THE ARIZONA WILDLIFE CONSERVATION STRATEGY

A COMPREHENSIVE STRATEGY FOR CONSERVING ARIZONA'S WILDLIFE AND THEIR HABITATS | **2022-2032**







The Arizona Wildlife Conservation Strategy

(2022-2032)

FINAL

November 2022

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COVER PHOTOS

All photos by George Andrejko. (From upper left) black-footed ferret, cactus wren, greater western mastiff bat, cactus ferruginous pygmy-owl, lowland burrowing treefrog, Gila trout, Gila monster.

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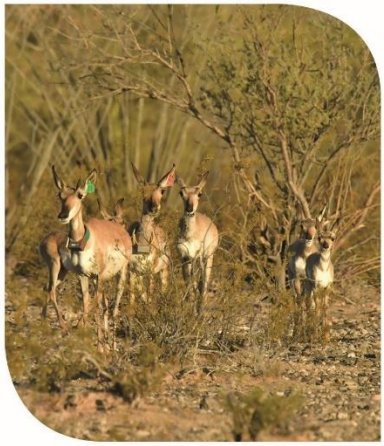



Golden eagle


Sonoran pronghorn


Huachuca woodlandsnail

AWCS Executive Summary

Welcome to the Arizona Wildlife Conservation Strategy (AWCS)! This marks an exciting new era in wildlife conservation in Arizona. By utilizing the AWCS and its many conservation tools and resources, we can work together to help conserve our precious wildlife and their habitats for generations to come.

The AWCS is Arizona's official State Wildlife Action Plan (SWAP). Mandated by the U.S. Congress under the State and Tribal Wildlife Grant Program, the AWCS fulfills the Department's obligation to create a 10-year strategy to conserve and protect our state's most vulnerable wildlife and their habitats. To that end, at the heart of the AWCS is our goal to "keep common species common." This plan takes a proactive approach to wildlife conservation, laying out clear and comprehensive conservation strategies to prevent population declines that could imperil species.

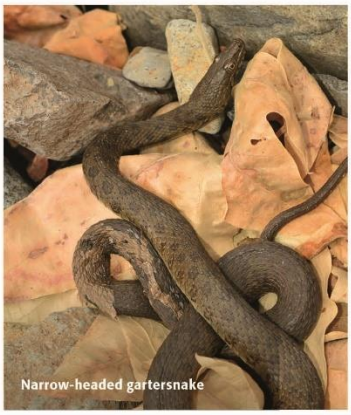
Our state is home to some of North America's most charismatic wildlife, from rare and federally-listed black-footed ferrets and California condors, to more common species like the Gila monster and American pronghorn. These species are found throughout Arizona's dramatic landscapes, from the sky islands and the Sonoran Desert of the south to the rolling grasslands and high peaks in the north. Residents and visitors alike come to Arizona for these resources, to enjoy the outdoors and—hopefully—get a glimpse of the wonderful wildlife that calls Arizona home.

Conserving these wildlife and their habitats for future generations takes work. It requires funding and other resources. It takes dedicated staff and partnerships. But first, it takes a plan. The AWCS provides that plan. The AWCS is the culmination of several years' work, dozens of staff expertise, and consultation with our many conservation partners, from federal and state agencies, non-government organizations, Native tribes, and concerned citizens alike. The AWCS reinforces the Department's commitment to and belief in the power of collaborative approaches to wildlife conservation.

The first couple of chapters of this document contain background information and introductory material, including a short introduction to the AWCS, a description of our revision process, and a road map to where the reader can find the **Eight Required Elements**.

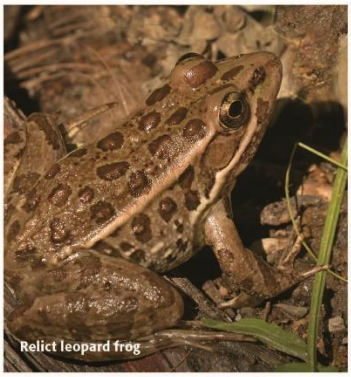
The next few chapters get into the heart of the AWCS and explore our comprehensive conservation plan. Chapter 1 covers Arizona's unique biodiversity (**Element 1**) and our process of updating a list of prioritized wildlife, known as Species of Greatest Conservation


Mount Graham red squirrel


Narrow-headed gartersnake


Gila trout


Humpback chub


Relict leopard frog


Sonora mud turtle

Need (SGCN). Chapter 2 provides detailed profiles on the seventeen key habitat types found throughout the state, and our regional collaborative efforts (**Element 2**). Chapter 3 describes the many challenges facing our species and habitats, from agriculture to climate change and from development to invasive species (**Element 3**). Chapter 4 then covers the many conservation actions that can be implemented to remedy, reduce, or eliminate threats to wildlife and their habitats (**Element 4**). In Chapter 5 you'll find details on how the Department updated the AWCS to meet the needs of Arizona over the next decade (**Element 6**). Chapter 6 describes our methods for public involvement and partner participation, two vital resources that helped shape the AWCS during its multi-year revision process (**Elements 7 and 8**). Finally Chapter 9 outlines an exhaustive collection of monitoring methods the Department uses to help monitor the effectiveness of our conservation actions (**Element 5**).

The AWCS is so much more than a conservation plan. It's a roadmap for wildlife conservation in Arizona. Unlike previous iterations of our SWAP, the AWCS will also be offered in a web-based version (**awcs.azgfd.com**). The result is an accessible and interactive statewide conservation strategy. Not only will the plan be offered, but several web-based conservation tools and data resources will be available to the public. The AWCS website includes updated species distribution models, a data warehouse, species profiles, a map of Conservation Opportunity Areas (COAs), and so much more. We hope the AWCS will greatly improve the public's knowledge and engagement with the Department's conservation efforts. On behalf of the Department, I invite all Arizonans to join us on this journey, to work together to help in the conservation of wildlife throughout Arizona.

Ty E. Gray
Director, Arizona Game and Fish Department

Foreword

The last iteration of Arizona's State Wildlife Action Plan (SWAP) was accepted by the U.S. Fish and Wildlife Service's National Acceptance Advisory Team in 2012. This document was the culmination of a multi-year effort during which the Arizona Game and Fish Department (AZGFD) 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 10 years.

A lot has changed in Arizona since the completion of our last SWAP more than a decade ago: Our state's human population continues to grow at a rate above average for the country. Metropolitan areas are expanding and suburban and exurban areas continue to outpace growth of our neighbors in the desert southwest. Demand for water continues to stress our landscape and wildlife, from the southern borderlands to the high-elevation habitats in northern Arizona. We have seen the emergence of new wildlife diseases and introduction of new invasive species. Some species have been newly listed under the Endangered Species Act (ESA) while others have been delisted. Development of renewable energy sources has created a drive to consider the impacts of such development on wildlife and habitats, while traditional non-renewables continue to make us seek innovative solutions to strike the delicate balance between economic growth and natural resource conservation. Above it all, the specter of climate change inches ever closer, threatening to permanently alter our natural landscapes and wildlife habitats that make Arizona so unique.

It is these threats, among many others, that have led AZGFD to develop a new comprehensive conservation strategy to address the myriad of challenges facing our state's wildlife and their habitats. **The Arizona Wildlife Conservation Strategy (AWCS)** is a new vision for wildlife conservation and a strategy that encourages all Arizonans to participate in helping to protect our most vulnerable species. The AWCS is Arizona's official SWAP for 2022 and, not only features a 10-year strategic plan, but for the first time, this comprehensive statewide conservation strategy will exist in a web-based platform, providing multiple on-line tools and data viewers, along with a comprehensive data management system — another first for our state. Perhaps most importantly, the AWCS will greatly increase public engagement with AZGFD's conservation work and long-term strategic plan (SWAP) and promote collaborative conservation efforts amongst all Arizonans.

The Arizona Wildlife Conservation Strategy (AWCS) is a new vision for wildlife conservation and a strategy that encourages all Arizonans to participate in helping to protect our most vulnerable species.

What is the Arizona Wildlife Conservation Strategy?

Developed by AZGFD, the AWCS is the blueprint for conserving Arizona's fish and wildlife resources. This multi-year initiative was developed with considerable input from resource professionals, federal and state agencies, Native American tribes, local governments, recreational groups, conservation organizations, and private citizens. The AWCS will guide conservation on the ground by fostering partnerships and promoting coordination of prioritized activities with readily available wildlife data.

The purpose of the AWCS is to:

- Collectively develop and implement priority actions that address the needs of vulnerable species and habitats.
- Identify areas on the landscape with the greatest potential for conserving and protecting the most species with the greatest need.
- Provide a combination of data, expert knowledge, and decision-support tools to guide strategic development and land management that minimizes negative impacts to wildlife and habitat.
- Expand our conservation community through engagement of government agencies, non-governmental organizations, tribes, industry, and citizens, with a common goal of preserving Arizona's natural heritage.

What makes the AWCS a comprehensive strategy?

In following our vision for a comprehensive conservation framework, the AWCS identifies actions benefitting diverse conservation targets, such as individual Species of Greatest Conservation Need (SGCN), specific habitats, entire taxonomic groups, or all of Arizona's wildlife. Expanding the scope to be inclusive of all of Arizona's wildlife opens the door to engagement with diverse interest groups and presents additional opportunities for landscape-scale conservation.

The first key component of the AWCS is a habitat-based conservation plan that is driven by data. This 10-year plan — also known as the SWAP — is a roadmap for the AWCS and an integral part of a comprehensive conservation strategy as it identifies current and potential challenges, sets conservation priorities, provides recommended actions, describes actionable goals to conserve our wildlife and habitats, and so much more. For the first time, specific geographic areas are identified on the landscape — called Conservation Opportunity Areas (COAs) — that reflect multiple conservation priorities to create an integrated framework for action that can be scaled up or down as conditions change. The result is an actionable plan that focuses conservation where it's needed most.

Species of Greatest Conservation Need (SGCN) are those species identified by AZGFD that are most in need of conservation actions. The AWCS focuses on more than 500 SGCN across Arizona.

The second key component of the AWCS is a sophisticated data management system and web-based tools and data viewers that supports conservation planning and informs land use decisions. These user-friendly data management systems and tools provide an innovative web-based platform for

enhanced collaboration, information sharing, and ultimately, a pathway forward in our collective conservation efforts.

Why is a statewide conservation strategy important?

With the multitude of global, regional, and local changes and challenges occurring in the environment and on the landscape, it is imperative that we embrace a strategy that brings awareness, science, and action together to drive how we manage the land, water, and wildlife in Arizona. The AWCS takes a proactive approach to conserve wildlife and natural areas before they become rare and more costly to protect. The AWCS identifies specific conservation efforts that preempts the need to list species under the ESA by "keeping common species common." The AWCS also addresses a wide variety of concerns — both on-going and potential — for wildlife and habitat conservation.

Today, we often focus on the economic value of wildlife resources. Although wildlife bring important economic benefits to Arizona, there are other equally important wildlife-related services that contribute to the enhanced quality of life for Arizonans: Exploring the wide-open spaces around us, a chance encounter with wildlife in their natural environment, and sharing these experiences with others are just a few of the benefits to our health and well-being. Taking actions today to protect these open spaces and the wildlife that we share them with will ensure that future generations can connect with the natural environment and experience the incredible beauty and diversity that exists in Arizona's wild places.

How can I use the AWCS?

The AWCS has been created for everyone. From the general public to government agencies to conservation groups, the AWCS is an essential resource for all Arizonans. By exploring the easy-to-use AWCS website, Arizonans can explore AZGFD's latest 10-year strategy for conserving wildlife and their habitats. Users of the AWCS can identify species and areas throughout the state where conservation actions are needed, and discover ways that individuals, organizations, and agencies can support, collaborate, and contribute to the protection and recovery of our vulnerable natural resources. For example, government agencies can reference the recommended actions and goals for each habitat type as they make decisions on appropriate use of the lands they manage; environmental groups and conservation organizations can use information on the conservation status of species and identify opportunities for partnership; and outdoor recreational groups can use the AWCS to guide their efforts to secure access in open spaces while minimizing impacts to areas occupied by vulnerable species.

What the AWCS does not do:

- Provide regulatory authority
- Impose additional limitations or rules on landowners or citizens
- Replace or supersede any management or implementation plans (although it may guide the development of such plans)

Those using the AWCS can also use the Conservation Analysis Tool (CAT), a powerful web-based data visualization and decisions-support tool. The CAT can be used during early planning phases of

development, allowing industry to strategically site facilities in areas that avoid sensitive natural resources while reducing the risk of regulatory issues at later project phases. The CAT can also help industries as well as conservation groups identify areas on the landscape with particularly high conservation value, where focusing conservation efforts would provide maximum benefit to all of Arizona's wildlife resources.

The use of the AWCS, including resources and tools described within, is completely voluntary and provides opportunities for all Arizonans to take action in the effort to preserve our natural heritage. By providing a comprehensive plan driven by data along with user-friendly tools, the AWCS is forging a new and exciting future for conservation in Arizona.

Introduction

Background of the AWCS

In 2001, a decade-long initiative involving a coalition of more than 3,000 conservation organizations from across the United States recognized the need for additional proactive wildlife conservation, culminating with the passage of federal legislation that established the State Wildlife Grant (SWG) program. Since the program was first implemented, SWG funds have been used to support conservation activities intended to "keep the common species common," thereby preventing species from declining to the point that they need protection under the ESA, and to assist in recovery of those species that were already listed. Under this program, SWG funds are used to conserve wildlife and their habitats, as well as related recreational and educational activities. In order to qualify for SWG funding, every state and territory is required to develop a state wildlife action plan (SWAP) that details the actions necessary to keep common species common. Our action plan — now known as the Arizona Wildlife Conservation Strategy (AWCS) — is the third iteration of Arizona's SWAP for conserving and protecting fish and wildlife resources.

In the subsequent years since the original SWAP was published, we have seen many successes, the development of some new challenges, and the creation of new opportunities as conditions throughout Arizona's landscapes continue to change. The population of the state has grown considerably, rising nearly 12% from an estimated 6.4 million in 2010 to nearly 7.2 million in 2020 (US Census Bureau 2020). To meet these changes, we continue to expand the scope and scale of the AWCS to address current issues and incorporate new data, and we expand the focus of the plan to a more inclusive strategy that seeks to conserve and protect all of Arizona's wildlife.

This integrated, data-driven approach allows us to protect and restore habitats across the landscape that benefit all species while attending to the needs of individual species where appropriate. This strategy allows us to produce the best outcomes while maximizing the conservation benefit of limited conservation dollars. As the AWCS guides our conservation work over the next decade, we will continue to engage and collaborate with the public, government agencies, non-governmental organizations, and all who hold a stake in maintaining healthy wildlife populations for generations of Arizonans to come.

Key Changes for the AWCS

Each iteration of a SWAP sees various updates to better reflect changing conditions to wildlife and their habitats, as well as the onset of new information and conservation methods. Today, the AWCS contains many key changes since the last action plan was published in 2012, and with these changes come improvements to our 10-year strategy. These changes include:

- Expanding the scope of the strategy to include all of Arizona's wildlife, while continuing to acknowledge that rare and vulnerable species require significant attention.

- Providing improved utility through a series of habitat profiles that identify the relationships between species and their environment; identifying threats to species and their habitats, and recommending specific actions to address or eliminate threats within each of the major habitat types.
- Encouraging all citizens to connect with the natural environment by identifying potential collaborative conservation efforts, creating a community with a deeper understanding of and appreciation for our shared natural resources.
- Aligning with agency long-term strategic vision, resource management plans, and targeted conservation plans to "keep common species common."
- Offering an enhanced website and decision-support tools so Arizonans can better engage with AZGFD's long-term conservation strategy and participate in collaborative conservation efforts throughout the state.

The AWCS includes a broad range of conservation targets that, while still maintaining appropriate emphasis on the conservation of uncommon or at-risk species, this new approach further recognizes the interconnectedness of species and their environment, the effects of threats on the larger landscape, and the value in working collectively toward common goals. The AWCS also provides resources and tools to effectively plan for and manage conservation programs targeting not only fish and wildlife species, but the diverse landscapes across Arizona.

The AWCS does not provide operational level direction, rather it serves as an overarching plan to guide the development of operations, implementation, and management plans. The agencies and organizations that participated in the development of the AWCS are responsible for or involved in different levels of conservation for which they have developed management plans that address specific conservation targets in greater detail. The AWCS does not in any way invalidate those plans or detract from partner efforts to manage their lands and resources effectively.

Striving to provide a platform for conservation, prioritization, and action, the AWCS focuses on building partnerships by identifying common goals and shared priorities. Our collective efforts will result in greater benefits for species and healthier ecological systems that function to support wildlife and provide diverse recreational opportunities for all citizens.

Funding for Conservation

Wildlife conservation in Arizona is funded through several different sources, and the work is accomplished by partnerships between government agencies and the conservation community. Much of this funding has traditionally come from hunting and fishing groups and funds administered by the U.S. Fish and Wildlife Service (USFWS). Some of these funding sources include:

The Pittman-Robertson Fund is made available to state wildlife agencies through the Federal Wildlife Restoration Act of 1937. The Act was established in response to concern over decreasing wildlife populations throughout the United States. Pittman-Robertson funds are generated through excise tax on firearms, ammunition, and archery equipment. The funds are distributed annually and

may be used for a variety of activities, including restoring bird and mammal populations and to acquire, develop, and manage wildlife habitat.

The Dingell-Johnson Fund was established in 1950 as part of the Sportfish Restoration Act. Funds are generated through an excise tax on fishing gear, equipment, and certain types of fuel. Funds are distributed to state wildlife agencies to be utilized for habitat acquisition and restoration, sportfish stocking, research, surveys, boating access facilities, and educational programs.

The Cooperative Endangered Species Conservation Fund (Section 6 of the ESA) is a tool that provides limited amounts of funding to states and territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program also provides funding to states and territories for species and habitat conservation actions on non-federal lands.

In Arizona, two funding sources have been indispensable in providing for conservation work targeting our state's at-risk species, including our SGCN:

- **The Heritage Fund** was created through the efforts of a broad coalition of Arizona citizens. It designates up to $10 million each year from lottery ticket sales that go to support the conservation and protection of the state's wildlife and natural areas. Heritage Fund dollars help us manage our rich wildlife diversity, including threatened and endangered species. The Heritage Fund is also used to help urban residents coexist with wildlife, to educate the public about the environment and wildlife conservation, and to create new opportunities and provide access for outdoor recreation, such as wildlife viewing. Over the years, Heritage funding has also conserved nearly 18,000 acres for public enjoyment and wildlife conservation and establishment of wildlife areas.
- **The State Wildlife Grants program (SWG)** was established in 2002 in response to the growing need for a source of wildlife conservation funding specifically targeting nongame species. An emphasis of the program is on identification and proactive management of at-risk species (those identified as SGCN) and preventing them from declining to the point that they need protection under the ESA.

In addition to the funding sources mentioned above, AZGFD has aggressively sought ways to augment these primary federal/state funds by pursuing other conservation-focused funding sources, such as those available through the Natural Resource Conservation Service (NRCS). Programs like the Environmental Quality Incentives Program (EQIP) can be leveraged, in partnership with an agricultural producer, to provide mutually-beneficial habitat improvements on the ground. Many of these grants, including Pittman-Robertson, Dingell-Johnson, and Section 6 ESA funding require non-federal matching funds typically at a 3:1 ratio. To acquire these matching funds, AZGFD works with our partners for "in-kind" match — such as volunteer work — that can be credited toward a project's overall value, or donations such as the Nongame Checkoff on state tax returns, a voluntary program which allows Arizona taxpayers to donate to wildlife conservation through their annual state tax return. Regardless of the matching source, all federal funding has specific eligibility requirements and must be pre-approved through an annual work plan.

Road Map to the Eight Required Elements

To qualify for SWG funds and to ensure they are allocated to appropriate conservation targets, a current SWAP must address the following eight elements:

1. **Species distribution and abundance** including low and declining populations that are indicative of the diversity and health of the state's wildlife.
2. **Habitat locations and conditions** essential to the conservation of species identified in Element 1.
3. **Threats to species and habitat** and priority research and survey efforts needed to identify factors which may assist in restoration and conservation.
4. **Actions to conserve species and habitat** including priorities for implementation.
5. **Plan for monitoring effectiveness of actions** facilitating adaptive management approaches.
6. **Procedures for updating the plan** to maintain current, useful information ensuring effective response to changing conditions.
7. **Partner involvement** throughout review and revision of the SWAP as well as implementation.
8. **Public participation** to increase awareness and support for conservation needs and to encourage involvement in implementation of the SWAP.

These eight required elements ensure a certain degree of consistency across SWAPs, allowing for multi-state and regional conservation efforts while fostering effective conservation actions to be assessed at a broader scale.

While enforcing consistency, the eight required elements still provide significant flexibility for each state to tailor their SWAP to their unique situations and incorporate innovative conservation approaches, making it an effective strategy from which to tier operational and implementation plans. Here in Arizona, the AWCS not only satisfies the requirements for participation in the State Wildlife Grants Program, it also provides a foundation for the conservation of all of Arizona's fish and wildlife species. In addressing the eight required elements for every SWAP, the following key changes were made and included in the AWCS:

Element 1. Information on Species Distribution and Abundance

The SGCN vulnerability criteria were refined by combining categories within criteria to make the assessment a more straightforward, repeatable process. Also, the fragmentation status criterion was removed because we decided it would be better addressed as a threat in Chapter 3: Conservation Challenges. The resulting SGCN list was further prioritized according to tiers of vulnerability that reflect AZGFD's management commitments using the same system established in the previous SWAP. These tiers are now Tier 1, 2, and 3 rather than Tier 1A, 1B, and 1C. However, the criteria for placing a species in each of the tiers remains largely the same with the exception of a few changes to Tier 1. Methods for assigning tiers are detailed in Chapter 1: Arizona's Biodiversity. The full SGCN

list, along with the vulnerability criteria scores can be found in Appendix D: Species of Greatest Conservation Need with Vulnerability Scores.

Changes to the SGCN Tier 1 include the following:

- Candidate species under ESA were removed
- Coverage under the Bald/Golden Eagle Protection Act was added
- Coverage under a Conservation Strategy and Assessment or a Strategic Conservation Plan was added

We also focused on the availability and quality of habitat suitability models for SGCN. Species experts at AZGFD conducted an analysis of current SGCN models and prioritized modeling needs for the AWCS. The SGCN that either did not have a model or had a model that was determined to need improvements were given high priority, whereas the species that already had models which reasonably described the potential distribution were given lower priority. To model all SGCN, AZGFD contracted with the Research Foundation for the State University of New York (SUNY) to focus exclusively on developing robust habitat suitability models in coordination with AZGFD staff.

Element 2. Descriptions of Habitat Locations and Conditions

We also reassessed and revised our approach to habitat conservation and management. Arizona is a large, topographically, and physiographically complex state with a wide variety of land uses, ranging from heavily-protected natural areas to highly-developed urban areas. Wildlife occurs in every habitat type in the state and wildlife species often rely on variability within and among habitats to survive. Therefore, although we recognize the need to establish conservation priorities, we identified all habitat types as inherently valuable to the natural heritage of Arizona and worthy of conservation actions. Chapter 7: Habitat Profiles details the various habitats found throughout the state and provides important information on habitat conditions, SGCN species, primary threats to the habitat, potential partners, and more.

Our method for prioritizing areas within each habitat type included identification of specific Conservation Opportunity Areas (COAs). Detailed profiles for each COA — including information such as a habitat description, SGCN species that occur in the COA, and conservation actions — are found in Appendix G: Aquatic Conservation Opportunity Areas and Appendix H: Terrestrial Conservation Opportunity Areas.

Conservation Opportunity Areas (COAs) are part of the landscape where conservation efforts can have significant benefits to SGCN wildlife. Research, data, and expertise identified the many COAs described throughout the AWCS.

The Brown and Lowe (1982, 1990) biotic communities classification system, which was used for the first and second iterations of Arizona's SWAP, remains the system of choice as it provides the optimal planning unit for associating areas on the landscape with conservation strategies.

Element 3. Descriptions of Threats to Species and Habitat

Rather than describing an exhaustive list of threats with relative levels of importance, as was done with Arizona's previous SWAP, the AWCS now emphasizes threats in the context of species and their habitats. We reassessed threats and consolidated the list into two major threat categories according to the World Conservation Union-Conservation Measures Partnership (Salafsky et al. 2008) classification of direct threats to biodiversity. Using a standard system for categorizing threats not only facilitates regional and multi-state coordination by providing a consistent nomenclature, but also allows us to link conservation strategies to threats, and identify conservation actions to be taken to counter the effects or minimize impacts. Threats to species are detailed in Chapter 3: Conservation Challenges. Later, threats to Arizona's major habitat types are detailed and presented along with conservation actions to remedy these threats in Chapter 8: Threats and Conservation Actions.

Element 4. Descriptions of Actions to Conserve Species and Habitats

The AWCS also includes a revised approach to identifying specific actions that benefit wildlife and their habitats. Rather than listing all possible actions, we now describe seven broad conservation action categories that have proven successful in conserving and protecting wildlife and their habitats in Arizona. These seven categories have been adapted from Salafsky et al. (2008) and are described in detail in Chapter 4: A Comprehensive Conservation Approach. These categories encompass the more detailed activities that have been, and will continue to be, conducted as part of conservation and recovery efforts.

These conservation action categories play an important role in Chapter 8: Threats and Conservation Actions. In this chapter, the AWCS describes specific threats facing each habitat type as well as conservation actions that will address one or more of the primary threats. By addressing these key challenges and tying actions to conservation targets, this approach makes the AWCS an actionable plan for conserving and protecting Arizona's fish and wildlife resources.

Finally, the COA profiles found in Appendix G: Aquatic Conservation Opportunity Areas and Appendix H: Terrestrial Conservation Opportunity Areas detail specific, actionable conservation efforts within each habitat type.

Element 5. Plan for Monitoring Species and Their Habitats

Species and habitat monitoring is a cornerstone of meeting conservation goals. Tracking trends in species and habitats, measuring the effectiveness of conservation actions, and adapting management activities to address any changes are integral parts of the AWCS. Most of the highest-priority SGCN found in Arizona are currently monitored by AZGFD staff and our partners via rigorous monitoring plans. These monitoring plans may be implemented at different scales, including multi-species, single species, and habitat evaluations. Chapter 9: Monitoring details the various monitoring plans AZGFD currently uses for monitoring species and their habitats.

Element 6. Procedures for Updating this Plan

The AWCS is a living document and set of tools. Likewise, an important part of wildlife conservation is adaptive management, or the ability to alter management plans as situations change. A lot can

happen over the next 10 years: Environmental regimes change, new threats such as disease might arise, new information may be obtained, and many other unforeseen problems may affect wildlife and their habitats. The AWCS is a web-based, interactive plan which will allow for updates, edits, and changes as they present themselves. This new web-based presentation means the AWCS will always be up-to-date with the latest information to help inform conservation efforts over the next 10 years. Chapter 5: Keeping the AWCS Current details our approach to updating our plans over the next decade.

Element 7. Partner Involvement

Improved coordination and engagement with partners were two of the main goals for the AWCS. To that end, we partnered with Creative Strategic Resources, an Oregon-based company that specializes in outreach, communication, and strategic planning to develop a comprehensive engagement strategy. The strategy included an online survey, internal messaging to ensure staff were well-informed of the revisions, and ways they could support the outreach effort. Other elements of this strategy included creation of a list of key AWCS talking points to ensure consistent messaging to stakeholders, and engaging partners in a series of small focus group discussions to identify stakeholder values, address concerns, and develop collective goals and priority actions based on mutual interests. Chapter 6: Conservation Partnerships details our extensive efforts to gain input from our many partners and collaborators around the state.

Six focus groups were hosted in November of 2020, including federal agencies (24 participants), tribes (3 participants), local governments (10 participants), nonprofit organizations (4 participants), academia (7 participants), and industry (4 participants). Focus group participants were asked about what most concerns them about native fish and wildlife and their habitats, what has changed in the past decade that could affect how AZGFD plans for wildlife and their habitats, priority issues that should be addressed in the AWCS, what tools could be used to better integrate information relative to planning, and what goals AZGFD should set to achieve mutual outcomes. An additional focus group between AZGFD and USFWS Ecological Services Field Offices (ESFO) occurred in January of 2021. Attendees described their priorities for Arizona fish and wildlife and their habitats during the next decade and discussed ideas for building continuity of collaboration among ESFO and AZGFD staff.

In April of 2021, AZGFD hosted three additional focus groups to share what AZGFD staff learned from previous focus groups and how it was implementing and addressing the input the agency received. Federal agencies participated in a focus group on April 9 (20 attendees plus 10 AZGFD staff). The tribes and one Federal agency representative participated in a focus group on April 12 (4 attendees plus 10 AZGFD staff). Non-governmental organizations, local governments, academia, and industry participated in a focus group on April 13 (30 attendees plus 9 AZGFD staff). During each of these focus group sessions, Department staff shared recommendations from the November 2020 focus group

discussions they will be implementing, tasks they are currently implementing, and tasks they will be partially or not fully implementing.

Roadmap to the Eight Required Elements

Element	Page Number
1. Species Distribution and Abundance	Pages 9-17
2. Habitat Locations and Conditions	Pages 18-25; 104-206
3. Threats to Species and Habitat	Pages 26-70; 207-272
4. Actions to Conserve Species and Habitat	Pages 71-87; 207-272
5. Plan for Monitoring Effectiveness of Actions	Pages 273-280
6. Procedures for Updating this Plan	Pages 88-93
7. Partner Involvement	Pages 94-103
8. Public Participation	Pages 94-103

Element 8. Public Participation

The AWCS was developed with considerable input from resource professionals, federal and state agencies, Native American tribes, local governments, recreational groups, conservation organizations, academia, and private citizens. Outreach to inform development of the AWCS included a public survey in 2020, followed by a series of focus groups in November of 2020, January of 2021, and April of 2021. We conducted additional public meetings in September 2021 to gain input on the AWCS. All outreach was conducted remotely as a result of the COVID-19 pandemic. On-line surveys and outreach video conferences were announced via the AZGFD website, press releases, E-news subscription updates, and social networking notices.

A total of 2,345 people participated in the survey to describe their familiarity with the 2012 SWAP. Other information gleaned from the survey included the frequency with which they use information/maps from the SWAP, their opinion on the effectiveness of AZGFD in protecting wildlife and their habitat over the last decade, the top 10 threats to Arizona fish and wildlife and their habitats, the importance of activities to address key stressors to Arizona fish and wildlife and their habitats, and changes they would like to see in the 2022 SWAP update.

Additional public forums were conducted in September 2021 where AZGFD staff presented the AWCS to the public. These presentations included the vision and goals of the AWCS, introduction to the AWCS functionality and tools, and the integration of recommendations and comments from the public review process and stakeholder engagement. Detailed summaries of our partner involvement and public participation — and how we incorporated changes into the AWCS as a result of these productive meetings — can be found in Chapter 6: Conservation Partnerships.

Chapter 1: Arizona's Biodiversity

Thanks to a variety of habitats across the state, Arizona is one of the most biologically diverse states in the nation, ranking third in the number of native bird species, second for reptiles, fifth for mammals, and eighth for overall vertebrate diversity (Stein 2002). In total, Arizona is home to more than 800 native fish and wildlife species, the highest biodiversity of any inland state. As the agency charged with managing all of Arizona's wildlife, AZGFD also manages several species of non-native sportfish and game birds, providing exceptional recreational opportunities for hunters and anglers. These non-native species are managed in balance with native wildlife.

Species of Greatest Conservation Need (SGCN)

To qualify for funding under the State and Tribal Wildlife Grants Program (STWG), each state is directed to develop and implement actions which benefit those species identified as most in need of conservation in an effort to preclude them from the listing under the ESA (TWW 2003). These species are identified as Species of Greatest Conservation Need (SGCN), and represent those wildlife species identified by AZGFD that are most in need of conservation actions.

To better guide conservation efforts, a vulnerability assessment was first completed for all species over which AZGFD has statutory authority as defined in Arizona Revised Statutes Title 17. The complete list of these species can be found in Appendix C: Master Species List. The list of species determined to be "vulnerable" is available in Appendix D: Species of Greatest Conservation Need with Vulnerability Scores. This species list also reflects the taxonomic level at which AZGFD manages fish

Arizona is home to nearly 4,000 species of native plants, several thousand species of pollinating insects, and more than 200 species of native crustaceans and mollusks. Though AZGFD does not have statutory authority over plant and insect species, we recognize the crucial role these taxa play in the ecosystems and wildlife communities of the state. Several resources are available to explore the conservation status and needs of Arizona's native plants and pollinators including:

SEINet/Symbiota Project: Compiled plant information from southwestern herbaria
Arizona Heritage Database Management System Species Lists: AZGFD webpage with links to species lists that includes information on global, federal lands, state, and ESA conservation status (where applicable)
National Bee Distribution Tool: An on-line map and data viewer developed by USFWS focused on bee species richness across the U.S.
Arizona Rare Plant Advisory Group Sensitive Plant List: In 2014, botanists from Arizona and the Southwest completed an assessment of native Arizona plants identifying relative level of conservation concern

and wildlife. For sensitive plant species, vulnerability was only assessed under Species Vulnerability Criterion 2: Federal or State Legal Status.

Sensitive plant species were defined as having at least one of the following ranks: Listed Endangered (LE) or Listed Threatened (LT) under the ESA; Highly Safeguarded (HS) or Salvage Restricted (SR) under the Arizona Native Plant Law (NPL); or G1 (Critically Imperiled) as assigned by NatureServe (NatureServe 2022). See Appendix E: Sensitive Plant Species of the AWCS for the full list of sensitive plant species and their legal status. These efforts help satisfy Element 1 of the Eight Required Elements by identifying SGCN species, ranking them according to vulnerability, and providing updated information on species distribution and abundance.

Updating Arizona's SGCN

In early 2020, a team of AZGFD species experts conducted a series of meetings to determine appropriate criteria for assessing species vulnerability. The 2012 SWAP criteria were used as a starting point (AZGFD 2012). The team determined that the criteria were still applicable and only minor refinements were made to remove unnecessary complexity and to provide more clarity in the criteria descriptions. The list of SGCN will be updated as additional data become available. The vulnerability criteria described below reflect those refinements and were used by AZGFD biologists to complete species evaluations.

Species were scored for each of the seven vulnerability criteria detailed below. If a species ranked as "vulnerable" (i.e., score = "1") under one or more of the seven vulnerability criteria, it was included in the SGCN list. Ranks were not additive.

