Spermophilus tridecemlineatus*	Thirteen-lined Ground Squirrel
Microtus mexicanus	Mexican Vole	*Spermophilus variegatus*	Rock Squirrel
Microtus mexicanus hualpaiensis	Hualapai Mexican Vole	*Spilogale gracilis*	Western Spotted Skunk
Microtus montanus	Arizona Montane Vole	*Sylvilagus audubonii*	Desert Cottontail
Mustela frenata	Long-tailed Weasel	*Sylvilagus floridanus*	Eastern Cottontail
Mustela nigripes	Black-footed Ferret	*Sylvilagus nuttallii grangeri*	North Kaibab Mountain Cottontail
Myotis auriculus	Southwestern Myotis	*Sylvilagus nuttallii pinetis*	Southwestern Cottontail
Myotis californicus	California Myotis	*Tadarida brasiliensis*	Mexican Free-tailed Bat
Myotis ciliolabrum	Western Small-footed Myotis	*Tamias cinereicollis*	Gray-collared Chipmunk
Myotis evotis	Long-eared Myotis	*Tamias dorsalis*	Cliff Chipmunk
Myotis occultus	Arizona Myotis	*Tamias minimus*	Least Chipmunk
Myotis thysanodes	Fringed Myotis	*Tamias quadrivittatus*	Colorado Chipmunk
Myotis velifer	Cave Myotis	*Tamias umbrinus*	Uinta Chipmunk
Myotis volans	Long-legged Myotis	*Tamiasciurus hudsonicus*	Red Squirrel
Myotis yumanensis	Yuma Myotis	*Tamiasciurus hudsonicus grahamens*	Mt Graham Red Squirrel
Nasua nasua	White-nosed Coati	*Taxidea taxus*	American Badger
Neotoma albigula	Western White-throated Woodrat	*Tayassau tajacu*	Collared Peccary
Neotoma cinerea	Bushy-tailed Woodrat	*Thomomys bottae*	Botta's Pocket Gopher
Neotoma lepida	Desert Woodrat	*Thomomys bottae subsimilis*	Harquahala Southern Pocket Gopher
Neotoma mexicana	Mexican Woodrat	*Thomomys talpoides*	Northern Pocket Gopher
Neotoma mexicana mexicana	Mexican Woodrat	*Thomomys umbrinus intermedius*	Southern Pocket Gopher
Neotoma stephensi	Stephen's Woodrat	*Urocyon cinereoargenteus*	Common Gray Fox
Notiosorex cockrumi	Cockrum's Desert Shrew	*Ursus americanus*	American Black Bear
Notiosorex crawfordi	Crawford's Desert Shrew	*Vulpes macrotis*	Kit Fox

Nyctinomops femorosaccus	Pocketed Free-tailed Bat	*Vulpes vulpes*	Red Fox
Nyctinomops macrotis	Big Free-tailed Bat	*Zapus hudsonius luteus*	New Mexican Jumping Mouse
Odocoileus hemionus crooki	Desert Mule Deer		

Appendix E: Species of Greatest Conservation Need

Note: In the 2005 Tier column NA denotes "Not Applicable" and UNK denotes "Unknown Status"

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Amphibian	Arizona Treefrog (Huachuca-Canelo Hills DPS)	*Hyla wrightorum* (Huachuca-Canelo Hills DPS)	1A	NA	3	1	2	1	1	2	3	1
Amphibian	Chiricahua Leopard Frog	*Rana chiricahuensis*	1A	1A	3	1	1	1	1	3	1	2
Amphibian	Lowland Leopard Frog	*Rana yavapaiensis*	1A	1B	3	1	3	3	3	3	2	1
Amphibian	Northern Leopard Frog	*Rana pipiens*	1A	1B	3	1	1	2	2	2	3	3
Amphibian	Plains Leopard Frog	*Rana blairi*	1A	1B	3	1	0	1	0	3	3	3
Amphibian	Relict Leopard Frog	*Rana onca*	1A	1A	3	1	0	1	1	3	1	3
Amphibian	Sonoran Tiger Salamander	*Ambystoma mavortium stebbinsi*	1A	1A	3	1	2	3	1	2	3	1
Amphibian	Tarahumara Frog	*Rana tarahumarae*	1A	1B	3	1	1	1	1	3	3	1
Amphibian	Arizona Tiger Salamander	*Ambystoma mavortium nebulosum*	1B	1C	3	3	3	3	1	2	3	3
Amphibian	Arizona Toad	*Bufo microscaphus*	1B	1B	3	3	0	3	2	2	2	1
Amphibian	Barking Frog	*Craugastor augusti*	1B	1B	3	3	0	1	1	3	3	3
Amphibian	Desert Pacific Treefrog	*Pseudacris hypochondriaca*	1B	1C	3	3	0	1	0	2	3	3
Amphibian	Lowland Burrowing Treefrog	*Smilisca fodiens*	1B	1B	3	3	0	2	3	2	3	1
Amphibian	Sonoran Desert Toad	*Bufo alvarius*	1B	NA	3	3	3	3	3	3	3	1
Amphibian	Sonoran Green Toad	*Bufo retiformis*	1B	UNK	3	3	3	2	3	2	3	1
Amphibian	Great Basin Spadefoot	*Spea intermontana*	1C	1C	3	3	0	2	3	2	3	3
Amphibian	Great Plains Narrow-mouthed Toad	*Gastrophryne olivacea*	1C	1B	3	3	0	2	3	2	3	3
Amphibian	Mountain Treefrog	*Hyla wrightorum*	1C	1C	3	3	0	3	3	2	3	2
Amphibian	Western Chorus Frog	*Pseudacris triseriata*	1C	1C	3	3	0	2	2	2	3	3
Bird	American Peregrine Falcon	*Falco peregrinus anatum*	1A	1B	3	1	3	3	2	3	3	3
Bird	Bald Eagle	*Haliaeetus leucocephalus*	1A	1A	3	1	4	1	2	3	2	3
Bird	California Condor	*Gymnogyps californianus*	1A	1A	3	1	4	1	1	2	3	3
Bird	California Least Tern	*Sternula antillarum browni*	1A	NA	3	1	4	1	0	2	0	3
Bird	Masked Bobwhite	*Colinus virginianus ridgwayi*	1A	1A	3	1	1	1	1	3	1	1
Bird	Mexican Spotted Owl	*Strix occidentalis lucida*	1A	1A	3	1	2	3	2	3	1	2
Bird	Northern Aplomado Falcon	*Falco femoralis septentrionalis*	1A	1A	1	1	0	2	0	3	1	3
Bird	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	1A	1A	3	1	2	3	3	2	1	2
Bird	Sprague's Pipit	*Anthus spragueii*	1A	1B	3	1	0	2	0	3	3	3
Bird	Thick-billed Parrot	*Rhynchopsitta pachyrhyncha*	1A	1B	1	1	2	2	1	2	0	1
Bird	Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	1A	1A	3	1	2	3	3	3	1	2
Bird	Yuma Clapper Rail	*Rallus longirostris yumanensis*	1A	1A	3	1	3	3	3	3	3	3
Bird	Abert's Towhee	*Melozone aberti*	1B	NA	3	3	0	3	3	3	3	1
Bird	American Bittern	*Botaurus lentiginosus*	1B	1B	3	3	1	2	0	3	3	3
Bird	American Dipper	*Cinclus mexicanus*	1B	1C	3	3	1	3	1	3	1	3
Bird	Arizona Bell's Vireo	*Vireo bellii arizonae*	1B	NA	3	3	1	3	3	3	3	2
Bird	Arizona Botteri's Sparrow	*Peucaea botterii arizonae*	1B	1B	3	3	3	2	3	3	3	1
Bird	Arizona Grasshopper Sparrow	*Ammodramus savannarum ammolegus*	1B	1B	3	3	0	3	3	3	3	1
Bird	Arizona Woodpecker	*Picoides arizonae*	1B	1C	3	3	3	2	3	3	3	1

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Bird	Azure Bluebird	*Sialia sialis fulva*	1B	1B	3	3	3	2	3	3	3	1
Bird	Black-billed Magpie	*Pica hudsonia*	1B	1B	3	3	1	2	1	3	1	3
Bird	Black-capped Gnatcatcher	*Polioptila nigriceps*	1B	1B	3	3	4	2	4	3	3	1
Bird	Blue-throated Hummingbird	*Lampornis clemenciae*	1B	1C	3	3	2	2	2	3	3	1
Bird	Broad-billed Hummingbird	*Cynanthus latirostris*	1B	NA	3	3	4	2	4	3	3	1
Bird	Buff-collared Nightjar	*Caprimulgus ridgwayi*	1B	1C	3	3	0	2	2	3	3	1
Bird	Cactus Ferruginous Pygmy-Owl	*Glaucidium brasilianum cactorum*	1B	1A	3	3	1	2	1	3	1	3
Bird	California Black Rail	*Laterallus jamaicensis coturniculus*	1B	1B	3	3	0	1	2	3	3	3
Bird	Common Nighthawk	*Chordeiles minor*	1B	NA	3	3	1	3	3	3	3	3
Bird	Desert Purple Martin	*Progne subis hesperia*	1B	1C	3	3	0	2	3	2	3	1
Bird	Dusky Grouse	*Dendragapus obscurus*	1B	1C	3	3	3	1	3	3	3	3
Bird	Dusky-capped Flycatcher	*Myiarchus tuberculifer*	1B	NA	3	3	4	2	4	3	3	1
Bird	Elegant Trogon	*Trogon elegans*	1B	1B	3	3	4	2	2	3	3	1
Bird	Evening Grosbeak	*Coccothraustes vespertinus*	1B	1C	3	3	1	2	0	3	3	3
Bird	Ferruginous Hawk	*Buteo regalis*	1B	1B	3	3	1	2	2	3	2	3
Bird	Five-striped Sparrow	*Amphispiza quinquestriata*	1B	1B	3	3	0	2	2	3	3	1
Bird	Gila Woodpecker	*Melanerpes uropygialis*	1B	NA	3	3	0	3	3	3	3	1
Bird	Gilded Flicker	*Colaptes chrysoides*	1B	NA	3	3	2	3	3	3	3	1
Bird	Golden Eagle	*Aquila chrysaetos*	1B	NA	3	3	1	3	1	3	3	3
Bird	Gould's Turkey	*Meleagris gallopavo mexicana*	1B	1C	3	3	4	2	4	2	3	1
Bird	Gray Catbird	*Dumetella carolinensis*	1B	1B	3	3	0	2	3	3	1	3
Bird	Gray Jay	*Perisoreus canadensis*	1B	1C	3	3	1	1	1	3	3	3
Bird	Le Conte's Thrasher	*Toxostoma lecontei*	1B	1C	3	3	2	3	2	3	1	2
Bird	Lincoln's Sparrow	*Melospiza lincolnii*	1B	1C	3	3	0	1	2	3	3	3
Bird	MacGillivray's Warbler	*Oporornis tolmiei*	1B	1C	3	3	1	2	2	3	2	3
Bird	Magnificent Hummingbird	*Eugenes fulgens*	1B	1C	3	3	4	2	3	3	3	1
Bird	Mexican Chickadee	*Poecile sclateri*	1B	1C	3	3	2	1	3	3	3	1
Bird	Mississippi Kite	*Ictinia mississippiensis*	1B	1B	3	3	0	1	2	3	2	3
Bird	Mountain Plover	*Charadrius montanus*	1B	1C	3	3	1	2	2	2	3	3
Bird	Mountain Pygmy-Owl	*Glaucidium gnoma gnoma*	1B	UNK	3	3	0	2	3	3	3	1
Bird	Northern Buff-breasted Flycatcher	*Empidonax fulvifrons pygmaeus*	1B	1B	3	3	0	2	1	3	1	1
Bird	Northern Goshawk	*Accipiter gentilis atricapillus*	1B	1B	3	3	1	3	2	3	2	3
Bird	Pacific Wren	*Troglodytes pacificus*	1B	1C	3	3	0	1	2	3	3	3
Bird	Pine Grosbeak	*Pinicola enucleator*	1B	1B	3	3	0	1	2	3	3	3
Bird	Pinyon Jay	*Gymnorhinus cyanocephalus*	1B	NA	3	3	1	2	3	2	3	3
Bird	Rose-throated Becard	*Pachyramphus aglaiae*	1B	1B	3	3	1	2	1	3	3	1
Bird	Rufous-winged Sparrow	*Peucaea carpalis*	1B	NA	3	3	4	2	3	3	3	1
Bird	Savannah Sparrow	*Passerculus sandwichensis*	1B	1C	3	3	0	1	3	2	3	3
Bird	Sulphur-bellied Flycatcher	*Myiodynastes luteiventris*	1B	1C	3	3	4	2	3	3	3	1
Bird	Swainson's Thrush	*Catharus ustulatus*	1B	1B	3	3	0	1	0	3	3	3
Bird	Thick-billed Kingbird	*Tyrannus crassirostris*	1B	1B	3	3	4	2	4	3	3	1
Bird	Violet-crowned Hummingbird	*Amazilia violiceps*	1B	1B	3	3	4	2	3	3	3	1
Bird	Western Burrowing Owl	*Athene cunicularia hypugaea*	1B	NA	3	3	1	3	2	3	2	3
Bird	Western Grasshopper	*Ammodramus savannarum*	1B	1B	3	3	0	1	1	3	1	3