Species were considered to have "unknown status" if there were insufficient data to determine the species' vulnerability under one or more of the criteria (i.e., if none of the seven criteria were scored as "1," but one or more of the seven categories scored "0"). The following details each of the seven vulnerability criteria:

SGCN were scored on the following seven criteria:

1. Extirpated Status
2. Federal or State Legal Status
3. Declining Status
4. Disjunct Status
5. Demographic Status
6. Concentration Status
7. Distribution Status

1. Extirpated Status

Species that historically occurred in Arizona, but are thought to no longer exist here, although populations continue to persist in other states or in México.

Score	Description
0	Insufficient data

1	Extirpated from Arizona
2	Does not meet the criteria described above

2. Federal or State Legal Status

The legal status of each species, subspecies or distinct population segment determines this criterion score. Vulnerable species include vertebrates, mollusks, crustaceans, or plants that are currently listed federally under the ESA as endangered or threatened, including those populations considered essential or nonessential experimental under section 10(j) of the ESA; recently delisted species that are undergoing post-delisting monitoring; species with a signed Candidate Conservation Agreement (CCA), Candidate Conservation Agreement with Assurances (CCAA), Conservation Strategy and Assessment or Strategic Conservation Plan; or 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. Vulnerable species also include plant species with federal status (Listed Endangered or Listed Threatened under the ESA), state status (Highly Safeguarded or Salvage Restricted under the Arizona Native Plant Law) or G1 (Critically Imperiled) as assigned by NatureServe.

Score	Description
1	Listed endangered or threatened -or- No open season in Arizona -or- Has a signed CCA, CCAA, Conservation Strategy and Assessment or Strategic Conservation Plan -or- Is covered under the Bald/Golden Eagle Protection Act
2	Does not meet the criteria described above

3. Declining Status

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 term is longer (up to a maximum of 100 years); see definition of "Global Short-Term Trend" (Master et al. 2012). The trend may be recent or current, and the trend may or may not be known to be continuing. Trends may be smooth, irregular, or sporadic. Fluctuations will not normally count as trends, but an observed change should not be considered as merely a fluctuation rather than a trend unless there is evidence for this. 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.

Score	Description
0	Insufficient data
1	Decline of > 30%
2	Does not meet the criteria described above

4. Disjunct Status

Vulnerable species are represented by populations that have been geographically separated from the main population and, thus, vulnerable to population 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 that occurs only in the White Mountains in Arizona, 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 not included. Peripheral populations (Arizona populations at the margins of the species distribution) are not considered vulnerable under this criterion.

Score	Description
0	Insufficient data
1	Disjunct population: one 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 one to few populations that are separated by relatively large distances from one another
2	Does not meet the criteria described above

5. Demographic Status

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

Score	Description
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	Does not meet the criteria described above

6. Concentration Status

Species that have a portion of their life history during 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, and breeding aggregations of some amphibians.

Score	Description
0	Insufficient data
1	Concentrating populations: found in a limited number of groups at high concentration for all, much, or a critical portion of their life cycle
2	Does not meet the criteria described above

7. Distribution Status

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 or Harris's hawk).

Score	Description
0	Insufficient data
1	> 70% of the global species' breeding range is within Arizona -or- > 90% of the United States segment of the species' breeding range is within Arizona
2	Does not meet the criteria described above

Assigning SGCN Tiers

During this scoring process, the team sought support and input from species experts from partner organizations before finalizing the new SGCN list. Following this initial vulnerability assessment scoring, the resulting SGCN list was further refined into three tiers as follows:

Tier 1: Deemed vulnerable (scored a "1") in at least one of the seven above categories AND matches at least one of the following:

- Federally listed as endangered or threatened under the ESA
- Recently removed from ESA and currently requires post-delisting monitoring
- Specifically covered under a signed conservation agreement CCA or a CCAA or a Conservation Strategy and Assessment or Strategic Conservation Plan
- Closed season species (i.e., no take permitted) as identified in Arizona Game and Fish Commission Orders 40, 41, 42 or 43

Tier 2: Deemed vulnerable (scored a "1") in at least one of the seven categories described, but matched none of the additional criteria for Tier 1.

Tier 3: Species with "unknown status" in at least one of the seven above categories but don't rise to a Tier 2. 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.

Table 1: *SGCN totals by taxonomic group and tier.*

Taxonomic Group	Tier 1	Tier 2	Tier 3	2022 Total
Amphibians	8	6	1	15
Birds	11	107	39	157
Fish	22	10	1	33
Invertebrates	27	42	139	208
Mammals	11	53	23	87
Reptiles	14	35	2	51
All Groups	**93**	**253**	**205**	**551**

See Appendix D: Species of Greatest Conservation Need with Vulnerability Scores for the complete list of SGCN with associated tier ranking (includes indicators of status changes from the previous assessment in 2012).

The SGCN list is used to develop conservation strategies to aid in prioritization of projects and activities and to develop recommendations for land management activities and development

projects that consider wildlife impacts. The SGCN list also plays a critical role in defining Conservation Opportunity Areas (COAs), a new element included in the AWCS that highlights specific areas on the landscape where conservation effort will be most beneficial for SGCN and other wildlife (see Chapter 4: Arizona's Conservation Approach).

Conservation for Common Species

Arizona's more common fish and wildlife species are equally important to SGCN, although they may not require the same level of targeted conservation efforts. These species, which include many of our game and sport fish as well as nongame species like the greater roadrunner, chuckwalla, and desert horned lizard, among many others, are recognized for their ecological value, social significance, and economic importance.

Common species play significant roles in the ecosystem and they must be managed in a manner that maintains healthy population levels and proper balance in the larger system. To meet our conservation goals, AZGFD has a variety of management plans for game species and sport fish, and biologists also monitor the overall status and health of many common nongame species. Many of the management practices that benefit game species and sport fish, such as habitat enhancement, are beneficial to native species as well.

AZGFD Game Management
Comprehensive game management planning aimed at protecting, restoring, and managing game populations and their habitats, maintaining the natural diversity of Arizona, and providing wildlife-oriented recreational opportunities.

AZGFD Fisheries Management
Watershed-based aquatic management planning approach that emphasizes interactions between sportfish and native aquatic wildlife.

It's also important to recognize that certain management techniques and practices for game species and sport fish can negatively-impact some native species. For example, stocked sportfish can displace, compete, hybridize with, and prey on native fishes. In response, AZGFD thoroughly evaluates potential impacts to native fish and wildlife populations prior to implementation of such actions and attempts to minimize negative impacts where and when possible. For instance, the portion of the Verde River between Clarkdale and Camp Verde has a sport fish recreation emphasis and a native fish conservation emphasis. To minimize impacts to native fishes, triploid rainbow trout (which are unable to reproduce) are stocked to prevent trout from establishing a population. Furthermore, trout tend to not survive the warm summers, and most are captured by anglers.

Species Distribution Modeling

Following the ranking of SGCN species, we created habitat suitability models for all Tier 1 and Tier 2 SGCN to represent the potential distribution for an individual species. Focus was given to SGCN species, however models for additional species may be developed and made available as time allows. While we attempted to establish a consistent modeling approach for most species, alternative

approaches were needed for some species. The quantity and quality of occurrence data, known distribution/range of a species, and availability of existing models created a scenario where different methods were optimal for different species. Prior to developing/updating models, AZGFD species experts completed a review of the current SGCN species distribution models developed over the past 10 years. The SGCN were prioritized based on availability and/or accuracy of existing models with the goal of modeling all Tier 1 and Tier 2 SGCN.

For most species, modeling methods included Random Forests (RF) and basic envelope niche models. For fish species, we used simple distribution maps that correspond with Watershed Management Plans (WMPs), which identify priority species for each management unit.

Random Forest is a commonly used machine learning ensemble method for estimating species distributions, and our preferred approach for species for which habitat had not yet been modeled and for those species whose habitat models needed improvement. In addition to being intuitive and performing well with a small set of known locations, a major advantage of using this approach is that the RF model script includes code to generate a comprehensive report capturing metadata and assessing the quality of key model components, providing a tool to identify model limitations and to indicate appropriate use. The result is a transparent process and reproducible model.

Where existing envelope niche models were deemed accurate by AZGFD species experts, these models were simply updated and metadata were recorded. Inputs for envelope niche models included the following base layers:

- **Vegetation Associations:** a modified version of USGS's SWReGAP land cover layer or, in certain cases, LANDFIRE National Vegetation Classification layer
- **Elevation and Slope Associations:** a 30m digital elevation model (DEM) for Arizona
- **Watershed Associations:** HUC boundaries at the 10-digit level created by the Natural Resources Conservation Service (NRCS)
- **Species Occurrence Data:** used to identify watersheds associations for individual SGCN species

Potential distributions for fish species are mapped using basic GIS processing (ArcGIS Pro v. 2.8.0) to relate species to streams, reaches, and water bodies in each management unit as established in AZGFD WMPs. These WMPs identify goals, desired outcomes, and priority species that are managed within each management unit. The WMPs represent a thorough evaluation and comprehensive management framework for ensuring conservation and protection of native fishes as well as abundant sportfishing opportunities in Arizona.

Filling the Data Gaps

Increasing our state's knowledge of wildlife resources and requirements will improve our ability to take appropriate actions to protect and conserve wildlife and their habitats for future generations. Continued focused research is needed to better understand fish and wildlife species responses to

conservation challenges including climate change. In addition, some data necessary to evaluate the vulnerability of the Tier 3 species are missing. Filling those data gaps will be a focus moving forward.

Currently, AZGFD is developing a Wildlife Data Warehouse (WDW), a centralized data repository for all of the wildlife data collected by AZGFD. The WDW will allow mining of data across projects and over time. Data will be pulled, in near real time, into a data viewer — the Conservation Analysis Tool (CAT) — allowing for spatial analyses to occur regularly, as appropriate, depending on the type of data and how it was collected. Changes on the landscape will be tracked through the CAT and can be used to reassess species' status as needed and adjust information regarding the Conservation Opportunity Areas (COAs). The web-based AWCS will allow AZGFD to update existing information on species, threats, and landscapes, as it becomes available, and to share those data publicly through the web AWCS website. See Appendix D: Species of Greatest Conservation Need with Vulnerability Scores for a full list of Tier 3 SGCN by taxonomic group.

Chapter 2:
Arizona's Extraordinary Landscapes

Arizona's approximately 73 million acres encompass a wide range of topographic features and climatic conditions which contribute to the diversity of ecosystems found throughout the state. Elevations range from about 75 feet above sea level (near Yuma) up to 12,643 feet at its highest point (San Francisco Peaks near Flagstaff). Generally, elevation across the state increases from west to east and from south to north.

Much of Arizona receives most of its precipitation during two seasons, the annual summer monsoon (July through September) and during the winter months, typically December through February, when storms carry moisture from the Pacific Ocean (Mock 1996). Annual precipitation ranges from less than three inches per year in the southwestern portion of the state to more than 40 inches at higher elevations in the White Mountains in east-central Arizona (Arizona State Climate Office 2021). Winter rain or snow represent the majority of precipitation in northern portions of the state, while precipitation occurs mostly in the form of summer rains in the southern portion. The Sonoran Desert, extending across the southwestern portion of Arizona, typically receives nearly equal amounts of summer and winter rain.

Variability in climates, elevations, landforms, vegetative communities, watercourses, and soil types creates many different environments throughout Arizona. These environments range from the hot, dry deserts of southern Arizona, through grasslands and woodlands in mid-elevations, to the cold and wet montane and subalpine forest environments in the higher elevations. In addition, isolated mountains throughout southeastern Arizona, known as "sky islands," 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. These aquatic systems cover only about 0.4% of Arizona's landscapes, but play an outsized role in providing water and other resources for our state's wildlife (Ffolliot et al 2004 and UA Cooperative Extension 2007). In addition to supporting Arizona's 34 species of native fish and 27 species of sport fish, aquatic and riparian communities provide foraging, nesting, shelter, and water for a large percentage of terrestrial wildlife species in Arizona. Migratory birds, bats, and pollinating insects also depend on these vital travel corridors for daily and seasonal movements as well as annual migrations between North and South America.

Several important rivers flow through Arizona, the largest being the Colorado River which runs through the Grand Canyon and forms the western boundary of Arizona with California. The Gila, Salt, and Verde rivers drain the northern-central portion of Arizona, and carry water to reservoirs that

support the cities in central and southern Arizona. The north-flowing San Pedro River in southern Arizona is one of the last remaining free-flowing rivers in the desert southwest. This river provides critical resources for a great diversity of migratory birds and other native wildlife (Stromberg and Tellman 2009). Many smaller creeks and tributaries have perennial or intermittent flow while springs, ciénegas (marshes), and stock tanks (livestock ponds) are scattered throughout Arizona, providing valuable habitat and water for wildlife use. These terrestrial and aquatic ecosystems that exist across the Arizona landscape support diverse fauna and flora and form the foundation for the AWCS habitat-based approach to conservation.

Defining Arizona's Key Habitat Types

Protecting and restoring key habitats, associated species assemblages, and the processes that maintain a natural balance within the larger system, requires collaboration among those that own and manage the land and those responsible for managing the resources on the landscape. Collectively developing conservation goals and priority actions for each major habitat type is key to achieving meaningful outcomes for wildlife. Continued coordination is also imperative to ensure emerging issues are addressed through proactive management compared with more costly and less effective reactive measures.

In Chapter 7: Habitat Profiles, the AWCS provides a series of detailed habitat profiles developed by AZGFD species and habitat experts. Each of these profiles benefited from extensive stakeholder review and input. The habitat profiles identify the unique characteristics of each habitat type and also address the key challenges (known as "threats") and conservation opportunities (known as "conservation actions") within Arizona's four major habitat groups, including desertscrub, grassland, woodland and forest, and aquatic systems.

The terrestrial habitat types are based on the biotic communities described by Brown and Lowe (1980, 1994; Figure 1). This mid-scale classification is useful for identifying priorities and developing conservation actions that can be effectively implemented at multiple scales and across jurisdictions. Thirteen unique terrestrial habitats are described in the profiles found in Chapter 7: Habitat Profiles. Meanwhile, aquatic and riparian habitats are described in four aquatic habitat types: lotic systems (rivers and streams), lentic systems (lakes and reservoirs), wetlands (ciénegas, ephemeral pools, and seeps), and springs.

Each habitat profile includes the following information:

- **Habitat Description** along with a map that briefly describes that habitat type and main characteristics, threats, and other features
- **Significant Habitat Features** describes any features or microhabitats that are particularly important to certain species within the habitat type
- **Key Conservation Species (SGCN)** which describes all of the SGCN species known to occur within the habitat type
- **Additional Influential Species** lists other non-SGCN that may play a critical role in the habitat system
- **Primary Threats** describes the main challenges facing this habitat type
- **Conservation Actions** details specific conservation measures that can be taken to address each of the threats to the habitat and SGCN
- **Conservation in the Context of Climate Change** focuses on specific threats to the habitat type brought on by changes to the climate
- **Conservation Opportunity Areas (COAs)** lists the specific areas where recommended conservation actions can take place on the landscape
- **Partnerships** identifies potential collaborators who may have interest, or are currently working with, that particular habitat type; these identified parties may also play a key role in conservation efforts at an identified COA
- **Important Conservation Resources** provides references to management and recovery plans and documents which provide specific actions and objectives related to species associated with the habitat type

While the habitat profiles identify key species whose vulnerabilities warrant active management, it may be appropriate to shift focus to different species as conditions and needs change, or to take advantage of opportunities targeting the full suite of SGCN, including those species for which information is lacking. The 3-tiered SGCN list (described in Chapter 1: Arizona's Biodiversity) provides the flexibility to efficiently address species needs as they arise while strategically prioritizing actions where they are needed most.

Chapter 8: Threats and Conservation Actions builds on the profiles described in the previous chapter to further address two of the eight required elements, including Element 3 (Threats to species and habitats) and Element 4 (Actions to conserve species and habitats). This chapter details the specific threats facing each of the habitats profiled using the standardized lexicon and first and secondary threat categories adapted from Salafsky et al. (2008). Conservation actions utilize the same standardized lexicon to identify specific actions that can be taken to reduce or eliminate the threats to each habitat type.

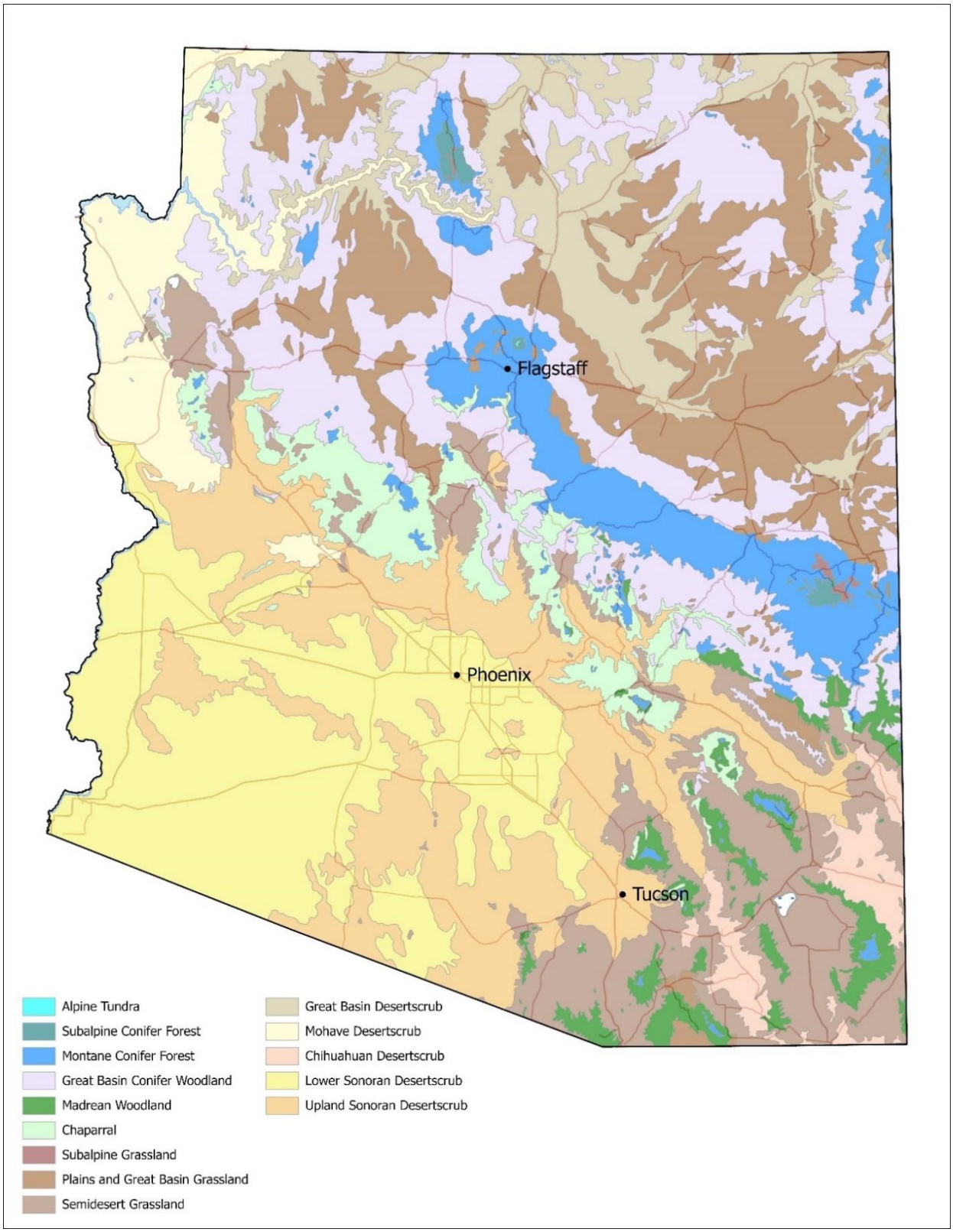


Figure 1: *Brown and Lowe's Biotic Communities of the Southwest, (1994) adapted to define habitat types for the AWCS.*

Regional and International Conservation Initiatives

Conservation of species and their habitats, of course, does not end at state or international borders. Foraging and breeding habitats, migratory corridors, and watersheds, are just a few of the resources that Arizona shares with its neighbors in New Mexico, California, Nevada, Utah, Colorado, and across the international border into Mexico. While the Brown and Lowe classification is well-known among agencies and organizations in Arizona, other regional classification systems may be more familiar to our neighboring states and partners in Mexico. To facilitate coordinated efforts at a broader scale and improve our ability to aggregate information at a regional level, the AWCS will also rely on two other widely-used datasets: Level III Ecoregions (Griffith et al. 2014) and Bird Conservation Regions (BCRs; Bird Studies Canada and NACBI 2014; Figure 2).

Ecoregions are areas where ecosystems are similar and possess common characteristics such as ecosystem quality and quantity of the environmental resource. This ecoregion framework is adapted from Omernik (1987) with mapping done in collaboration with EPA regional offices, other federal agencies, state resource management agencies, and neighboring North American countries. Level III Ecoregions are a 2013 revised version derived from a multi-agency collaboration between the USDA, EPA, USGS, TNC and several state agencies (Griffith et al. 2014). This ecological framework divides the landscape into regions with similarities in physical and biological characteristics including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.

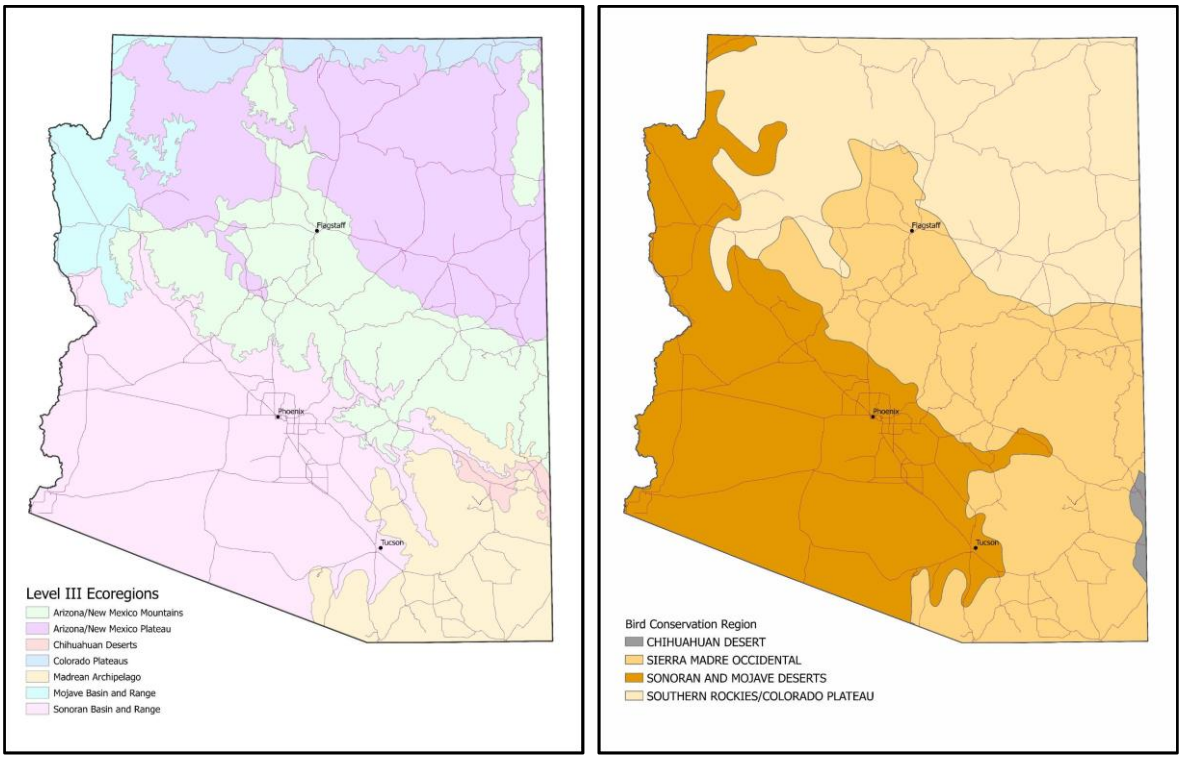


Figure 2: *The U.S. EPA's Level III Ecoregions (left) and Bird Conservation Regions used in the AWCS.*

The BCRs are similar to Level III Ecoregions in that they divide the landscape into areas with similar characteristics, however the BCRs divide North America into regions with similar bird communities, habitats, and resource management issues (NABCI 2020). This widely-used framework developed by the Commission for Environmental Cooperation (CEC) has become the standard for developing coordinated bird conservation initiatives and landscape level strategies and priorities across state, provincial, and international boundaries.

The finer-scale Southwest Regional Gap Analysis Project (SWReGAP) was also incorporated into the AWCS. These classifications are well known and are an easy way to crosswalk between the mid-scale Brown and Lowe biotic communities and local-scale ecological units used in AWCS habitat suitability modeling.

Regional Collaboration

In 2020, the Association of Fish and Wildlife Agencies (AFWA) published a report titled *President's Task Force on Shared Science and Landscape Conservation Priorities: Final Report* (Mawdsley et al 2020), which recognized that landscape scale, cross-jurisdictional collaborations are valuable for fish and wildlife agencies in order to achieve statutorily-required conservation of fish and wildlife and their habitats. The report also identifies that SWAPs are foundational documents for regional- and landscape-scale coordination toward conservation goals, including goals that scale beyond state or other jurisdictional boundaries. In line with this, the report recommends that "AFWA convene a diverse work group to assess and develop recommendations on how SWAPs can improve range-wide conservation of Species of Greatest Conservation Need (SGCN) and contribute to regional and/or national landscape conservation priorities."

To meet these goals identified in the AFWA report, AZGFD has partnered with our colleagues at the Nevada Department of Wildlife (NDOW) in an attempt to foster development and implementation of a cross-jurisdictional approach to conservation in the west. Through regular communications and data/information sharing, the two state wildlife agencies are working together as their respective SWAP revisions move forward. This cooperative approach ensures that each agency will meet the individual needs of their state while simultaneously considering needs that stretch beyond respective state boundaries.

Like all state wildlife agencies, AGFD and NDOW were required to develop SWAPs to secure federal State Wildlife Grant funding. The United States Fish and Wildlife Service (USFWS) is a critical partner in the process and is supporting the state effort. Several things are happening both within Nevada and Arizona, and within the national conversation on SWAPs, including:

- Consideration of supporting SGCN through additional technical expertise or new value-added mapping and modeling tools
- Fostering the implementation of long-term conservation actions through partnerships between regional USFWS and state wildlife agencies or regional associations

Through this important Arizona-Nevada collaboration, we are currently exploring how we might use additional technical expertise and new mapping or modeling tools to accomplish several goals:

1. Identify which species' ranges the two states share across boundaries and map where they may occur on the landscape.
2. Coordinate identification of threats and conservation actions for these species and their habitats.
3. Identify shared areas of conservation value or potential that could define transboundary Conservation Opportunity Areas (COA) that currently are not part of either state's SWAP.
4. Help address climate change effects at more regional scales that can in turn help us direct habitat restoration and protection efforts.

The on-going collaborative efforts between AZGFD and NDOW are in their initial stages at the time of this publishing. However, these discussions are already proving fruitful and have expanded to include our other neighboring states, including representatives from the California Department of Fish and Wildlife, Utah Division of Wildlife Resources, and New Mexico Department of Game and Fish. Since Arizona and Nevada will finalize their latest SWAP revisions in 2022 (the other states will be completed in 2025), AZGFD and NDOW are taking the lead in defining the parameters of this region-wide collaboration.

Initial efforts of the AZGFD-NDOW collaboration include:

- Define ecosystem/habitat classification at a regional scale using Ecoregions Level III from the EPA. Since each state appears to classify habitats slightly different in order to meet their own needs, using a more coarse-grained ecoregions classification system will provide us with a universal, regional-wide habitat classification system to better facilitate efforts between states.
- Identify the various SGCN that Arizona and Nevada share. Define threats and conservation actions facing these species according to standardized lexicon from Salafsky et al. (2008).
- Identify potential transboundary COAs in our shared landscape and potential collaborative efforts that we can implement as well as other valuable resources, such as potential partners and funding sources.

Western States Regional Decision Support Tool

The Critical Habitat Assessment Tool (CHAT) is a GIS-based decision support tool managed and maintained by the Western Association of Fish and Wildlife Agencies (WAFWA). The tool identifies important wildlife habitats and key wildlife corridors across the west and represents state-level priorities. Currently, AZGFD is collaborating with 14 other state fish and wildlife agencies to make up-to-date, regional level wildlife data available through the CHAT. The tool is designed to improve collaboration between state wildlife agencies, their partners, and the public. It is publicly accessible and appropriate for landscape-scale conservation planning and analysis. For more information and to access the CHAT, visit the Western Association of Fish and Wildlife Agencies website (www.wafwachat.org).

International Conservation

While AZGFD is responsible for conserving, enhancing and restoring Arizona's diverse wildlife resources and habitats for current and future generations, AZGFD also has a long-history of binational wildlife collaborations with partners in Mexico and Canada. These efforts started more than 30 years ago with activities associated with shared species of common conservation concern, such as certain native fish and the endangered Sonoran pronghorn. Since the mid-1990s, most international collaboration efforts have been coordinated by AZGFD's International and Borderlands Program. These successful binational collaborations have received important recognition and awards from state and federal agencies from both countries.

Over the last few years, our partnership with groups in Mexico, particularly with the State of Sonora, have achieved important goals for the management and conservation of wildlife and their habitats. Our successful collaborations with Mexico have allowed us to exchange wildlife genetic material and expand the knowledge of the natural history of species common to the border area. The information collected has assisted AZGFD and other state and federal agencies in the decision-making process and has helped develop an effective management program for those species that occur on both sides of the border. In addition to native fishes and Sonoran pronghorn, AZGFD has collaborated on the management and recovery of black-tailed prairie dog, Mexican wolf, lesser long-nosed bat, white-tailed deer, thick-billed parrot, masked bobwhite, cactus ferruginous pygmy owl, Gould's turkey, Sonoran desert tortoise, flat-tailed horned lizard, as well as waterfowl, shorebirds, and native frogs. In 2019, and in collaboration with Sonoran partner state agencies, we implemented a wildlife inventory project on private properties within Sonora's Sky Island region.

Since 1996, AZGFD's International and Borderlands Program has led an effort in wetland training and capacity building in Mexico with the assistance of wetland scientists and managers from the United States, Canada, and Mexico. Other training opportunities to Mexican partners provided by our program include: introduction to the use of camera-traps in wildlife monitoring, breeding bird surveys, zoonotic diseases, golden eagle monitoring, and white-tailed and mule deer management. In addition, AZGFD has actively participated in binational recovery teams, the AFWA's International Relations Committee, the Arizona-Mexico Commission, the Border Governors Conference, the North American Commission on Environmental Cooperation, Good Neighbor Environmental Program, Sonoran Joint Venture, Desert Landscape Conservation Cooperative, Convention on Biological Diversity, and the Canada/Mexico/U.S. Trilateral Committee for Wildlife and Ecosystem Conservation and Management.

Chapter 3: Conservation Challenges

Arizona's diverse climate patterns and geologic features contribute to the unique ecological regions and species assemblages found throughout the state. These landscapes include a host of environments, ranging from alpine tundra conditions found on the San Francisco Peaks where elevation exceeds 12,000 feet and precipitation averages up to 40 inches per year, to the Sonoran Desert where average rainfall can be as little as three inches a year and the lowest elevations are just above sea level. Between these extremes exist some of the most diverse habitats in North America which are home to an equally-diverse number of wildlife species.

Many of Arizona's biodiversity hotspots are inherently vulnerable due to their scarcity or limited extent or both. When additional stressors are placed on vulnerable species and natural communities from anthropogenic sources, the result can be devastating and long lasting. Throughout Arizona's history and even pre-history, humans have impacted the landscape. Human settlements have caused land conversion, and growing human populations continue to result in loss of wildlife habitat. While mining, agriculture, and timber harvest have been important industries in Arizona since the 1880s, even with modernized practices, these industries continue to present unique challenges to wildlife and the greater environment. More recent and growing industries, such as renewable energy, tourism, outdoor recreation, along with the depletion of groundwater and expansion of transportation and service corridors to meet the needs of our growing population, have exponentially increased stressors to Arizona's wildlife and their habitats.

Land use changes and modifications to natural disturbance regimes, such as natural fire regimes, are contributing to habitat loss, modification, and fragmentation, resulting in population declines of several native species. These changes are also leading to the introduction and expansion of non-native species that displace native species. In addition, we are just beginning to understand how our actions are contributing to climate variability, and how climate change will influence Arizona's wildlife, which may intensify existing threats or create new and unexpected challenges.

Conservation Opportunities

While these challenges seem daunting, the good news is that there are actions that can be implemented to reduce and, in some cases, eliminate some threats, helping individual species to better cope with remaining challenges. In many cases, reduction of selected threats can increase the resiliency of ecological systems and wildlife communities to other threats.

The threats discussed in this chapter do not represent an exhaustive list of all challenges facing wildlife and their habitats in Arizona. However, these threats are currently having, or are likely to have, the most significant negative effects on fish and wildlife populations in the state. In Chapter 7: Habitat Profiles, these threats are linked to recommended conservation actions for each habitat type.

By linking threats with recommended conservation actions, the AWCS provides an actionable plan to guide conservation efforts on the landscape. Specific habitat profiles and their associated threats and conservation actions are particularly valuable for managers, planners, and landowners who are responsible for on-the-ground implementation and local-level management decisions.

Threats are natural processes or human activities that may cause destruction, degradation, and/or impairment of biodiversity and/or habitats.

Conservation actions are activities that can be implemented to reach conservation goals and counteract adverse effects from threats.

One goal of the AWCS is to provide the information needed to easily incorporate environmental responsibility into decision-making processes, thereby facilitating progress while simultaneously conserving our wildlife and preserving the integrity of our landscapes. Regardless of our background, experience, or position, we are all stewards of the land and its resources, and it is up to each of us to protect and care for it. Greater awareness of the effects our actions have on our environment may be the single most important driver of positive change. Incorporating the values of wildlife and natural communities into decision-making processes can be accomplished proactively, complementing economic productivity and ensuring recreational access where needed.

Incorporating Best Management Practices (BMPs) for Wildlife Conservation

AZGFD regularly collaborates with a variety of public and private partners to incorporate Best Management Practices (BMPs) into projects to avoid adverse impacts to wildlife and habitats. Some of these examples include:

- The Army National Guard regularly uses AZGFD's Sonoran Desert Tortoise (SDT) Best Management Practices prior to each training event, (e.g., every soldier receives modular annual SDT awareness training, and they are briefed prior to each training event).
- The Federal Highway Administration (FHWA) and Arizona Department of Transportation (ADOT) coordinate with AZGFD to incorporate wildlife-friendly features and BMPs into the design and construction of their roadways.
- Telecommunication towers use wildlife-friendly BMPs when siting and constructing their towers.
- Transmission line developers have also incorporated BMPs and mitigation to reduce impacts to wildlife and their habitats.
- Mining companies have worked with AZGFD to incorporate wildlife BMPs and mitigations to lessen their impacts on wildlife and their habitat.

Acknowledging the Effects of Multiple Threats

Many of the threats described in this chapter coincide geographically and act in a cumulative or synergistic manner making it difficult, and perhaps impossible, to separate individual causal factors that influence habitats or species. Multiple factors are closely linked in cause-and-effect relationships across spatial and temporal scales. Adverse effects from multiple threats can have

cumulative effects that are much more significant than the additive effects alone, with one or more threats predisposing species to additional stressors (Paine et al. 1998). For example, reduced fire frequency from a century of fire suppression, coupled with prolonged dry periods, is partly responsible for conditions that have allowed for major insect outbreaks in recent years (Peet 1988). Affected stands with high tree mortality quickly accumulate dead standing and downed woody fuels, greatly increasing the risk of catastrophic, stand-replacing wildfire. Meanwhile historical grazing practices add an additional layer of complexity by reducing fine fuels and altering structure and composition of forest and woodland communities which further alter the natural fire regime. These highly-disturbed systems are now at greater risk of invasion from non-native species, especially when faced with a changing climate. Species that typically occupy these areas are then forced, if possible, to either adapt or move to more suitable habitat. When suitable habitat conditions disappear, or shift faster than populations can adjust, the likelihood of species extirpation or extinction increases (Malcolm et al. 2006). Given the synergistic effects of multiple factors, it is difficult to predict the overall impact these factors will have on Arizona landscapes, habitats, and wildlife.

Using a Standardized Lexicon for Threats

For the AWCS, we have adopted a standardized lexicon for threats and conservation actions. Using this standardized approach follows recommendations outlined in "Best Practices for State Wildlife Action Plans" by the Association for Fish and Wildlife Agencies (AFWA 2012). The use of universal terminology for conservation efforts will help facilitate cooperation and collaboration, especially between entities that share resources across state lines and other jurisdictions. Per AFWA's recommendation, AZGFD adopted the standard lexicon outlined in Salafsky et al. (2008) and adapted this classification of threats and conservation actions for the AWCS. Specific changes included altering the numbering system slightly and removing some categories that have little or no relevance in Arizona.

Threats to Arizona's Wildlife and Their Habitats

The establishment of standardized language to describe all threats and conservation efforts is not an easy task, especially in a state as large and diverse as Arizona. The eleven broad categories of threats discussed below represent the most significant challenges to Arizona's wildlife and habitats today. Sub-categories described in each section have been modified from Salafsky et al (2008) to better reflect those threats unique to Arizona. (Note: Threats are alphabetized and do not indicate priority or ranking in any form.)

Eleven categories of threats

1. Agriculture
2. Biological Resource Use
3. Climate Change
4. Development
5. Disease, Pathogens, and Parasites
6. Energy Production and Mining
7. Human Intrusions and Disturbance
8. Invasive and Problematic Species
9. Natural System Modifications
10. Pollution
11. Transportation and Service

1. Agriculture

Agriculture is an important industry and way of life in Arizona. According to a recent report by the Arizona Department of Agriculture, the industry generated $23.3 billion for Arizona's economy in 2018 while supporting more than 138,000 full- and part-time jobs (Bickel et al. 2017). Our agricultural lands produce a variety of food crops and goods, including vegetables, fruits, nuts, feed crops, milk, beef, eggs, and more. Due to Arizona's year-round growing season, low corporate tax structure and available workforce, the industry is, and likely will be, a vital component of the state's economy for many years to come.

Agriculture's impact to land, water, and wildlife resources, however, cannot be overlooked. According to the Arizona Department of Water Resources (ADWR), agriculture operations consume approximately 72% of the available water in the state (ADWR 2021). While the irrigated agriculture industry has implemented several conservation-based management practices and employed advanced technology to improve efficiency and reduce water use, the level of consumption poses a direct threat to riparian habitat and puts stress on wildlife. Conversion of natural landscapes to agriculture fields and livestock operations can result in wildlife habitat loss, degradation, and fragmentation, while also altering the soil and vegetation composition and displacing native plants and pollinators.

Threats to Wildlife

- Direct mortality
- Increased competition
- Habitat loss

Threats to Habitats

- Complete conversion or loss of habitat
- Habitat isolation and fragmentation
- Altered hydrological processes
- Indirect effects to adjacent natural lands

Fortunately, many Arizona farmers and ranchers participate in conservation programs and/or employ sustainable agriculture practices that help reduce the impact to natural resources while enhancing environmental quality. The following are just a few of the innovative and wildlife-friendly methods Arizona's agricultural producers are using:

- Installation of wildlife-friendly fencing
- Livestock water troughs built with wildlife escape ramps
- Restoration and enhancement of rangelands to encourage native grasses and vegetation
- Establishing partnerships with beekeepers to support pollinator habitat
- Improving water use efficiency through canal lining, crop rotation and cover crops, no-till practices, efficient irrigation systems using weather sensing and crop analysis technology, tailwater reuse, and bed and furrow shaping

Annual and Perennial Crops

Arizona's farmers raise many specialty crops and, in fact, the state is the nation's second leading producer of cantaloupes, honeydews, pistachios, and dates, and the third largest producer of fresh market vegetables (AZDA 2018). The nut and date crop industry is growing rapidly. With approximately 22,000 acres of pecans in production annually, the state is becoming known for its productive nut farms.

In addition to the direct habitat loss and modification mentioned above, these industries also threaten wildlife through indirect effects. Where broadcast pesticides are used, the potential for contamination of surrounding lands and water bodies exists. Pesticide particles can easily move off-site via wind currents, and some can move through and persist in waterways. These particles and residues can harm sensitive plants and animals and can be hazardous to human health. Some of the pesticides being used also have the potential to negatively-impact the invertebrate community, especially pollinators. Efforts are generally made to reduce the impact by timing the applications so that it doesn't coincide with flowering.

Aquatic systems and species of fish and amphibians are particularly vulnerable to contamination by runoff from irrigated fields. Fertilizer runoff increases nutrients in water bodies, leading to algal blooms which can lower dissolved oxygen levels, causing stress, disease, and death of sensitive aquatic species. Pesticides can build up in food sources, cause abnormalities in aquatic species and poison fish and wildlife. Sediment transport from irrigated fields can reduce water clarity and visibility, negatively affect foraging efficiency of fish and piscivorous birds, and result in increased sedimentation of aquatic habitats.

To reduce the risk of contamination, farmers can utilize Integrated Pest Management (IPM) principles and invest in irrigation system improvements to increase water use efficiency. The EPA has several resources on the effects of pesticide drift to humans and the environment, as well as best management practices for reducing drift and runoff.

Livestock Farming and Ranching

Cattle ranching and dairy production likely have an even larger effect on wildlife and natural habitats. Ranching has been a part of Arizona's heritage for more than 300 years and still plays a significant role in the rural economy. Arizona dairy farms produce about 4.2 billion pounds of milk annually, much of which is processed and sold locally. Arizona dairies, ranches, and associated cooperatives and organizations employ thousands of Arizonans and feed even more.

The ecological impact of these operations, including the infrastructure, ground disturbance, and agricultural runoff, affect local wildlife, vegetation, and water quality. Fencing, corrals, and associated buildings can create barriers to species movements. Depending on the intensity and duration of grazing and the aridity of the area being grazed, soil erosion and alteration to native vegetation can permanently alter and degrade habitats, especially around riparian areas. In many parts of the state, riparian systems and streams have been altered by years of over-grazing, with resulting long-term changes to streambank characteristics and changes to the plant community

structure. In recognition of this impact to the environment, many livestock operations have adopted specific management practices that have the potential to significantly reduce negative impacts to the natural communities with which they share the land. Managing cattle numbers at appropriate levels that the landscape can support, implementing rotational grazing, and restricting cattle use near the most sensitive habitat such as riparian habitats are key actions that ranchers can implement.

Ranchers in Arizona represent some of the greatest advocates for wildlife and conservation and contribute immensely to on-the-ground habitat enhancement work across the state. Continued collaborations with ranchers are critical to maintaining the health of our wildlife populations and their habitats. The key conservation programs that facilitate this invaluable conservation partnership are highlighted in the Landowner Incentive Programs section of Chapter 4: A Comprehensive Conservation Approach.

2. Biological Resource Use

Consumptive use of natural resources such as hunting, fishing, timber harvest, and collecting wildlife for management, research and cultural purposes is part of sustainable management. These activities also help preserve our own heritage and instill multi-generational appreciation and care for the natural world. However, in some cases, these activities can have negative effects on nongame fish and wildlife species, as well as wildlife habitat. In addition, while managed and permitted consumption of wildlife is legal and part of the very fabric of Arizona's history, illegal collection of wildlife is of considerable concern for some of our state's most rare and at-risk species.

Timber Harvest

Forest bird communities are generally sensitive to changes in stand structure and vegetation composition (Dykstra et al. 1997). Many SGCN birds, including the northern goshawk, spotted owl, evening grosbeak, Cassin's finch, Townsend's solitaire, hermit thrush, Grace's warbler, red-faced warbler, western purple martin, Clark's nutcracker, red crossbill, and northern flicker are all vulnerable to timber harvest, with the level of vulnerability depending on the method and extent of harvest. Some species prefer mature trees and cool microhabitats for foraging and nesting, attributes that are often removed from the landscape during harvest. Other negative effects can include reduced species richness, altered community composition, and decreased nest success (Sallabanks and Arnett 2005). Meanwhile, forest-dependent and cavity-nesting bird species are negatively-affected by forest thinning and timber harvest due to reductions of large snags and loss of habitat and primary food sources.

Threats to Wildlife

- Direct mortality
- Disturbance/disruption of critical life stages

Threats to Habitats

- Complete conversion or loss of habitat
- Habitat isolation and fragmentation
- Altered hydrological processes
- Indirect effects to adjacent natural lands

For example, the threatened Mexican spotted owl is a species that may be negatively-affected by timber harvest, because it prefers old-growth, closed-canopy mixed conifer forest as well as deep canyons. The species experienced population declines in the 1980s in the southwest as timber harvest, forest thinning, and wildfire reduced old-growth forest (Ganey and Balda 1989). As part of the USFWS Mexican Spotted Owl Recovery Plan, management strategies were developed and included establishing Protected Activity Areas (PACS) surrounding known owl nest, roost sites, and recovery habitat. Efforts such as this are designed to reduce negative impacts from continued timber harvest and stand-replacing wildfires on national forest lands. The AWCS helps foster the implementation of these and other recovery and management plans for SGCN. by providing recommendations for conservation actions, highlighting areas where conservation efforts would be most effective (COAs), and offering other tools for the public and our partners to achieve conservation goals for SGCN.

Collection and Harvest of Wildlife

Because of Arizona's rich and unique amphibian and reptile diversity, our state is extremely popular among "herpers," the enthusiasts who enjoy searching for, photographing, and sometimes collecting these animals. These wildlife enthusiasts come from all over Arizona and other states and countries, hoping to see species that may not occur outside of Arizona or the southwest. The observations, photos, and records they often share with us can contribute to our ability to manage some species more effectively.

Unfortunately, Arizona's unique fauna also appeals to individuals who want to collect animals for the illegal pet trade. Some of the most popular species that are collected illegally include rattlesnakes such as the Arizona black, banded rock, ridge-nosed, speckled, and twin-spotted rattlesnakes. Mountain kingsnakes, rosy boas, Gila monsters, Madrean alligator lizards, horned lizards, Sonoran green toads, and Sonoran desert toads are also popular targets for poachers. While there is no evidence of population effects from *legal* collection (i.e. for licensed recreation or scientific purposes), illegal collecting has certainly threatened local populations of some species that are highly prized in the pet trade (Jones and Goode, 2020).

In addition to the reptiles listed above, there is a very high demand for turtles in the illicit global trade for pets, food, medicinal markets, and products. In the U.S., box turtles comprise the largest number in the illegal pet trade, primarily due to the bright yellow lines radiating in sunburst patterns on their shell, and their relatively small size. To protect ornate box Turtles, AZGFD has prohibited collection from the wild since 2006.

Although not a widespread recreational activity, falconry is practiced in Arizona and is regulated by AZGFD. Harris's hawks are the number one raptor harvested for falconry in Arizona. Although harvest rates are established by AZGFD Commission Order 25 to prevent over-harvest, collecting young Harris's hawks for falconry is still considered a threat to this SGCN raptor, mostly due to the persistence of illegal, unpermitted harvesting.

Predator Management

Predators play an important role in any ecosystem. However, these species can sometimes have adverse impacts to populations of prey species, some of which may be SGCN such as the American pronghorn. Other species impacted by predators may be of high economic or recreational value such as mule deer or elk. Predator management is a vital wildlife management tool that AZGFD uses to find that delicate balance between predator and prey populations. When necessary, AZGFD manages predator species for various reasons, such as reducing human-wildlife conflict, managing prey populations for ecological or recreational purposes, and reducing adverse effects on other wildlife populations.

Predator management can often be controversial and AZGFD recognizes the diverse opinions on the matter. To find the balance between social, economic, and recreational concerns over predators, AZGFD implements targeted, area-specific predator management plans. Examples of these targeted management actions include managing specific areas where bighorn sheep or pronghorn translocations will occur or implementing predator management in areas where AZGFD wildlife populations are below management objectives due to predation.

Living with Predators

The Mexican wolf is an endangered species that was once extirpated from Arizona as a result of multiple threats including habitat loss, overhunting, and removal due to political and social issues. The Mexican wolf has been successfully reintroduced to a recovery area in east-central Arizona and western New Mexico, although there are still controversial political issues surrounding the presence of this species.

Key threats to its survival today include human-wildlife conflict and vehicle collisions. Concern among some Arizona residents about the impact that this species may have on their lifestyle and local economy is an important consideration and must be balanced with the need to facilitate a self-sustaining population. For additional information see AZGFD's Mexican Wolf Reintroduction and Management webpage and the USFWS Mexican Wolf Recovery Plan.

Hunting and Fishing

As the state's wildlife agency, AZGFD carefully manages game species and sport fish to maintain healthy populations and to allow for wildlife-oriented recreational opportunities. Hunting and fishing are regulated to ensure sustainable population levels preventing game and sport fish species from experiencing significant population fluctuations. Internal coordination with nongame and native aquatics programs ensure that the needs of SGCN are considered and addressed through integrated wildlife and fisheries management plans.

3. Climate Change

The global climate is changing. Shifts to warmer daytime and night temperatures, and altered precipitation patterns such as timing and intensity of precipitation, are stressing natural systems

and creating optimal conditions for wildfires, pests, diseases, and invasive species (AFWA 2009). Arizona has already begun to experience these climate shifts and the new or intensified corresponding threats that result from such changes.

Changes in Temperature Regimes

According to a 2014 report by the U.S. Global Change Research Program, annual average temperatures in the Southwest are projected to rise by 2.5°F to 5.5°F by 2041-2070 and by 5.5°F to 9.5°F by 2070-2099 under current emission rates (Garfin et al. 2014). In Arizona, the increase in average temperatures is predicted to be coupled with reduced precipitation, especially in the winter and spring months (Mellillo et al. 2014).

Changes in Precipitation and Hydrological Regimes

In the Southwest, water is our greatest limiting resource. As the climate changes and water availability decreases, all living things will feel the impact of an increasingly limited supply of this vital natural resource. Climate models suggest that Arizona may continue to see a reduction in annual precipitation (Brown et al. 1997, Burrell et al. 2020). In addition to less moisture overall, reduced snowpack across the entire Colorado River Basin would result in reduced spring runoff into rivers and reservoirs, and less surface water available to sustain growing human populations. Less water for us means less water for wildlife. A long-term trend of dry winters and reduced monsoonal precipitation, combined with increasing water consumption by a growing human population, may cause once-perennial streams to run dry, resulting in complete loss of valuable aquatic and riparian habitat. We may also see significant modifications to the hydrological regime of many aquatic systems, especially those with interrupted perennial, intermittent, or ephemeral flow patterns.

For example, a 2014 modeling effort to predict changes to hydrologic connectivity in the Verde River Basin suggested that, "flowing portions of the river network will diminish between 8% and 20% in spring and early summer and become increasingly isolated by more frequent and longer stretches of dry channel fragments" (Jaeger et al. 2014). The increased extent and duration of dry channel segments has negative implications for the entire ecosystem by disrupting natural energy and nutrient transport patterns, as well as anticipated changes to associated vegetation communities. Impacts to native fishes are particularly concerning as their access to spawning and rearing habitat and seasonal refuge areas would be increasingly limited (Jaeger et al. 2014).

Threats to Wildlife

- Direct mortality
- Disease susceptibility
- Increase competition
- Altered seasonality of resources

Threats to Habitats

- Increased wildfire intensity
- Altered hydrological processes
- Decline in plant diversity
- Ecosystem conversion

Another study of impacts of several climate change scenarios on the Upper San Pedro River riparian area in southeastern Arizona indicated an on-going transition from riparian to more xeric habitat types, especially when the cumulative effects of groundwater pumping for agriculture and urban water use were considered (Kepner et al. 2016). A reduction in the cottonwood/willow gallery forest

community would have dramatic impacts on many migratory bird species who rely on these lush habitats. Springs and ciénegas, which exist where groundwater intercepts the surface, are at high risk of complete conversion resulting in habitat loss for several of Arizona's at-risk species including the desert pupfish, Gila topminnow, Chiricahua leopard frog, and several springsnail species.

Case Study: Collaborating for Water Conservation

In partnership with Arizona Land and Water Trust (ALWT), AZGFD recently completed a five-year water conservation project on the Lower San Pedro River Wildlife Area. This 2,000-acre property features miles of perennial surface water and mature cottonwood galleries, creating quality habitats for several SGCN, including southwestern willow flycatcher, yellow-billed cuckoo, and lowland leopard frog. However, the wildlife area, along with much of the surrounding landscapes, has been degraded in recent decades due, in part, to groundwater pumping and invasive plants, such as salt cedar.

To help reverse these trends, AZGFD collaborated with ALWT to reduce groundwater pumping at the site. By converting 100 acres of high-water-use crop to a low-water-use native grass pasture, more than 700 million gallons of water (approximately 2,000 acre-feet) have remained in the river system over the five-year project term for the benefit of wildlife, riparian vegetation, and rural water users. Thanks to AZGFD's diligent management of the fields with local agricultural cooperators, the native grass pasture has become home to a flock of turkeys with enhanced habitat for passerine, migratory birds, rodents, and herpetofauna. The water savings developed through this project represent a major conservation win for AZGFD and ALWT, as this project represents the largest water transaction on the Lower San Pedro River for ALWT's Desert Rivers Program.

Habitat Shifts and Ecosystem Conversion

A changing climate has the potential to greatly alter the delicate relationships between the biotic and abiotic elements in any ecosystem. The result can be ecosystem conversion, where vegetative communities are slowly replaced by species better suited to a warmer, drier climate (Garfin et al. 2014). Ultimately, these conversions can result in habitat shifts, leading to replacement of entire wildlife communities.

Although drought is a top concern, changes in the timing of precipitation events can also have adverse effects by altering competitive interactions between plant species, thus changing community composition. For example, increases in winter precipitation may 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.

As temperatures increase and precipitation patterns change, Arizona may experience terrestrial ecosystem conversion from forest to grassland and from grassland to desert, forcing wildlife to adapt or migrate to more suitable areas (if suitable habitat exists). Those that do not have dispersal capabilities, or where barriers restrict movement, loss of biodiversity and/or species extinction could result. The "sky islands" of southeastern Arizona are particularly vulnerable to conversion, and in some areas the hotter, drier conditions and intense wildfires are already causing portions of these biodiversity hotspots to transition from mixed-conifer and ponderosa pine forest to shrub and annual grass-dominated communities. In addition, changes in climate are predicted to cause a shift in timing of important physiological events in the life cycles of plants and animals, such as plants and host-specific pollinators. This may lead to misalignment of food availability and reproduction, disrupting the balance of natural systems and putting additional stress on vulnerable species (AFWA 2009; Margolis et al. 2011).

Drought and other changes to precipitation regimes can lead to habitat shifts and influence populations of large ungulates such as elk and white-tailed deer. Changes to precipitation directly affect plant communities as well as quality and quantity of forage for ungulates (Walther et al. 2002). Forage quality and quantity can influence ungulate survival, body condition of individuals, and calving success, among many other factors (Rubin et al. 2000; Bender et al. 2013). Although many of Arizona's ungulates are not considered SGCN, these large, wide-ranging species have considerable influence on the habitats wherever they occur, and play an important role in the natural ecosystems that support many SGCN, such as overgrazing by elk which may reduce regeneration of aspen trees in sensitive alpine habitats (Scotter 1980; Clement et al 2019).

Drier conditions are also expected to have economic impacts, especially in the agriculture sector where long-term drought can reduce important crops like fruits and nuts, and have devastating effects on livestock production due to lack of forage and water. Tourism and outdoor recreation industries would also be impacted due to reduced streamflow and a shorter snow season (Garfin et al. 2014). Many of the outdoor recreational activities that Arizona supports could be greatly restricted due to lack of water. For the 1.5 million residents and countless visitors who routinely participate in water-dependent activities like fishing, kayaking, snowboarding, and birding, a warming climate will almost certainly adversely affect these pursuits and have significant residual impacts to local and statewide economies.

There is no doubt that the combination of a hotter and drier climate will affect every aspect of our lives and the lives of the plants and animals with which we share the extraordinary Arizona landscape. However, there are steps that we can take to reduce impacts and promote resilience as conditions change.

Adaptation Planning Approach and the AWCS

In 2014, the Intergovernmental Panel on Climate Change's *5th Assessment Report* clearly stated the imminent threat before us as "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia" (IPCC 2014). However, what is less certain is *how* conditions will change, the rate at which they will do so, and how natural

communities and individual species will respond and cope to changes in the environment. In light of this uncertainty and due to the complex interactions between existing threats and climate change, we chose to conduct a broad assessment of major threats to native fish and wildlife species rather than a vulnerability assessment specific to climate change impacts. These threats — along with SGCN vulnerable to the threats — are briefly noted in each of the habitat profiles in Chapter 7. The threats, along with suggested conservation actions to remedy the threats, are described in more detail in Chapter 8: Threats and Conservation Actions.

Climate Change Adaptation and Mitigation Strategies

We decided against an in-depth analysis of potential climate change impacts because this was not deemed cost-effective nor highly valuable at this time. Rather than committing limited resources to assessing individual species' responses to highly-uncertain variables, AZGFD opted for an approach that would identify the most critical needs and identify immediate actionable strategies. The strategies listed below form a baseline for adaptive planning with the intent of identifying additional conservation targets and modifying our approach as our knowledge of climate change impacts improves. These strategies were adapted from guidelines by the Association of Fish & Wildlife Agencies (AFWA 2009). Recommendations for implementing these climate change adaptation and mitigation strategies can be found for each habitat type described in Chapter 7: Habitat Profiles under the section "Conservation in the Context of Climate Change."

Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes

Increasing the number and size of high-quality natural areas boosts the likelihood of preserving native biodiversity simply by providing more overall acreage of suitable quality habitat. With an abundance of quality habitats, biologically-diverse communities may be better able to adapt to changing conditions. As climate-vulnerable habitats become more rare or impaired, such as riparian areas and other aquatic habitats, it will be important to identify and protect climate change refugia to ensure these habitat types persist into the future. Coordinating with land management agencies, non-profit organizations, and landowners to establish priorities is an important initial step. To better meet these challenges, AZGFD will seek to work with city/county planners, local governments, and other partners in protecting riparian areas and aquatic habitats through better management of water resources for consumption or agricultural use.

Restore and maintain diverse habitats to support broad species assemblages

Restoring hydrological and natural fire regimes in areas dependent on these forms of natural disturbance is likely to benefit many of the species that currently occupy these areas, as well as those that may migrate to these areas in response to changing conditions. Focusing restoration efforts on COAs, especially those in habitat types associated with climate-vulnerable SGCN, will expand the network of intact habitat blocks and provide refuge for at-risk species.

Encourage and facilitate strategic planning for the renewable energy industry

With Arizona's ample sunshine and wind, renewable energy sources from wind and solar energy plants are particularly appealing alternatives to fossil fuels. These renewable energy sources, as well as thermal power energy, are feasible options when site selection adequately avoids high use areas for birds, raptors, and bats, installations don't disrupt important habitat connectivity areas, and the impact of resulting habitat loss is carefully evaluated. In addition, the effect of associated transmission lines must be evaluated and mitigated. Additionally, all properly-vetted sites that move to construction and energy production must be accompanied by comprehensive wildlife conservation strategies to minimize and/or mitigate wildlife impacts.

Maintain existing and identify new wildlife waters for drought mitigation

AZGFD has an ongoing program to enhance, establish, and maintain water sources for wildlife. This program relies heavily on close coordination with partners such as federal, state, and local governmental landowners, as well as private landowners, on whose land these waters are located. In addition to providing resources to establish or maintain these waters, AZGFD works closely with partners to encourage them to make waters accessible to wildlife. This coordination will become increasingly important in the face of continued climate change. In addition, there is a need to evaluate and prioritize if and where new waters may need to be developed, and to identify natural waters that need added protection or enhancement. As environmental conditions change, and if wildlife populations shift their ranges, the monitoring of surface waters will need to be a priority.

Identify and protect key wildlife corridors for landscape connectivity

This strategy depends on partnerships among agencies, industries, and landowners that have an interest in strategic land use that enables wildlife movement to function in the context of a working landscape. Conducting species movement studies and studies that identify likely future range shifts will help to prioritize protection and restoration efforts. Success in this endeavor will require landscape-scale collaboration where environmental responsibility, economic prosperity, and socio-cultural values are all recognized equally.

Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts

Identifying species and habitats likely to respond poorly to the changing conditions brought on by climate change will provide context for both species' recovery efforts and prioritization of habitat restoration projects. Research focused on ecosystem-level response to climate variability will guide realignment of management and restoration actions with predicted future conditions.

Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing

Although the collection of whole specimens is less common, biological samples are often collected to inform management decisions. Biological samples can be used for a variety of purposes such as evaluating genetic relationships, investigating disease history or prevalence, studying diets, determining population parameters such as pregnancy status, or even tracking exposure to hazardous substances. As the climate changes, AZGFD will continue existing wildlife health

surveillance programs, and incorporate additional disease testing as needed to inform management of emerging diseases.

Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management

Along with identifying species likely to respond poorly to changing climate conditions, long-term monitoring protocols will provide information on success of both species' recovery efforts and habitat restoration projects. Data collected during monitoring will inform management and align conservation actions with predicted future conditions.

Monitor and mitigate for introduced/invasive species

As environmental conditions continue to change, introduced invasive species will create additional stress on native wildlife through competition, predation, introduction of pathogens, and other adverse effects to habitats. AZGFD has an active aquatic invasive species program, focused on reducing the impact of these non-native invasive species. It will be necessary to develop and establish more comprehensive monitoring protocols and programs for both aquatic and terrestrial invasive species, and to establish and expand partnerships with other governmental and private partners to control the spread of both aquatic and terrestrial wildlife and plant species.

Establish new wild and/or captive populations of climate-vulnerable SGCN

Evaluate the need to establish new wild and/or captive populations of SGCN species will ensure persistence of the species. These activities would allow for preservation of unique genes to ensure the species can survive in the changing conditions brought on by climate change.

4. Development

Threats to Wildlife

- Direct mortality

Threats to Habitats

- Complete conversion or loss of habitat
- Degradation of biological condition
- Isolation/fragmentation

Development in Arizona continues at a record pace. As of July 2019, approximately 7.28 million people called Arizona home, an increase of 0.9 million people since April 2010 (U.S. Census Bureau 2020). Expanding cities along growing exurban areas, and an increasing network of roadways are just some of the threats to Arizona's wildlife. The infrastructure that will be required to support our growing population has the potential to greatly exacerbate degradation, fragmentation, and loss of habitat areas that support populations of wildlife. Increasing development can lead to the direct mortality of our wildlife species, and a growing human population will also require an increased demand for limited water resources, presenting even greater challenges for Arizona's wildlife and habitats. Planning for smart and sustainable growth is critical for the future of Arizona's wildlife, natural communities, and the quality of life for all who live in or visit Arizona.

Housing and Urban Areas

In 2019, Arizona ranked third in percentage growth rate in the U.S. with an annual growth of 1.7% (U.S. Census Bureau 2020). Between 2015 and 2019 Arizona welcomed approximately 548,000 new residents and added more than 300,00 new jobs to the already prospering economy (Arizona Commerce Authority 2020). While Phoenix and Tucson continue to grow as the predominant desert urban centers, rural development continues to proceed steadily throughout the state. This rapid growth certainly has its benefits, but it also presents a number of challenges to wildlife conservation, including habitat loss, fragmentation, and degradation, introduction of invasive species, and competition for water resources. Urban expansion, rural development, and the associated infrastructure and resource use, not only threatens wildlife and impairs ecological systems, it also creates a disconnect between humans and nature. As our state becomes increasingly urbanized and open spaces are reduced and access restricted, the ability of Arizonans to enjoy outdoor activities becomes more challenging, and their appreciation of wildlife and wildlands may be diminished.

An additional challenge presented by population growth and development is the increased area referred to as the wildlife urban interface (WUI). This zone is where the natural environment meets developed land and it requires extensive management to support natural processes that are typically maintained in natural systems. Managing human-initiated fires and responding to human-wildlife conflicts are just two examples of increased active management practices required to protect humans and property near the WUI.

When habitat is fragmented by urban growth and associated infrastructure, wildlife must find a way around or through the newly-developed area for daily, seasonal, or annual movements to find food, mates, and other resources. This increases the likelihood of interactions with humans, encounters that rarely end well for wildlife. In addition, the indirect effects of urban development, such as light and noise pollution which can alter wildlife behavior, and introduction of exotic plants and predators (e.g., dogs and cats), creates additional risk to native wildlife. Increasing connectivity for wildlife to mitigate the effects of habitat loss and fragmentation in a planned manner can reduce the frequency of negative interactions and allow animals to move to the resources they need. Increased habitat connectivity helps make wildlife more resilient to a number of climate-change induced stressors. See AZGFD's extensive work on increasing connectivity for wildlife.

5. Disease, Pathogens, and Parasites

Wildlife populations are constantly changing. However, populations are under increasing pressure due to a number of factors, including climate change, habitat loss and modification, habitat fragmentation, and introduction of invasive species. These changes can contribute to the emergence of infectious diseases in wildlife populations.

Threats to Wildlife
- Direct mortality
- Decreased population vigor

Threats to Habitats
- Degradation of biological condition
- Decreased biodiversity

Wildlife species are subject to diseases resulting from exposure to bacteria, viruses, parasites, toxins, and other biological and physical agents. Wildlife species can also be

natural hosts for diseases that affect humans, some of which are transmitted directly while others are transmitted via vectors like insects. Climate also plays a role in disease dynamics in multiple ways, including altering the abundance and distribution of insect vectors and increasing the spread of pathogens in aquatic systems due to altered water temperature, quantity, or flow. Species forced to live outside of their preferred temperature range may be more susceptible to disease, parasites, and pathogens.

To combat these emerging threats, AZGFD manages for the health of fish and wildlife by monitoring susceptible populations and responding to and investigating significant disease and mortality events. Engaging and educating the public to prevent further spread or introduction of wildlife diseases is also critical in our efforts to stem the tide of wildlife diseases. The public can report their observations of recently dead wildlife to AZGFD by calling the **Wildlife Disease Hotline at (623) 236-7201**.

Examples of diseases affecting Arizona's terrestrial wildlife species include avian botulism, elaeophorosis, chytridiomycosis, epizootic hemorrhagic disease, plague, pneumonia (in bighorn sheep), rabies, rabbit hemorrhagic disease, ranavirus, snake fungal disease, trichomoniasis, and tularemia. Important pathogens affecting aquatic species include largemouth bass virus, koi herpes virus, spring viremia of carp virus, infectious pancreatic necrosis virus, infectious hematopoietic necrosis virus, viral hemorrhagic septicemia virus, bacterial coldwater disease, columnaris, bacterial kidney disease, enteric redmouth disease, furunculosis, and whirling disease.

Those diseases yet to be reported in Arizona, such as white-nosed syndrome (WNS) which affects bats, and chronic wasting disease (CWD) in deer and elk, are being closely monitored because confirmed cases have occurred in neighboring states. For example, AZGFD began conducting CWD surveillance in 1998 by acquiring samples annually through four different processes:

- A sample submission process through a reimbursement program established with taxidermy and meat processor businesses
- Collection of samples at check stations on the Kaibab Plateau
- Collection of samples from hunter-harvested animals by regional personnel
- Targeted surveillance of animals exhibiting signs consistent with CWD

Meanwhile, AZGFD is conducting surveillance for WNS by coordinating with governmental and non-governmental partners to collect environmental samples from bat habitats, as well as trapping and swabbing bats in the early spring to test for WNS.

Diseases Affecting Amphibians, Reptiles, and Fish

Compared with their terrestrial counterparts, wildlife that depend on aquatic habitats for part or all of their life stages tend to be more susceptible to environmental changes, especially the introduction of diseases and other pathogens. Due to their limited dispersal ability, specific habitat requirements, and the cumulative effects of multiple threats, amphibians are especially vulnerable to disease. Management strategies focused on understanding the effects and preventing introduction and

spread of disease are a priority at local, regional, and global levels. Currently, AZGFD is working to monitor and manage the following diseases affecting aquatic wildlife in Arizona:

Chytridiomycosis affects amphibians and is caused by the chytrid fungus (*Batrachochytrium dendrobatidis*). The fungus spreads and persists in aquatic environments where it attacks the keratin in the skin of amphibians. Introduced species such as bullfrogs, African clawed frogs, and barred tiger salamanders (introduced for the bait trade) are known to harbor chytridiomycosis, yet they experience few symptoms of the disease (Bradley et al. 2002). While some native amphibian populations seem to be relatively unaffected by the disease, others are highly susceptible and the disease is contributing to population declines. In partciular, chytridiomycosis has caused declines in lowland leopard frogs, Chiricahua leopard frogs, and Tarahumara frogs.