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
	Sparrow	*perpallidus*										
Bird	Western Snowy Plover	*Charadrius alexandrinus nivosus*	1B	1B	3	3	1	1	0	3	3	3
Bird	Whiskered Screech-Owl	*Megascops trichopsis*	1B	1C	3	3	3	2	3	3	3	1
Bird	Wood Duck	*Aix sponsa*	1B	1B	3	3	4	1	4	3	3	3
Bird	Yellow Warbler	*Dendroica petechia*	1B	NA	3	3	0	3	3	3	1	3
Bird	Yellow-eyed Junco	*Junco phaeonotus*	1B	1C	3	3	3	2	3	3	3	1
Bird	Acorn Woodpecker	*Melanerpes formicivorus*	1C	NA	3	3	0	3	3	3	3	3
Bird	American Pipit	*Anthus rubescens*	1C	1C	3	3	0	2	3	3	3	3
Bird	American Three-toed Woodpecker	*Picoides dorsalis*	1C	1B	3	3	0	2	3	3	3	3
Bird	Baird's Sparrow	*Ammodramus bairdii*	1C	1B	3	3	0	2	0	3	3	3
Bird	Band-tailed Pigeon	*Patagioenas fasciata*	1C	NA	3	3	0	3	2	2	3	3
Bird	Bendire's Thrasher	*Toxostoma bendirei*	1C	UNK	3	3	0	3	3	3	3	2
Bird	Black-bellied Whistling-Duck	*Dendrocygna autumnalis*	1C	1B	3	3	0	2	3	2	3	3
Bird	Black-chinned Sparrow	*Spizella atrogularis*	1C	NA	3	3	0	3	3	3	3	3
Bird	Black-tailed Gnatcatcher	*Polioptila melanura*	1C	NA	3	3	0	3	3	3	3	3
Bird	Black-throated Gray Warbler	*Dendroica nigrescens*	1C	NA	3	3	0	3	3	3	3	3
Bird	Brewer's Sparrow	*Spizella breweri*	1C	NA	3	3	0	3	3	2	3	3
Bird	Bridled Titmouse	*Baeolophus wollweberi*	1C	NA	3	3	0	2	3	3	3	2
Bird	Brown-crested Flycatcher	*Myiarchus tyrannulus*	1C	NA	3	3	0	3	3	3	3	2
Bird	Bullock's Oriole	*Icterus bullockii*	1C	NA	3	3	0	3	3	3	3	3
Bird	Cassin's Sparrow	*Peucaea cassinii*	1C	NA	3	3	0	2	3	3	3	3
Bird	Chestnut-collared Longspur	*Calcarius ornatus*	1C	UNK	3	3	0	2	3	2	3	3
Bird	Clark's Grebe	*Aechmophorus clarkii*	1C	1B	3	3	0	2	0	2	3	3
Bird	Common Black-Hawk	*Buteogallus anthracinus*	1C	1B	3	3	0	2	3	3	3	2
Bird	Common Moorhen	*Gallinula chloropus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Common Poorwill	*Phalaenoptilus nuttallii*	1C	NA	3	3	0	3	3	3	3	3
Bird	Cordilleran Flycatcher	*Empidonax occidentalis*	1C	NA	3	3	0	3	3	3	3	3
Bird	Costa's Hummingbird	*Calypte costae*	1C	NA	3	3	0	3	3	3	3	2
Bird	Dusky Flycatcher	*Empidonax oberholseri*	1C	NA	3	3	0	3	3	3	3	3
Bird	Eastern Meadowlark	*Sturnella magna*	1C	NA	3	3	0	3	3	2	3	3
Bird	Elf Owl	*Micrathene whitneyi*	1C	NA	3	3	0	2	3	3	3	3
Bird	Flammulated Owl	*Otus flammeolus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Golden-crowned Kinglet	*Regulus satrapa*	1C	1C	3	3	0	2	3	3	3	3
Bird	Grace's Warbler	*Dendroica graciae*	1C	NA	3	3	0	3	3	3	3	3
Bird	Gray Flycatcher	*Empidonax wrightii*	1C	UNK	3	3	0	3	3	3	3	3
Bird	Gray Vireo	*Vireo vicinior*	1C	NA	3	3	0	3	3	3	3	3
Bird	Great Egret	*Ardea alba*	1C	1B	3	3	0	3	4	2	3	3
Bird	Greater Pewee	*Contopus pertinax*	1C	UNK	3	3	0	2	3	3	3	2
Bird	Harris's Hawk	*Parabuteo unicinctus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Hooded Oriole	*Icterus cucullatus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Juniper Titmouse	*Baeolophus ridgwayi*	1C	NA	3	3	0	3	3	3	3	3
Bird	Lazuli Bunting	*Passerina amoena*	1C	NA	3	3	0	2	3	3	3	3
Bird	Lewis's Woodpecker	*Melanerpes lewis*	1C	1C	3	3	0	3	3	2	3	3
Bird	Long-eared Owl	*Asio otus*	1C	NA	3	3	0	3	3	2	3	3
Bird	Lucy's Warbler	*Oreothlypis luciae*	1C	NA	3	3	0	3	3	3	3	2

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Bird	Marsh Wren	*Cistothorus palustris*	1C	1C	3	3	0	2	3	3	3	3
Bird	McCown's Longspur	*Rhynchophanes mccownii*	1C	1C	3	3	0	2	0	3	3	3
Bird	Mexican Jay	*Aphelocoma ultramarina*	1C	NA	3	3	0	2	3	3	3	2
Bird	Mexican Whip-poor-will	*Caprimulgus arizonae*	1C	UNK	3	3	0	2	3	3	3	3
Bird	Montezuma Quail	*Cyrtonyx montezumae*	1C	NA	3	3	0	2	3	3	2	2
Bird	Mountain Bluebird	*Sialia currucoides*	1C	NA	3	3	0	3	3	2	3	3
Bird	Northern Pygmy-0wl	*Glaucidium gnoma californicum*	1C	UNK	3	3	0	3	3	3	3	3
Bird	Northern Saw-whet Owl	*Aegolius acadicus*	1C	UNK	3	3	0	3	0	3	3	3
Bird	Olive Warbler	*Peucedramus taeniatus*	1C	NA	3	3	0	2	3	3	3	2
Bird	Olive-sided Flycatcher	*Contopus cooperi*	1C	1B	3	3	0	3	2	3	3	3
Bird	Orange-crowned Warbler	*Oreothlypis celata*	1C	1C	3	3	0	2	2	3	3	3
Bird	Painted Redstart	*Myioborus pictus*	1C	NA	3	3	0	2	3	3	3	2
Bird	Phainopepla	*Phainopepla nitens*	1C	NA	3	3	0	3	3	2	3	3
Bird	Prairie Falcon	*Falco mexicanus*	1C	NA	3	3	0	3	2	3	3	3
Bird	Red Crossbill	*Loxia curvirostra*	1C	NA	3	3	0	3	3	2	3	3
Bird	Red-faced Warbler	*Cardellina rubrifrons*	1C	NA	3	3	0	2	3	3	3	2
Bird	Red-naped Sapsucker	*Sphyrapicus nuchalis*	1C	1B	3	3	0	3	3	3	3	3
Bird	Sage Sparrow	*Amphispiza belli*	1C	NA	3	3	0	2	3	3	3	3
Bird	Sage Thrasher	*Oreoscoptes montanus*	1C	1B	3	3	0	3	3	2	3	3
Bird	Scaled Quail	*Callipepla squamata*	1C	NA	3	3	0	3	3	3	2	3
Bird	Scott's Oriole	*Icterus parisorum*	1C	NA	3	3	0	3	3	3	3	3
Bird	Snowy Egret	*Egretta thula*	1C	1B	3	3	0	3	4	2	3	3
Bird	Sora	*Porzana carolina*	1C	NA	3	3	0	3	3	3	3	3
Bird	Summer Tanager	*Piranga rubra*	1C	NA	3	3	0	3	3	3	3	3
Bird	Swainson's Hawk	*Buteo swainsoni*	1C	NA	3	3	0	3	3	2	3	3
Bird	Varied Bunting	*Passerina versicolor*	1C	NA	3	3	0	2	3	3	3	3
Bird	Vermilion Flycatcher	*Pyrocephalus rubinus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Virginia Rail	*Rallus limicola*	1C	UNK	3	3	0	3	3	3	3	3
Bird	Virginia's Warbler	*Oreothlypis virginiae*	1C	NA	3	3	0	3	3	3	3	3
Bird	Western Grebe	*Aechmophorus occidentalis*	1C	1C	3	3	0	3	2	2	3	3
Bird	Western Least Bittern	*Ixobrychus exilis hesperis*	1C	NA	3	3	0	3	3	3	3	3
Bird	Western Purple Martin	*Progne subis arboricola*	1C	1B	3	3	0	3	3	2	3	3
Bird	Western Screech-Owl	*Megascops kennicottii*	1C	NA	3	3	0	3	3	3	3	3
Bird	Western Scrub-Jay	*Aphelocoma californica*	1C	NA	3	3	0	3	3	3	3	3
Bird	White-crowned Sparrow	*Zonotrichia leucophrys*	1C	1C	3	3	0	3	3	3	3	3
Bird	White-throated Swift	*Aeronautes saxatalis*	1C	UNK	3	3	0	3	0	2	3	3
Bird	Williamson's Sapsucker	*Sphyrapicus thyroideus*	1C	NA	3	3	0	3	3	3	3	3
Bird	Yellow-breasted Chat	*Icteria virens*	1C	NA	3	3	0	3	3	3	3	3
Fish	Apache (Arizona) Trout	*Oncorhynchus gilae apache*	1A	1A	3	1	1	3	1	1	1	1
Fish	Beautiful Shiner	*Cyprinella formosa*	1A	1A	3	1	1	1	1	1	1	1
Fish	Bluehead Sucker	*Catostomus discobolus*	1A	1A	3	1	1	3	1	2	1	3
Fish	Bonytail	*Gila elegans*	1A	1A	3	1	1	1	1	2	1	1
Fish	Colorado Pikeminnow	*Ptychocheilus lucius*	1A	1A	3	1	1	1	1	2	1	3
Fish	Desert Pupfish	*Cyprinodon macularius*	1A	1A	3	1	1	3	1	1	1	2
Fish	Flannelmouth Sucker	*Catostomus latipinnis*	1A	1A	3	1	1	3	1	2	1	3
Fish	Gila Chub	*Gila intermedia*	1A	1A	3	1	1	3	1	2	1	1