Ranaviruses can affect amphibians, reptiles, and fish. In Arizona, Ambystoma tigrinum virus can be particularly devastating to tiger salamanders, causing mass mortalities. Ranaviruses, in general, can cause tissue necrosis that leads to organ failure and death. Larval and juvenile amphibians are particularly vulnerable. Ranaviruses spread through food, water, human handling, and aquatic recreational equipment and gear (Miller et al. 2011; Allender 2019).

Upper Respiratory Tract Disease (URTD) affects desert tortoises and is spread through direct contact with an infected tortoise. If not treated, the infection can be deadly. Signs of the disease include a runny nose and watery eyes. To prevent the spread of URTD, it is important to never release a captive tortoise into the wild.

Whirling Disease is a chronic inflammatory disease in salmonid fish caused by the myxozoan parasite *Myxobolus cerebralis*. The disease is characterized primarily by affected individuals displaying tight circular movements caused by spinal cord constriction and brain stem compression. The life cycle of *M. cerebralis* is temperature dependent and involves two hosts: salmonid fish and aquatic oligochaetes (*Tubifex tubifex*). Susceptibility to *M. cerebralis* varies with fish age, size, parasite dose, and environmental factors. Clinical signs of whirling disease may be evident three to eight weeks after infection. Survivors of long-term infections may only exhibit skeletal deformities (MacConnell and Vincent 2002).

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Whirling disease is spread by infected fish and by fish feeding on worms that harbor the parasite. Asymptomatic carriers of the parasite are common and can act as reservoirs for the parasite. While the disease does not affect humans, it can also be spread as a result of human activity. Cleaning, draining and drying aquatic equipment after use and never transporting fish between water bodies can help prevent the introduction of the disease to new areas. Arizona has a “no tolerance” policy that bans the stocking or importation of fish infected with whirling disease. However, the potential for accidental introduction still exists.

Largemouth Bass Virus Disease (LMBVD) is caused by an iridovirus. As the name suggests, the most commonly-reported species with LMBVD is largemouth bass with some infections affecting smallmouth bass. Subclinical infections occur in other members of the *Centrarchidae* family, but LMBV in fish of other families appears to be rare. The first known isolation of LMBV was from largemouth bass collected from Lake Weir, Florida, in 1991 (Grizzle and Brunner, 2002). The virus is highly communicable by waterborne transmission (Grant et al. 2005), but most infected fish do not show signs of disease. Causes of subclinical infections converting to overt disease are unknown.

Water temperature and other variables are usually suitable for largemouth bass during LMBVD outbreaks. This disease occurs during summer in adult fish with subclinical infections occurring during all seasons. Occasionally, LMBVD causes a noticeable fish kill in wild populations, but there can be a decreased abundance of older age classes even when a fish kill is not observed (Maceina and Grizzle 2006). Diseased fish swim lethargically near the surface of the water and then lose equilibrium. Some moribund fish have an overinflated swim bladder and less commonly have exudate in the swim bladder.

Koi Herpesvirus Disease (KHVD) is caused by a recently recognized herpes-like virus also known as carp nephritis and gill necrosis virus. While clearly different from herpes viruses found in mammals, birds, and reptiles, the virus that causes KHVD is related to a group of herpes-like viruses found in fish and amphibians currently classified in the family *Herpesviridae*. Young koi and common carp are most susceptible although outbreaks and high mortality (90%) have been observed in larger and adult fish. Mortality begins approximately 7 to 14 days following contact with the virus most often via a recently introduced fish to the pond (koi) with one of two common outcomes: 1) the introduced fish dies shortly after introduction and spreads the virus to the naïve population, or 2) the introduced fish stays healthy yet the naïve fish succumb. The movement of the virus with suspected carriers has been the principal means by which the virus has spread so rapidly at both the regional and global scales.

Spring Viremia of Carp Virus (SVCV) is caused by the fish Rhabdovirus. The following names have historically been used for diseases that may have been caused by SVCV: swim-bladder inflammation (SBI), infectious dropsy, rubella, infectious ascites, hemorrhagic septicemia, and red contagious disease. In typical outbreaks, SVCV spreads horizontally during the winter when water temperatures are low and host immune systems are less active. When spring approaches and temperatures rise toward 50°F, fish develop clinical signs of SVCV and begin to die. Above 68°F, most fish are able to develop immunity to the virus and mortality ceases. Fish may also develop SVCV in the fall if temperatures are in the right range for virus transmission and disease. While SVCV has been isolated from fish lice (*Argulus* sp.) and leeches (*Pisicola* sp.) feeding on infected fish, there is no evidence that these mechanical vectors are important in the spread of SVCV.

Infectious Pancreatic Necrosis Virus (IPNV) and IPNV-like viruses were originally associated only with salmonid fish, several of which are found in Arizona, including brook trout, rainbow trout, and brown trout. These viruses have since been isolated from a variety of non-salmonid fish and invertebrates from freshwater, estuarine, and marine environments (Wolf 1988, Reno 1999).

Viral Hemorrhagic Septicemia Virus (VHS) is one of the most important viral diseases of finfish worldwide. In the past, VHS was thought to affect mainly rainbow trout reared at freshwater facilities in western Europe (Wolf 1988). Today, VHS is known as a cause of mortality in cultured and wild fish in freshwater and marine environments in several regions of the northern hemisphere.

Infectious Hematopoietic Necrosis Virus (IHNv) is caused by a Rhabdovirus. Observation from naturally-occurring disease and experimental infections indicate that fish up to two months of age are most susceptible. In recent years, epizootics have also been reported in yearling sockeye salmon and two-year-old kokanee salmon as well as adult rainbow trout. The disease is still less common and more chronic in larger fish than in smaller fish. Most IHNv occurs at temperatures of 59ºF or colder in freshwater. Horizontal transmission has been demonstrated and waterborne transmission can be accomplished in the laboratory. Clinically infected juvenile salmonids and carrier adults are the reservoirs of virus for waterborne transmission. No other reservoirs of virus have been identified.

Bacterial Kidney Disease (BKD) is caused by *Renibacterium salmoninarum*. All fishes in the family *Salmonidae* are considered susceptible (Elliott et al. 2014). Among non-salmonids, clinical BKD has been reported in cultured ayu (family *Plecoglossidae*), and the bacterium also has been isolated from kidneys, but not blood, of sea lampreys (Eissa et al. 2006). *R. salmoninarum* can be transmitted both vertically and horizontally, and the bacterium has been detected in both wild fish and hatchery populations (see reviews in Evelyn 1993; Fryer and Lannan 1993; Pascho et al. 2002). Infections can occur at any life stage in a salmonid population, but clinical signs of disease are uncommon in fish less than six months old (Evelyn 1993). The disease occurs over a wide range of temperatures.

Bacterial Coldwater Disease, also referred to as rainbow trout fry syndrome, fry mortality syndrome, peduncle disease, or low temperature disease, is caused by the bacterium, *Flavobacterium psychrophilum*. Coldwater disease and its causative agent have been reviewed by Cipriano (2005) and Barnes and Brown (2011). All salmonids are probably affected, but juvenile coho salmon along with rainbow trout and steelhead are particularly susceptible. Juvenile fish are primarily affected but infections also occur in yearlings and smolts. Epizootics frequently occur in fish held in protected water supplies and there is substantial evidence for vertical transmission of *F. psychrophilum* even when eggs are disinfected with iodophor.

Columnaris Disease is caused by the bacterium *Flavobacterium columnare* (Bernardet et al. 1996). Most freshwater fishes (cultured and wild) are considered susceptible to *F. columnare*. Columnaris disease can affect fish of all ages but is more prevalent in young fish. The severity and occurrence of the disease is generally greater in water temperatures greater than 68°F but the disease can also occur in lower water temperatures. Columnaris disease can occur in fish without any predisposing conditions but outbreaks are commonly associated with stressful rearing conditions such as low dissolved oxygen, high ammonia and nitrite concentrations, and overcrowding. Additionally, handling and injuries to the skin/mucosa may predispose fish to columnaris disease.

Diseases Affecting Birds

Avian Botulism is caused by a naturally occurring toxin produced by a bacterium that is associated with aquatic environments. It affects mainly waterfowl and aquatic bird species. Botulism can be managed effectively if mortalities are detected/reported early. When detected, carcasses should be picked up and disposed of as soon as possible. Water bodies can be managed through draining or flooding to alter the environmental conditions sufficiently to stop the production of Type C botulism, one of the prominent strains. Lastly, hazing can move other birds away from areas where the toxin has been detected, or where there have been other bird mortalities.

Avian Trichomoniasis is caused by a single-celled protozoan, and is a common parasite of doves and pigeons. However other birds such as domestic and wild turkeys, chickens, and raptors may also become infected. Infected birds experience weight loss, appear listless, excessive salivation, difficulty eating and drinking, and difficulty closing their mouths. Yellowish lesions may be seen around the beak or eyes of mourning doves and the face may appear "puffy." Doves and pigeons should be kept from congregating in large groups, particularly at food and water sources. Feeders, water dishes, platforms, and other surfaces should be decontaminated regularly with a 10% bleach solution (9 parts water: 1 part bleach). Risk of this disease can be reduced by avoiding overfeeding birds (e.g., only putting out a modest amount of seed out every other day so that all feed is gone before the next feeding).

Pigeon Paramyxovirus 1 is a viral infection of doves and pigeons that affects the nervous system. It is most commonly seen in Eurasian collared doves where it causes large mortality events in the summer. Dense populations around dairies and agricultural areas seem to contribute to the problem. Removing carcasses and limiting access to feed will reduce the prevalence.

Diseases Affecting Ungulates

Chronic Wasting Disease (CWD) is the single biggest threat to cervid (deer, elk, moose, reindeer, etc.) populations in North America and around the world. CWD is an untreatable and always-fatal neurologic disease affecting free-ranging and captive cervids and is characterized by progressive weight loss, abnormal behavior, and eventual death. Mule deer, white-tailed deer, and elk are all susceptible to the disease and once infected, populations can sustain severe declines. Since 1998, AZGFD has been conducting CWD surveillance and has tested more than 25,000 samples. CWD has not been detected in Arizona, despite bordering three CWD-positive states: New Mexico, Colorado, and Utah. Samples are collected by AZGFD staff at check stations and camps, from taxidermists and game meat processors, and directly from hunters. Hunters coming in from out of state or returning to Arizona should follow recommended guidelines to reduce the risk of introducing the disease. Such measures include cleaning equipment and vehicles including the undercarriage, not transporting whole carcasses (except to a meat processor), and removing all soft tissue from skulls and skull caps. Meat should be cut and wrapped or in quarters before crossing state lines.

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Elaeophorosis is a parasitic disease caused by the filarid worm (*Elaeophora schneideri*) that is transmitted by horseflies. It occurs in mule deer, white-tailed deer, elk, bighorn sheep, pronghorn, bison, and domestic sheep and goats. Signs of the disease can include facial swelling due to food impactions, tooth loss, and degeneration or fracture of jaw, muzzle and ear necrosis, malformed antlers, blindness, lack of coordination, facial or lower limb dermatitis, and death. The disease is seen more frequently in younger animals. Animals reported to be showing signs of the disease can be targeted and tested on a case by case basis.

Hemorrhagic Disease (HD) and Bluetongue (BTV) are infectious viral diseases transmitted by tiny biting flies. It has been reported in white-tailed deer, mule deer, bighorn sheep, elk, and pronghorn. Signs of HD and BTV infection include animals exhibiting depressed behavior, fever, a swollen head, neck, tongue, or eyelids, or having difficulty breathing. In severe cases, animals may die within one to three days. More often, they survive longer and may become lame, lose their appetite, or reduce their activity. Animals reported to be showing signs of the disease can be targeted and tested on a case-by-case basis.

Pneumonia is a bacterial respiratory disease observed in bighorn sheep. Infected bighorn sheep may show signs including severe coughing, nasal discharge, head shaking, drooping ears, fever, lethargy, and death. State wildlife managers, federal officials, and bighorn sheep advocates emphasize the need to reduce contact between wild and domestic sheep species, citing evidence of disease transfer. Although keeping wild and domestic sheep separate is challenging due to the relatively large distance bighorn sheep are known to travel (up to 30 miles), this is the most viable current management option available. Several states have reported severe losses in bighorn sheep populations with the disease. AZGFD considers pneumonia to be a serious threat and closely monitors Arizona's bighorn sheep herds for signs of the disease.

Diseases Affecting Other Mammals

Rabbit Hemorrhagic Disease Virus 2 (RHDV2) is a viral disease that only affects rabbits, causing sudden death. It can be spread through contact with infected rabbits, their meat or their fur, or materials coming in contact with them. In 2020 the disease was detected in jackrabbits and cottontails in Arizona and other parts of the southwestern United States. Wildlife managers are continuing to assess the impact of the introduction of this disease on rabbit populations.

To reduce the risk of spreading RHDV2, rabbit owners should wash their hands before and after working with rabbits and not share equipment with other owners. Avoiding contact with wild or feral rabbits is also important. Burying dead rabbits to reduce the risk of disease transmission is also recommended. If a case is suspected, veterinarians should contact USDA-APHIS or email **diseasereporting@azda.gov** to contact the State Veterinarian's Office or call 623-236-7201 for wildlife issues.

Plague is caused by a bacterium, *Yersinia pestis*, that exists in the flea-rodent cycle. Fleas become infected by feeding on animals such as chipmunks, prairie dogs, rabbits, ground squirrels, tree squirrels, mice, and woodrats that are infected with the bacteria. Infected fleas then transmit the

plague bacteria to other mammals and humans during the blood feeding process. Carnivores typically get plague by ingesting infected animals or from flea bites. Large scale die-offs can result in the sudden loss of entire colonies of prairie dogs or other mammals, and should be reported immediately.

Plague is naturally occurring in Arizona, mostly in the northern part of the state and above 5,000 ft. elevation. Flea control techniques for wildlife species are limited and in the early stages of development, but include placing powdered insecticides in animal burrows, and offering food containing insecticide or vaccine. Plague can be a very severe disease in humans, and can be transmitted through contact with an infected mammal or flea. Symptoms in humans typically appear within 2 to 6 days after exposure and include sudden onset of fever, chills, headache, nausea, vomiting, stomach and/or back pain, and weakness. Care should be taken to avoid contact with mammals such as rabbits, rodents, and prairie dogs. Protect pets by keeping them indoors or administering flea control for outdoor pets or animals.

Rabies is a virus that is typically transmitted via bite by an infected animal. Rabies travels through the nervous system into the affected animal's brain. Once symptoms begin, the disease is fatal. There are several behavioral symptoms associated with rabies. An infected animal may exhibit abnormal behavior such as being active during odd hours and appearing especially docile or extremely aggressive.

Once bitten, initial signs are flu-like and include general weakness, headache, or fever, but may progress to inflammation of the brain. Clinical symptoms include paralysis, anxiety, tingling in extremities, paranoia, delirium, agitation, insomnia, and hydrophobia (fear of drinking fluids due to difficulty swallowing). Once clinical symptoms begin, the disease is almost always fatal. People and pets that are exposed to rabid animals should receive post-exposure vaccinations to prevent the disease.

Humans and pets can contract rabies as well. Although exposure to rabid animals is rare, rabies is a serious risk in Arizona and AZGFD offers regular outlets to educate the general public about rabies and wildlife. To reduce the risk of contracting rabies, humans and pets should be kept away from wild animals. Minimize the available food sources around your property such as garbage and pet food. If handling dead carcasses, wear latex/nitrile gloves.

Tularemia is caused by the bacterium *Francisella tularensis* that can affect people, rabbits, hares, rodents, dogs, cats, pigs, sheep, and horses. It can be contracted through direct contact with ticks and biting flies. In Arizona, tularemia has been most commonly associated with mortalities in cottontails where the only sign of the disease is sudden death. In humans, the onset of symptoms typically occur within 3 to 5 days, but can take as long as 14 days to develop. People often have fever, headaches, diarrhea, muscle aches, joint pain, dry cough, and swollen lymph nodes. Fortunately, tularemia is treatable with antibiotics. To limit exposure, wear long pants and long-sleeved shirts and apply insect repellent.

Wildlife diseases are a growing global challenge with wide-ranging impacts beyond wildlife losses. The increased transport of animals and animal parts by humans has contributed to the spread of wildlife diseases, while changing environmental conditions (e.g., drought) can simultaneously influence disease distribution and make wildlife more susceptible to diseases. These challenges include ecological disturbance, human health and safety, health of domestic animals, and the economic impacts and losses that result. Many animal diseases that are transmitted to humans originate in wildlife species (Sleeman et al. 2017). AZGFD has drafted management plans for some diseases. Management actions include distribution of oral vaccines, oral insecticides, topical insecticides, addressing human actions that increase disease prevalence and distribution, modifying population management objectives, and modifying hunt structure. Even with these rigorous management plans, fighting wildlife disease is an on-going and ever-changing threat to wildlife and humans. Disease surveillance, vaccines, research, and public education programs are key management actions that will improve our understanding of wildlife diseases, help slow their spread, and reduce the devastating impacts on wildlife populations.

6. Energy Production and Mining

Although metallic and industrial mineral mining have a long history in Arizona, the state lacks major fossil fuel resources and has never been a leading producer of oil or natural gas. Only moderate amounts of coal have been extracted from the state's two coal fields and with the 2006 Renewable Energy Standard set by the Arizona Corporation Commission (ACC), the closing of the Navajo Generating Station in 2019, and Arizona Public Service's (APS) commitment to source 100% clean energy by 2050, coal production in Arizona is likely to decrease in the coming years.

In contrast, Arizona continues to take advantage of the state's plentiful renewable energy resources including solar, wind, and hydroelectric energy. In 2018, renewable energy provided about 13% of Arizona's electricity net generation (U.S. Energy Information Administration 2020). In 2017 solar energy surpassed conventional hydroelectric energy as the dominant form of renewable energy produced in Arizona (U.S. Energy Information Administration 2020). Arizona currently ranks second in the nation in solar energy production, bringing significant benefits to Arizona's economy, the country, and the environment.

Threats to Wildlife

- Direct mortality
- Disturbance/disruption of critical life stages

Threats to Landscapes

- Complete conversion or loss of habitat
- Degradation of biological condition
- Introduction of invasive species
- Isolation/fragmentation

Renewable energy is an important strategy to reduce our dependence on foreign oil, carbon emissions, and the release of other pollutants associated with fossil fuel generation. The Renewable Energy Standard and Tariff (REST) rule approved by the ACC in 2006, which requires 15% of the state's energy to come from renewable energy resources by 2025, indicates Arizona's commitment and support for this strategy. The manner in which the renewable energy industry plans for, develops, and operates utility-scale facilities can have significant implications for wildlife and natural

resources. Disturbance and habitat loss associated with land use change and development go beyond the main facility footprint. The construction of new or expansion of existing substations, new transmission lines, and associated access roads and other infrastructure also result in habitat loss and fragmentation, and wildlife mortality (e.g., when bird and bat species come into contact with transmission lines or wind turbines). The addition of roads such as service roads increases the spread of invasive plants, and the construction of additional solar facilities increases water demands. Opportunities to reduce impacts exist, however, appropriate project siting at the early stages of project development is one of the most effective ways to minimize these negative effects. Although only of small benefit to wildlife, some solar companies are now allowing native vegetation to reestablish within the solar facilities providing suitable habitat for smaller wildlife species that can negotiate the perimeter fencing.

Like solar facilities, mineral and rock mining can have negative impacts resulting from construction, drilling, and reclamation activities. Associated water use and potential contamination are also concerns because riparian areas are critical habitat for many native species. Exploratory drilling and new mining site proposals in Arizona must go through a comprehensive permitting process, including environmental compliance assessments and must adhere to health and safety regulations to minimize negative impacts to people and the environment. During early stages of project planning, it is important to coordinate with land, water, and wildlife managers so that siting and design stages incorporate conservation practices specific to the project area. This not only minimizes negative impacts to natural resources, but also reduces the risk of costly mitigation and/or redesign at later stages for the project proponent.

Solar Energy Development

There has been a major push for large utility-scale solar facilities throughout the western United States in recent years. In 2013, the Arizona BLM initiated the Restoration Design Energy Project (RDEP), which identified 192,100 acres of BLM-managed lands that may be most suitable for the development of renewable energy. Areas identified are near transmission lines or designated energy transportation corridors, close to population centers or industrial areas, and in areas where impacts on water usage would be moderate.

While there is clearly a need for renewable energy development, and great potential for solar energy in Arizona, it can have negative effects on wildlife and natural communities. 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 they may use significant amounts of groundwater if using wet-cooled systems. The resulting changes in drainage patterns, storm water runoff, and depth to groundwater could result in significant negative impacts to wildlife and their habitats.

Strategic siting of solar facilities to avoid known wildlife movement corridors and sensitive habitat such as riparian areas is an important step the industry can take to reduce environmental impacts

of utility-scale facilities. In order to protect Arizona's natural resources while still fostering growth of the solar industry, AZGFD has developed recommendations and protocols to reduce the impact of solar energy development on wildlife, which can be found in Guidelines for Solar Development in Arizona.

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 a viable source of clean, renewable energy that is generally supported in the conservation community. Climate adaptation strategies identify the need for more environmentally friendly energy sources that do not create air-polluting and climate-modifying emissions. However, wind turbines and their construction can adversely affect wildlife and habitats. Wind turbine towers in particular have been associated with mortality of large numbers of bats and birds (including raptors) when they are struck by moving blades (Kunz et al. 2007).

Effects of utility corridors include habitat fragmentation and disturbance from authorized and unauthorized use of access roads and pads, wildlife mortality due to collision with infrastructure, creation of new electrical transmission corridors, and the introduction of non-native plant species due to the disturbance of soil and native vegetation during construction and maintenance (Parendes and Jones 2000).

When wildlife needs and critical habitat areas are considered in project siting and design, many of the negative effects can be greatly reduced. Another AZGFD-produced guidebook, Guidelines for Reducing Impacts to Wildlife from Wind Energy Development in Arizona, which provides general guidance to project proponents on how to minimize or avoid impacts to wildlife and their habitats. However, for project-specific recommendations, it is important to coordinate with appropriate agencies including AZGFD.

Mining

Industrial minerals such as sand and gravel, clay, cement, and gypsum, and metallic minerals including copper, gold, silver, and uranium are mined throughout Arizona. Types of mining operations range from large-scale, open pit copper and uranium mines to small, abandoned hard rock mines. According to the USGS, Arizona produced $7 billion worth of minerals in 2021 (USGS 2021). Copper is the most abundant and valuable of Arizona's metallic minerals and accounts for almost 74% of the domestic copper production in the United States (USGS 2021). Of the approximately 27 major mines currently operating in Arizona, 10 are copper mines, eight of which are in the southeastern portion of the state (UA Superfund Research Program). While state and federal regulatory agencies, including the ADEQ, ADWR, and EPA, ensure operations meet environmental standards, there is still significant impact to the land, water, and wildlife in the vicinity of the mining sites.

Processing plants and the infrastructure associated with large-scale mining, as well as resulting waste, have the potential to permanently alter the immediate and surrounding environment, and can contaminate surface and groundwater. Also of concern is the considerable quantity of water required to operate the mines and process minerals. The water is typically sourced from a combination of underground aquifers, surface streams, and water provided through the Central Arizona Project (CAP; Singh, 2010). Mining operations within Active Management Areas (AMAs) where reliance on groundwater is especially high, such as for the Tucson AMA in southeastern Arizona, are particularly concerning. Riparian habitats in these areas can be impaired by increased water consumption, erosion, and contamination.

Wildlife impacts from mining include habitat fragmentation and loss when land is cleared and roads are built to support the operation, and ongoing disturbance from lighting, noise, and maintenance activities. Surrounding areas can also be impacted if invasive species are not controlled within the disturbed area of the mining site. It is recommended that each mine's general plan of operations should include a soils and vegetation management plan that acknowledges potential impacts and identifies measures to minimize and avoid negative effects. Mitigation measures and adjustments to mine operations may reduce negative impacts to wildlife and sensitive habitats, or provide mitigation measures to restore or enhance suitable habitat in nearby areas. Once the mine ceases operations, the reclamation process — during which adverse environmental effects are minimized and the mined area is returned to beneficial use — might restore habitats to conditions suitable for some wildlife (Jansen et al. 2006). However, long periods of operation and/or abandoned operations with no reclamation still pose a significant negative impact.

Several species of bats actually benefit from the excellent habitat provided by abandoned, underground mines. Managing mines for bats across Arizona has become an important conservation tool. The partnership between AZGFD, BLM, and the Arizona State Mine Inspector, has installed more than 125 gates at abandoned mine sites throughout the state which serve multiple purposes. The gates ensure public safety by restricting access to the site, while still allowing bats to enter and exit freely. The gates not only protect people from a serious hazard, they also protect bats from human disturbance.

7. Human Intrusions and Disturbance

Non-consumptive recreational activities, military exercises, and the international border are just a few of the ways that human activities can disrupt wildlife and alter their habitat. Although seemingly innocuous, even low- or no-impact activities can negatively affect wildlife by altering behaviors. Responses are varied depending on the sensitivity of the species and the duration, timing, and intensity of disturbance, and may include increased alertness, heightened stress-hormone levels and, in some cases, a decrease in survival and/or reproduction or even abandonment of an area (Bötsch et al. 2017).

Recreational Activities

It can be hard to accept that the recreational activities we are so passionate about, such as hiking, biking, horseback riding, off-road vehicle use, camping, and water sports, may negatively impact wildlife. However, the disturbance created and footprint left behind can degrade habitat, alter wildlife behavior, and even cause direct mortality. Simple practices like staying on designated roads and trails and following Leave No Trace guidelines can reduce this potential.

The attraction of Arizona's unique waterways consistently results in some of the highest densities of recreational boating in the country. Additionally, boaters have access to some high-quality wildlife riparian, reservoir, and riverine areas. These outstanding recreational opportunities introduce additional challenges for species that depend on aquatic and riparian habitats. Motorized watercraft discharge chemicals that reduce water quality, while both motorized and non-motorized watercraft are potential vectors for aquatic invasive species transportation and introduction. Both water-based and terrestrial recreation within riparian areas, especially during bird nesting and breeding season, can affect foraging behavior, cause repeated flushing of birds, and lead to nest abandonment for raptors, some species of waterfowl, and other riparian birds. (Boyle et al. 1985; Knight and Cole 1995).

Threats to Wildlife

- Direct mortality
- Altered behavior
- Introduction of disease/parasites

Threats to Landscapes

- Degradation of biological condition
- Decreased biodiversity
- Altered hydrological processes
- Changes to composition and structure

Off-Highway Vehicle (OHV) Use

Off-highway vehicle use is an increasingly popular recreational activity in Arizona. A 2020 University of Arizona study found that an estimated 24.4% of adult Arizonans engage in OHV use annually (Duval et al. 2020). A similar study conducted by Arizona State University in 2016-2017 found that residents and visitors spend approximately $1.8 billion dollars on OHV recreation in Arizona annually. While the socioeconomic importance of OHV recreation cannot be underestimated, it is also important to consider the impacts this activity has on the landscape and wildlife.

Paved, high-use roadways can fragment habitat, damage vegetation, increase erosion, and reduce connectivity. However, rural dirt roads and non-motorized trails can also result in similar negative impacts to wildlife and their habitats. OHV use can have a variety of direct and indirect effects on wildlife, with negative effects at the individual and population level. For example, high noise levels and increased human presence can trigger stress responses and lead to altered behavior or habitat use. In Arizona, the density of dirt roads was found to negatively influence space use by kit foxes (Jones et al. 2017). Direct mortality can result from vehicle-animal collisions, and animal injuries such as inner ear bleeding and hearing loss have been documented (Ouren et al. 2007). Indirect effects include collapsed burrows, degraded forage resources, or abandonment of key habitat or resources (Ouren et al. 2007), all of which can negatively affect population viability.

Popular off-roading areas like sand dunes and desert washes are important habitat for many reptile species including SGCN like the Yuman Desert, Mohave, and Mohawk Dunes fringe-toed lizards, flat-tailed horned lizard, Sonoran desert tortoise, and Mohave shovel-nosed snake. These areas are also home to more common small mammals like the banner-tailed, desert, and Merriam's kangaroo rats and the Arizona and desert pocket mice. Negative effects to these species can also have consequences for their natural predators. The high level of traffic and noise, degraded vegetation, and the fragmentation caused by increased road and trail densities are therefore serious management concerns.

In higher-elevation areas that receive more moisture, heavy off-road vehicle traffic can result in soil compaction, erosion, increased sedimentation, and altered hydrological patterns. Ground disturbance can also promote invasion of non-native plant species. While the movement of some species is relatively unimpeded by gravel roads or dirt routes, other wildlife, such as some small mammals and amphibians, may perceive this as a barrier to movement (Ouren et al. 2007).

Staying on designated roads and trails or in special-use areas, and limiting travel near or through riparian areas and meadows, can reduce impacts to species and habitats. However, the best outcomes overall may result from improved communication and cooperation between OHV groups, land management agencies, and natural resource managers. A greater understanding of the issues and mutual respect could lead to improved recreational opportunities and less damage to important wildlife habitat.

Military Exercises

Arizona's military facilities span large areas, especially in the southern portion of the state. Military activities include research, development, testing, and evaluation of weapon and space systems, subsystems, and components. Other regular activities include live bombing, air defense missile firing, mechanized brigade training exercises, battalion-size or smaller training exercises, landings and training courses, maintenance of fighter wing capabilities, and other general military training exercises. While many of these activities pose a threat to wildlife due to disturbance and habitat degradation, the facilities work to limit negative impacts through Integrated Natural Resources Management Plans that outline the significant natural resources on the landscape and define goals and objectives to ensure compatible use between the military mission and natural resource management. Military lands such as Barry M. Goldwater, Yuma Proving Ground, Fort Huachuca, and Luke Air Force Base offer high quality habitat and refuge for species such as the federally endangered Sonoran pronghorn, the Sonoran desert tortoise, and the rare flat-tailed horned lizard, all species that have lost important portions of their historical ranges to development.

For decades, AZGFD has worked closely with our partners at the Department of Defense (DOD) to help manage, monitor, and protect wildlife and habitats at several military installations around the state. Meanwhile, the Sentinel Landscapes Partnership is a national program that brings together federal agencies, state and local governments, non-governmental organizations, and private landowners in an effort to advance sustainable land use while protecting defense facilities from incompatible development of adjacent lands. The partnership connects private landowners with voluntary state

and federal assistance programs to maintain and enhance natural and working lands. In 2015, more than 62,000 acres surrounding Fort Huachuca were designated as a sentinel landscape with the goals of addressing water conservation issues, improving agricultural viability, restoring wildlife habitat, and protecting the military mission.

Border Issues

Arizona shares more than 350 miles of border with Mexico. Many wildlife species must move across this border on a daily, seasonal, or annual basis to obtain necessary resources such as food, cover, and water. AZGFD 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 negative impacts to borderland habitats. The border wall creates an impenetrable barrier to wildlife movement that may have significant impacts on several rare and imperiled species including the Mexican wolf, jaguar, ocelot, Sonoran pronghorn, as well as more common species like mountain lion and black bear (Flesch et al. 2009).

Dispersed camping, altered fire regimes, decreased water quality from pollutants, unauthorized roads and trails, illegal dumping and littering, increased poaching, and illegal collecting of wildlife also threaten plant and animal life in this region. In addition, although law enforcement activities are necessary, they often create a damaging network of two-track routes across the desert landscape (Whitbeck and Fehmi 2016). Significant increases in the human population along the Arizona-Mexico border result in changes to land use, dewatering of aquatic systems, and increased pollution (Updike et al. 2013). Cumulative effects from these stressors are resulting in habitat loss and fragmentation, introduction and spread of invasive species, increases in wildlife disease, and increased wildlife mortality.

While it is difficult to attribute changes in wildlife behavior, distribution, and habitat use to a specific cause, it is apparent that certain species are highly sensitive to the human disturbances discussed here. Factors such as colonial behavior, unique breeding patterns, limited distribution, or narrow habitat requirements increase vulnerability to these stressors (Boyle and Samson 1985).

8. Invasive and Problematic Species and Genes

Several contributing factors are increasing the introduction and spread of invasive or undesired plant and animal species throughout Arizona. These include intentional and non-intentional introduction of non-native species, as well as human-related disturbance and alteration of natural systems.

Climate change, and the resulting shifts in plant and animal communities, adds an additional layer of complexity as conditions change and native species are forced to respond through resistance, adaptation, or movement to more suitable areas. At the same time, changing conditions may create new habitat for non-native species. Invasive or undesired species may prey upon, outcompete, or transmit diseases to vulnerable native species. These stressors further impair native species' ability

to cope with changes to their environment. As non-native species become established, impacts to agricultural productivity, public utility operations, native aquatic species, tourism, and outdoor recreation, ecosystem services, and human well-being can all be negatively affected (USFWS 2012).

Threats to Wildlife

- Increased competition
- Increased predation
- Introduction of disease/parasites
- Hybridization

Threats to Landscapes

- Degradation of biological condition
- Decreased biodiversity

Once established, invasive or undesired species can be extremely difficult to control. Management is both time consuming and expensive. One study by Cornell University researchers estimated that invasive species damage and control costs the U.S. more than $120 billion annually (Pimental et al. 2000). Early detection and rapid response to invasive species is critical. Likewise, collaborating with public and private land managers at a landscape scale increases the likelihood of successful control while reducing the chances of re-establishment. These coordinated and dedicated eradication programs are possible and may have profound, positive effects on native wildlife populations.

Non-native and/or Invasive Animal Species

Invasive animal species are a major concern in Arizona. Whether introduced accidentally through imported goods or purposefully as a source of food or for sport hunting or fishing, when not managed properly, undesirable non-native species can cause a wide range of negative impacts to the environment as well as the economy. Several factors may contribute to their tendency to take over in new environments, including a lack of natural predators and diseases, highly competitive nature, and unique reproductive strategies.

Aquatic invasive species in Arizona are having a devastating effect on native aquatic wildlife through disease introduction, predation, and competition (Dolan and Mannan 2009). Aquatic invasive plants and animals are spread via interconnected waterways (e.g. Colorado River reservoirs), inter- and intrastate movement of watercraft, and the discard of live aquatic wildlife and plants (e.g. pets, bait fish, decorative aquatic plants) into local waters (AZGFD 2016). While AZGFD plays a leading role in control efforts as well as public information campaigns, ultimately it is everyone's responsibility to help control the spread and prevent the introduction of new aquatic invasive species through proper cleaning and decontamination of watercraft as well as appropriately discarding bait.

Quagga Mussels have spread from the Great Lakes to the western U.S. and have infested several important waters in Arizona including lakes Powell, Mead, Mohave, Havasu, Apache, Canyon, Saguaro, as well as the Lower Colorado River drainage, including Lake Pleasant. They pollute the shoreline, damage equipment and infrastructure, alter the aquatic food web, and cost millions of dollars to control. Quagga mussels filter incredible amounts of phytoplankton, reducing the amount available to other organisms, and altering the ecological balance of the lake which can promote the growth of nuisance algae (Invasive Mussel Collaborative 2018).

Problematic Aquatic Animal Species:
Quagga mussels • Zebra mussels • Crayfish • Bullfrogs • Red-eared sliders • Tiger salamanders • Green sunfish • Applesnails • New Zealand mudsnail

Problematic Terrestrial Animal Species:
Feral burros and horses • Starlings • Cowbirds • Feral hogs

The Don't Move a Mussel campaign provides the boating public with guidelines for cleaning, draining, and drying their boats to help stop the spread of this highly invasive mussel. This is currently our best defense as cost-effective eradication methods have not yet been developed, although research is underway (Invasive Mussel Collaborative 2018).

Bullfrogs are not native to the western U.S. They were first introduced in the early 1900s for sport, food, and inadvertently during fish stockings. Bullfrogs reproduce prolifically, laying up to 20,000 eggs in a single clutch and are capable of spreading without human intervention. Bullfrogs compete with and often prey upon many native aquatic species including fish, turtles, snakes, and a variety of invertebrates. Of particular concern are the detrimental effects that bullfrogs have on the federally-listed Chiricahua leopard frog and northern Mexican gartersnake. In addition to preying on or competing with these species, bullfrogs may harbor deadly diseases such as chytridiomycosis that can infect native amphibians (UA 2007). Efforts to remove bullfrogs from habitats where Chiricahua leopard frogs occur or will be introduced is an AZGFD management strategy that has been effective in several large landscapes in southeastern Arizona.

Crayfish are not native to Arizona and were originally introduced as fishing bait and as a biological control for aquatic vegetation in irrigation canals and ditches. Populations have since exploded in our lakes, ponds, rivers, and streams statewide. Crayfish have few natural predators and feed on aquatic plants, insects and other invertebrates, larval fish, snakes, and turtles. They may have played a role in population declines of several of our SGCN including the Chiricahua leopard frog, narrow-headed gartersnake, Sonoran mud turtle, Three Forks springsnail, Gila topminnow, loach minnow, and Little Colorado spinedace. Though anglers can still use crayfish as bait in waters where they are caught, they can no longer purchase, import, or transport live crayfish as bait.

Along with our federal and university partners, AZGFD has explored potential control measures for crayfish including trapping, pesticides, and pathogens (viral, fungal, and bacterial). Nearly all of these control measures have limitations or concerns on effectiveness or incidental impact on non-target wildlife. From a management standpoint, preventing their spread is the best approach because they are difficult to control once established. Continued outreach to the public is one of our best practices to help limit illegal stocking and movement of crayfish by people.

Although aquatic invasive species have caused great concern in Arizona, native species and habitats are also threatened by terrestrial invasive species:

Starlings, which were brought to the U.S. from Europe in the late 1800s, are a highly aggressive species that can take over nests of native birds, destroying eggs and killing nestlings (Dolin and Manaan 2009). They find saguaro cactus cavity nests particularly appealing to the detriment of native species like the Gila woodpecker.

Cowbirds expanded their range into Arizona from the Plains states as farming operations increased here in the early 1900s. They feed on seeds from harvested fields and grain from feedlots. Cowbirds are brood parasites and will lay their eggs in the nests of other species, replacing one or more of the existing eggs so their young are incubated and raised by the host bird. In this way, the cowbird contributes to population declines of some native species, including orioles, thrashers, towhees, and warblers (Audubon 2020).

Cowbirds and starlings are both common in urban areas where homeowners keep bird feeders full of mixes that include millet and cracked corn. One strategy for deterring these species is to use a mix of black oil sunflower seeds and safflower seeds which these invasive birds seem to find less palatable.

Feral burros and horses have become a concern throughout many parts of Arizona. Feral burros and horses compete with native wildlife for forage and water, and have been observed to displace wildlife from water. Reduced access to water is particularly detrimental during drought. Feral burros and horses also alter plant composition, reduce plant diversity and cover, and increase soil compaction and erosion, thereby putting native habitats at risk. Because these non-native species have few natural predators, and effective management options are currently limited, their numbers have grown beyond those determined to be appropriate for federally-designated management areas in most parts of the state. This has resulted in growing concern about their long-term effects on the health of natural habitats and native wildlife. In addition, they have become a safety hazard for motorists in some parts of Arizona.

Resources and Collaborative Management Efforts for Invasive Animal Species

- AZGFD State of Arizona Aquatic Invasive Species Management Plan is a statewide strategy to halt the spread and eliminate, where possible, aquatic invasive species from becoming further established in Arizona waters.
- BLM's Wild Horse and Burro Program provides information on herd management, ways to get involved, and research.

Non-native and/or Invasive Plant Species

Invasive plant species are causing serious ecological and economic impacts by outcompeting native species, and in some cases, taking over entire landscapes. Native habitats, agricultural lands, and parks that are taken over by invasive species require aggressive and costly invasive species management to control the spread and improve the quality of impaired land. Attributes that contribute to a species "invasiveness" include altered phenology, prolific seed production, seed dormancy, resistance to or dependency on fire, and moderate to high rates of dispersal and establishment.

Problematic Aquatic Plant Species:
Giant salvinia • Elephant grass • Hydrilla • Eurasian watermilfoil • Parrotfeather •Brazilian elodea

Problematic Terrestrial Plant Species:
Buffelgrass • Red brome • Cheatgrass • Fountain grass • Sahara mustard • Globe chamomile • Tamarisk • Sweet resin bush • Russian thistle • Tree of heaven • Diffuse knapweed

Many aquatic invasive plant species were first unintentionally introduced from the aquarium trade and aquatic nurseries where they were sold as ornamentals. Following introduction into an aquatic habitat, many of these species can easily spread to new bodies of water by watercraft and equipment. Once established, they can alter the water flow, quality, and recreational value of our lakes and rivers. As these species take over water bodies, they can form thick mats, blocking sunlight and depleting oxygen levels. Hydrilla, parrotfeather, Eurasian watermilfoil, and Brazilian elodea can all spread through vegetative fragmentation, where pieces of the plant break off and take root in other areas. These species are incredibly difficult to eradicate in infested waters, and the best method of controlling the spread is by thoroughly cleaning and draining watercraft and equipment and properly disposing of unwanted bait.

In low-elevation riparian areas, tamarisk (salt cedar) is posing the biggest threat to native systems. An invasive tree, tamarisk has benefited from variability in precipitation and temperature, because it adapts well to warmer and drier conditions associated with climate change. Dense stands along waterways alter surface flow, lower the water table, increase soil salinity, and displace native species. Native cottonwood, willow, and baccharis species suffer, as do wildlife such as threatened western yellow-billed cuckoos that rely on these native habitats. Tamarisk is fire-adapted and once established it is difficult to control due to deep tap roots and the ability to resprout readily when damaged.

In desert areas where fire is not a common ecological process, invasive species including red brome, cheatgrass, buffelgrass, Sahara mustard, and stinknet (a.k.a. globe chamomile) have invaded natural areas, threatened native species, and provide the fuel that allows fires to spread through desert areas. Once the fire burns through an area, these invasive plants are the first to recolonize, replacing non-fire-adapted native species like blue palo verde and the giant saguaro. The frequency and intensity of these fires decreases biodiversity and alters vegetation structure. Meanwhile, forested areas are seeing cheatgrass, dalmatian toadflax, and diffuse knapweed colonize and spread rapidly in severely burned areas (UA 2009). Even fire-adapted native species cannot compete with the rapid germination and growth of these invasives.

Resources and Collaborative Management Efforts for Invasive Plant Species

- Verde River Cooperative Invasive Plant Management Plan, led by Friends of the Verde River, provides a strategic approach for controlling invasive plants in the Verde River Watershed, while increasing community and stakeholder engagement.
- Arizona Department of Forestry and Fire Management Invasive Plant Grant Program provides funding by the State of Arizona and USFS to treat invasive plant infestations that threaten forested, woodland, or rangeland areas.
- Arizona Department of Agriculture Noxious Weed List is the official State list of invasive species that are known to aggressively spread and cause ecological and/or economic impacts. The list includes both species known to exist in Arizona and those that are problematic elsewhere.
- AZGFD State of Arizona Aquatic Invasive Species Management Plan is a statewide strategy to halt the spread and eliminate aquatic invasive species from becoming further established in Arizona waters.

Other Problematic Species

Additional problematic species in Arizona include insects such as bark beetles that can alter and degrade forest conditions, algae that can be highly damaging to native aquatic species and overall water quality, and native aquatic plants that form monocultures and lead to pond succession. These species are difficult to nearly impossible to control once introduced to an area. In addition, native wildlife and plants, in some situations, can be problematic to the maintenance of SGCN species.

Other Problematic Species:
Bark beetle • Non-native bees • Golden algae

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 native invertebrates and perform functions that are instrumental in sustaining forest health. However, in certain conditions the magnitude of impact can cause shifts in vegetative species composition and structure (Haack and Byler 1993). Drought, altered forest conditions, environmental stresses, late spring frosts, wind throw, and air pollution can encourage insect outbreaks (Haack and Byler 1993). For example, closely spaced, single-species stands are more likely to trigger outbreaks than are compositionally and structurally diverse forests, especially during vulnerable periods such as drought (Mattson and Haack 1987, Waring and Pitman 1983).

Overgrowth of some algae in water bodies can be harmful to aquatic wildlife, humans, and the economy. Conditions that promote these algal blooms include ample sunlight, slow moving water, and excess nutrients, especially nitrogen and phosphorus (EPA 2019). Aquatic species are impacted by reduced sunlight, depleted oxygen, and release of toxins to the point where mortality can occur. Some types of algae, including golden algae, a species introduced to Arizona in the past two decades, produce potent toxins leading to extensive fish kills. Algal blooms can have negative impacts to the economy when popular recreational water bodies are overcome with a scum-like surface of algae. Humans may be at risk if toxins are ingested, for example those toxins produced by microcystin. Not

all algae are toxic, however, and the Arizona Department of Environmental Quality monitors water quality and reports of algal blooms to protect our water bodies and keep Arizonans informed of potential safety concerns. In order to stop the spread of algae and other invasive aquatic species, it is critically important to thoroughly clean, drain, and dry watercraft and equipment and never move water, live animals, or plants from one body of water to another.

Some native aquatic plants can form dense monocultures and negatively-impact desired wildlife species in an area. For example, there are many ponds in Arizona that house refuge populations of Gila topminnow and desert pupfish. Native cattails, bullrushes, and various types of submersed vegetation can colonize these ponds, increase in abundance, leading to pond succession, where the lentic habitats gradually turn into a wetland, thus eliminating the fish habitat. It is therefore necessary to periodically control these types of vegetation to maintain fish habitat.

Occasionally, native wildlife can be problematic to the detriment of SGCN species. For example, American beavers are great modifiers of aquatic and riparian habitat and contribute to the overall health of these systems. Beaver activities can transform a stream from a series of pool-run-riffle sequences, to one more dominated by pools, thus affecting the fish assemblage. For riffle-occupying species like loach minnow, the disappearance of riffles will lead to the local disappearance of the species. Therefore, to maintain a recovery population of the endangered loach minnow, it may at times be necessary to control beaver.

9. Natural System Modifications

Changes in natural processes and ecological drivers influence all wildlife habitats in Arizona and the Southwest. While some habitats are more resilient or resistant to these modifications than others, the increased pressures from multiple interacting threats can take a toll on even the most resilient systems.

Hydrologic alteration of flow regimes, stream channelization, land management practices, and fire suppression are a few of the natural system modifications that have adverse effects on Arizona's natural communities. These modifications can fragment, convert, or destroy habitats, and greatly alter 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). As a result, the integrity of many terrestrial and aquatic habitats have been severely degraded at the population, community, and species levels of biological organization (Frissell 1993).

Fire and Fire Suppression

Wildfires were once an integral process in many forest, woodland, shrub, and grassland ecosystems in Arizona, and many of these habitats are considered fire-adapted. Fires stimulate grass and forb growth, cycled nutrients, and reduce fuel loads that could contribute to more severe fires in the future (Johnathan et al. 2020). A century of suppression along with a combination of climatic factors and human influence has created optimal conditions for devastating fires that are difficult, if not impossible, to control in forested landscapes. Unnaturally dense canopies, increase in small trees

and ladder fuels, lack of understory grasses and other herbaceous vegetation, increased fuel loads, and invasive species are a few of the characteristics of these altered landscapes. The tendency of fires in these areas to burn extremely hot and fast reduces many of the ecological benefits and puts humans, property, and wildlife at risk. Population growth and development within and adjacent to fire-adapted landscapes is a contributing factor because fire suppression is often implemented for protection, thereby altering the natural fire regime that these ecosystems rely on.

Grasslands

Fire suppression and intense grazing has led to shrub encroachment, proliferation of non-native species, and soil erosion in areas that once were dominated by native perennial grasses and forbs. Additional factors such as climate variability (especially rainfall patterns) can have significant influence on community composition and extent, while fragmentation can contribute to altered fire regimes by limiting fire spread (Geiger and McPherson 2005).

Threats to Wildlife

- Direct mortality
- Disturbance of critical life stages

Threats to Landscapes

- Increased fire intensity
- Altered fire return interval
- Altered hydrological processes
- Changes to composition and structure
- Decreased biodiversity
- Conversion/loss
- Isolation/fragmentation

Some grassland-dependent birds, including the Arizona grasshopper sparrow, Chihuahuan meadowlark, short-eared owl, chestnut-collared longspur, Baird's sparrow, and Sprague's pipit, prefer more extensive, open native grasslands with limited areas of woody shrub for breeding or for wintering.

Both intense grazing and fire suppression promotes the expansion of shrub species that, in turn, out-compete native forbs and grasses. Pronghorn, and other grassland-obligate species are highly dependent on these open grasslands in order to meet their daily and seasonal nutritional requirements. The major limiting factors for pronghorn are poor fawn recruitment rates, a result of combined poor habitat conditions, lack of nutritional forage, and predation.

Several rangeland conservation programs exist to assist ranchers in increasing productivity and resilience in Arizona's grasslands. See AZGFD's Landowner Incentive Programs for information about these programs.

Forests and Woodlands

Historically, naturally occurring fires within Arizona's ponderosa pine and lower mixed-conifer forests and woodlands were frequently low-intensity fires. These fires helped maintain stands of older trees with an open, park-like structure (Moir and Dieterich 1988). At higher elevations, mixed conifer and spruce-fir forests (wetter forest types) exhibited less frequent fire return intervals, and fires were generally stand-replacing fires of higher intensity (Pyne 1984, Walstad et al. 1990, Agee 1993). Improper grazing practices and systematic fire suppression over the past century combined with prolonged drought, has altered herbaceous vegetation composition, increased fuel loading, and

stimulated development of ladder fuels, leading to increases in fire size, frequency, and intensity. As disturbance regimes shift outside the ranges to which dominant species are adapted, potential for post-fire forest regeneration to prior composition and structure may be compromised (Coop et al. 2020).

In the southwest, evidence of ecosystem conversion has been cited in the Jemez Mountains of New Mexico where a series of three large, severe fires burned through the forest over a 25 year period (SW CASC 2020). The conifer forests in many areas have been replaced by shrublands as shrubby and herbaceous species quickly resprout after fires. Related studies have only recently been initiated, so it is unknown when, or if, the conifer forests will regenerate in these severely-burned areas. Smaller-scale community type conversions have occurred post-fire in the Santa Catalinas of southeastern Arizona where shrubland has replaced mixed-conifer forest. Likewise, on Mount Elden just outside Flagstaff, areas once dominated by ponderosa pine forests are now open grassland more than 40 years post-fire (Falk et al. 2019).

The Four Forest Restoration Initiative (4FRI)

Since 2009, AZGFD has played an integral role in the Four Forest Restoration Initiative (www.4FRI.org), which was created in order to accelerate an ambitious, landscape-scale restoration program to improve and sustain watershed health, enhance wildlife habitat, promote the reintroduction of natural fire, and improve overall forest resilience. This initiative includes Prescott, Tonto, Apache Sitgreaves, Kaibab and Coconino national forest lands, and spans 2.4-million-acres across Arizona.

The 4FRI stakeholders include members of local, county, and state governments, NGOs, institutions, and industry representatives, many of whom are involved in work groups that focus on different initiative components and special projects. A key strategy with this initiative is the utilization of appropriately-scaled business and industry to harvest, process, and sell wood products. This will reduce treatment costs and provide restoration-based work opportunities that will create jobs.

As the southwest continues to experience extreme wildfire events coupled with increased temperatures and long-term drought, researchers are exploring management options and predicted outcomes based on three categories:

- **Resistance**: Actions that attempt to preserve existing ecosystems (i.e. forest thinning)
- **Recovery:** Actions intended to reestablish vegetation types that existed previously (i.e. replanting)
- **Reorganization:** Actions that acknowledge the inevitable conversion of an ecosystem and work within the context of climate change to allow a novel community to establish

Many of our grasslands have experienced increases in woody encroachment which reduces the available habitat for grassland-dependent species such as black-tailed prairie dog and black-footed ferret. Increased fuel loads and climate change have resulted in unpredictable fire patterns in many

mountainous habitats which impact New Mexico meadow jumping mouse by both removal of vegetation and degradation of the riparian habitat with post-fire flooding. Fire suppression, livestock grazing, and logging on Mt. Graham in the Pinaleño Mountains has resulted in larger, high-intensity wildfires which directly removes habitat for endangered Mt. Graham red squirrel that can take decades, if not centuries, to replace.

Desertscrub

Desertscrub landscapes historically had very low wildfire frequencies. Although lightning occasionally ignites desert fires, low fuel volumes and sparsely distributed vegetation would ordinarily prevent the significant spread of fire (McLaughlin and Bowers 1982; Brooks 1999). However, inappropriate grazing regimes, rangeland modifications, and climate variability have contributed to large-scale invasion by a variety of invasive grasses and forbs. This increase in fine fuels has resulted in an increase in catastrophic wildfires in the Sonoran and Mohave deserts (Brooks 1999; Esque and Schwalbe 2002; Brooks and Matchett 2006). Larger fires and shortened fire return intervals further alter desertscrub by favoring non-native vegetation over native perennial species (Brooks and Chambers 2011). In the Sonoran Desert, long-lived species such as saguaros and palo verdes that evolved in a fire-free setting, are particularly vulnerable. In some instances, native species thresholds are exceeded such that native desert shrublands are being converted to non-native annual grasslands (Brooks and Pyke 2001; Esque and Schwalbe 2002).

Desertscrub communities are home to several SGCN reptiles and amphibians that may lack the adaptive capacity to respond favorably to altered fire regimes. Although studies of the effects of wildfires on reptile species occupying desertscrub habitat are limited, direct mortalities have been documented during post-fire surveys (Esque et al. 2003; Simons, 1989). Indirect effects of wildfires including vegetation-type conversion, reduced structural complexity, altered thermoregulatory conditions, and reduction in food resources also pose a threat to the abundance and diversity of reptile and amphibian species in desert systems.

Riparian Areas

Stochastic events such as wildfire and post-fire flooding pose serious threats to riparian habitats and native fish populations, particularly in systems already impacted by drought and invasive species. Altered timing of fires, higher fuel loads, broader geographic extent, and increased fire intensity can produce substantially greater quantities of sediment/ash and cause greater loss of native vegetation (Coop et al. 2020). Meanwhile the resulting soil instability reduces infiltration and increases run-off which can have an immediate and detrimental effect on fish and amphibians (Ketcham and Koprowski 2013). Accumulation of the increased sediment may also alter habitat, and reduce water quality, especially dissolved oxygen.

Many native fish populations are now isolated into headwater habitats upstream of barriers, and this can protect them from downstream threats. However, large-scale wildfires can completely eliminate riparian habitat zones and post-fire floods can eliminate entire fish populations. For example, the Wallow Fire of 2011, Arizona's largest wildfire in history, eliminated or severely impacted several

native trout populations and the loss of riparian habitat resulted in high water temperatures above the optimal suitability for trout. These factors make wildfire and post-fire floods one of the greatest threats to native fish in the state.

Dams and Water Management and Use

The combination of an arid climate, highly-populated metropolitan areas, and a substantial agricultural industry makes Arizona's water resources both highly valuable and highly vulnerable. The chart below from the Arizona Department of Water Resources summarizes Arizona's water supply sources (Figure 3).

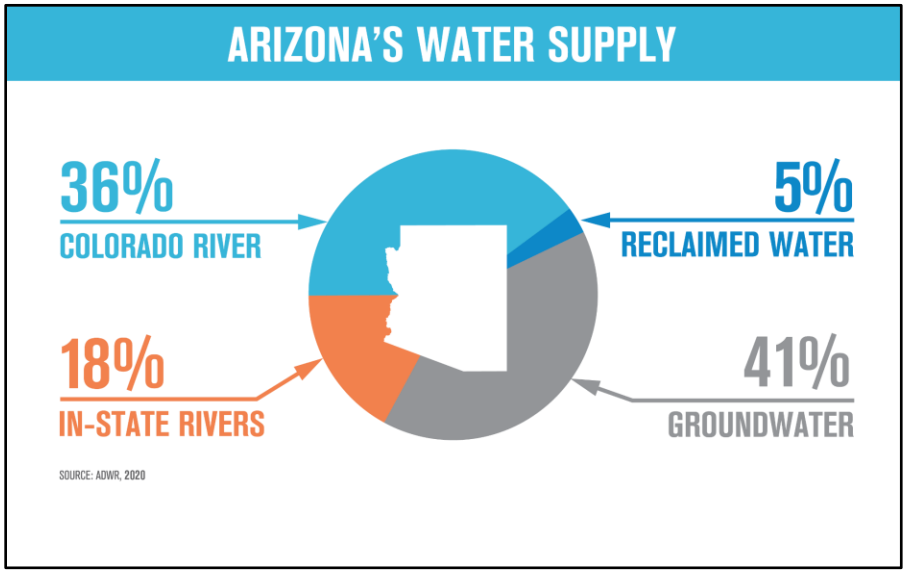

Figure 3: *Arizona's portfolio of water supply (ADWR).*

Agricultural and urban areas have always depended on groundwater pumping, dams, reservoirs, channelization projects, and water diversion structures to meet their water demands (Cheney et al. 1990). These water diversion tools divert water out of natural channels which changes the natural variability of stream flow quantity, timing, and frequency across both time and space. The changes to stream flow affect several aspects of the river and riparian habitat, such as physical structure, energy flow, sediment transport, water temperature, and water quality. In turn, these changes impact aquatic and riparian plant and animal species (Ffoliott et al. 2004).

In addition to altering the quantity, timing and duration of surface flow, dams and impoundments also create barriers that fragment species ranges, preventing upstream and downstream movement of fishes and other aquatic species, including riparian plant dispersal. The manner in which a dam regulates water flow can also have significant impacts on the floodplain both upstream and downstream. The altered disturbance regime places additional stress on native species while creating opportunities for non-native species to take hold and invade the vulnerable areas, to the point of becoming the dominant vegetation.

Groundwater drawdown for agricultural, municipal, and industrial uses has and will likely continue to cause aquifer reductions, resulting in loss of stream connectivity and riparian habitat (Zaines 2006). The resulting loss of groundwater discharged as surface flow reduces connectivity and is a major concern that may intensify as a result of extended drought conditions related to climate change. While all riparian habitat is dynamic and subject to natural cycles of loss and regeneration, fragmentation and loss related to groundwater depletion can have considerable effects on small ciénegas, springs, seeps, marshes, alluvial valley aquatic and riparian areas and their associated species (Tiller, Hughes, and Bodner 2012). For example, spring "improvements," in which spring output is captured in collection structures and exported to make it available to human-determined uses, limits the extent of the wetted zone in the ciénega or around the spring, changing the biological structure of these highly diverse, increasingly rare habitats (Minckley 2013). Wildlife are affected either through diminishing water availability or, in the case of many native amphibian and invertebrate species, degradation or total loss of habitat.

While Arizona's intense water management techniques have substantial anthropogenic benefit, the modifications and disturbances lead to degraded and fragmented habitat that is unable to support the historically rich suite of native species that would otherwise thrive in our aquatic and riparian systems. For example, the creation of dams and reservoirs in the Colorado River, including Glen Canyon Dam in 1963, and the construction of the dams and reservoirs on the Salt River from 1912-1958, altered the flow regime and temperatures, impacting several endemic species including Colorado pikeminnow, humpback chub, razorback sucker, and bonytail. The four species were subsequently listed as endangered and recovery efforts have been underway for decades. The creation of the Central Arizona Project (CAP) canal, which delivers Arizona's allocation of Colorado River water, was predicted to result in the introduction of undesirable non-native species to central Arizona watersheds and which the USFWS determined was likely to jeopardize the continued existence of spikedace, loach minnow, Gila chub, and the Gila topminnow, all of which are listed as endangered.

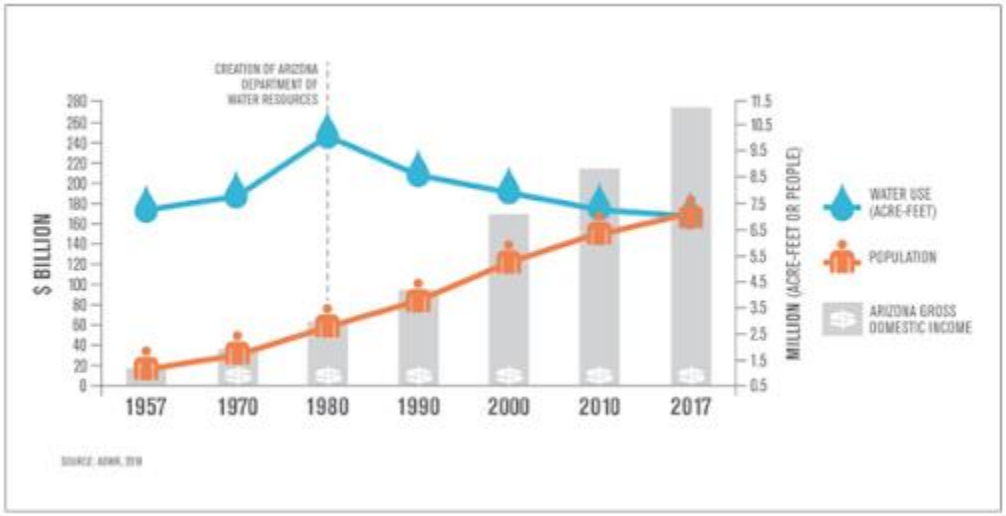

Figure 4: *Arizona's water use vs. population in recent decades (ADWR).*

According to the ADWR, the overall water use in Arizona has decreased over the last 30-40 years even with a considerable increase in population as shown in Figure 4. The reduction is attributed to investments in water conservation and infrastructure and the reuse of water (ADWR 2021).

10. Pollution

Pollution in its many forms is a threat to wildlife and human health. Household sewage, urban water waste, mine tailings, and agricultural runoff make their way to aquatic systems and impact water quality, degrade habitat, and in some cases make it unsuitable for fish and wildlife and unsafe for humans.

Rodenticides and lead-based ammunition pose mortality threats to many raptor species. Although the number of raptor deaths associated with secondary poisonings is not well known, many individual mortality events have been documented. Non-lethal levels of rodenticides and lead may lead to a variety of survival, reproductive, and developmental issues.

Threats to Wildlife

- Disturbance of critical life stages
- Direct mortality

Threats to Landscapes

- Degradation of biological condition

Illegal dumping is a completely preventable threat that exposes humans and wildlife to chemicals and toxins and can result in trash entering waterways and degrading water quality. In addition, the quality of recreational activities is reduced when natural areas are overrun with trash and debris.

Discarded or lost fishing line and tackle is also a threat to wildlife, especially riparian birds as they collect it for nest material (Hunt et al. 1992; Beatty et al. 1998). Other wildlife species may become entangled while swimming or visiting lake shorelines and they can ingest material while feeding on dead fish. Recovering lost fishing line when possible can greatly reduce this threat to wildlife.

Wildlife are negatively impacted by pollution in multiple ways. Directly ingesting or absorbing chemicals or feeding on species that have accumulated toxins can lead to increased physiological stress, susceptibility to disease, pathogens, and parasites, and mortality. Their habitat is also altered and degraded when chemicals and waste are transported to natural environments.

This is a conservation challenge that each of us contributes to in some form every day. By considering the potential impacts of our actions and choosing environmentally-friendly alternatives where possible, we can all play a role in reducing the impact of pollution to wildlife and natural communities and improve the quality of life for all Arizonans.

11. Transportation and Service Corridors

Meeting the needs of Arizona's growing population requires upgrading existing transportation and service corridors as well as constructing new transportation infrastructure. Large-scale projects like the proposed I-11 corridor, which will connect Las Vegas to southern Arizona, and smaller scale improvements such as widening or paving county roadways are constantly being planned for and implemented across the state. Considering the impact these projects may have on wildlife and their habitats, and making design or siting modifications to reduce these impacts where possible, can streamline the environmental compliance and approval process while also contributing to the conservation of Arizona's wildlife and the safety of motorists traveling roadways.

Threats to Wildlife

- Direct mortality
- Disruption of critical life stage
- Reduced gene flow
- Reduced dispersal ability

Threats to Landscapes

- Degradation of biological condition
- Isolation/fragmentation

All animals move across the landscape to varying extents in order to acquire the resources necessary for survival such as food, water, protective cover, and mates. Large animals such as mountain lions, black bears, elk, and mule deer may roam over vast expanses that can encompass thousands of acres, while smaller animals such as tassel-eared squirrels and northern leopard frogs engage in essential movements on a much smaller scale (Van Riper and Ockenfels 1998). Some animal movements occur on a daily basis, while seasonal migrations may occur annually, and the dispersal of young from their natal sites to secure new breeding territories happens only once in an individual's lifetime. Man-made infrastructure can affect each of these movement patterns and may pose a threat to the long-term persistence of wildlife populations (Watson and Klingel 2006). Anthropogenic infrastructure can create both physical barriers and behavioral barriers to wildlife movement. Physical barriers encompass a wide range of features such as roadways, irrigation canals, residential and commercial development, fencing, and changes to habitat. Behavioral barriers may occur when wildlife species avoid areas near roads and railways related to the degree of human disturbance, such as traffic density and secondary development (Luell et al. 2003).

Roadways

Connecting communities and providing goods, services, and economic opportunities are essential functions of our transportation infrastructure. As Arizona's population grows, more efficient connections are required to meet our needs and those of our visitors. With this increase in highway, road, and urban development, we've also seen increased interactions with wildlife and fragmentation of their habitat. Each year in the United States more than 200 motorists are killed and thousands more are injured in animal-vehicle collisions (Huijser et al. 2008). Countless animals are injured or killed while property damage is measured in the millions of dollars.

While human and wildlife safety concerns are of highest priority, construction and modification of transportation corridors present additional ecological challenges. Ground disturbance associated

with roadway construction, and vehicles traveling on the roadways once operational, can introduce or spread invasive plant species across right-of-ways and onto adjacent lands. Pollution by toxins, nutrients, and noise from the transportation corridor can create edge effects on adjacent hydrology and microclimate, reducing the suitability of the remaining habitats (Murcia 1995; Reijnen et al. 1995; Boarman and Sazaki 2006; Eigenbrod et al. 2009; Parris and Schneider 2009). These effects spread into the surrounding landscape and contribute to the loss and degradation of natural habitat several times larger than the area of the road footprint itself. The effects are influenced by road and traffic characteristics, landscape topography and hydrology, wind, and vegetation. In addition, the resulting impacts on wildlife also depend on the sensitivity of the species in the vicinity.

Table 2: *Examples of AZGFD-led wildlife crossing projects completed in recent years.*

Yr. Completed	Installation of Wildlife Crossing Structure
2000-2006	11 crossing structures and 6 bridges that function as crossing structures installed along State Route 260
2007	Roadside animal detection system on State Route 260
2013	2 wildlife underpasses along State Route 260
2011	3 overpass structures along US 93 just south of Hoover Dam and the Nevada state line
2016	2 crossing structures (1 overpass and 1 underpass) north of Tucson on State Route 77
2018	6 crossing structures (1 overpass, 5 underpasses) along the Boulder City Bypass portion of I-11

Road and bridge construction 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 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).

The negative effects associated with road construction and improvements can often be reduced and/or mitigated by identifying and accommodating fish and wildlife movement areas during early stages of roadway design. The Federal Highway Administration's (FHWA's) Wildlife Crossing Structure Handbook (FHWA 2011) and ADOT's Integrated Roadside Vegetation Management Guidelines and Clean Water Act Guidance Manual provide general guidance on designs that minimize roadway impacts to wildlife movement.

Identifying important wildlife movement areas during the construction of new roads or improvements allows for the informed siting of wildlife-friendly over- and underpasses and exclusionary fencing that can greatly reduce the likelihood of wildlife-vehicle collisions and

decrease the roadway's habitat fragmentation impact. AZGFD conducts numerous studies on wildlife movement to identify movement corridors that can then be incorporated into the planning process for roads and highways (Table 2). Through partnerships with FHWA, ADOT, and Nevada Department of Transportation, and others, crossing structures have been installed in several high traffic areas throughout the state, providing safe movement corridors for many species of wildlife and greatly reducing the number of wildlife-vehicle collisions.

Flight Paths

Low-level flights by fixed-wing and rotary aircraft can startle and change behavior in some mammal and bird species. Those species thought to be particularly susceptible include pronghorn, bighorn sheep, raptors, and waterfowl (Efroymson et al. 2001). However, studies of species responses to low-level flights are generally lacking for several taxonomic groups including reptiles, bats, and invertebrates.