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Fish	Gila Topminnow	*Poeciliopsis occidentalis occidentalis*	1A	1A	3	1	1	3	1	1	1	1
Fish	Gila Trout	*Oncorhynchus gilae gilae*	1A	1A	3	1	1	1	1	1	1	1
Fish	Headwater Chub	*Gila nigra*	1A	1B	3	1	2	3	1	2	1	1
Fish	Humpback Chub	*Gila cypha*	1A	1A	3	1	1	1	1	2	1	1
Fish	Little Colorado Spinedace	*Lepidomeda vittata*	1A	1A	3	1	1	3	1	2	1	1
Fish	Little Colorado Sucker	*Catostomus sp.*	1A	1B	3	1	1	3	1	2	1	1
Fish	Loach Minnow	*Tiaroga cobitis*	1A	1A	3	1	1	2	1	2	1	2
Fish	Mexican Stoneroller	*Campostoma ornatum*	1A	1B	3	1	2	1	1	1	1	3
Fish	Quitobaquito Pupfish	*Cyprinodon eremus*	1A	1A	3	1	3	1	1	1	1	1
Fish	Razorback Sucker	*Xyrauchen texanus*	1A	1A	3	1	1	3	1	2	1	3
Fish	Roundtail Chub	*Gila robusta*	1A	1B	3	1	1	3	1	2	1	2
Fish	Sonora Chub	*Gila ditaenia*	1A	1A	3	1	1	1	1	2	1	1
Fish	Spikedace	*Meda fulgida*	1A	1A	3	1	1	1	1	1	1	3
Fish	Virgin Chub	*Gila seminuda*	1A	1A	3	1	1	2	1	2	1	1
Fish	Virgin Spinedace	*Lepidomeda mollispinis mollispinis*	1A	1A	3	1	1	2	1	2	1	1
Fish	Woundfin	*Plagopterus argentissimus*	1A	1A	3	1	1	2	1	2	1	1
Fish	Yaqui Catfish	*Ictalurus pricei*	1A	1A	3	1	1	1	1	1	1	3
Fish	Yaqui Chub	*Gila purpurea*	1A	1A	3	1	1	1	1	2	1	1
Fish	Yaqui Topminnow	*Poeciliopsis occidentalis sonoriensis*	1A	1A	3	1	1	1	1	1	1	3
Fish	Zuni Bluehead Sucker	*Catostomus discobolus yarrowi*	1A	1A	3	1	1	1	1	2	1	3
Fish	Desert Sucker	*Catostomus clarki*	1B	1B	3	3	2	3	1	2	1	2
Fish	Longfin Dace	*Agosia chrysogaster*	1B	1B	3	3	2	3	1	1	1	2
Fish	Machete	*Elops affinis*	1B	1C	3	3	1	1	1	2	1	3
Fish	Sonora Sucker	*Catostomus insignis*	1B	1B	3	3	2	3	1	2	1	2
Fish	Speckled Dace	*Rhinichthys osculus*	1B	1B	3	3	2	2	1	1	1	3
Fish	Striped Mullet	*Mugil cephalus*	1B	1C	3	3	1	1	1	2	1	3
Fish	Yaqui Sucker	*Catostomus bernardini*	1B	1B	1	3	1	1	1	2	1	3
Invertebrate	Brown Springsnail	*Pyrgulopsis sola*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	Bylas Springsnail	*Pyrgulopsis arizonae*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	California Floater	*Anodonta californiensis*	1A	1B	3	1	1	1	1	2	1	2
Invertebrate	Desert Springsnail	*Pyrgulopsis deserta*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	Fossil Springsnail	*Pyrgulopsis simplex*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	Gila Tryonia	*Tryonia gilae*	1A	1B	3	1	4	1	3	3	1	1
Invertebrate	Grand Wash Springsnail	*Pyrgulopsis bacchus*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	Huachuca Springsnail	*Pyrgulopsis thompsoni*	1A	1A	3	1	3	1	0	3	1	1
Invertebrate	Kanab Ambersnail	*Oxyloma haydeni kanabensis*	1A	1A	3	1	3	1	2	3	1	2
Invertebrate	Kingman Springsnail	*Pyrgulopsis conica*	1A	1B	3	1	0	1	0	3	1	1
Invertebrate	Montezuma Well Springsnail	*Pyrgulopsis montezumensis*	1A	1B	3	1	3	1	0	3	1	1
Invertebrate	Niobrara Ambersnail	*Oxyloma haydeni haydeni*	1A	1B	3	1	3	1	3	3	1	3
Invertebrate	Page Springsnail	*Pyrgulopsis morrisoni*	1A	1A	3	1	4	1	3	3	1	1
Invertebrate	Quitobaquito Tryonia	*Tryonia quitobaquitae*	1A	1A	3	1	4	1	3	3	1	1
Invertebrate	Rosemont Talussnail	*Sonorella rosemontensis*	1A	NA	3	1	0	0	0	0	0	1
Invertebrate	San Bernardino Springsnail	*Pyrgulopsis bernardina*	1A	1B	3	1	3	1	1	3	1	3
Invertebrate	San Xavier Talussnail	*Sonorella eremita*	1A	1A	3	1	3	1	2	3	1	1
Invertebrate	Three Forks Springsnail	*Pyrgulopsis trivialis*	1A	1A	3	1	3	1	2	3	1	1
Invertebrate	Verde Rim Springsnail	*Pyrgulopsis glandulosa*	1A	1B	3	1	3	1	0	3	1	1

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Invertebrate	Wet Canyon Talussnail	*Sonorella macrophallus*	1A	1A	3	1	3	1	2	3	1	1
Invertebrate	Arizona Cave Amphipod	*Stygobromus arizonensis*	1B	1B	3	3	1	1	2	1	1	1
Invertebrate	Clark Peak Talussnail	*Sonorella christenseni*	1B	1B	3	3	0	1	0	3	1	1
Invertebrate	Mimic Talussnail	*Sonorella imitator*	1B	1B	3	3	3	1	2	3	1	1
Invertebrate	Montezuma Well amphipod	*Hyalella montezuma*	1B	NA	3	3	0	1	0	3	1	1
Invertebrate	Papago Talussnail	*Sonorella papagorum*	1B	1B	3	3	0	1	0	3	1	1
Invertebrate	Pinaleno Mountainsnail	*Oreohelix grahamensis*	1B	1B	3	3	0	1	0	3	1	1
Invertebrate	Pinaleno Talussnail	*Sonorella grahamensis*	1B	1B	3	3	2	1	0	3	1	1
Invertebrate	Squaw Peak Talussnail	*Sonorella allynsmithi*	1B	1B	3	3	0	1	0	3	1	1
Invertebrate	Agua Caliente Talussnail	*Sonorella santaritana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Amber Glass	*Nesovitrea electrina*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	amphipod	*Hyalella azteca*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Ancha Mountainsnail	*Oreohelix anchana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Apache Snaggletooth	*Gastrocopta cochisensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Apache Talussnail	*Sonorella apache*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Aqua Dulce Talussnail	*Sonorella meadi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Arizona Holospira	*Holospira arizonensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Arizona mantleslug	*Pallifera pilsbryi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ash Gyro	*Gyraulus parvus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Baboquivari Talussnail	*Sonorella baboquivariensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Bear Canyon Talussnail	*Sonorella danielsi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Bearded Mountainsnail	*Oreohelix barbata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Beavertail Fairy Shrimp	*Thamnocephalus platyurus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Big Emigrant Talussnail	*Sonorella optata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Black Mesa Talussnail	*Sonorella russelli*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Blue Mountain Woodlandsnail	*Ashmunella pilsbryana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Blue Talussnail	*Sonorella caeruliflumnis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Bradshaw Talussnail	*Sonorella bradshaveana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Bristletail Clam Shrimp	*Cyzicus setosa*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Carved Glyph	*Glyphyalinia indentata*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Cave Creek Holospire	*Holospira chiricahuana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Cave Creek Woodlandsnail	*Ashmunella chiricahuana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Cayuse Physa	*Physella osculans*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Chihuahuan Desert Fairy Shrimp	*Streptocephalus mackini*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Chiricahua Talussnail	*Sonorella virilis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Chiricahua Woodlandsnail	*Ashmunella proxima*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Cockerell's Striate Disc	*Discus shimekii cockerelli*	1C	1B	3	3	0	0	0	0	0	0
Invertebrate	Colorado Fairy Shrimp	*Branchinecta coloradensis*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Corkscrew Physa	*Physella humerosa*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Crested Snaggletooth	*Gastrocopta cristata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Crestless Column	*Pupilla hebes*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Cross Snaggletooth	*Gastrocopta quadridens*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Cummings Mountainsnail	*Oreohelix yavapai cummingsi*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Dagger (no common name)	*Pupoides nitidulus*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Desert Tadpole Shrimp	*Triops newberryi*	1C	UNK	3	3	0	0	0	0	0	0

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Invertebrate	Diablo Mountainsnail	*Oreohelix houghi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Disc Gyro	*Gyraulus circumstriatus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Dos Cabezas Talussnail	*Sonorella bicipitis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Doubtful Canyon Talussnail	*Sonorella waltoni*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Dragoon Talussnail	*Sonorella ferrissi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Eastern Desertsnail	*Eremarionta rowelli*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Empire Mountain Talussnail	*Sonorella imperialis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Escabrosa Talussnail	*Sonorella bartschi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ethologist Fairy Shrimp	*Eubranchipus serratus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Evening Talussnail	*Sonorella vespertina*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Forest Disc	*Discus whitneyi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Freshwater Snail	*Fossaria techella*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Galiuro Talussnail	*Sonorella galiurensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Garden Canyon Talussnail	*Sonorella dalli*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Glossy Pillar	*Cionella lubrica*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Glossy Valvata	*Valvata humeralis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Golden Fossaria	*Fossaria obrussa*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Grand Canyon Talussnail	*Sonorella coloradoensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Greater Plains Fairy Shrimp	*Streptocephalus texanus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Happy Valley Talussnail	*Sonorella bequaerti*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Holarctic Clam Shrimp	*Lynceus brachyurus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Hollow Tuba	*Chaenaxis tuba*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Holospira (no common name)	*Holospira campestris*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Holospira (no common name)	*Holospira cionella*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Holospira (no common name)	*Holospira millestriata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Horseshoe Canyon Talussnail	*Sonorella binneyi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Huachuca Mountainsnail	*Oreohelix concentrata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Huachuca Talussnail	*Sonorella huachucana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Huachuca Woodlandsnail	*Ashmunella levettei*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Kaibab Fairy Shrimp	*Branchinecta kaibabensis*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Kitt Peak Talussnail	*Sonorella xanthenes*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Knobbedlip Fairy Shrimp	*Eubranchipus bundyi*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Las Guijas Talussnail	*Sonorella sitiens*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Leslie Canyon Talussnail	*Sonorella pedregosensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Little Talussnail	*Sonorella parva*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Longtail Tadpole Shrimp	*Triops longicaudatus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Madera Talussnail	*Sonorella clappi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Mellow Column	*Columella columella*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Mexican Beavertail Fairy Shrimp	*Thamnocephalus mexicanus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Mexican Clam Shrimp	*Cyzicus mexicanus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Mexican Coil	*Helicodiscus eigenmanni*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Mexican Rams-horn	*Planorbella tenuis*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Mexico Ambersnail	*Succinea luteola*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Milk Ranch Talussnail	*Sonorella micromphala*	1C	NA	0	3	0	0	0	0	0	0

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Invertebrate	Milk Snail	*Otala lactea*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Minute Gem	*Hawaiia minuscula*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Mogollon Woodlandsnail	*Ashmunella mogollonensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Montane Snaggletooth	*Gastrocopta pilsbryana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Mustang Talussnail	*Sonorella mustang*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	New Mexico Fairy Shrimp	*Streptocephalus dorothae*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Oak Creek Talussnail	*Sonorella compar*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Papago Talussnail	*Sonorella ambigua*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Picacho Talussnail	*Sonorella simmonsi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Pond slug	*Deroceras laeve*	1C	NA	3	3	0	0	0	3	0	0
Invertebrate	Portal Talussnail	*Sonorella neglecta*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Posta Quemada Talussnail	*Sonorella rinconensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Protean Physa	*Physella virgata*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Pungent Talussnail	*Sonorella odorata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Pygmy Fossaria	*Fossaria parva*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Pygmy Sonorella	*Sonorella micra*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Quartzite Hill Talussnail	*Sonorella bowiensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Quick Gloss	*Zonitoides arboreus*	1C	NA	0	3						
Invertebrate	Rampart Talussnail	*Sonorella reederi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ramsey Canyon Talussnail	*Sonorella granulatissima*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Reed's Mountain Woodlandsnail	*Ashmunella ferrissi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ribbed Dagger	*Pupoides hordaceus*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ribbed Pinwheel	*Radiodiscus millecostatus*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Ribbed Spot	*Punctum californicum*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Richinbar Talussnail	*Sonorella ashmuni*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Rincon Talussnail	*Sonorella bagnarai*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Rock Fossaria	*Fossaria modicella*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Rock Pool Fairy Shrimp	*Branchinecta packardi*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Rocky Mountainsnail	*Oreohelix strigosa meridionalis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Rotund Vertigo	*Vertigo berryi*	1C	1C	3	3	0	0	0	0	0	0
Invertebrate	San Francisco Brine Shrimp	*Artemia franciscana*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Sanford Talussnail	*Sonorella tryoniana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Santa Catalina Talussnail	*Sonorella sabinoensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Santa Rita Ambersnail	*Succinea grosvenori*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Santa Rita Talussnail	*Sonorella walkeri*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Sharp Sprite (A Planorbid Snail)	*Promenetus exacuous*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Short Finger Clam Shrimp	*Lynceus brevifrons*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Shortneck Snaggletooth	*Gastrocopta dalliana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Sierra Ancha Talussnail	*Sonorella anchana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Silky Vallonia	*Vallonia cyclophorella*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Silver Creek holospira	*Holospira sherbrookei*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Slim Snaggletooth	*Gastrocopta pellucida*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Sluice Snaggletooth	*Gastrocopta ashmuni*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Sonoran Snaggletooth	*Gastrocopta prototypus*	1C	NA	0	3	0	0	0	0	0	0

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Invertebrate	Sonoran Talussnail	*Sonorella magdalenensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Southwestern Fringed-snail	*Thysanophora hornii*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Spineynose Clam Shrimp	*Leptestheria compleximanus*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Spinytail Fairy Shrimp	*Streptocephalus sealii*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Spruce Snail	*Microphysula ingersolli*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	St. Francis Talussnail	*Sonorella franciscana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Stocky Holospira	*Holospira ferrissi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Stongrib Holospira	*Holospira danielsi*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Straightbacked Clam Shrimp	*Eocyzicus digueti*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Striate Disc	*Discus shimekii*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Stronghold Canyon Talussnail	*Sonorella dragoonensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Subalpine Mountainsnail	*Oreohelix subrudis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Suboval Ambersnail (1)	*Catinella avara*	1C	NA	3	3	3	0	3	3	3	0
Invertebrate	Suboval Ambersnail (2)	*Catinella vermeta*	1C	NA	3	3	0	0	3	3	3	0
Invertebrate	Superstition Mountains Talussnail	*Sonorella superstitionis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Table Top Talussnail	*Sonorella milleri*	1C	1C	3	3	0	0	0	0	0	0
Invertebrate	Teasing Holospira	*Holospira tantalus*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Thin-lip Vallonia	*Vallonia perspectiva*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Tiny Peaclam	*Pisidium insigne*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Tollhouse Canyon Talussnail	*Sonorella delicata*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Top-heavy Column	*Pupilla syngenes*	1C	NA	3	3	0	0	0	0	0	0
Invertebrate	Tortolita Talussnail	*Sonorella tortillita*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Total Wreck Talussnail	*Sonorella imperatrix*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Two-ridge Rams-horn	*Helisoma anceps*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Ubiquitous Peaclam	*Pisidium casertanum*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Vagabond Holospira	*Holospira montivaga*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Versitle Fairy Shrimp	*Branchinecta lindahli*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Walnut Canyon Talussnail	*Sonorella coltoniana*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Western Glass Snail	*Vitrina pellucida alaskana*	1C	UNK	3	3	0	0	0	0	0	0
Invertebrate	Whetstone Holospira	*Holospira whetstonensis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Whetstone Talussnail	*Sonorella insignis*	1C	NA	0	3	0	0	0	0	0	0
Invertebrate	Yavapai Mountain Snail	*Oreohelix yavapai*	1C	1B	3	3	0	0	0	0	0	0
Mammal	Black-footed Ferret	*Mustela nigripes*	1A	1A	3	1	3	2	3	3	3	2
Mammal	Black-tailed Prairie Dog	*Cynomys ludovicianus*	1A	1A	3	1	0	0	0	1	0	3
Mammal	Hualapai Mexican Vole	*Microtus mexicanus hualpaiensis*	1A	1A	3	1	4	1	3	1	1	3
Mammal	Jaguar	*Panthera onca*	1A	1A	3	1	0	1	1	3	1	3
Mammal	Lesser Long-nosed Bat	*Leptonycteris yerbabuenae*	1A	1A	3	1	3	2	3	1	3	1
Mammal	Mexican Gray Wolf	*Canis lupus baileyi*	1A	1A	3	1	1	1	1	3	2	1
Mammal	Mt Graham Red Squirrel	*Tamiasciurus hudsonicus grahamens*	1A	1A	3	1	1	1	2	3	3	1
Mammal	New Mexican Jumping Mouse	*Zapus hudsonius luteus*	1A	1B	3	1	1	1	0	3	3	3
Mammal	Ocelot	*Leopardus pardalis*	1A	1A	3	1	0	0	0	3	0	3
Mammal	Sonoran Pronghorn	*Antilocapra americana sonoriensis*	1A	1A	3	1	1	1	1	2	1	1

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Mammal	Abert's Chuska Squirrel	*Sciurus aberti chuscensis*	1B	1C	3	3	0	1	0	3	3	2
Mammal	Allen's Lappet-browed Bat	*Idionycteris phyllotis*	1B	UNK	3	3	0	3	1	2	3	1
Mammal	America Pronghorn	*Antilocapra americana americana*	1B	1C	3	3	3	2	1	2	2	3
Mammal	American Beaver	*Castor canadensis*	1B	1C	3	3	0	1	2	3	1	3
Mammal	Antelope Jackrabbit	*Lepus alleni*	1B	NA	3	3	3	2	3	2	3	1
Mammal	Arizona Gray Squirrel	*Sciurus arizonensis*	1B	1C	3	3	4	1	3	3	3	1
Mammal	Arizona Montane Vole	*Microtus montanus*	1B	1C	3	3	3	1	3	3	3	1
Mammal	Arizona Myotis	*Myotis occultus*	1B	UNK	3	3	1	3	2	2	3	2
Mammal	Arizona Pocket Mouse	*Perognathus amplus*	1B	UNK	3	3	0	3	0	3	3	1
Mammal	Arizona Shrew	*Sorex arizonae*	1B	1B	3	3	0	1	3	3	3	1
Mammal	Banner-tailed Kangaroo Rat	*Dipodomys spectabilis*	1B	NA	3	3	2	1	3	3	1	3
Mammal	California Leaf-nosed Bat	*Macrotus californicus*	1B	1B	3	3	3	3	3	1	2	2
Mammal	Cave Myotis	*Myotis velifer*	1B	NA	3	3	3	3	3	1	3	3
Mammal	Chiricahua Fox Squirrel	*Sciurus nayaritensis chiricahuae*	1B	1B	3	3	3	1	3	3	3	1
Mammal	Cockrum's Desert Shrew	*Notiosorex cockrumi*	1B	UNK	3	3	0	1	0	3	3	1
Mammal	Colorado Chipmunk	*Tamias quadrivittatus*	1B	1C	3	3	3	2	0	3	1	3
Mammal	Colorado River Cotton Rat	*Sigmodon arizonae plenus*	1B	1C	3	3	0	1	0	3	3	0
Mammal	Coues whitetail deer	*Odocoileus virginianus couesi*	1B	NA	3	3	4	3	3	2	2	1
Mammal	Desert Bighorn Sheep	*Ovis canadensis mexicana*	1B	1B	3	3	4	2	2	2	1	2
Mammal	Gray-collared Chipmunk	*Tamias cinereicollis*	1B	1C	3	3	3	3	3	3	1	1
Mammal	Greater Western Mastiff Bat	*Eumops perotis californicus*	1B	1B	3	3	0	3	2	1	3	2
Mammal	Gunnison's Prairie Dog	*Cynomys gunnisoni*	1B	1A	3	3	3	1	2	1	2	3
Mammal	Harquahala Southern Pocket Gopher	*Thomomys bottae subsimilis*	1B	1B	3	3	0	1	0	3	0	0
Mammal	Harris' Antelope Squirrel	*Ammospermophilus harrisii*	1B	NA	3	3	3	3	3	3	3	1
Mammal	Houserock Valley Chisel-toothed Kangaroo Rat	*Dipodomys microps leucotis*	1B	1B	3	3	0	1	0	3	3	1
Mammal	Kaibab Squirrel	*Sciurus aberti kaibabensis*	1B	1C	3	3	3	1	3	3	3	1
Mammal	Kit Fox	*Vulpes macrotis*	1B	UNK	3	3	0	3	1	3	1	2
Mammal	Least Chipmunk	*Tamias minimus*	1B	1C	3	3	3	2	0	3	1	3
Mammal	Little Pocket Mouse	*Perognathus longimembris*	1B	UNK	3	3	3	1	3	3	3	3
Mammal	Long-tailed Vole	*Microtus longicaudus*	1B	1C	3	3	0	1	3	3	3	3
Mammal	Mexican Free-tailed Bat	*Tadarida brasiliensis*	1B	1C	3	3	3	3	3	1	3	3
Mammal	Mexican Vole	*Microtus mexicanus*	1B	1C	3	3	0	1	0	3	3	2
Mammal	North Kaibab Mountain Cottontail	*Sylvilagus nuttallii grangeri*	1B	1C	3	3	3	1	3	3	3	1
Mammal	Pale Townsend's Big-eared Bat	*Corynorhinus townsendii pallescens*	1B	UNK	3	3	0	3	1	2	3	3
Mammal	Pocketed Free-tailed Bat	*Nyctinomops femorosaccus*	1B	UNK	3	3	0	3	2	2	3	1
Mammal	Prospect Valley White-tailed Antelope Squirrel	*Ammospermophilus leucurus tersus*	1B	1B	3	3	0	1	0	3	3	1
Mammal	Red Fox	*Vulpes vulpes*	1B	1C	3	3	3	2	3	3	1	3
Mammal	Rock Mouse	*Peromyscus nasutus (difficilis)*	1B	UNK	3	3	3	1	3	3	3	2
Mammal	Rocky Mountain Bighorn	*Ovis canadensis canadensis*	1B	1C	3	3	4	1	2	2	1	2