The visual image and sound of aircraft can stress wildlife, and may interfere with feeding, mating, nesting, fledging, and predation. Direct mortality of wildlife due to physical collision has been reported especially where flight paths are in close proximity to habitat and migration routes (Efroymson et al. 2001). The Federal Aviation Administration (FAA) maintains a database of aircraft/wildlife strikes (FAA Wildlife Strike Database) and documented more than 1,500 between 2010-2020 in Arizona (FAA 2021). The vast majority of these reports involved birds, although other taxa including bats and rabbits have also been documented. 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.

Utility and Service Lines

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). Collision and electrocution may both cause wildlife mortality, with some research estimating that up to 57 million individual wildlife are killed by collisions and another 11.6 million individuals die from electrocution each year in the United States (Loss et al. 2014). Raptors are particularly vulnerable due to their tendency to perch or nest on transmission lines.

The Avian Power Line Interaction Committee (APLIC) developed guidelines for protecting birds on power lines. The suggested practices are aimed at either providing the birds with an alternative safe place to perch or discouraging birds from landing on potentially unsafe areas of the pole (APLIC 2006). Modifying conductor separation and grounding procedures are two primary considerations that can be applied to new and existing transmission lines. Additionally, retrofitting pole-tops of existing transmission lines is a commonly used technique to prevent electrocution. Collisions can be reduced by using devices to increase line visibility (Eccleston and Harness 2018).

Utility corridors also impact other wildlife species by fragmenting habitat, creating disturbance from authorized and unauthorized use of access roads, contaminating areas due to application of herbicides in right-of-way maintenance, and the introduction of non-native plant species. Power

companies like Arizona Public Service (APS) have adopted standards for right-of-way management that allow for low-growth vegetation rather than mowing and broadcast-spraying (Right-Of-Way Stewardship Council 2016). As human populations continue to encroach upon and fragment wildlife habitat, appropriate planning and management of utility corridors will likely become increasingly important.

Chapter 4: A Comprehensive Conservation Approach

The same environmental conditions that help foster the diverse array of wildlife and habitats in Arizona have also made our state a very attractive area for humans as well. Warm winter climates in the lower elevations and cool summers in the high country, along with a prospering economy and a myriad of outdoor recreational opportunities, have encouraged an increasing number of people to visit our state and to call Arizona home.

Whether educating our children, serving our country, raising cattle, working the fields, caring for the ill and elderly, or designing innovative new technologies, Arizonans work hard to ensure our state remains safe, prosperous, and filled with outstanding opportunities for all walks of life. Just as important — and equally fulfilling as opportunities for growth and development — are opportunities to play, to relax, and to connect with the great outdoors. Arizona's open spaces, natural beauty, and diverse flora and fauna contribute to the state's attractiveness and the high quality of life for residents. These natural resources also provide significant contributions to the state's economy through activities such as wildlife watching, hunting and fishing, hiking, OHV use, and much more.

As we continue to grow, build, and expand our recreation footprint, we put tremendous pressures on Arizona's natural communities. Infrastructure expansion, recreational pressures, and increased water usage are resulting in significant habitat degradation, fragmentation, and loss. At a landscape level, this disturbance impairs essential processes that not only sustain wildlife, but also provide services to humans, including food production, protection from natural hazards, purification of air and water, and climate regulation (SWASC 2020). In a recent study by the Center for the Future of Arizona (CFA), 80% of 2,000 respondents between 18 and 40 years of age ranked planning and policies that balance natural resource sustainability with opportunities for economic growth as one of their largest concerns (Center for the Future of Arizona 2020). Balancing these needs will require innovative partnerships, forethought, and careful planning to facilitate development and economic prosperity while maximizing conservation of our precious natural resources.

Public Lands

More than 40% of Arizona's landscape exists as public lands, much of which has some level of protection and/or is managed for multi-use. Through partnerships and collaboration, a great deal of effort is put forth to maintain and restore the value of these open spaces for Arizonans and for wildlife. Table 3 shows a general breakdown of land status in Arizona. The corresponding map (Figure 6) shows ownership and management spatially (ASDM 2020).

Table 3: Percentages of land ownership in Arizona (ASLD October 2010).

Jurisdiction/Landowner	Percent of State Acreage
Bureau of Land Management	16.69%
Bureau of Reclamation	0.24%
National Forest	15.3%
National Parks and Monuments	3.55%
Military	3.78%
National Wildlife Refuges	2.35%
Total Federal Lands	**41.43%**
Tribal Lands	27.57%
State Trust Lands	12.73%
Arizona Game and Fish Department	0.05%
Local or State Parks	0.22%
Private	17.52%
Total All Lands	**100%**

Working Landscapes

Private landowners are important conservation partners in Arizona. Nearly 18% of Arizona's land is privately owned, a large portion of which can be classified as working landscapes such as farms and ranches. These areas bridge the gap between highly-developed urban centers and more rural natural areas. In addition, grazing allotments are common among the sprawling federally-managed public lands in Arizona. In a state experiencing so many changes, these working landscapes — and the people who manage them — play an increasingly important role in providing habitat for wildlife and corridors for wildlife movements.

Landowner Incentive Programs

A variety of opportunities exist for private landowners to contribute to conservation in Arizona. Many of these programs lead to substantial benefits to agricultural operations through increased productivity. The AZGFD Landowner Relations Program (LRP) is a statewide program that focuses on partnering with private landowners and agricultural producers to implement mutually beneficial habitat projects and secure public recreational access. The LRP provides support for projects that demonstrate benefit to multiple wildlife species. Within the LRP, several subprograms exist that

target different interest groups and individuals, offer diverse benefits, and contribute to wildlife conservation at local and landscape scales.

Several other federal landowner incentive programs are also active in Arizona. Some of these include:

- ADEQ Water Quality Improvement Grant Program (WQIG)
- NRCS Environmental Quality Incentives Program (EQIP)
- NRCS Agricultural Conservation Easement Program (ACEP)
- NRCS Conservation Stewardship Program (CSP)
- NRCS Regional Conservation Partnership Program (RCPP)
- NRCS Healthy Forests Reserve Program (HFRP)
- USFWS Partners for Fish and Wildlife Program

The USFWS also provides opportunities for landowners to contribute to the recovery of species listed as endangered or threatened under the Endangered Species Act (ESA) as well as those species currently being considered for listing. Examples include Safe Harbor Agreements (SHAs), Habitat Conservation Plans (HCPs), Candidate Conservation Agreements with Assurances (CCAAs), Candidate Conservation Agreements (CCAs), and Conservation Banking. See the USFWS Endangered Species webpage for details.

Arizona's Approach to Wildlife Conservation

As the state's wildlife agency, AZGFD is responsible for conserving and managing Arizona's fish and wildlife. Meanwhile, we strive to provide wildlife enthusiasts with a rich outdoor recreational experience while navigating the conservation challenges that come with rapid growth and a thriving economy. It's a complex balancing act to meet the needs of so many constituents while ensuring the future of the state's wildlife and their habitats. To do this effectively, we rely on sound science, a driven and passionate team of experts, partnerships with outside groups and agencies, and input from equally driven and enthusiastic Arizonans. Together, we are all stewards of Arizona's lands and natural resources and we all play a role in the care and protection of the valuable resources our state has to offer. Working together, we ensure that future generations will be afforded the same outstanding opportunities to enjoy Arizona's natural beauty and rich biodiversity.

Our new conservation approach under the AWCS has three main components:

1. **Habitat-based conservation:** Identify threats to habitats and prioritize conservation actions that benefit multiple species.
2. **Data management:** Collect, manage, and interpret data and information to guide management decisions; these resources will also be used in web-based conservation tools for planning and general public use.
3. **Conservation actions:** Identify actionable and feasible conservation actions to reduce or eliminate threats while identifying conservation areas that benefit individual species, a suite of species, and/or their habitats.

A Habitat-based Approach

For this latest revision of our 10-year comprehensive conservation plan, the AWCS takes a holistic, habitat-based approach to wildlife conservation in Arizona. Utilizing systematic priority setting, Chapter 7: Habitat Profiles identifies primary threats to the seventeen major habitats throughout Arizona. Chapter 8: Threats and Conservation Actions then describes a suite of specific conservation actions that can be implemented to address each threat by habitat type.

Examples of habitat-based conservation actions may include:

- Protect wildlife corridors essential to the movement of species
- Acquire land and water rights to pursue conservation agreements
- Partner with agricultural producers on projects that benefit livestock and wildlife
- Control the spread of invasive and problematic species

In each habitat profile found in Chapter 7: Habitat Profiles, we've identified Conservation Opportunity Areas (COAs). The COAs reflect collective conservation priorities identified during a series of focus group discussions with partners across Arizona, as well as in-house analyses by species and habitat experts, to identify areas on the landscape where conservation actions can be implemented. Results of these efforts identified more than 300 aquatic COAs and 130 terrestrial COAs. These COAs represent focal areas on the landscape with high conservation value and potential for successful project outcomes. Detailed profiles of COAs can be found in Appendix G: Aquatic COA Profiles and Appendix H: Terrestrial COA Profiles.

This new habitat-based approach has several advantages, one of which is a shift to integrated species management, instead of single-species management. Through careful consideration of the potential effects of a proposed action on multiple species in a given habitat, we can prioritize actions that will lead to greater benefit for more species, while more effectively leveraging limited conservation dollars and other resources.

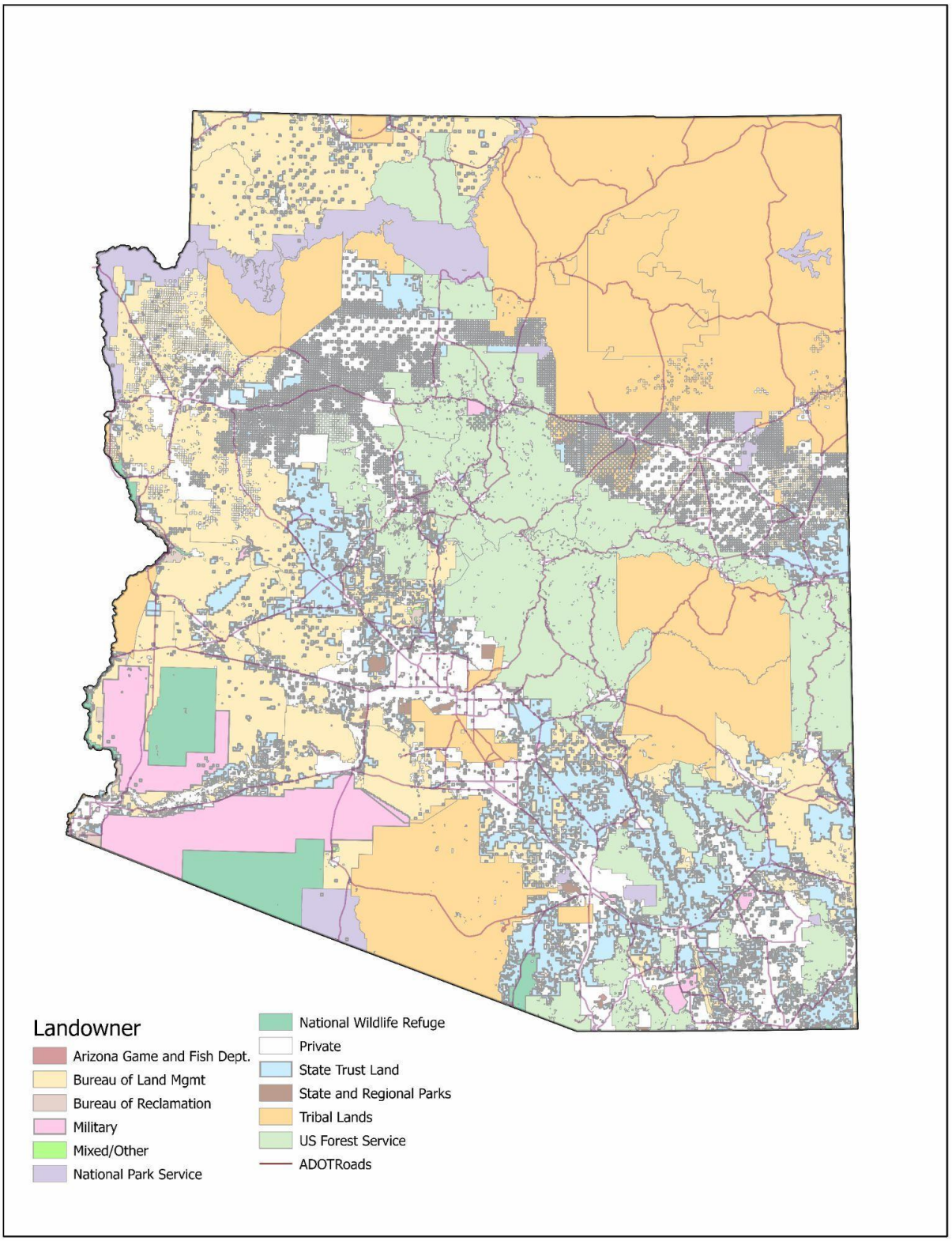

Figure 5: *Spatial representation of land ownership across Arizona. (ASLD).*

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Adopting an approach that addresses the needs of multiple species and prioritizes actions that capitalize on these opportunities will be of ever-increasing importance as we face large-scale threats like climate change and development, which have the potential to alter habitat conditions faster and to a greater extent than ever before. When faced with the complexity and magnitude of current and emerging threats, conserving large intact habitat blocks and preserving connectivity may be our best strategies for maintaining biodiversity into the future.

Case Study: Coordinating Avian Research

Arizona's avifauna is particularly diverse with more than 500 native bird species documented in the state (Corman and Wise-Gervais 2005), many of which have a significant portion of their distribution (seasonal or year-round) in Arizona. To understand the magnitude of threats on bird populations and to help mitigate those threats, a myriad of interested partners formed the Arizona Bird Conservation Initiative (ABCI) in 1991. Coordinated by AZGFD, ABCI is a voluntary partnership of government agencies, conservation groups, academic institutions, private businesses, and citizens working to conserve, monitor, and enhance bird populations and their habitats with the goal of "keeping common birds common."

An integral component of ABCI, is the Arizona Coordinated Bird Monitoring Program (AZCBM), which coordinates existing projects, supports projects implemented by partners, and collaborates on the design and implementation of new projects with interested stakeholders. Some of these projects are part of long-term national efforts, others are statewide breeding bird monitoring, while still others are one-time surveys to address a specific data need, such as the North American Breeding Bird Survey, Grassland Bird Surveys, and the Colonial Waterbird Nest Survey. These projects determine species status, distribution, and long-term population trends for breeding and wintering birds in Arizona, including many SGCN.

These and other monitoring efforts completed as part of the AZCBM provide data to support inclusion or removal of species from the list of SGCN and in prioritization of those species. It also documents AZGFD's goal of keeping common species common and highlighting declining species in which research and conservation efforts are needed.

Leveraging Wildlife Data: The Wildlife Data Warehouse (WDW)

Proper collection, analysis, and interpretation of data are all important components of conservation efforts. So too is data management. Currently, AZGFD is gathering all relevant wildlife data collected by staff, by our partners, and by the general public to be housed in a centralized data storage system, known as the Wildlife Data Warehouse (WDW). Applications are being built to improve data sharing

and access to comprehensive data sets from multiple sources. The WDW will allow AZGFD and partners to utilize the full power of data to inform decisions and plan for conservation.

Web-based applications that are part of the AWCS include AZGFD's powerful Arizona's Online Environmental Review Tool (ERT) for data visualization, and the forthcoming Conservation Analysis Tool (CAT), which is designed to facilitate development while minimizing effects on wildlife. The ERT is a project analysis tool utilized by the general public, industry, other government agencies and AZGFD alike. The CAT, under the guidance provided by the AWCS, seeks to bridge the gap between industry and conservation by facilitating strategic development that minimizes effects to wildlife and important habitat through data-driven analysis and careful siting. Both the ERT and CAT utilize COAs and other data from the WDW to address remaining effects by identifying specific locations on the landscape where opportunities exist to directly benefit individual species that are being affected. In many cases, CAT outputs can identify conservation options that will also benefit additional species that utilize the habitat. Tools like the ERT and CAT make the AWCS a powerful comprehensive conservation strategy for all Arizonans.

In order to make sound management decisions, land and resource managers, planners, and developers must have access to biological data. Likewise, they must also understand and appreciate how ecological systems, and the species they support, are affected by our actions. Because humans now influence all landscapes in Arizona, it is essential that we plan responsibly to lessen the adverse impacts caused by continued development and economic growth. By providing wildlife data and decision-support tools today, the AWCS creates an innovative platform to facilitate responsible conservation actions for tomorrow and beyond.

Conservation Actions

Conservation actions are specific actions that can be taken to address threats to species and their habitats. These conservation actions are identified in Chapter 8: Threats and Conservation Actions and later detailed in Appendix G: Aquatic COA Profiles and Appendix H: Terrestrial COA Profiles. Conservation actions are intended to be implemented through fostering partnerships and coordination of prioritized activities. In order to identify these conservation actions and make meaningful impacts, AZGFD received extensive input from federal, state, and local government, Tribal nations, NGOs, industry, and private citizens.

The conservation actions identified throughout the AWCS may be implemented at three basic scales:

1. **Landscape-level actions** are developed through collaboration with multiple entities and typically implemented over the course of several years. Projects may extend across different habitat types, or in some cases, statewide. An example of landscape-level actions are the projects implemented as part of the Four Forest Restoration Initiative (4FRI) which spans multiple National Forests across northern Arizona with goals of restoring ecosystem processes and improving forest resiliency. Broad suites of species will benefit from such efforts.

2. **Site-specific actions** focus on a specific habitat and typically benefit multiple species. Examples of site-specific actions that may be implemented include the riparian area restoration projects occurring at the Sipe Wildlife Area, an AZGFD property. This habitat restoration project was designed to improve stream bank stability, reduce erosion, remove invasive plant species, and replant native plant species. These efforts will improve habitat for a suite of taxa that depend on healthy riparian habitats, including Little Colorado spinedace, tiger salamander, terrestrial garter snake, waterbirds, and many more.

3. **Species-specific actions** are more targeted efforts that address the needs of a specific species or group of species. An example of a species-specific action is AZGFD's efforts to re-establish black-footed ferrets near Aubrey Valley. Black-footed ferrets are an endangered species that depend upon sufficient densities of prairie dogs for both food and shelter.

Classification of Conservation Actions

Conservation actions used in the AWCS were developed from the classification standards established through a partnership between the International Union for the Conservation of Nature (IUCN) and Conservation Measures Partnership (Salafsky et al. 2008). Much like the threats identified in the habitat profiles of the AWCS (Chapter 7: Habitat Profiles), these conservation action classifications rely on a standardized lexicon in an effort to better facilitate regional collaboration between states and other entities utilizing state wildlife action plans. Conservation actions for each habitat type are detailed in Chapter 8: Threats and Conservation Actions. Using this standardized lexicon, conservation actions used in the AWCS are broken into seven broad categories:

1. Land and Water Protection

Actions that identify, establish, or expand parks, wildlife areas, and other protected areas to benefit wildlife and their habitats. Some examples of conservation actions include: acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas; identify wildlife corridors essential to the movement of species between high quality habitat blocks.

Case Study: Partnering to Preserve Riparian Habitats Along the Verde River
In May 2018, four partners, including Hauser and Hauser Farms, NRCS, AZGFD and The Nature Conservancy (TNC), finalized a voluntary conservation agreement that would prevent future development on approximately 513 acres of Park Central Farm in Yavapai County near Camp Verde. This privately-owned farm encompasses 230 acres of a healthy cottonwood-willow forest along the Verde River. Funding for the $6.5 million acquisition of the Park Central Farm voluntary land agreement came from the NRCS, The Nina Mason Pulliam Charitable Trust (through TNC), and AZGFD.

The area serves as a critical wildlife corridor between the Coconino and Prescott National Forests. Streamside forests provide a home to many SGCN, including the southwestern willow flycatcher and western yellow-billed cuckoo. Further up from the river, bobcat, mountain lion, and mule deer can also be found. This collaborative effort represented a major win to secure protections for a vital wildlife movement corridor in a region experiencing increased habitat fragmentation due to development.

2. Land and Water Management

Implement projects focused on improving the quality of altered systems to create suitable habitat and/or habitat features for wildlife. Examples of conservation actions include: increase connectivity by removing barriers and impediments to species movement; control the spread of invasive and problematic species; restoring degraded habitats to improve ecosystem function.

3. Species Management

Actions that establish and/or augment populations of fish and wildlife species in high-quality habitats, with an emphasis on SGCN. Examples of conservation actions include: captive breeding programs, protecting refugia to ensure at-risk species have viable populations; research that to determine status and conditions of populations and habitats so that resources can be appropriately allocated where they are most needed; and evaluating the effectiveness of management actions and adapting the approach as necessary.

Case Study: Propagation of Endangered Desert Fish Lineages
Established in 2000, AZGFD's Aquatic Research and Conservation Center (ARCC) is working to protect future generations of desert fish. The ARCC currently houses three distinct genetic lineages of spikedace and four lineages of loach minnow, as well as two endangered fish species endemic to the Gila River Basin of Arizona and New Mexico. These fish are held as refuge populations against extinction in the wild and are actively propagated to support reintroductions into watersheds from which these species have been extirpated.

Over the last two decades, investigative trials have been conducted at ARCC to identify factors that influence captive spawning. Techniques are continually refined at ARCC to increase production while maintaining fitness and genetic congruity with wild populations. Captive propagation of endangered fish species remains an important tool for managers, supporting conservation programs, and aiding recovery of native fish in the Southwest.

4. Education and Awareness

Actions that raise awareness of issues facing wildlife and their habitats and increasing support through outreach efforts, educational programs, and engagement with policymakers. Examples of these conservation actions include: Increase awareness of effects of specific threats (i.e. climate change, invasive and problematic species, illegal take of reptiles and amphibians) on wildlife species and habitats with an emphasis on how the threats can be reduced; engage with non-traditional constituents to cultivate an interest in and appreciation for wildlife and natural areas; provide opportunities for students to learn about careers in natural resource management and to contribute to wildlife conservation; educate new outdoor enthusiasts on safe, ethical practices and proper behavior in natural settings and in proximity to wildlife; expand wildlife viewing programs and other non-consumptive wildlife-related recreational activities.

Case Study: Watchable Wildlife Programs

Along with our partners like the Desert Botanical Gardens, AZGFD hosts diverse events for wildlife and nature enthusiasts such as wildlife viewing tours, bat nettings, bighorn and bison viewing tours, wildlife photography events, and more. Additionally, AZGFD's Wildlife Viewing Program (WVP) hosts a series of streaming wildlife cameras that allow constituents an intimate glimpse into the daily life of Arizona species from the comfort of their own homes and offices.

One goal of the WVP is largely designed to engage non-traditional constituents, informing them about the mission of AZGFD, and to ensure future support from the entire constituency. The WVP works on a cost-recovery model, charging modest fees for experiential and educational events. The WVP provides an easy and exciting way to increase public awareness of the value of wildlife and habitat and the need to conserve irreplaceable assets.

5. Law and Policy

Actions that develop, change, and inform legislation and regulations to benefit wildlife and their habitats. Examples of conservation actions include: Educate legislators on the role of AZGFD as the primary steward of Arizona's public trust wildlife resource; engage in legislative activities to support or oppose the modification of state and federal statutes to safeguard and enhance the ability of AZGFD to conserve wildlife through science-driven management; develop relationships with elected officials, conservation partners, stakeholders, and members of the public that enhance the ability of AZGFD to anticipate future needs, adapt to change, and perform conservation activities in compliance with applicable laws and regulations.

6. Livelihood, Economic, and Other Incentives

Actions that rely on economic and other incentives to create opportunities to partner with Arizona agricultural producers, private landowners, and other working landscapes. Examples of these conservation actions include: Share information on the benefits of participating in species recovery programs such as Safe Harbor Agreements (SHAs) and Habitat Conservation Plans (HCPs) with interested landowners; support the development of incentive programs to encourage substitution of non-toxic alternatives to lead-based ammunition in order to prevent wildlife and human exposure and health risks; raise awareness of the health benefits associated with outdoor recreational activities and the ecosystem services provided by highly-functioning natural communities.

7. External Capacity Building

Actions that build on current infrastructure to develop new or expand upon current conservation efforts. Examples of these conservation actions include: Form and provide support for partnerships and alliances to promote information sharing, learning, and collaboration; provide technical

assistance to landowners interested in enhancing wildlife habitat on their property; continue fostering partnerships with academic institutions including the AZGFD University Liaison Program.

Case Study: Conserving Bird Species in the U.S. and Mexico

The Sonoran Joint Venture (SJV; www.sonoranjv.org) is a partnership of diverse organizations and individuals with a shared commitment to the conservation of more than 700 bird species that breed, winter, and/or migrate in the southwestern United States and northwestern Mexico. Through integration of the strategies, goals, and objectives of existing regional, national, and international bird conservation plans, SJV has developed a comprehensive strategy that serves as a blueprint for regional bird conservation.

In Arizona, AZGFD collaborates with SJV to develop a series of species accounts intended to support field work and land management decisions. This project provides an easy-to-use resource to bring the needs of bird species into the decision-making process. Each account summarizes key conservation details including status, habitat needs, and threats as well as recommended management activities to support birds on both sides of the border.

Conservation in the Context of Climate Change

In addition to the conservation action categories identified above, the Climate Change discussion in Chapter 3: Conservation Challenges describes Climate Change Adaptation Strategies (CCAS) to address habitat and species vulnerabilities. These strategies were adapted from the Association of Fish & Wildlife Agencies (AFWA 2009) and are incorporated into the individual habitat profiles in Chapter 7: Habitat Profiles in the section, "Conservation in the Context of Climate Change." This section outlines broad options for incorporating applicable climate change strategies into the conservation actions developed for each habitat type. Examples of CCAS used in the AWCS include:

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

While the previous section described the various conservation actions to help reduce or eliminate threats to wildlife and their habitats, the question remains: Where on the landscape is it most important for us to implement these actions? The AWCS answers this question with the development of Conservation Opportunity Areas (COAs). This is a mechanism for prioritizing on-the-ground conservation by identifying specific locations on the landscape where investments are most likely to lead to substantial gains for wildlife. The COAs were created to help implement the AWCS and should be considered voluntary guidance for specific areas where conservation efforts would be most effective, based on species and habitat expertise, as well as wildlife and spatial data. COAs reflect the best areas for conservation and were determined without regard to jurisdiction and landownership. In addition, COAs will not be subject to any new regulations nor do they have any regulatory effect..

We created two broad categories of COAs, terrestrial and aquatic. Both terrestrial and aquatic COAs are intended to complement each other and in many cases are located in the same area.

Identifying Terrestrial COAs

To identify terrestrial COAs, AZGFD used the latest data and expertise and also incorporated input from outside organizations, agencies, and individuals. Terrestrial COAs represent geographic areas with high conservation value and high potential for successful project outcomes. Terrestrial COAs vary in size, from just a few acres where the conservation goal might focus on a single spring that is home to an endemic springsnail species, to entire mountain ranges, where the conservation goals apply to a larger landscape and include the protection of an Important Bird Area (IBA) or several wide-ranging SGCN. Whether large or small, every terrestrial COA was required to have one or more of the following conservation attributes:

- Areas where threatened and endangered species have been documented
- Areas with high wildlife diversity including SGCN
- Riparian areas and other specialized habitats
- Proximity to protected lands
- Areas that contribute to a known movement corridor

Identifying areas of high conservation value was just one step in the terrestrial COA process. Conservation efforts, of course, are inherently limited by resources such as funding, staff hours, and land ownership. To ensure success, we carefully analyzed each potential terrestrial COA, and refined our final list, to make sure each site possessed qualities that would lead to successful on-the-ground conservation efforts. Examples of qualities that affect the potential for success and were therefore an integral part of the COA evaluation process include:

- Land ownership/jurisdiction

- Feasibility of conservation actions and project success
- Costs associated with protection or implementation of activities
- Likelihood of partner involvement

The following datasets were used to help identify and refine terrestrial COAs:

- Arizona HDMS Element Occurrences
- Arizona HDMS Point Observation Data
- AZGFD Species Observation Data
- Brown and Lowe's Biotic Communities of the Southwest (1994)
- The Nature Conservancy's Resilient and Connected Network (2016)

The terrestrial COAs were then subjected to review by an internal team of species and habitat specialists. The COAs were further refined to remove areas on Tribal lands. Teams then created detailed COA profiles for each, examples of which are available at the end of this chapter.

Identifying Aquatic COAs

To identify aquatic COAs, we used AZGFD's Watershed-based Fish Management Process (WFMP). This process provides systematic, data-driven methods to develop fisheries management plans at various scales. The WFMP was first implemented in 2009 to develop watershed management plans with the goal of balancing sportfish opportunities with conservation and restoration of Arizona's native aquatic wildlife resources. (We applied this process to identify COAs in the lentic and lotic habitat types. Wetlands and springs COAs were identified using the terrestrial COA method describe above.) Through the WFMP process, AZGFD has developed plans for nearly 800 management units across the state. These plans were then assigned a management priority:

- *High:* Management units that presently contain threatened, endangered, candidate, or proposed native aquatics species with a signed conservation agreement and/or the presence of critical habitat.
- *Medium*: Management units containing other native aquatic species with multiple age classes.
- *Low:* Management units where native aquatic species are rare, non-sustainable, or not present.

To identify aquatic COAs, AZGFD chose all units identified as "high" priority (N=166) and "medium" priority (N=110). Several other management units with "low" priority or no priority were also selected as aquatic COAs where AZGFD expertise felt that the unit warranted special conservation value as a COA. Ultimately, AZGFD identified more than 302 aquatic COAs and 130 terrestrial COAs. Complete lists of COAs can be found in Appendix G: Aquatic Conservation Opportunity Areas (COAs) and Appendix H: Terrestrial Conservation Opportunity Areas (COAs). A brief list of COAs by habitat type can be found in Chapter 7: Habitat Profiles.

COA Profiles

Following the identification of each COA, AZGFD staff created a detailed profile for each that will be available on the AWCS website. A map of current COAs identified for inclusion in the AWCS is found below (Figure 6) and example COA profiles can be found at the end of this chapter. These COA profiles should be considered voluntary guidance for where conservation efforts would be most effective, according to AZGFD data and staff expertise. Main components of each COA profile include:

COA Description

Narrative that describes the COA, including habitat descriptions, immediate threats, potential conservation actions and other pertinent information.

Primary Threats and Conservation Actions

Similar to the Habitat Profiles in the AWCS, the COA profiles include primary threats and conservation actions using the standardized lexicon defined by Salafsky et al (2008). In addition, conservation actions outline specific actions that can be taken to address primary threats in the COA.

Strategy Species

For each COA we created a new category of priority wildlife, known as Strategy Species. This list of species is primarily SGCN (Tiers 1, 2, and 3) that are known to occur, or have potential to occur, within the defined boundaries of the COA. Strategy Species were initially identified by crosswalking Arizona Heritage Data Management System (HDMS) records, including element occurrence data (EO) and point observation data (POD). The list of Strategy Species was then further refined by species and habitat experts. While the Strategy Species are primarily SGCN Tiers 1, 2, and 3, we also added some game and non-SGCN species when warranted, if that species plays an outsized role in the ecosystem, such as American beaver or elk (see definition of Other Influential Species on p. 91). Ultimately, the Strategy Species list reflects a prioritized list of species that may benefit from conservation actions within that particular COA.

Potential Partners

Identifies potential partners, including government agnecies, NGOs, recreation clubs, and other organizations that are associated with the COA or Strategy Species. Partners are completely voluntary and only recommendations identified by AZGFD as to which agencies and organizations may collaborate to implement conservation actions.

Relevant Conservation Plans

Provides links to important documents that are relevant to habitat and species conservation within the COA, such as species recovery plans, land management plans, and so on.

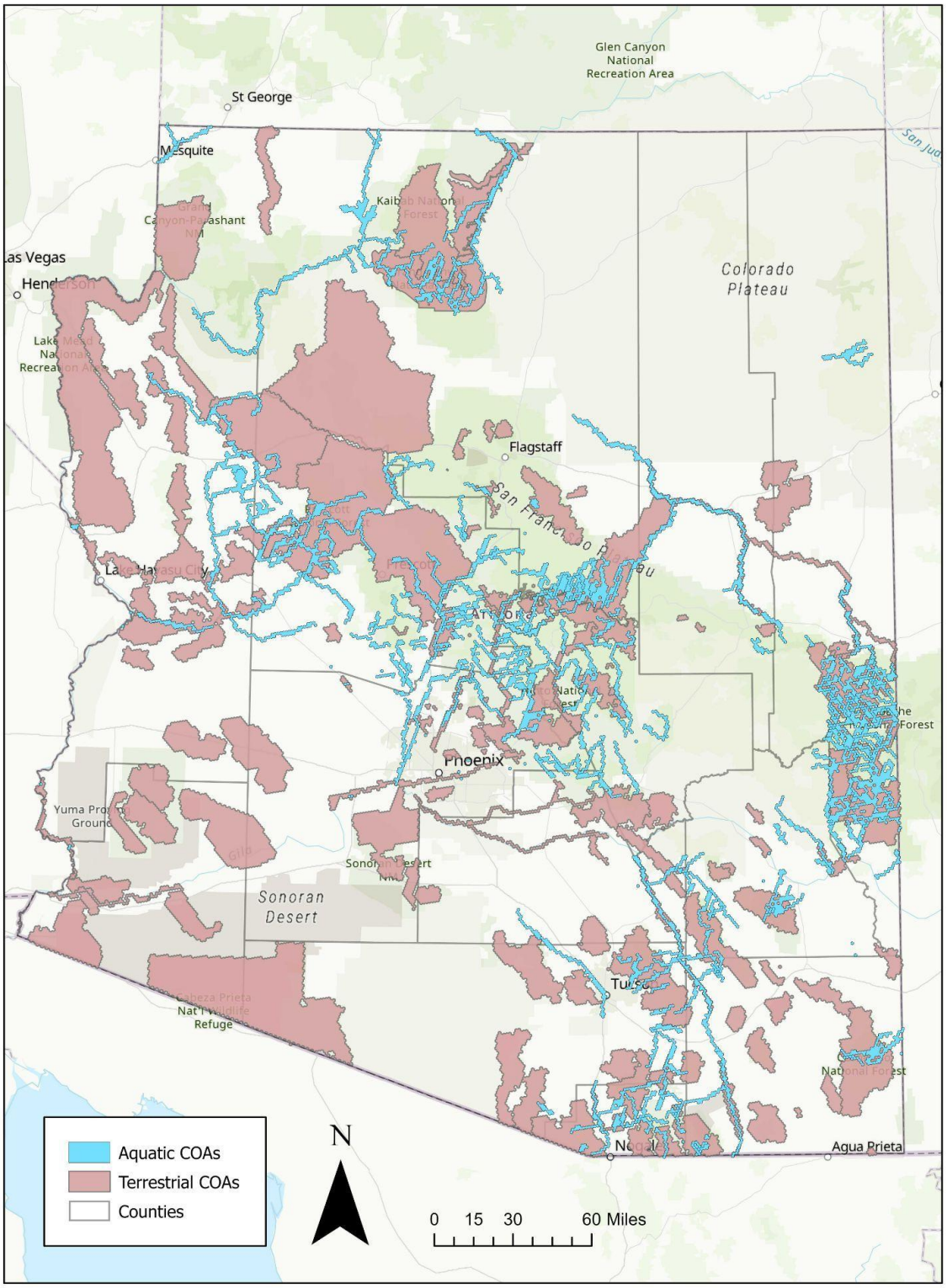


Figure 6: *Terrestrial and aquatic COAs identified in the AWCS.*

Buenos Aires COA Profile (Example 1)

The Buenos Aires National Wildlife Refuge comprises this entire COA. In 1985, the Buenos Aires Ranch was purchased by the U.S. Fish and Wildlife Service for conservation of the endangered masked bobwhite quail.