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
	Sheep											
Mammal	Southeastern River Otter	*Lontra canadensis lataxina*	1B	1C	3	3	3	2	3	3	1	3
Mammal	Southern Pocket Gopher	*Thomomys umbrinus intermedius*	1B	1B	3	3	0	1	0	3	0	0
Mammal	Southwestern Cottontail	*Sylvilagus nuttallii pinetis*	1B	1C	3	3	3	1	3	3	3	3
Mammal	Southwestern River Otter	*Lontra canadensis sonora*	1B	1B	1	3	0	0	0	0	0	0
Mammal	Spotted Bat	*Euderma maculatum*	1B	1B	3	3	3	3	2	1	3	3
Mammal	Springerville Pocket Mouse	*Perognathus flavus goodpasteri*	1B	1B	3	3	0	2	0	3	3	1
Mammal	Stephen's Woodrat	*Neotoma stephensi*	1B	UNK	3	3	0	3	3	3	3	1
Mammal	Uinta Chipmunk	*Tamias umbrinus*	1B	1C	3	3	0	1	0	3	3	3
Mammal	Underwood's Mastiff Bat	*Eumops underwoodi*	1B	1B	3	3	0	2	0	2	3	1
Mammal	Water Shrew	*Sorex palustris*	1B	1B	3	3	3	1	3	3	3	3
Mammal	Western Red Bat	*Lasiurus blossevillii*	1B	1B	3	3	0	3	1	2	3	2
Mammal	Western Yellow Bat	*Lasiurus xanthinus*	1B	1B	3	3	0	2	3	3	3	1
Mammal	White-bellied Long-tailed Vole	*Microtus longicaudus leucophaeus*	1B	1B	3	3	0	1	0	3	3	1
Mammal	Wupatki Arizona Pocket Mouse	*Perognathus amplus cineris*	1B	UNK	3	3	0	3	0	3	3	1
Mammal	Yuma Hispid Cotton Rat	*Sigmodon hispidus eremicus*	1B	1B	3	3	0	1	0	3	0	1
Mammal	Yuma Myotis	*Myotis yumanensis*	1B	NA	3	3	3	3	3	1	3	3
Mammal	Apache Pocket Mouse	*Perognathus apache melanotis*	1C	UNK	3	3	0	2	0	3	0	0
Mammal	Arizona Cotton Rat	*Sigmodon arizonae cienegae*	1C	NA	3	3	0	0	0	3	0	3
Mammal	Canyon Mouse	*Peromyscus crinitus*	1C	UNK	3	3	0	2	0	3	3	3
Mammal	Chisel-toothed Kangaroo Rat	*Dipodomys microps celsus*	1C	1C	3	3	0	2	2	3	3	3
Mammal	Desert Woodrat	*Neotoma lepida*	1C	UNK	3	3	0	3	0	3	3	3
Mammal	Dwarf Shrew	*Sorex nanus*	1C	UNK	3	3	0	2	3	3	3	3
Mammal	Fulvous Harvest Mouse	*Reithrodontomys fulvescens*	1C	UNK	3	3	0	2	0	3	0	3
Mammal	Golden-mantled Ground Squirrel	*Spermophilus lateralis*	1C	1C	3	3	0	2	3	3	3	3
Mammal	Hispid Cotton Rat	*Sigmodon hispidus*	1C	UNK	3	3	0	2	0	3	0	3
Mammal	Hog-nosed Skunk	*Conepatus leuconotus*	1C	UNK	3	3	0	2	0	2	0	0
Mammal	Long-eared Myotis	*Myotis evotis*	1C	UNK	3	3	0	3	0	2	3	3
Mammal	Long-tailed Pocket Mouse	*Chaetodipus formosus*	1C	UNK	3	3	0	3	3	3	3	0
Mammal	Long-tailed Weasel	*Mustela frenata*	1C	UNK	3	3	0	2	2	3	3	3
Mammal	Merriam's Shrew	*Sorex merriami*	1C	1B	3	3	0	2	3	3	3	3
Mammal	Mexican Long-tongued Bat	*Choeronycteris mexicana*	1C	1B	3	3	0	2	2	2	3	2
Mammal	Northern Grasshopper Mouse	*Onychomys leucogaster*	1C	UNK	3	3	3	3	0	3	3	3
Mammal	Northern Pocket Gopher	*Thomomys talpoides*	1C	UNK	3	3	0	2	0	3	3	3
Mammal	Plains Harvest Mouse	*Reithrodontomys montanus*	1C	1B	3	3	0	2	0	3	0	3
Mammal	Rock Pocket Mouse	*Chaetodipus intermedius*	1C	NA	3	3	3	3	3	3	3	0
Mammal	Southern Grasshopper Mouse	*Onychomys torridus*	1C	UNK	3	3	3	3	0	3	3	2
Mammal	Southern Red-backed Vole	*Clethrionomys gapperi*	1C	UNK	3	3	3	2	0	3	3	3
Mammal	Southwestern Myotis	*Myotis auriculus*	1C	UNK	3	3	0	2	2	2	3	2
Mammal	Spotted Ground Squirrel	*Spermophilus spilosoma*	1C	1B	3	3	0	2	0	3	3	0
Mammal	Tawny-bellied Cotton Rat	*Sigmodon fulviventer*	1C	UNK	3	3	0	2	0	3	0	2
Mammal	Thirteen-lined Ground	*Spermophilus tridecemlineatus*	1C	UNK	3	3	0	2	0	3	3	3

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
	Squirrel											
Mammal	Western Spotted Skunk	*Spilogale gracilis*	1C	UNK	3	3	0	3	3	3	0	3
Mammal	Yavapai Arizona Cotton Rat	*Sigmodon arizonae jacksoni*	1C	UNK	3	3	0	0	0	3	0	0
Mammal	Yellow-nosed Cotton Rat	*Sigmodon ochrognathus*	1C	1C	3	3	0	2	0	3	0	3
Reptile	Flat-tailed Horned Lizard	*Phrynosoma mcallii*	1A	1A	3	1	2	2	1	3	1	3
Reptile	Gila Monster	*Heloderma suspectum*	1A	NA	3	1	3	3	3	3	2	1
Reptile	Massasauga	*Sistrurus catenatus*	1A	1A	3	1	1	1	1	3	1	3
Reptile	Milksnake	*Lampropeltis triangulum* (Cochise County)	1A	1B	3	1	0	0	0	3	0	0
Reptile	Mojave Desert Tortoise	*Gopherus agassizii*	1A	1A	3	1	2	2	2	3	2	3
Reptile	Narrow-headed Gartersnake	*Thamnophis rufipunctatus*	1A	1B	3	1	1	1	1	3	1	2
Reptile	New Mexico Ridge-nosed Rattlesnake	*Crotalus willardi obscurus*	1A	1A	3	1	0	1	1	3	3	3
Reptile	Northern Mexican Gartersnake	*Thamnophis eques megalops*	1A	1B	3	1	1	1	1	3	1	1
Reptile	Ornate Box Turtle	*Terrapene ornata*	1A	1B	3	1	0	2	2	3	1	3
Reptile	Ridge-nosed Rattlesnake	*Crotalus willardi*	1A	1A	3	1	0	1	3	3	3	1
Reptile	Rock Rattlesnake	*Crotalus lepidus*	1A	NA	3	1	3	2	3	3	3	3
Reptile	Sonoran Desert Tortoise	*Gopherus morafkai*	1A	1B	3	1	3	3	2	3	2	1
Reptile	Sonoyta Mud Turtle	*Kinosternon sonoriense longifemorale*	1A	1A	3	1	2	1	2	3	3	1
Reptile	Tucson Shovel-nosed Snake	*Chionactis occipitalis klauberi*	1A	1B	1	1	1	3	1	3	1	1
Reptile	Twin-spotted Rattlesnake	*Crotalus pricei*	1A	1B	3	1	3	1	3	3	3	1
Reptile	Arizona Black Rattlesnake	*Crotalus cerberus*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Arizona Mud Turtle	*Kinosternon arizonense*	1B	1B	3	3	0	2	2	3	3	1
Reptile	Arizona Night Lizard	*Xantusia arizonae*	1B	1C	3	3	3	1	3	3	3	1
Reptile	Arizona Skink	*Plestiodon gilberti arizonensis*	1B	1B	3	3	0	1	3	3	3	1
Reptile	Arizona Striped Whiptail	*Aspidoscelis arizonae*	1B	1B	3	3	0	3	3	3	3	1
Reptile	Bezy's Night Lizard	*Xantusia bezyi*	1B	1C	3	3	3	1	3	3	2	1
Reptile	Brown Vinesnake	*Oxybelis aeneus*	1B	1B	3	3	3	2	3	3	3	1
Reptile	Canyon Spotted Whiptail	*Aspidoscelis burti*	1B	1B	3	3	3	1	3	3	2	1
Reptile	Chihuahuan Black-headed Snake	*Tantilla wilcoxi*	1B	1C	3	3	3	2	3	3	3	1
Reptile	Gila Spotted Whiptail	*Aspidoscelis flagellicauda*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Goode's Horned Lizard	*Phrynosoma goodei*	1B	UNK	3	3	3	3	3	3	2	1
Reptile	Green Ratsnake	*Senticolis triaspis*	1B	1C	3	3	3	2	3	3	2	1
Reptile	Hooded Nightsnake	*Hypsiglena* species novum	1B	NA	3	3	3	3	3	3	3	1
Reptile	Mohave Fringe-toed Lizard	*Uma scoparia*	1B	NA	3	3	2	1	3	3	1	3
Reptile	Pai Striped Whiptail	*Aspidoscelis pai*	1B	1C	3	3	3	3	3	3	3	1
Reptile	Painted Turtle	*Chrysemys picta*	1B	1C	3	3	0	1	0	3	0	3
Reptile	Red-back Whiptail	*Aspidoscelis xanthonota*	1B	1B	3	3	3	1	3	3	3	1
Reptile	Regal Horned Lizard	*Phrynosoma solare*	1B	UNK	3	3	3	3	3	3	2	1
Reptile	Rosy Boa (Mexican Rosy Boa)	*Lichanura trivirgata*	1B	1C	3	3	3	2	3	3	3	1
Reptile	Saddled Leaf-nosed Snake	*Phyllorhynchus browni*	1B	UNK	3	3	3	3	3	3	2	1

			Tier		Vulnerability Criteria Scores							
Taxonomic Group	Common Name	Scientific Name	2011	2005	Extirpated Status	Federal or State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Fragmentation Status	Distribution Status
Reptile	Slevin's Bunchgrass Lizard	*Sceloporus slevini*	1B	1B	3	3	2	1	2	3	3	1
Reptile	Sonora Mud Turtle	*Kinosternon sonoriense sonoriense*	1B	1C	3	3	0	3	1	3	1	2
Reptile	Sonoran Collared Lizard	*Crotaphytus nebrius*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Sonoran Coralsnake	*Micruroides euryxanthus*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Sonoran Shovel-nosed Snake	*Chionactis palarostris*	1B	1B	3	3	3	2	3	3	2	1
Reptile	Sonoran Whipsnake	*Masticophis bilineatus*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Thornscrub Hook-nosed Snake	*Gyalopion quadrangulare*	1B	1B	3	3	3	2	3	3	3	1
Reptile	Tiger Rattlesnake	*Crotalus tigris*	1B	NA	3	3	3	3	3	3	2	1
Reptile	Variable Sandsnake	*Chilomeniscus stramineus*	1B	NA	3	3	3	3	3	3	3	1
Reptile	Western Black Kingsnake	*Lampropeltis getula nigrita*	1B	1C	3	3	0	2	0	3	3	1
Reptile	Eastern Yellow-bellied Racer	*Coluber constrictor flaviventris*	1B	1C	3	3	0	1	0	3	0	3
Reptile	Yaqui Black-headed Snake	*Tantilla yaquia*	1B	1C	3	3	3	2	3	3	3	1
Reptile	Yellow Mud Turtle	*Kinosternon flavescens*	1B	1B	3	3	0	1	2	3	1	3
Reptile	Yuman Desert Fringe-toed Lizard	*Uma rufopunctata*	1B	1B	3	3	2	1	3	3	1	1
Reptile	Black-necked Gartersnake	*Thamnophis cyrtopsis*	1C	1C	3	3	3	3	0	3	2	3
Reptile	Chihuahuan Spotted Whiptail	*Aspidoscelis exsanguis*	1C	UNK	3	3	0	2	3	3	3	3
Reptile	Western Red-tailed Skink	*Plestiodon gilberti rubricaudata*	1C	UNK	3	3	0	0	0	3	3	3
Reptile	Western Shovel-nosed Snake	*Chionactis occipitalis*	1C	1C	3	3	0	3	3	3	2	3
Reptile	Western Skink	*Plestiodon skiltonianus*	1C	NA	3	3	3	2	0	3	3	3

Appendix F: Participating Agencies in the Public Meetings and Workshops

Animal Defense League of AZ	Natural Resources Conservation Service
Arena	Navajo County Public Works
Audubon AZ	Navajo Nation
AZ Dept of Agriculture	Noon Ranch
AZ Dept of Transportation	Northern Arizona University
AZ Desert Sheep Society	Northland Research
AZ State Forestry Division	Pima County
Pinal County	Pinal County Open Space
AZ State University	Pyeatt Ranch
AZ Wilderness Coalition	R&W Farming
AZ Wildlife Federation	ReSEED Advisors
Bureau of Land Management	Rocky Mountain Elk Foundation
Center for Biological Diversity	Salt River Pima-Maricopa Indian Community
City of Glendale	Salt River Project
City of Goodyear	Sierra Club
City of Peoria	Sky Island Alliance
City of Tucson	Terraforma Planning & Design
Cochise County	The Nature Conservancy
Coconino County	Tohono O'odham Nation
Coconino Natural Resource Conservation District	Town of Oro Valley
Colorado River Indian Tribes	Town of Marana
Defenders of Wildlife	Tucson Electric and Power
El Paso Gas Inc	University of Arizona
EN3 Professionals	UniSource Energy Corporation
Enviro Systems Management	UNS Gas, Inc.
Environmental Planning Group	US Army Fort Huachuca
Federal Highway Administration	US Army Garrison
Fennemore Craig	US Department of Agriculture
Grand Canyon Wildlands Council	US Fish and Wildlife Service
Hopi Tribe	US Forest Service
Kingman Daily Miner	US Marine Corps Yuma Air Station
Life in the Forest	White Mountain Apache Tribe
Logan Simpson Design Inc	Wild at Heart
Maricopa County	Yuma County
National Park Service	

Appendix G: Planning Documents

The following documents in the Department's documents database are filed according to the Document ID numbers preceding each citation.

21 Minckley, WL and DK Duncan. 1998. Environmental Assessment and Habitat Conservation Plan for El Coronado Ranch. US Fish and Wildlife Service. Phoenix, Arizona. 39 pp.

26 Sorensen, JA and CB Nelson. 2002. Interim Conservation Plan for *Oxyloma* (*haydeni*) *kanabensis* complex and related ambersnails in Arizona and Utah. Arizona Game and Fish Department. Phoenix, Arizona. 43 pp.

27 US Fish and Wildlife Service (USFWS). 1995. Kanab ambersnail (*Oxyloma haydeni kanabensis*) recovery plan. US Fish and Wildlife Service. Denver, Colorado. 21 pp.

28 Arizona Game and Fish Department and US Fish and Wildlife Service. 2008. Conservation Agreement for the San Xavier Talussnail (*Sonorella eremita*). US Fish and Wildlife Service. Albuquerque, New Mexico. 17 pp.

29 Arizona Game and Fish Department. 2002. Conservation Assessment and Strategy Wet Canyon Talussnail (*Sonorella macrophallus*). US Forest Service, Coronado National Forest. Safford Ranger District, Arizona. 31 pp.

31 US Fish and Wildlife Service (USFWS). 1994. Yaqui Fishes Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 48 pp.

32 US Fish and Wildlife Service (USFWS). 2002. Bonytail (*Gila elegans*) Recovery Goals: amendment and supplement to the Bonytail Chub Recovery Plan. US Fish and Wildlife Service, Mountain-Prairie Region (6). Denver, Colorado. 54 pp.

33 US Fish and Wildlife Service (USFWS). 2002. Colorado pikeminnow (*Ptycholcheilus incius*) Recovery Goals: amendment and supplement to the Colorado Squawfish Recovery Plan. US Fish and Wildlife Service, Mountain-Prairie Region (6). Denver, Colorado. 53 pp.

34 Marsh, PC and DW Sada. 1993. Desert Pupfish (*Cyprinodon macularius*) Recovery Plan. US Fish and Wildlife Service. Phoenix, Arizona. 67 pp.

35 Weedman, DA. 1999. Gila Topminnow (*Poeciliopsis occidentalis occidentalis*) Revised Recovery Plan. U.S. Fish and Wildlife Service. Albuquerque, New Mexico. 58 pp.

36 US Fish and Wildlife Service (USFWS). 2003. Gila Trout Recovery Plan (3rd revision). US Fish and Wildlife Service. Albuquerque, New Mexico. 78 pp.

41 US Fish and Wildlife Service (USFWS). 2002. Humpback chub (*Gila cypha*) Recovery Goals: amendment and supplement to the Humpback Chub Recovery Plan. US Fish and Wildlife Service, Mountain-Prairie Region (6). Denver, Colorado. 71 pp.

42 US Fish and Wildlife Service (USFWS). 1998. Little Colorado River spinedace (*Lepidomeda vittata*) Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 51 pp.

43 US Fish and Wildlife Service (USFWS). 1990. Loach Minnow Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 38 pp.

44 US Fish and Wildlife Service (USFWS). 2002. Razorback sucker (*Xyrauchen texanus*) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. US Fish and Wildlife Service, Mountain-Prairie Region (6). Denver, Colorado. 78 pp.

45 US Fish and Wildlife Service (USFWS). 1992. Recovery Plan for Sonora Chub (*Gila ditaenia*). US Fish and Wildlife Service, Region 2. Albuquerque, New Mexico. 50 pp.

46 US Fish and Wildlife Service (USFWS). 1990. Spikedace Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 38 pp.

47 US Fish and Wildlife Service (USFWS). 1994. Virgin River Fishes Recovery Plan. US Fish and Wildlife Service. Salt Lake City, Utah. 45 pp.

48 Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. Flat-tailed Horned Lizard Interagency Coordinating Committee. 78 pp.

49 Murray, RC and V Dickinson (editors). 1996. Management plan for the Sonoran Desert population of the desert tortoise in Arizona. Arizona Interagency Desert Tortoise Team. 55 pp.

51 US Fish and Wildlife Service. 1985. New Mexico Ridgenose Rattlesnake Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 59 pp.

53 US Fish and Wildlife Service. 2002. Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) Recovery Plan. US Fish and Wildlife Service. Phoenix, Arizona. 67 pp.

54 Hinman, KE and TK Snow (editors). 2003. Arizona Bat Conservation Strategic Plan. Arizona Game and Fish Department. Phoenix, Arizona. 182 pp.

55 Johnson, TB and WE Van Pelt. 1997. Conservation assessment and strategy for the jaguar in Arizona and New Mexico. Arizona Game and Fish Department. Phoenix, Arizona. 24 pp.

56 Pierson, ED, MC Wackenhut, JS Altenbach, P Bradley, P Call, DL Genter, CE Harris, BL Keller, B Lengus, L Lewis, B Luce, KW Navo, JM Perkins, S Smith, and L Welch.. 1999. Species conservation assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii townsendii* & *Corynorhinus townsendii pallescens*). Idaho Conservation Effort, Idaho Department of Fish and Game. Boise, Idaho. 42 pp.

57 US Fish and Wildlife Service (USFWS). 1982. Mexican Wolf Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 103 pp.

58 US Fish and Wildlife Service (USFWS). 1988. Black-footed Ferret Recovery Plan. US Fish and Wildlife Service. Denver, Colorado. 154 pp.