Conservation Goal(s):

- Restore, conserve, and manage a diversity of wildlife and habitat through strategies focusing on environmental and biological integrity
- Foster binational cooperation with individuals, organizations, and agencies to strengthen endangered species management

Primary Threats

- Overgrazing and increased stocking rates are adversely affecting grassland diversity
- Non-native plant species have taken over areas once dominated by native vegetation

Potential Conservation Actions

- Remove non-native, undesirable, and/or invasive wildlife and plant species
- Continue with masked bobwhite recovery measures, including breeding, fostering, and reintroduction
- Collaborate with partners to develop and implement management plans, recovery actions, and to determine effectiveness of specific management efforts
- Identify wildlife corridors essential to movements between high quality habitat blocks

Habitats Present

semidesert grassland, Madrean woodland

Strategy Species

Chiricahua leopard frog, desert box turtle, Gila topminnow, masked bobwhite, Sonoran Desert tortoise, yellow-billed cuckoo, antelope jackrabbit, Arizona grasshopper sparrow, cactus ferruginous pygmy-owl, Arizona mud turtle, buff-collared nightjar, giant spotted whiptail, hooded nightsnake, pocketed free-tailed bat

Protected Areas and Other Areas of Conservation Value

Buenos Aires National Wildlife Refuge

Potential Partners

USFWS, Altar Valley Conservation Alliance, Friends of Buenos Aires NWR, Arizona Antelope Foundation

Relevant Conservation Plans

Buenos Aires National Wildlife Refuge Final Comprehensive Conservation Plan
Masked Bobwhite Recovery Plan

Associated COAs

Arivaca Creek

House Rock Valley Wildlife Area COA Profile (Example 2)

The House Rock Valley Wildlife Area is managed by AZGFD and provides habitat for a wide array of wildlife species. Among these are an American bison conservation herd, refugia for northern leopard frogs, a diverse assemblage of bats, burrowing owls, year-round range for American pronghorn, important winter range for mule deer, and stopover migrating shorebirds and waterfowl.

Conservation Goal(s):

Manage Wildlife Area habitats for a broad diversity of self-sustaining game and nongame species, and for recreational activities including hunting and wildlife viewing.

Primary Threats

- Overgrazing and increased stocking rates are adversely affecting grassland diversity
- Climate change favors shrub species over perennial grasses and causing grasslands to transition to desertscrub
- The lack of wildfires on the plains and great basin grassland landscape has resulted in the encroachment of pinyon pine and juniper tree species
- Invasive and problematic species compete with native fauna, over-utilize native species, and cause habitat damage

Potential Conservation Actions

- Improve water conservation measures at three dirt tanks
- Improve wetland habitats at dirt tanks that serve as refuge sites for northern leopard frog
- Perform periodic genetic assessments and surveillance for disease to guide our management of our northern leopard frog populations
- Implement range monitoring and improvement projects to meet American bison herd goals

Habitats Present

Great Basin desertscrub, Plains and Great Basin grassland, Great Basin conifer woodlands

Strategy Species

Chiricahua leopard frog, northern leopard frog, Arizona toad, flammulated owl, Mexican spotted owl, northern pygmy owl, northern goshawk, dusky grouse, band-tailed pigeon, bald eagle, pine grosbeak, red crossbill, red-faced warbler

Protected Areas and Other Areas of Conservation Value

HRWA is on the North Kaibab Ranger District. The Kaibab Plateau, managed by NPS and USFS, and Saddle Mountain Wilderness (USFS) are adjacent to HRWA. At lower elevations, most of House Rock Valley is managed by the BLM.

Potential Partners

USFWS, USFS, BLM, NPS, Grand Canyon Trust, Plateau Ranches

Relevant Conservation Plans

House Rock Wildlife Area Management Plan

Bison Management Plan

Chapter 5:
Keeping the AWCS Current

Arizona's new AWCS is far more than a document. The AWCS offers both a comprehensive, 10-year conservation plan (SWAP) as well as a dynamic on-line presence complete with a set of innovative web-based planning tools. As a plan, the AWCS incorporates new data and information, identifies key changes and threats to wildlife and their habitats, and offers actions to meet our overall conservation goal to "keep common species common." By providing web-based data visualization and decision support tools — such as the COA map viewer and the CAT — the AWCS is also a vital resource to guide strategic investments, mitigation, and conservation that will have the greatest benefit for wildlife in Arizona.

The AWCS is the result of a multi-year effort requiring the dedication of various AZGFD workgroups and teams, input from numerous partners and stakeholders, and the general public. In 2012, the USFWS approved the last revision of our 10-year plan and this latest revision will be completed in 2022. Through the rigorous revision process, the AWCS incorporates new data and information, key changes occurring in Arizona, and factors influencing the management of lands in our state. Numerous threats that affect fish and wildlife include the state's human population growth, climate change, increasing demand for renewable energy sources, emergence of new wildlife diseases, and the increasing number of invasive species. Each of these — and many more — are addressed in the AWCS with the understanding that these threats are fluid and constantly changing their influence on wildlife and their habitats. The AWCS meets the challenges of this variable environment as a comprehensive, web-based planning resource that can be edited, updated, and altered to meet changing conditions.

Early in the revision 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, emerging or changing threats, and shifting societal pressures. The advantage of the AWCS that integrates our 10-year plan into a fully web-based platform is that AZGFD staff will be able to continuously revise species, habitat, and threat information data as they become available. In addition, AZGFD will be able to continuously update our list of Conservation Opportunity Areas (COAs), a new and critical component of the AWCS that fosters widespread public and stakeholder engagement and collaboration in conservation efforts. Finally, since the AWCS provides a dynamic, web-based platform for our conservation strategy, we will be able to host annual meetings with stakeholders to review the AWCS. Comments, suggestions, or changes to the AWCS that are minor revisions will then be submitted to USFWS for approval. Upon approval, AZGFD can incorporate these changes into the AWCS's web platform..

Roadmap to Revise Arizona's Plan

For each revision of the AWCS/SWAP, AZGFD embarks on a multi-year review process to make key changes to the strategy based on the latest information and data available. Over the past two years, AZGFD has been revising the AWCS and building off changes from the 2012 plan, formerly known as the Comprehensive Wildlife Conservation Strategy (CWCS). This section outlines the major changes to the new AWCS according to each of the Eight Required Elements and indicates where the details of those changes can be found.

Element 1: Species distribution and abundance including low and declining populations that are indicative of the diversity and health of the state's wildlife

Changes were made to the various components of Element 1. These included changes to the Master Species List for Arizona (Appendix C: Master Species List) which was revised to reflect the taxonomic level at which wildlife is managed in the state. A new vulnerability analysis was conducted by AZGFD staff and these scores were applied to the Master Species List using revised and more defensible criteria. (See Chapter 1: Arizona's Biodiversity for more detailed explanation of vulnerability analysis and definitions of vulnerability criteria.) As a result of this analysis, we created an updated SGCN list (Table 4). See Appendix D: Species of Greatest Conservation Need with Vulnerability Scores for full list of SGCN and vulnerability scores.

Table 4: *SGCN totals by taxonomic group and tier.*

Taxonomic Group	Tier 1	Tier 2	Tier 3	2022 Total	2012 Total
Amphibians	8	6	1	15	19
Birds	11	107	39	157	145
Fish	22	10	1	33	35
Invertebrates	27	42	139	208	184
Mammals	11	53	23	87	94
Reptiles	14	35	2	51	54
All Groups	**93**	**253**	**205**	**551**	**531**

Following the vulnerability analysis, we created new habitat suitability models for nearly all Tier 1 and Tier 2 SGCN. Species leads at AZGFD completed a review of the current SGCN species distribution models developed over the past 10 years. These SGCN were then prioritized based on availability and/or accuracy of existing models. In total these efforts modeled 290 SGCN of various taxa. Chapter 1: Arizona's Biodiversity details our modeling efforts.

Element 2: Habitat locations and conditions essential to the conservation of species identified in Element 1

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 occurs in and uses 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.

The AWCS relies on Brown and Lowe's (1980, 1994) mid-scale classification system to identify the 17 habitat types described in Chapter 7: Habitat Profiles. Habitat specialists and species leads at AZGFD developed detailed habitat profiles that describe the locations and conditions of habitats throughout Arizona. Included in these profiles are narrative descriptions of the habitat type including natural history, native flora and fauna that occur, key habitat features, and current challenges and trends. Other information detailed within these habitat profiles include an updated list of SGCN that occur within the habitat type, primary threats to the habitat, challenges in the context of climate change, a list of potential partners for conservation efforts, and more. Each habitat profile also includes a list of potential COAs where conservation efforts would be most beneficial to SGCN and their habitats. Finally, habitat profiles also include a list of Additional Influential Species, which are non-SGCN, but species that can play out-sized roles in any ecosystem and utlimately affect SGCN popoulations. For example, American beavers can pond lotic systems and potentially alter community composition of native aquatics species and also encourage the recruitment of invasives such as bullfrogs. Acknowledging these direct and indirect effects of influential species on SGCN must be considered when planning and implementing any management actions.

Element 3: Threats to species and habitat and priority research and survey efforts needed to identify factors which may assist in restoration and conservation

Throughout the AWCS, we address the many challenges facing Arizona's wildlife and their habitats and provide potential conservation efforts that can reverse or remedy these threats. From disease to climate change to renewable energy development, Chapter 3: Conservation Challenges is dedicated to detailing the exhaustive list of threats facing Arizona's wildlife and their habitats today.

Unlike previous versions of the SWAP, the AWCS fully utilizes a standardized lexicon for threats described in Salafsky et al. (2008). Adopting this lexicon for threats was first recommended by AFWA in 2012 shortly after the publishing of our previous SWAP. This standardized lexicon uses a hierarchical system with different levels, similar to the Linnaean System of taxonomy. For the AWCS we made minor changes to the lexicon to better address our environmental conditions here in Arizona. This standardized lexicon is now found throughout the AWCS. A full integration of this lexicon in the AWCS will greatly improve our collaborative efforts with neighboring states as we move forward together to better conserve the resources we share across borders. Threats are first briefly identified in each of the habitat profiles found in Chapter 7: Habitat Profiles. Then in Chapter 8: Threats and Conservation Actions, the AWCS goes into greater detail about how each threat is affecting habitats and the wildlife that occur there.

Element 4: Actions to conserve species and habitat including priorities for implementation

Following the identification of threats and utilization of Salafsky's standardized lexicon, the AWCS fully integrates conservation actions that specifically address each threat by offering potential actions to remedy the identified threats. Chapter 8: Threats and Conservation Actions details these potential actions by habitat type.

To address the growing threat of climate change, the AWCS includes a section "Conservation in the Context of Climate Change" in each of the habitat profiles detailed in Chapter 7. This section identifies many actions that can address climate change and its effects, both directly and indirectly. Some of those actions are being implemented currently by AZGFD and many can best be accomplished by our partners and the public.

A new and innovative component of the AWCS is the addition of Conservation Opportunity Areas (COAs). These are specific areas on the landscape that AZGFD staff and partners identified to help prioritize on-the-ground conservation efforts where investments are most likely to lead to substantial gains for wildlife. More than 400 terrestrial and aquatic COAs are identified in the AWCS, ranging from small stock tanks to entire mountain ranges. Some COAs are specific to individual species that are in need of targeted conservation efforts while other COAs emphasize the conservation of multiple species found in a particularly threatened habitat type.

Chapter 7: Habitat Profiles first identifies each COA found in that habitat type. Appendix G: Aquatic COA Profiles and Appendix H: Terrestrial COA Profiles then provides an in-depth look at each individual COA. Each COA profile includes a brief description of the site, SGCN present, primary threats, and potential conservation actions, among other valuable information. Each profile then offers a list of potential partners as well as actionable conservation actions that could remedy imminent threats to the COA.

These COAs will be an integral part of the new on-line presence of the AWCS. The COA map is a dynamic tool to help visualize the current and potential areas of conservation throughout the state. This interactive, user-friendly map is intended to be used by, not only AZGFD, but the general public, our partners agencies, local governments, and so on. One goal of integrating COAs into the AWCS and providing an on-line tool is to foster partnerships with other agencies, conservation groups, and the general public by providing a comprehensive, state-wide map of actionable conservation areas where partners can collaborate to meet common goals.

Element 5: Plan for monitoring effectiveness of actions facilitating adaptive management approaches

Chapter 9: Monitoring was revised primarily for clarity, to update the literature and on-going monitoring efforts. This chapter includes an exhaustive list of current protocols, management plans, and other guiding documents used by AZGFD and our partners to monitor SGCN and their habitats.

Since the AWCS will be fully web-based, we'll have the opportunity to update and make minor revisions to our monitoring efforts as conditions on the ground change and new information presents itself over the next 10 years.

Element 6: Procedures for updating the plan to maintain current, useful information ensuring effective response to changing conditions

Arizona's new AWCS is far more than a document that guides wildlife conservation over the next decade. The AWCS is a fully integrated data management system that allows AZGFD to share data on the SGCN, the threats and conservation actions, and the landscape models with all of our partners and with the public through the use of the Wildlife Data Warehouse (WDW). The advantage of taking this approach to the AWCS is that we will be able to continuously revise species, habitat, and threat data as information becomes available. Notably, because of the new on-line format, feedback from our partners and public can be incorporated in real time. This allows AZGFD to engage in true adaptive management while limiting the need for constant revisions of the plan itself.

However, AZGFD recognizes that many changes will occur over the next decade: Priorities will change, landscapes will be altered, species' status will change, programs are completed and new programs are launched. We are fully committed to reviewing this document as required by USFWS guidelines and performing a full review and revision as needed by 2032 and incorporate major revisions to the status of species, habitat conditions, threats to wildlife, and monitoring. As part of the on-going review process, AZGFD will continuously monitor public comment through various resources and will hold public meetings to review the revision at that time. AZGFD will also obtain minor revisions from USFWS as needed through time.

Element 7: Partner involvement throughout review and revision of the SWAP as well as implementation

As part of AZGFD's commitment to partnerships and collaboration, throughout 2020 and 2021, we held various outreach efforts with stakeholders, from federal and state agencies, to Tribes, NGOs, and other interested parties. More than 40 entities were represented over 10 stakeholder focus groups, all of which were performed on-line as a result of the Covid-19 pandemic. Chapter 6: Conservation Partnerships details our collaborative efforts with our various stakeholders and much of the valuable information gathered and incorporated into the AWCS.

Feedback from these outreach efforts was instrumental in helping AZGFD shape our current plan, by identifying priorities and providing feedback for us to create an innovative, user-friendly platform in the AWCS. We are fully committed to continuing this productive stakeholder outreach process as we approach our next major revisions for 2032. In the meantime, we will be hosting semi-regular stakeholder outreach events to gain input in subsequent years and make changes to the AWCS as needed.

Element 8: Public participation to increase awareness and support for conservation needs and to encourage involvement in implementation of the SWAP

Broad public participation is a critical component to any comprehensive conservation strategy and the AWCS is no exception. During the two-year revision process, AZGFD hosted several public forums to present the AWCS to a wide audience. The goal of such outreach was to introduce the AWCS, outline our goals and priorities, provide progress updates, and receive feedback on how to improve our strategy and tools.

In the spring of 2020, we initiated our public outreach with a broad survey about the AWCS. With the help of social media, email listserv, and direct mailing to targeted audiences, we received more than 2,300 responses from a wide variety of constituencies, including conservation organizations, private landowners, representatives from local governments, and concerned citizens, among others. Responses provided us with valuable input about our vision for the AWCS. Results from these public outreach efforts and changes we incorporated into the AWCS can be found in Chapter 6: Conservation Partnerships.

In September 2021, we hosted a series of virtual presentations about the AWCS. The purpose of these presentations was to engage the general public about the AWCS and gain feedback. More than 90 individuals attended these on-line forums, many of whom provided valuable feedback and suggestions on how to improve the AWCS.

As a result of our public outreach efforts, we incorporated several changes to the AWCS. Some of these more substantial changes included:

- Increased emphasis on climate change and wildlife connectivity
- Improved public awareness and trainings of the AWCS
- Identification of priority areas for conservation
- Agreed to develop an industry engagement strategy and promote use of the AWCS

Chapter 6: Conservation Partnerships

As part of the revisions process — and to meet two of the Eight Required Elements — AZGFD held a series of public surveys and forums as well as stakeholder focus groups throughout 2020 and 2021. The purpose of these broad outreach efforts was to offer a forum to present the AWCS to the general public and our partners and to provide updates on the AWCS revision process. Perhaps, most importantly, these outreach efforts gave us a chance to obtain feedback from these vital constituents on how to improve the AWCS to make it the most effective, comprehensive, and innovative conservation strategy possible.

As a result of these outreach efforts, AZGFD has incorporated several of these suggestions and concerns identified by the general public and our stakeholder partners. Incorporating these changes would allow us to meet mutual outcomes to help conserve wildlife while simultaneously meeting the needs of Arizonans. Some of the changes we incorporated to the AWCS include:

- Increased emphasis on climate change and wildlife connectivity
- Improved public awareness and trainings of the AWCS
- Identified actionable priority areas for conservation
- Developed an industry engagement strategy and promote use of the AWCS

Public Participation Summary

Outreach to inform development of the AWCS included a wide-ranging public survey in 2020, followed by a series of focus groups in November of 2020, January of 2021, and April of 2021. Three public forums also were held in September 2021. The outcomes of the survey, focus groups, and public forums helped inform the development of the AWCS and the associated web presence and on-line planning tools. We contracted Lisa DeBruyckere of Creative Resource Strategies, LCC, to work with AZGFD staff to develop and implement an outreach strategy to engage the public and partners in the development of the AWCS. The outreach was conducted remotely as a result of the Covid-19 pandemic.

In August of 2020, we conducted a public survey via AZGFD's email listserv, social media posts, and direct email to targeted partners. The purpose of this survey was to share information about the AWCS and revision process, and obtain initial input and feedback on the core concepts. A total of 2,345 people responded to the survey. Respondents represented a variety of backgrounds and interests, including, among others, interested citizens, landowners, conservation organizations, and representatives from local, state, and federal governments. These public surveys provided us valuable information on how to improve the AWCS by focusing on three main topics: 1) The public's

engagement with the current SWAP, 2) What the public view as the top threats to wildlife and habitats in Arizona, and 3) What changes would they like to see in the AWCS for 2022. Selected results from these surveys are detailed below.

Public Engagement and the AWCS

To gauge public awareness of the AWCS, we first asked respondents to describe their familiarity with the 2012 SWAP. A total of 46% stated they were "not at all familiar"; 38% were "somewhat familiar"; 13% were "familiar"; and 3% were "very familiar" (Figure 7).

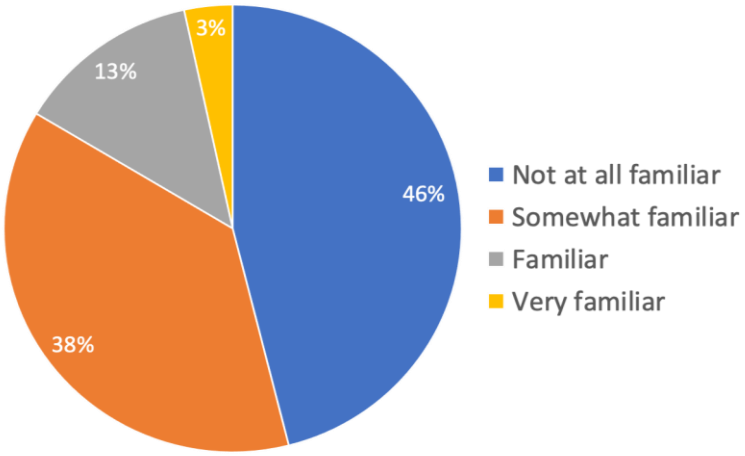


Figure 7: *Survey respondents described their familiarity with the 2012 SWAP.*

Survey respondents described their frequency of using information, or maps, from the 2012 SWAP. A total of 49% responded "Never"; 22% responded "Sometimes"; 19% responded "Rarely"; 8% responded "Often"; and 2% responded "All the time" (Figure 8).

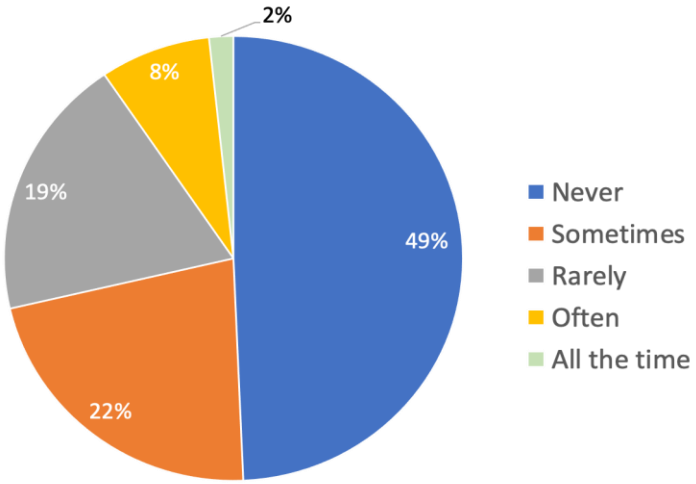


Figure 8: *Survey respondents described the frequency with which they use information/maps from the 2012 SWAP.*

Survey respondents then asked to describe how they have used the 2012 SWAP (99% response; Figure 9). The most common uses of the 2012 plan were to obtain maps or data layers on species of interest (31%) and to assess the distribution and abundance of species (28%).

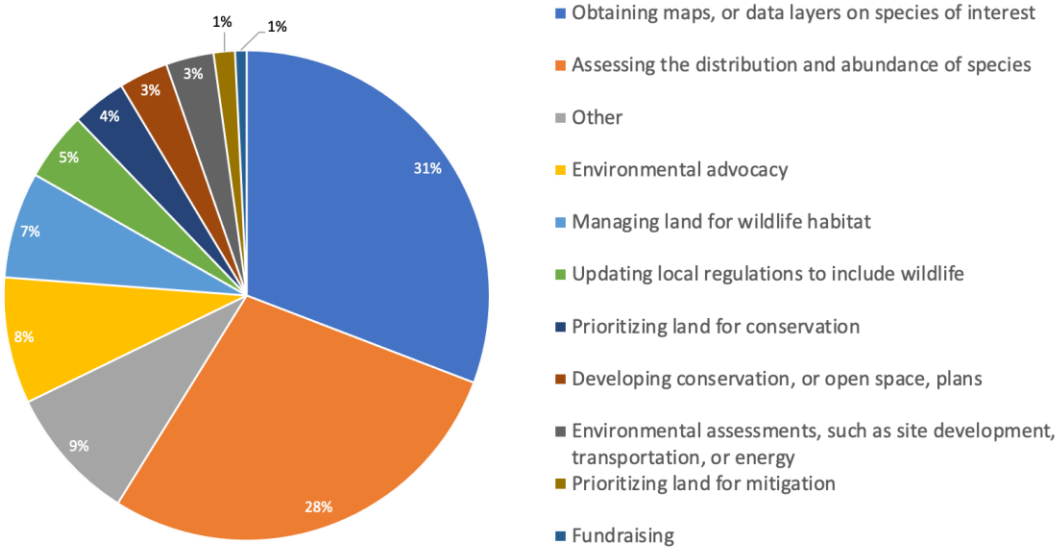


Figure 9: *Survey respondents that have used the 2012 SWAP described how they have used the plan.*

Survey respondents were asked to assess the effectiveness of AZGFD in protecting wildlife and natural lands in the last decade (99.96% response; Figure 10). A total of 85% of respondents rated AZGFD as very effective/effective/somewhat effective in protecting wildlife and natural lands in the last decade.

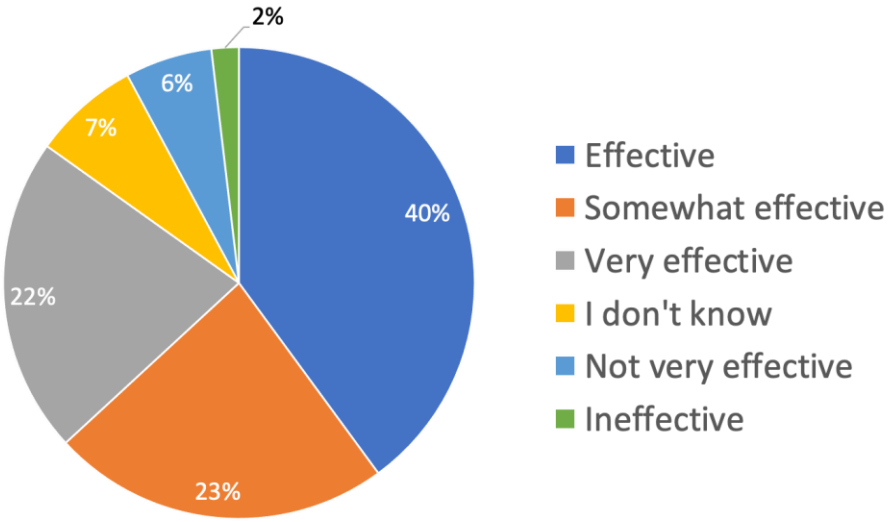


Figure 10: *Survey respondents described the effectiveness of AZGFD in protecting wildlife.*

Identifying Threats to Wildlife and Habitats

Survey respondents were then asked to describe their perceived impact of 22 threats that currently have, or will have, on Arizona fish and wildlife and their habitats (100% response; Figure 11). Respondents then rated these 22 potential threats as "high impact" and "very high impact." Top 10 threats identified were: drought, urban growth, water quality and quantity, groundwater depletion and springhead use, altered surface hydrology, rural development, barriers to animal movement, invasive species, motorized off-road recreation, and unnatural fire regimes.

Other threats included: border effects, disease/pathogens/parasites, grazing by ungulates, illegal fish stocking, insect infestations, excess nutrients/algal blooms, roads for motorized vehicles, shrub and woodland invasions, solar energy development, and barriers to private landowners that seek to implement conservation actions.

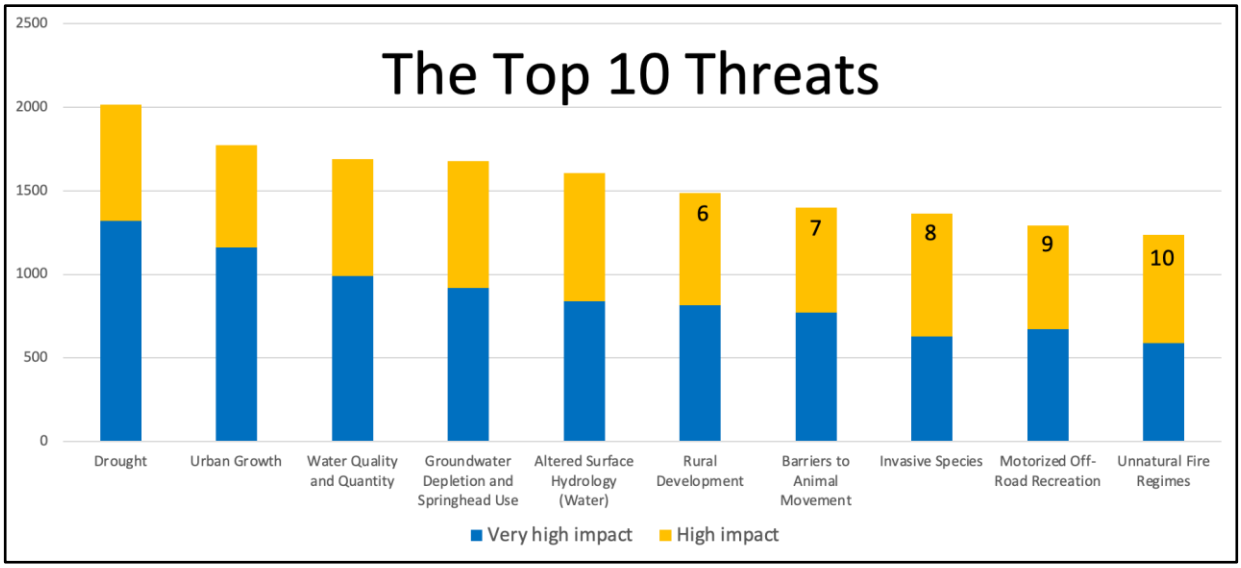


Figure 11: *Survey respondents described the extent threats are having, or will have, on wildlife.*

Survey respondents were then asked to describe the importance of activities to address threats to Arizona fish and wildlife and their habitats (Figure 12). Activities were described as either "very important" or "important" to address threats to wildlife and their habitats. These include, in order of importance: science and data, funding, monitoring, education, research, long-term vision, land use planning, enforcement of existing regulations, local volunteers, regulations, partnerships, acquiring land for conservation, and scientific experts.

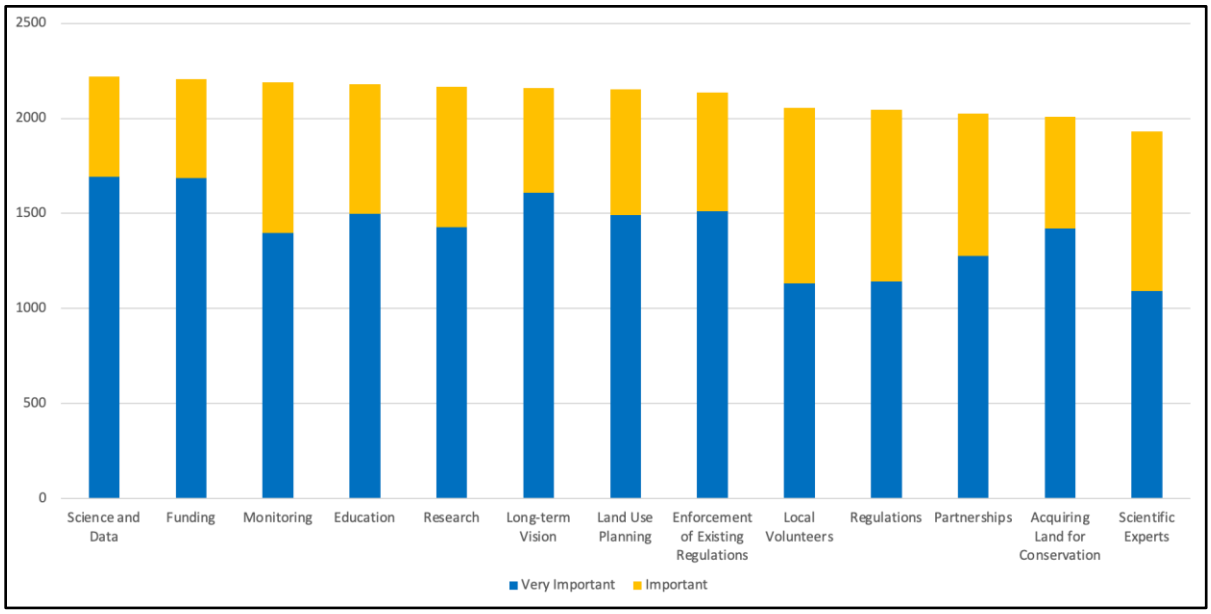


Figure 12: *Survey respondents described the importance of activities to address key stressors.*

Changes for the AWCS

Survey respondents were asked if they had suggested changes that should be made to the 2012 SWAP (Figure 13). Respondents that did provide input made suggestions in the areas of enforcement/regulations, hunting tags and fishing seasons, water catchments for wildlife and conservation, education and public awareness, wolves and predators, funding, and road use/OHV.

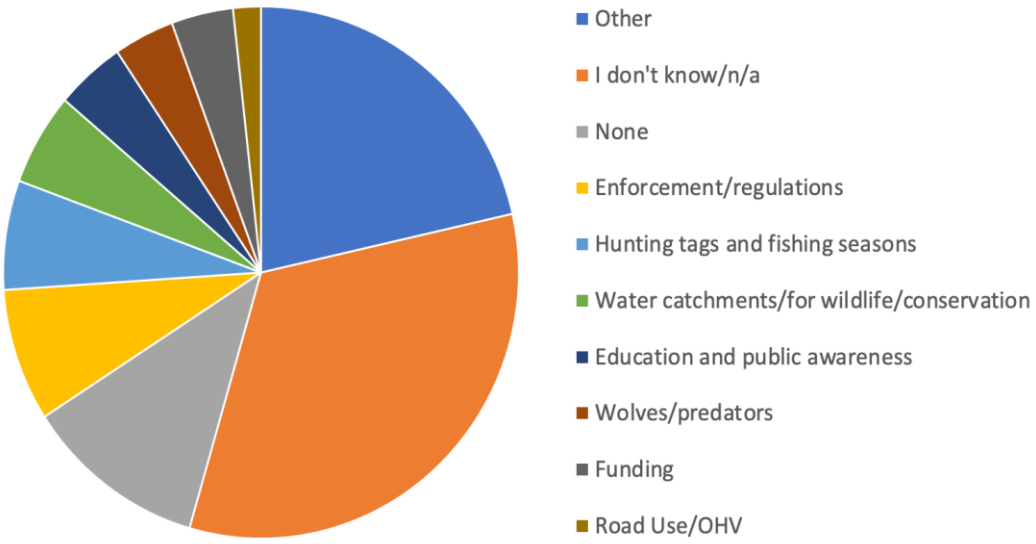


Figure 13: *Survey respondents described suggested changes they would like to see in the AWCS.*

Survey respondents were then asked to provide suggestions to improve partnerships, resources, or programs to conserve and protect Arizona fish and wildlife and their habitats (95% response; Figure 14). Respondents described improved public awareness (43%), improved access to science, data, coordination/collaboration to prioritize existing funding and seek new sources of funding (31%), training on how to use the SWAP and decision support tools for land management practitioners and planners (21%), and improved access to science, data and information about the distribution and abundance of Arizona fish and wildlife and their habitats (4%).