59 US Fish and Wildlife Service (USFWS). 1990. Listed Cats of Texas and Arizona Recovery Plan (with emphasis on the Ocelot). US Fish and Wildlife Service. Albuquerque, New Mexico. 131 pp.

61 Arizona Game and Fish Department (AGFD), Bureau of Land Management (BLM), and California Department of Fish and Game. 1980. Topock North Habitat Management Plan. Bureau of Land Management. Yuma, Arizona. 37 pp.

62 Arizona Game and Fish Department (AGFD) and Bureau of Land Management (BLM). 1980. Silver Bell - Baboquivari Habitat Management Plan. Bureau of Land Management. Baboquivari, Arizona. 96 pp.

63 Bureau of Land Management (BLM) and Arizona Game and Fish Department (AGFD). 1983. The Virgin River-Pakoon Basin Habitat Management Plan. Bureau of Land Management. St. George, Utah. 240 pp.

70 US Fish and Wildlife Service (USFWS). 1993. Draft Lower Colorado River National Wildlife Refuges Comprehensive Management Plan and Environmental Assessment. US Fish and Wildlife Service. Albuquerque, New Mexico. 56 pp.

72 US Fish and Wildlife Service (USFWS). 2003. Buenos Aires National Wildlife Refuge Final Comprehensive Conservation Plan. US Fish and Wildlife Service. Sasabe, Arizona. 233 pp.

73 US Fish and Wildlife Service (USFWS). Cabeza Prieta National Wildlife Refuge Draft Comprehensive Conservation Plan, Wilderness Stewardship Plan and Environmental Impact Statement – DRAFT.

76 Salt River Project and the City of Phoenix. 2008. Horseshoe Lake and Bartlett Lake Habitat Conservation Plan. Salt River Project and the City of Phoenix.

78 Trousil, J. 2001. Integrated Natural Resources Management Plan and Environmental Assessment, US Army Intelligence Center and Fort Huachuca, Arizona 2001-2005 , Final Draft. US Army Intelligence Center and Fort Huachuca. Fort Huachuca, Arizona. 294 pp.

80 Arizona Game and Fish Department (AGFD), Region IV. 1997. Alamo Wildlife Area Alamo Lake State Park Joint Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 55 pp.

81 Arizona Game and Fish Department (AGFD), Region I. 1997. Allen Severson Memorial Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 17 pp.

82 Arizona Game and Fish Department (AGFD), Region I. 1997. Apache Trout Management Areas Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 15 pp.

83 Arizona Game and Fish Department (AGFD), Region V. 1997. Arivaca Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 11 pp.

84 Arizona Game and Fish Department (AGFD), Region VI. 1997. Arlington Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

85 Arizona Game and Fish Department (AGFD), Region VI. 1997. Base and Meridian Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 17 pp.

86 Arizona Game and Fish Department (AGFD), Region I. 1997. Bear Springs Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

87 Arizona Game and Fish Department (AGFD), Region I. 1997. Becker Lake Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 13 pp.

88 Arizona Game and Fish Department (AGFD), Region I. 1997. Black River Lands (PS and Fite ranches) Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

89 Arizona Game and Fish Department (AGFD), Region V. 1997. Bog Hole Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 18 pp.

90 Arizona Game and Fish Department (AGFD). 1997. Canyon Creek Hatchery Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

91 Arizona Game and Fish Department (AGFD), Region I. 1997. Chevelon Creek Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 15 pp.

92 Arizona Game and Fish Department (AGFD), Region I. 1997. Chevelon Ranches (Dye, Vincent, Duran, Tillman and Wolfe) Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

93 Arizona Game and Fish Department (AGFD), Region V. 1997. Cluff Ranch Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 20 pp.

94 Arizona Game and Fish Department (AGFD), Region III. 1997. Colorado River Nature Center Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 11 pp.

95 Arizona Game and Fish Department (AGFD), Region I. 1997. Concho Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

96 Arizona Game and Fish Department (AGFD), Region VI. 1997. Cunningham Tracts Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 8 pp.

97 Arizona Game and Fish Department (AGFD), Region I. 1997. Fool Hollow Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 11 pp.

98 Arizona Game and Fish Department (AGFD), Region VI. 1997. Gila River Lands (PLO 1015, Green, GSA Properties) Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 11 pp.

99 Arizona Game and Fish Department (AGFD), Region I. 1999. Grasslands Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 19 pp.

100 Arizona Game and Fish Department (AGFD), Region II. 1997. House Rock Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 24 pp.

101 Arizona Game and Fish Department (AGFD), Region I. 1997. Jacques Marsh Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 1997 pp.

102 Arizona Game and Fish Department (AGFD), Region II. 1997. Lamar Haines Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 14 pp.

103 Arizona Game and Fish Department (AGFD), Region I. 1997. Luna Lake Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

104 Arizona Game and Fish Department (AGFD), Region V. 1997. Manhattan Claims Property Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 9 pp.

105 Arizona Game and Fish Department (AGFD), Region V. 1997. Wilcox Playa Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 15 pp.

106 Arizona Game and Fish Department (AGFD), Region V. 1997. Whitewater Draw Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 28 pp.

107 Arizona Game and Fish Department (AGFD), Region I. 1996. Wenima Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 22 pp.

108 Arizona Game and Fish Department (AGFD), Region III. 1997. Upper Verde River Property Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 13 pp.

109 Arizona Game and Fish Department (AGFD) Fisheries. 1997. Tonto Creek Hatchery Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

110 Arizona Game and Fish Department (AGFD), Region V. 1997. Three-Bar Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 8 pp.

111 Arizona Game and Fish Department (AGFD), Region IV. 1997. Texas Hill Property Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 9 pp.

112 Arizona Game and Fish Department (AGFD), Region II. 1997. Sunflower Flat Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

113 Arizona Game and Fish Department (AGFD) Fisheries. 1997. Sterling Springs Hatchery Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 9 pp.

114 Arizona Game and Fish Department (AGFD), Region I. 1997. Springerville Marsh Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

115 Arizona Game and Fish Department (AGFD), Region I. 1997. Sipes White Mountain Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 29 pp.

116 Arizona Game and Fish Department (AGFD) Fisheries. 1997. Silver Creek Hatchery Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

117 Arizona Game and Fish Department (AGFD), Region I. 1997. Show Low Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 8 pp.

118 Arizona Game and Fish Department (AGFD), Region VI. 1997. Santa Rosa Wash Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 7 pp.

119 Arizona Game and Fish Department (AGFD), Region II. 1997. Ryan Field Station Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 9 pp.

120 Arizona Game and Fish Department (AGFD), Region V. 1997. Roper Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 8 pp.

121 Arizona Game and Fish Department (AGFD), Region VI. 1997. Roosevelt Lake Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 6 pp.

122 Arizona Game and Fish Department (AGFD), Region VI. 1997. Robbins Butte Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 21 pp.

123 Arizona Game and Fish Department (AGFD), Region II. 1997. Raymond Ranch Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 6 pp.

124 Arizona Game and Fish Department, Region I. 1997. Rainbow Lake Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 9 pp.

125 Arizona Game and Fish Department (AGFD), Region IV. 1996. Quigley Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 26 pp.

126 Arizona Game and Fish Department (AGFD), Region V. 1997. Powers Butte Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

127 Arizona Game and Fish Department (AGFD), Region IV. 1997. Painted Rock Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 10 pp.

128 Arizona Game and Fish Department (AGFD) Fisheries. 1997. Page Springs Hatchery Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 12 pp.

129 Arizona Game and Fish Department (AGFD), Region III. 1997. Packard Ranch/Tavasci Marsh Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 14 pp.

131 Arizona Game and Fish Department (AGFD), Region IV. 1997. Nelsson Property Management Plan. Arizona Game and Fish Department. Phoenix Arizona. 6 pp.

132 Arizona Game and Fish Department (AGFD), Region IV. 1997. Mittry Lake Wildlife Area Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 37 pp.

133 Arizona Game and Fish Department (AGFD), Region V. 1997. May Memorial Wildlife Property Management Plan. Arizona Game and Fish Department. Tucson, Arizona. 11 pp.

134 Arizona Game and Fish Department (AGFD) and Bureau of Land Management (BLM). 1997. East Harcuvar Mountains Interdisciplinary Management Plan. Arizona Game and Fish Department. Phoenix. 53 pp.

135 Arizona Game and Fish Department (AGFD) and Bureau of Land Management (BLM). 1996. Black Mountain Ecosystem Management Plan and Environmental Assessment. US Dept of Interior, Bureau of Land Management. Kingman Resource Area, Kingman, Arizona. 150 pp.

136 Arizona Game and Fish Department (AGFD) Region II and Bureau of Land Management (BLM). 1994. Black Rock Habitat Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 102 pp.

137 Arizona Game and Fish Department (AGFD) Region IV and Bureau of Land Management (BLM). 1986. Buckskin Mountain/Cactus Plain Habitat Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 21 pp.

138 Arizona Game and Fish Department (AGFD) Region II. 1979. Clayhole Habitat Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 49 pp.

139 Arizona Game and Fish Department (AGFD) Region III. 1987. Hualapai Habitat Management Plan. Arizona Game and Fish Department. Kingman, Arizona. 147 pp.

140 Arizona Game and Fish Department (AGFD), Bureau of Land Management (BLM), US Fish and Wildlife Service (USFWS). 1996. Kofa National Wildlife Refuge and Wilderness and New Water Mountains Wilderness Interagency Management Plan and Environmental Assessment. US Department of Interior. Yuma, Arizona. 84 pp.

141 Arizona Game and Fish Department (AGFD) Region IV. 1987. Laguna-Martinez Habitat Management Plan. Arizona Game and Fish Department. Phoenix, Arizona. 50 pp.

142 Arizona Game and Fish Department (AGFD) Region IV and Bureau of Land Management

(BLM). 1981. Lake Havasu Habitat Management Plan. Arizona Game and Fish Department. Yuma, Arizona. 76 pp.

144 Bureau of Land Management (BLM), AGFD Region IV. 1980. Lower Gila South Habitat Management Plan. Bureau of Land Management. Yuma, Arizona. 66 pp.

145 Arizona Game and Fish Department (AGFD), Region V. 1981. Middle Gila Habitat Management Plan. Arizona Game and Fish Department. Tucson, AZ. 133 pp.

147 Bureau of Land Management (BLM), Tucson Field Office. 1998. Muleshoe Ecosystem Management Plan and Environmental Assessment. Bureau of Land Management. Tucson, Arizona. 206 pp.

148 Arizona Game and Fish Department (AGFD) Region IV and Bureau of Land Management (BLM) Yuma District. Palomas Plain Habitat Management Plan - DRAFT

158 Arizona Game and Fish Department (AGFD), Region III and Bureau of Land Management (BLM) AZ Strip District. 1982. Parashaunt Habitat Management Plan. Bureau of Land Management. Kingman, AZ. 155 pp.

159 US Fish and Wildlife Service. 1991. Hualapai Mexican Vole Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 28 pp.

160 US Fish and Wildlife Service (USFWS). 1993. Mount Graham Red Squirrel Recovery Plan. US Fish and Wildlife Service, Arizona Ecological Services State Office. Phoenix, Arizona. 172 pp.

161 US Fish and Wildlife Service (USFWS). 1995. Lesser Long-nosed Bat Recovery Plan. US Fish and Wildlife Service, Arizona Ecological Services State Office. Albuquerque, New Mexico. 449 pp.

162 US Fish and Wildlife Service (USFWS). 1998. Final Revised Sonoran Pronghorn Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 70 pp.

163 Van Pelt, WE. 1999. The Black-tailed Prairie Dog Conservation Assessment and Strategy. Arizona Game and Fish Department. Phoenix, Arizona. 55 pp.

164 US Fish and Wildlife Service (USFWS). 1998. Biological Opinion on the effects of construction and operation of various facilities in Kearny, Arizona on Southwestern Willow Flycatchers. US Fish and Wildlife Service. Albuquerque, New Mexico. 37 pp.

165 US Fish and Wildlife Service (USFWS). 2002. Southwestern Willow Flycatcher Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico.

167 Keddy-Hector, DP. 1990. Northern Aplomado Falcon Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 56 pp.

168 Klute, DS, LW Ayers, MT Greene, WH Howe, SL Jones, JA Shaffer, SR Sheffield, and TS Zimmerman. 2003. Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States. US Department of Interior, Fish and Wildlife Service. Washington, DC. 108 pp.

169 Latta, MJ, CJ Beardmore and TE Corman. 1999. Arizona Partners in Flight Bird Conservation Plan. Version 1.0. Arizona Game and Fish Department. Phoenix, Arizona. 331 pp.

170 US Fish and Wildlife Service (USFWS). 1996. California Condor Recovery Plan. US Fish and Wildlife Service. Portland, Oregon. 62 pp.

171 Johnson, TB and BA Garrison. 1996. California Condor Reintroduction Proposal for the Vermilion Cliffs, northern Arizona. Arizona Game and Fish Department. Phoenix, Arizona. 102 pp.

172 Arizona Condor Review Team. 2002. A review of the first five years of the California condor reintroduction program in northern Arizona. US Fish and Wildlife Service. Sacramento, California. 62 pp.

203 US Fish and Wildlife Service (USFWS). 2002. Southwestern Willow Flycatcher Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico.

204 US Fish and Wildlife Service (USFWS). 1995. Recovery plan for the Mexican spotted owl. US Fish and Wildlife Service. Albuquerque, New Mexico. 164 pp.

208 US Fish and Wildlife Service (USFWS). 2004. Final revised environmental assessment, management plan, and implementation guidance: Take of nestling American peregrine falcons in the contiguous United States and Alaska for use in falconry. US Fish and Wildlife Service. 68 pp.

209 US Fish and Wildlife Service (USFWS). 2003. Monitoring Plan for the American peregrine falcon, a species recovered under the Endangered Species Act. US Fish and Wildlife Service. Portland, Oregon. 53 pp.

210 US Fish and Wildlife Service (USFWS). 1983. Yuma Clapper Rail Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 51 pp.

211 Driscoll, JT, KV Jacobson, GL Beatty, JS Canaca, and JG Koloszar. 2006. Conservation assessment and strategy for the bald eagle in Arizona. Arizona Game and Fish Department. Phoenix, Arizona. 69 pp.

212 US Fish and Wildlife Service (USFWS) and US Forest Service (USFS). 2000. Potential Conservation Strategy for the Three Forks springsnail (*Pyrgulopsis trivialis*).

214 Arizona Game and Fish Department. 2009. Candidate Conservation Agreement with

Assurances for the Page Springsnail (*Pyrgulopsis morrisoni*). Arizona Game and Fish Department. 57 pp.

215 Hurt, C. and P. Hedrick. 2006. Conservation Genetics of Arizona Springsnails: Identifying Management Units and Regions of Endemism. Final Report for Arizona Game and Fish Department Heritage Grant Award I04005.

218 Relict Leopard Frog Conservation Team. 2005. Conservation Agreement and Rangewide Conservation Assessment and Strategy for the Relict Leopard Frog (*Rana onca*). Relict Leopard Frog Conservation Team. 164 pp.

219 Ramsey Canyon Leopard Frog Conservation Team. 2007. Ramsey Canyon Leopard Frog Conservation Agreement and Conservation Assessment and Strategy. Ramsey Canyon Leopard Frog Conservation Team. 99 pp.

222 Arizona Game and Fish Department (AGFD) and US Fish and Wildlife Service (USFWS). 2006. Safe Harbor Agreement for the Chiricahua Leopard Frog in Arizona between Arizona Game and Fish Department and U.S. Fish and Wildlife Service. Arizona Game and Fish Department and US Fish and Wildlife Service. 75 pp.

230 Arizona Trout Recovery Team. 1983. Arizona Trout (Apache Trout) Recovery Plan. US Fish and Wildlife Service (USFWS). Albuquerque, New Mexico. 25 pp.

231 Utah Department of Natural Resources, Division of Wildlife Resources. 2004. Range-wide Conservation Agreement for Roundtail Chub *Gila robusta*, Bluehead Sucker *Catostomus discobolus*, and Flannelmouth Sucker *Catostomus latipinnis*. Colorado River Fish and Wildlife Council. Salt Lake City, Utah. 14 pp.

234 Field, K.J, M.J. Sredl, R.C. Averill-Murray and T.B. Johnson. 2004. A Proposal to Re-establish Tarahumara Frogs (*Rana tarahumarae*) into Big Casa Blanca Canyon, Arizona. Arizona Game and Fish Department. Phoenix, Arizona. 67 pp.

235 Arizona Game and Fish Department. 2007. Safe Harbor Agreement for topminnows and pupfish in Arizona. Arizona Game and Fish Department. Phoenix, Arizona. 36 pp.

237 The Nature Conservancy, Arizona Chapter and Arizona Ecological Services Office, US Fish and Wildlife Service. 2005. Safe Harbor Agreement for Gila topminnow and desert pupfish on lands owned by The Nature Conservancy within the Aravaipa Creek watershed. US Fish and Wildlife Service. Phoenix, Arizona. 36 pp.

238 Arizona Game and Fish Department (AGFD). Statewide Small Mammal Conservation Plan – DRAFT.

239 Cantrell, C and T Hedricks. 2006. Arizona Statewide Conservation Agreement for roundtail chub, headwater chub, flannelmouth sucker, Little Colorado River sucker, bluehead sucker, and Zuni bluehead sucker. Arizona Game and Fish Department. Phoenix, Arizona. 78 pp.

240 Arizona Game and Fish Department (AGFD),US Fish and Wildlife Service (USFWS), and Bureau of Land Management. State Conservation Agreement and Strategy for the Sonoran Population of the Desert Tortoise - DRAFT

241 Arizona Game and Fish Department (AGFD), US Fish and Wildlife Service (USFWS), and National Park Service. Quitobaquito/ Rio Sonoyta Conservation Agreement and Strategy for the Sonoyta Mud Turtle, Sonoyta Pupfish, Quitobaquito Spring Snail, and Longfin Dace - DRAFT

246 U.S. Fish and Wildlife Service. 1990. Bonytail Chub Recovery Plan. US Fish and Wildlife Service. Denver, Colorado. 35 pp.

247 Utah Department of Natural Resources, Division of Wildlife Resources. 1995. Conservation Agreement and Strategy for Virgin Spinedace (*Lepidomeda mollispinis mollispinis*). US Fish and Wildlife Service. Denver, Colorado. 44 pp.

248 US Fish and Wildlife Service. 1990. Humpback Chub Recovery Plan. US Fish and Wildlife Service. Denver, Colorado. 43 pp.

249 US Fish and Wildlife Service. 1983. Gila and Yaqui Topminnow Recovery Plan. US Fish and Wildlife Service. Albuquerque, New Mexico. 56 pp.

250 US Fish and Wildlife Service. 1990. Colorado Squawfish Recovery Plan. US Fish and Wildlife Service. Denver, Colorado. 56 pp.

251 US Fish and Wildlife Service. 1998. Razorback sucker (*Xyrauchen texanus*) Recovery Plan. US Fish and Wildlife Service. Denver, Colorado. 81 pp.

253 O'Neill, DM. 2006. White-tailed prairie dog and Gunnison's prairie dog conservation strategy. Western Association of Fish and Wildlife Agencies. Laramie, Wyoming. 21 pp.

254 US Fish and Wildlife Service (USFWS). 1995. Masked Bobwhite Recovery Plan, second revision. US Fish and Wildlife Service. Albuquerque, NM. 86 pp.

256 U.S. Fish and Wildlife Service. 2006. Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan. U.S. Fish and Wildlife Service. Albuquerque, New Mexico. 149 pp.

259 Averill-Murray, R. C. (editor). 2000. Survey Protocol for Sonoran Desert Tortoise Monitoring Plots, reviewed and revised. Arizona Game and Fish Department. Phoenix, Arizona. 46 pp.

262 Arizona Condor Review Team. 2007. A review of the second five years of the California condor reintroduction program in the southwest. US Fish and Wildlife Service. Sacramento, California. 80 pp.

263 U.S. Fish and Wildlife Service. 2003. Monitoring plan for the American Peregrine Falcon,

A species recovered under the Endangered Species Act. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Pacific Region. Portland, OR. 54 pp.

264 Zylstra, E.R. and R.J. Steidl. 2009. Designing a framework for monitoring Sonoran desert tortoises (*Gopherus agassizii*) in Arizona. Final report to the Arizona Game and Fish Department. . Phoenix, Arizona. 65 pp.

265 Grandmaison, D.D.. 2010. Monitoring desert tortoise occupancy on the Arizona Army National Guard's Florence Military Reservation, Pinal County, Arizona. 20 pp.

266 Arizona Game and Fish Department. 2010. Ornate Box Turtle Watch. Arizona Game and Fish Department. http://www.azgfd.gov/w_c/boxturtlewatch.shtml

267 Western Association of Fish and Wildlife Agencies. 2007. Gunnison's prairie dog conservation plan: Addendum to the white-tailed and Gunnison's prairie dog conservation strategy. Western Association of Fish and Wildlife Agencies. Laramie, Wyoming. 39 pp.

268 Underwood, J.. 2007. Interagency Management Plan for Gunnison's Prairie Dogs in Arizona. Nongame and Endangered Wildlife Program. Arizona Game and Fish Department. Phoenix, Arizona. 83 pp.

269 U.S. Fish and Wildlife Service WNS Surveillance Working Group. White-nose syndrome national plan draft disease surveillance implementation plan - DRAFT

270 U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, New Mexico Department of Game and Fish, and Arizona Game and Fish Department. 2008. Gila River Basin Native Fishes Conservation Program, revised strategic plan 2008-2012. Arizona Game and Fish Department. Phoenix, az. 16 pp.

272 Bart J., T. Corman, L. Dunn, E. Juarez and A. Manning. 2010. Arizona Riparian Bird Surveys: Field Manual for Rapid Surveys. Arizona Bird Conservation Initiative. Arizona Coordinated Bird Monitoring Program

273 Frederick, Glenn. 2010. Scotia Canyon bullfrog eradication. Arizona Game and Fish Department Heritage Grant Proposal I10001.

274 USFWS. 1998. Implementing Agreement, El Coronado Ranch, West Turkey Creek, Cochise County, Arizona; Habitat Conservation Plan, to Establish a Program for the Conservation of Yaqui Chub, Yaqui Form of Longfin Dace, and Yaqui Catfish. 20 pp.