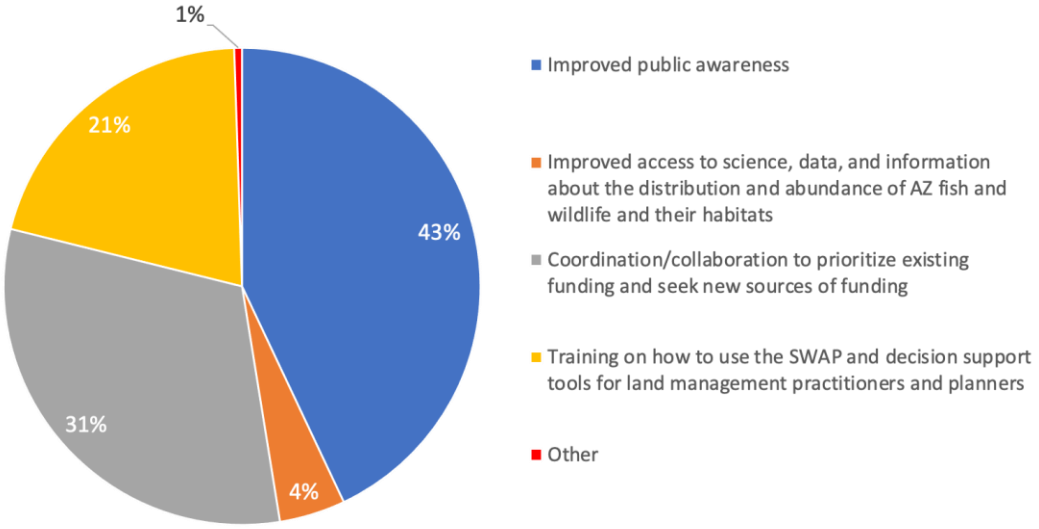


Figure 14: *Survey respondents articulated suggestions to improve partnerships, resources, or programs to conserve and protect Arizona fish and wildlife and their habitats.*

Public Forums

In September 2021, AZGFD conducted a series of public forums. The forums were held virtually on three consecutive days and consisted of the same general content presented by AZGFD staff. The purpose of these presentations was to provide an update on the status of the AWCS and its key components while offering the public an opportunity to comment on the AWCS. A total of 90 individuals from the public attended the online forums, which were held virtually because of the Covid-19 pandemic. Presentations by AZGFD staff were followed by a short question and answer period. Participants were also asked to complete a short online survey.

Overall, public response to the AWCS was positive. From these forums and suggestions/comments we received from the attendees, we developed several next steps to continue engagement with the public and our partners. Some of these efforts include:

- Host meetings with the public, and specifically the target audiences that will use the AWCS (e.g., federal agencies, developers) once the online tools and data development/analysis are completed.
- Develop a one-pager infographic that clearly articulates the role of the AWCS and State Wildlife Action Plan relative to other facets and programs of the AZGFD (e.g., hunt guidelines, fish management).
- Continue to share progress and elements of the AWCS through the magazine, social media, partners, and others to enhance awareness, understanding, and support for the AWCS and AZGFD's role in the conservation and management of Arizona's wildlife and their habitats.

Stakeholder Engagement Summary

In the fall of 2020 and spring 2021, AZGFD conducted a series of stakeholder engagement focus groups with representatives from around the state. All 10 focus groups were conducted virtually in response to the Covid-19 pandemic. Representatives from more than 40 groups participated in these discussions, including representatives from federal, state, and local governments, Native American tribes, NGOs, industry, universities, and more. Attendees of these focus groups included our partners from:

- **Federal Agencies:** USFWS, USBR, USDA Wildlife Services, BLM, Federal Highway Administration, USFS, NPS, US Army Yuma Proving Ground, USAF Luke Air Force Base—Barry M. Goldwater Range
- **Academia:** University of Arizona, Northern Arizona University, Grand Canyon University, Arizona State University
- **Native American Tribes:** White Mountain Apache Tribe, Salt River-Pima-Maricopa Indian Community, Hopi Tribe
- **Local Government:** City of Peoria, City of Flagstaff, Pima County
- **NGOs:** Grand Canyon Chapter of the Sierra Club, Quail Forever/Pheasants Forever, Audubon Arizona, Friends of Northern Arizona Forests
- **Industry:** Asarco Silver Bell Mining, Westland Resources, Inc., Matrix Design Group

In November of 2020, AZGFD hosted a series of focus group sessions to ask the following questions to gauge current engagement with the 2012 SWAP and to identify what changes they'd like to see in the 2022 AWCS. Responses are presented in bullet points:

1. Describe ways in which you use, or intersect with the SWAP:

- Federal agencies use it for permitting, such as NEPA and ESA compliance as well as natural resource planning.
- Tribes use SWAP to inform wildlife and fishery management programs.
- Local governments use the SWAP for wildlife connectivity and corridor assessments, information on threatened and endangered species, and land acquisition.

- Academia uses the SWAP for in-classroom discussions, grant writing, maps, and information on species and habitats.
- Industry uses the SWAP for NEPA and ESA compliance.

2. What most concerns you about the status of fish and wildlife and their habitats in Arizona?

Top concerns included:

- Wildlife and habitat connectivity
- Climate change
- Invasive plants and animals
- Habitat degradation
- Water (quality and quantity)
- Wildfire
- Degradation of riparian habitats
- Disease issues
- Increasing development
- Impacts of non-native fish species
- The need for a broader social understanding of trade-offs between natural resources and economic and social values
- Lack of resources to manage species when they become listed

3. What has changed in Arizona in the past decade that could potentially affect how AZGFD thinks about and plans for its fish and wildlife populations and their habitats?

Top concerns included:

- Climate change
- Invasive and non-native species
- Development
- Human population growth and activities
- Regulatory environment

4. What priority issues/strategies/approaches would you like to see in the new iteration of the AWCS?

Responses included:

- Outreach and education
- Prioritize conservation efforts for wildlife and their habitats
- Increased accessibility/training to AWCS tools and data
- Expanded partnerships and collaborations

5. What tools could you use to better integrate information on Arizona's fish and wildlife and their habitats into your projects and planning?

Types of tools/information suggested:

- Climate scenarios

- Invasive species
- Historical data (showing change to distribution over time)
- Restoration project and mitigation lands data layers
- Species abstracts
- Resources to help identify what conservation strategies work together and which do not
- AZGFD liaisons at universities

Suggestions for data accessibility:

- Develop data that are usable for regional planners
- Develop interactive viewer to better understand trends on the ground
- Identify priority areas for restoration
- Make it more accessible to the general public

6. Describe one or more goals the AWCS could emphasize to achieve mutual outcomes.

Responses included:

- Ensuring the AWCS aligns with existing conservation plans (i.e. USFS plans, city comprehensive plans)
- Connectivity and wildlife corridor management
- Ensure Tribes are part of the discussion for management objectives
- Train the next generation of students with the AWCS

7. What else could AZGFD do better with entities to achieve their goals and ensure the health of fish and wildlife in Arizona?

Responses included:

- Fund students and county liaison positions
- Improve coordination with partners
- Increase coordination with ASLD as well as USFS and BLM
- Engage more with industry as a conservation partner
- Use the AWCS to increase messaging of conservation priorities
- Meet annually to review the AWCS with stakeholders and discuss ways to improve the strategy and tools

In April of 2021, AZGFD convened three additional focus groups to share the outcomes of the initial focus group discussions that occurred in November 2020. The purpose of these new focus groups was to review and summarize those initial talks and discuss how the recommendations would be implemented into the AWCS. Attendees of this second round of focus groups included our partners from:

- **Federal Agencies:** USFWS, USBR, USFS, NPS, Yuma Crossing National Heritage Area, Fort Huachuca
- **Native American Tribes:** Navajo Nation, Salt River-Pima-Maricopa Indian Community, Hopi Tribe

- **Academia:** Northern Arizona University, University of Arizona
- **Local Government:** City of Peoria, City of Flagstaff, Pima County, Navajo County, Pinal County, Maricopa County, Big Sandy NRCS
- **NGOs:** Tucson Audubon Society, Phoenix Zoo, Trout Unlimited, Willow Creek Environment, The Nature Conservancy, Be Outdoors Arizona, Altar Valley Conservation Alliance, Borderlands Restoration Network, Audubon Southwest, McDowell-Sonoran Preserve, Sierra Club
- **Industry:** Asarco Silver Bell Mining

Integration into the AWCS Revision

The public outreach and stakeholder forum processes were opportunities for AZGFD staff to engage with the many partners that are a critical part of the AWCS revision process. These discussions and surveys proved to be extremely valuable to help inform the AWCS and make sure we're meeting mutual outcomes for all. These outreach efforts contributed to the following changes to the AWCS:

- **Greater emphasis on identification of threats to species and their habitats and addressing these threats through specific conservation actions.** The AWCS contains an extensive chapter detailing the most prescient threats facing wildlife and their habitats. We also added a chapter that details threats and identifies conservation actions by habitat type that can be taken to remedy threats.
- **Creating prioritized conservation opportunity areas.** We developed an exhaustive network of Conservation Opportunity Areas (COAs) throughout the state that identify the best areas for conservation actions. This web-based tool will be available on the AWCS website after launching in 2022. These COAs not only identify areas of conservation but also foster on-the-ground collaborations with our partners.
- **Increased visibility and interaction with the AWCS.** The AWCS website and on-line tools will greatly increase awareness with the strategy and encourage more public involvement with the AWCS moving forward.
- **Emphasis on climate change stressors.** In order to meet the threats and challenges posed by a changing climate, we've added sections in each habitat profile that address climate change stressors, bringing additional emphasis to what the public and partners view as an increasing threat to wildlife and their habitats.
- **Implement AWCS training.** As part of our overall strategy, once the AWCS website and tools launch in 2022, we will be implementing trainings, presentations, and other public outreach efforts to ensure the public, governments, industry, and other partners are fully engaged with the AWCS and taking advantage of its many benefits.

Chapter 7: Habitat Profiles

Arizona is a large state and home to a rich topographic and biological variety of habitats, from high-elevation alpine tundra to low-lying and arid desert environments. This range in habitats contributes to Arizona's rank as the third most biodiverse state in the nation, home to more than 500 bird species, 72 fish species, 25 amphibians, 164 mammals, and more than 100 species of reptiles (Stein 2002). The state covers nearly 73 million acres, with elevations from 75 feet above sea level (near Yuma) to mountain peaks higher than 12,000 feet (near Flagstaff). In between are sprawling urban areas, rural working lands, rolling grasslands, fragile rivers and lakes, and so much more. Each of these habitats plays an important role in supporting the many species of wildlife from a variety of taxonomic groups, while also providing critical ecosystem services to humans, such as clean air and water, as well as recreational opportunities like hunting and fishing, hiking and birdwatching. Likewise, each of these habitats present its own unique challenges and opportunities to protect the resources for Arizona's wildlife.

Similar to the last two iterations of the SWAP, the AWCS relies on a slightly modified version of the Brown and Lowe (1980, 1994) biotic communities classification system to define the 17 major habitat types that are profiled in this chapter. Each of the habitat types profiled falls into four distinct habitat systems in Arizona: desertscrub, grassland, forest/woodland, and aquatic/riparian. This chapter contains overviews for each of the system types, complete with general descriptions, overall history of the system in Arizona, and current conservation efforts. These are followed by individual habitat profiles which benefited from extensive input from stakeholders and internal AZGFD review by habitat and species experts. These habitat profiles are at the heart of the AWCS as they provide potential conservation actions to reduce or eliminate threats to each habitat type and their associated wildlife species. Each of the habitat profiles included in this chapter contains detailed habitat descriptions, SGCN wildlife and sensitive plant species that occur there, primary threats facing the habitat type, a list of conservation opportunity areas, climate change conservation strategies, and much more.

Desertscrub Overview

All four of North America's deserts can be found in Arizona, three of which are considered "warm" deserts (Sonoran, Chihuahuan, Mohave) and one is considered a "cold" desert (Great Basin). Although all four share the common factor of aridity, each has a unique set of physical characteristics with distinct suites of plants and animals (Brown 1994). As a result, this habitat group contributes significantly to Arizona's exceptionally high biodiversity. Together, these habitats make up approximately 45% of the landscape in Arizona and each provides important habitat for fish and wildlife species.

Upper and Lowland Sonoran Desertscrub

The most biodiverse of all North American deserts, the Sonoran Desert spans the south-central and southwestern portions of Arizona and extends into Sonora, Mexico and southeastern California. Much of the Sonoran Desert landscape is characterized by low mountain ranges separated by large open valleys (Basin and Range topography). Vegetation composition is generally more diverse here than the Mohave or Chihuahuan deserts, with leguminous trees, shrubs, and cacti, including the iconic giant saguaro cactus, covering the desert valleys and foothills. Typical climate consists of hot, dry summers and mild winters with precipitation occurring in a bimodal pattern with two "wet" periods: July to September (monsoon) and December to February (Bradley and Colodner 2019). Warm winters are a distinguishing characteristic of the Sonoran Desert, where winter frosts are rare. Approximately 60 species of mammals, 350 bird species, 20 amphibians, 100 reptiles, and 30 species of native fish make their home in the Sonoran Desert for at least a portion of their life cycle. In addition, an estimated 2,000 species of plants and more than 200 species of native bees also occupy the Sonoran Desert region (Nabhan 2015).

The Phoenix and Tucson metropolitan areas lie within the Sonoran Desert and continue to expand as more and more visitors and new residents are drawn to the area's warm climate, beautiful landscape, outdoor recreational activities, and economic opportunities. The population growth and corresponding development are threatening the biodiversity and overall health of natural communities in the Sonoran Desert region.

The Sonoran Desert comprises two distinct desertscrub types, the lower Sonoran desertscrub and upland Sonoran desertscrub, characterized by different topography and vegetative communities (Dimmit and Fusari 2015). See lower Sonoran desertscrub and Upland Sonoran desertscrub habitat profiles for further details.

Mohave Desertscrub

The Mohave Desert in Arizona occurs in the northwestern and north-central portions of the state, covering much of Mohave County as well as portions of Yavapai County. The Mohave Desert also covers a large area of southeastern California and extends into southern Nevada and the extreme southwestern corner of Utah. Elevation is a bit higher than the Sonoran Desert and the climate is

generally cooler with more winter precipitation (USGS 2005). Winter frosts are common. Basin and range topography characterizes the Mohave Desert with desertscrub habitat throughout the broad valleys. Other than the Joshua tree and soaptree yucca, smaller shrubs, grasses, and annual forbs dominate lower elevation areas.

In Arizona, the Mohave Desert is sparsely populated. Kingman is the largest city with a population of approximately 31,000 in 2020. A large portion of the land is State Trust or owned by BLM, where livestock and wild burro grazing, along with outdoor recreational activities such as off-highway vehicle use, have impaired undeveloped areas and altered the desert plant community composition. Specifically, abundance and diversity of native grasses have been reduced with a subsequent increase in shrub density and non-native annuals (Zuliana et al. 2021). In recent years, the expansion of irrigated farmlands in Mohave County has caused concern regarding increased groundwater pumping. The depletion of groundwater from the desert aquifers could create serious issues for the citizens of Kingman and surrounding areas and would further stress parched Mohave Desert habitats (Burrell 2020). See the Mohave Desertscrub habitat profile for further details.

Chihuahuan Desertscrub

The Chihuahuan Desert occurs primarily in Mexico; however, it extends into portions of Texas, New Mexico, and a small portion of southeastern Arizona. Although the topography consists of the same Basin and Range pattern as the Sonoran and Mohave deserts, the Chihuahuan Desert climate differs, in that it generally receives more of its precipitation during the summer monsoons (Briggs et al. 2019). Winters are generally colder due to the higher elevation compared to the Sonoran Desert. Overall climate in this habitat type is characterized by hot summers and cool, dry winters. Biodiversity is rich in the Chihuahuan Desert with many endemic species, a result of long-term isolation by mountain ranges to the east and west. This geographic isolation also increases vulnerability to threats such as climate change, livestock grazing, agriculture, and sand and gravel mining (Hruska et al. 2017). The combination of habitat degradation, barriers to wildlife movement, pollution, and invasion of non-native species from these anthropogenic sources is taking a toll on this region (Poulos et al. 2013).

A rare and important desert riparian area, the undammed San Pedro River and riparian corridor, provides high quality habitat for many species of migrating birds as well as many other native fish and wildlife species (Brand et al. 2010, Stromberg and Tellman 2009). Today, more than one-third of the river corridor is protected, thanks to collaborative conservation efforts between AZGFD and our partners like TNC and BLM. Several wildlife SGCN, including the loach minnow, desert pupfish, and spikedace have been reintroduced to waters in the San Pedro watershed.

About 30% of the Chihuahuan Desert in Arizona is owned and managed by BLM. An additional 40% of this desert is State Trust land, where livestock grazing and recreational activities including off-highway vehicle use are common. State Trust land also has the potential to be developed, contributing to additional habitat loss and fragmentation. See the Chihuahuan desertscrub habitat profile for further details.

Great Basin Desertscrub

Portions of Great Basin desertscrub habitat occur on the plateaus of northern Arizona. Here, lower, drier, and sparsely-vegetated areas exist adjacent to more topographically diverse cliff-bench complexes where higher elevations and more annual moisture bring greater abundance and diversity in vegetation. Blackbrush, ephedra, rabbitbrush, white ratany, and broom snakeweed are typical shrubs found in the relatively shallow, sandy soils. Livestock grazing and altered fire regimes are major sources of impacts to Great Basin desertscrub habitat. Many of these areas that once supported native shrubs are now invaded by non-native annual grasses. See the Great Basin desertscrub habitat profile for further details.

Conservation of Desertscrub Systems

From the Great Basin to Lower Sonoran, Arizona's desertscrub systems are as varied as they are unique to one another. However, they all share specific biotic and abiotic characteristics that make them highly susceptible to environmental change. Low annual precipitation rates, lack of fire-tolerant vegetation, and invasive species make all of Arizona's desertscrub habitats highly vulnerable to the many threats facing us today. One of the most critical threats to all of Arizona's desertscrub systems is climate change. Slight temperature changes as well as changes to the timing and amount of precipitation that occurs could have substantial and long-lasting impacts to these habitats and species. Habitat fragmentation and loss due to urban and suburban sprawl is also having increasingly adverse effects to these systems, especially in the Sonoran Desert regions that surround growing urban areas of Tucson and Phoenix.

Currently, there are several local, state, and national initiatives that have implemented public/private partnerships to accomplish desertscrub conservation in Arizona:

- The Central Arizona Conservation Alliance (CAZCA) brings together public and private entities under the guidance of the goals of the Regional Open Space Strategy (ROSS). Mostly focused on the Sonoran Desert region, partners in the Alliance include Desert Botanical Garden, Pinal and Maricopa counties, AZGFD, and others.
- Founded in 1995, the non-profit Altar Valley Conservation Alliance works to conserve productive working landscapes in the Sonoran Desert west of Tucson. The Alliance is primarily made up of many ranchers and private landowners in collaboration with other private and public entities, including AZGFD, Pima County, University of Arizona, the Arizona Land and Water Trust, TNC, and several others.
- The Desert Bird Conservation Plan is a project of California Partners in Flight and Point Blue Conservation Science (formerly Point Reyes Bird Observatory) that was developed to guide conservation policy and action on behalf of desert habitats and wildlife. The geographic scope of this plan includes the Mojave Desert in California, southern Nevada, and western Arizona, as well as the Sonoran Desert in California, western Arizona, and Sonora and Baja

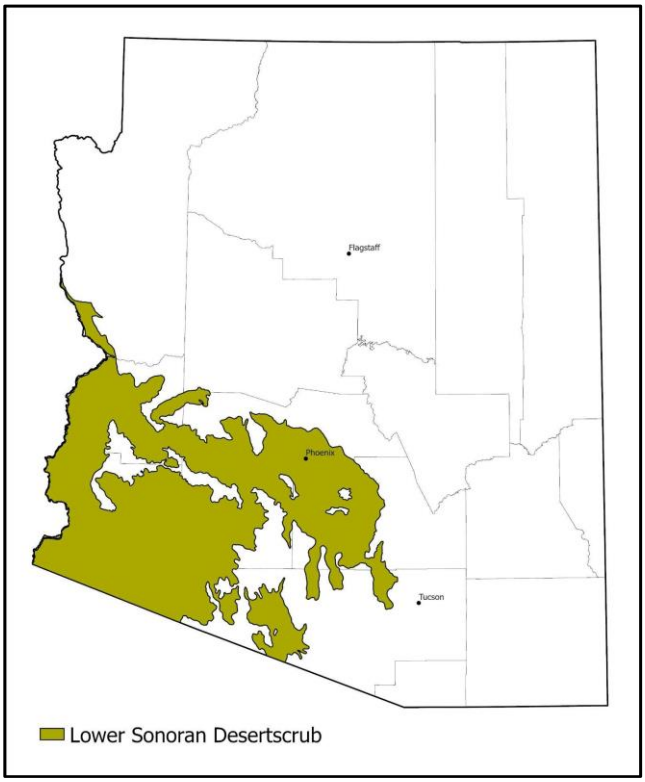
California Norte, Mexico. There are many federal, state, university, private and public entities associated with this plan.

Some of the broader and most relevant plans to desertscrub habitats and species (with web links) can be found in each of the habitat profiles, such as:

- Candidate Conservation Agreement for the Sonoran Desert Tortoise (*Gopherus morafkai*) in Arizona - 2015
- Sonoran Desert Conservation Plan (Pima County)
- Sonoran Pronghorn Recovery Plan, 2nd Revision (2016)
- Lower Colorado River Multi-Species Conservation Program Final Habitat Conservation Plan (2004)
- Memorandum of Understanding Between the Bureau of Land Management and the US Fish and Wildlife Service to Promote the Conservation of Migratory Birds
- Southwestern Willow Flycatcher Recovery Plan
- A National Plan for Assisting States, Federal Agencies and Tribes in Managing White-Nose Syndrome in Bats, May 2011
- Western Burrowing Owl Management Resources

Lower Sonoran Desertscrub
Habitat Profile

Lower Sonoran desertscrub is the most arid habitat found in Arizona. The vegetation community is dominated by drought-tolerant, low, open stands of creosote bush and white bursage. Winter annuals make up the bulk of the remainder of the vegetation and their blooms can be surprisingly colorful in wet years. Columnar cacti, ocotillo, and cholla, although present, are less abundant than in the neighboring Upland Sonoran desertscrub. Larger trees, such as ironwood, palo verde, and mesquite are largely confined to washes and other drainages (Brown et al. 2017).



The basin and range landscape typically comprises broad, relatively flat valleys separated by scattered, small mountain ranges (Dimmitt 2015). These xeric mountain ranges provide habitat for desert bighorn sheep, Sonoran desert tortoises, and other saxicolous species. Stabilized and active dunes are present throughout this habitat which support a variety of dune and sand-specialist species of plants and animals such as ajo lilies, desert sandfood, flat-tailed and Goode's horned lizards, Yuman desert and Mojave fringe-toed lizards, and sidewinders. LeConte's thrasher, round-tailed ground squirrel, desert kangaroo rat, and kit fox are also present in this habitat type (Turner 1994).

The lower reaches of the Colorado and Gila rivers flow through this dry desert region providing a variety of important aquatic and riparian habitats for many fish and wildlife species. Additionally, these riparian areas provide water for agricultural and municipal uses. At least 21% of this habitat type has been lost due to development and agriculture. Approximately 45% of lower Sonoran desertscrub is federal land, including Barry M. Goldwater Range, Yuma Proving Ground, and Cabeza Prieta and KOFA National Wildlife Refuges. Because of this ownership, opportunities may exist to protect and restore large tracts of land in this region.

Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Riparian areas**, such as the Gila, Bill Williams, and Colorado Rivers, are important for wildlife and support the only cottonwood and willow forest in lower Sonoran desertscrub. This riparian forest and associated marshlands provide critically important habitat for a variety of species, including Yuma Ridgway's rail, California black rail, southwestern willow flycatcher, western yellow-billed cuckoo, and northern Mexican gartersnake. Additionally, these river systems provide some of the only perennial water found in these hyper-arid areas.
- Stabilized and active **dune systems** are unique to lower Sonoran desertscrub habitat in Arizona. These sandy areas provide habitat for a variety of sand-specialized species such as several desert fringe-toed lizard species, flat-tailed horned lizards, Mojave and resplendent shovel-nosed snakes, sidewinders, and desert kangaroo rats. A variety of dune and sand specialist plants can also be found in these areas, including ajo lily, scaly-stemmed sand plant, sandfood, Gander's cryptantha, tansy spectaclepod, desert twinbugs, saw-toothed ditaxis, galleta grass, Emoryi's indigobush, Schott's wire-lettuce, and fanleaf crinklemat (Felger et al. 2003).
- **Ephemeral washes and pools** are important breeding habitats for a variety of desert anurans, including Sonoran green toad, Sinaloan narrow-mouthed toad, lowland burrowing treefrog, and Sonoran desert toad (Brennen and Holycross 2009). Washes, despite their ephemeral nature, support higher densities of mesquite and ironwood compared to the surrounding plains. These linear woodlands serve as nesting sites for birds, provide browse and cover for ungulates, and act as movement corridors for a variety of wildlife species.
- **Bedrock tinajas** are small rain-filled pools that develop in bedrock depressions created by wind and water erosion found in the Cabeza Prieta, Gila, Kofa, and Tinajas Altas mountains. These features collect water during rare periods of rain and are vital sources of water for desert bighorn sheep and other montane species.
- **Bajadas** are the coalescence of alluvial fans along a mountain front where fine sediment is deposited at the end of dry washes and other drainages. Because of this soil composition, these slopes can host a greater diversity of vegetation and more complex vertical structure compared to surrounding areas.
- **Saguaro cacti** are a keystone species in the Sonoran desert, providing a variety of resources for deasert fauna. Saguaros provide nectar, pollen, and fruit for two species of SGCN nectarivorous bats, as well as a host of other pollinator species, that occur across much of southern Arizona. Saguaros also provide cavities for nesting avian species such as cactus ferruginous pygmy owl and western screech owl. Invasive buffelgrass — which outcompetes native flora and provides fuel for wildfire -- is a major threat to these iconic keystone species.

Key Conservation Species (SGCN)

The following list represents species in this habitat type that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Sonoran green toad, Sinaloan narrow-mouthed toad, lowland burrowing treefrog, Sonoran desert toad

Birds: Costa's hummingbird, LeConte's and Bendire's thrashers, verdin, western screech-owl, bald eagle, golden eagle, loggerhead shrike, California black rail, southwestern willow flycatcher, Yuma Ridgway's rail, western yellow-billed cuckoo
Invertebrates: Phoenix (Squaw Peak) talussnail, eastern desertsnail
Mammals: Sonoran pronghorn, Harris' antelope squirrel, antelope jackrabbit, California leaf-nosed bat, lesser long-nosed bat, Mexican free-tailed bat, western red bat, pocketed free-tailed bat, greater western bonneted bat
Reptiles: Goode's horned lizard, flat-tailed horned lizard, Yuman desert fringe-toed lizard, Mojave fringe-toed lizard, Mohawk dunes fringe-toed lizard, Sonoran collared lizard, speckled rattlesnake, Sonoran desert tortoise, Arizona mud turtle, Gila monster, Sonoran coralsnake, three-lined boa

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

scaly sandplant, sandfood

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Couch's spadefoot toad, desert iguana, sidewinder, chuckwalla, resplendent shovel-nosed snake, Mojave rattlesnake, black-tailed gnatcatcher, lesser nighthawk, Gambel's quail, mourning dove, white-winged dove, desert bighorn sheep, mule deer, desert cottontail, pallid bat, western yellow bat, cave myotis, canyon bat, mule deer; invasive plant species include stinknet, giant salvinia, tamarisk, sahara mustard

Primary Threats to Lower Sonoran Desertscrub

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1	Annual and perennial non-timber crops
		1.3	Livestock farming and ranching
2	Biological Resource Use	2.1	Unlawful collection of terrestrial animals
		2.2	Unlawful collection of terrestrial plants
3	Climate Change	3.1	Habitat shifting and alteration
		3.2	Droughts
		3.3	Changes in temperature regimes
		3.4	Storms and flooding

Code	Level 1 Threats	Code	Level 2 Threats
4	Residential and Commercial Development	4.1 4.2 4.3	Housing and urban areas Commercial and industrial areas Tourism and recreation areas
5	Disease, Pathogens, and Parasites	NA	NA
6	Energy Production and Mining	6.2 6.3	Mining and quarrying Renewable energy
7	Human Intrusion and Disturbance	7.1 7.3	Recreational activities Work and other activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1 9.2	Fire and fire suppression Dams and water management
10	Pollution	10.1 10.2 10.3 10.4	Household sewage and urban wastewater Industrial and military effluents Agricultural and forestry effluents Garbage and solid waste
11	Transportation and Service Corridors	11.1 11.2	Roads and railroads Utility and service lines

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Encourage and facilitate strategic planning for the renewable energy industry.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Identify populations that could benefit from assisted migrations and/or translocation.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.
- Establish new wild and/or captive populations of climate-vulnerable SGCN.
- Maintain existing and identify new wildlife waters for drought mitigation.
- Monitor and mitigate for introduced/invasive species.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Bouse Dunes	BLM
Cave Creek Linkage	USFS, BLM, ASLD, Private
Colorado River Nature Center Wildlife Area	AZGFD, BLM
Estrella Maricopa Corridor	BLM, ASLD
Harquahala Plain TNC Preserve	BLM, ASLD, Private
Hassayampa River	USACE, BLM, Private, Cities of Buckeye and Wickenburg
Imperial-Cibola	USFWS
King Valley	USFWS
Lower Colorado River Gadsden Riparian	ASLD, BLM, Private
Lower Salt and Gila Rivers	ASLD, BLM, AZSP, USACE, Private
Mittry Lake Wildlife Area	AZGFD
Mohawks	BLM, DOD
Muggins-Laguna-Gila Complex	BLM, ASLD
Palomas Plains	BLM, DOD, USFWS, ASLD
Phoenix Area Snails	City of Phoenix, City of Glendale, City of Peoria, Maricopa County Parks, ASLD, AZGFD, USFS
Ranegras Plain	BLM, USFWS, ASLD
Vekol Valley	BLM
Yuma Desert	DOD, USBR

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

Department of Defense (DOD) Yuma Proving Ground, DOD Barry M. Goldwater Range, DOD U.S. Marine Corps, DOD Air Force, USFWS Kofa National Wildlife Refuge, USFWS Cabeza Prieta National Wildlife Refuge, USFWS Imperial National Wildlife Refuge, USFWS Cibola National Wildlife Refuge, USFWS Arizona Ecological Services, Sonoran Desert National Monument, USBR, BLM, Gila River Indian Community, Ak-Chin Indian Community, Colorado River Indian Tribes, Arizona-Sonora Desert Museum, Arizona Center for Nature Conservation-Phoenix Zoo, Desert Botanical Garden, Lower

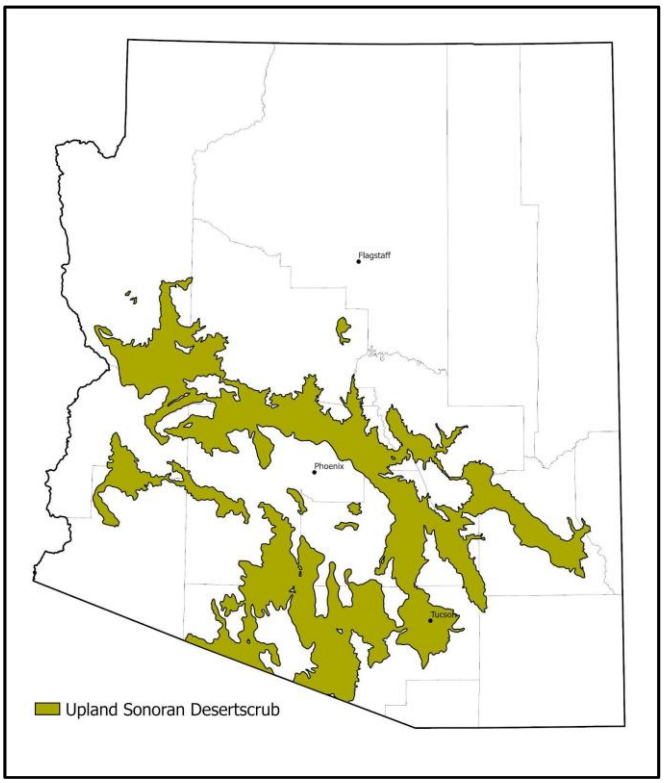
Colorado River Multi-Species Conservation Program, Yuma Crossing National Heritage Area, Maricopa County Parks, Pinal County Open Space and Trails, Pima County Office of Conservation and Sustainability, City of Phoenix Parks and Recreation, City of Glendale Parks and Recreation, Audubon Arizona, ADOT, USACE, Buckeye, Avondale, Marana, USGS, Gila Bend, NRCS, Maricopa County Flood Control District, ASU, UA, Sonoran Joint Venture, Arizona Field Ornithologists, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Important Conservation Resources

The following are relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Flat-tailed Horned Lizard Rangewide Management Strategy (2003)
- Final Sonoran Pronghorn Recovery Plan, 2nd Revision (2016)
- Lower Colorado River Multi-Species Conservation Program Final Habitat Conservation Plan (2004)
- Candidate Conservation Agreement for the Sonoran Desert Tortoise (*Gopherus morafkai)* in Arizona
- Western Burrowing Owl Management Resources
- A National Plan for Assisting States, Federal Agencies and Tribes in Managing White-Nose Syndrome in Bats, May 2011.
- Memorandum of Understanding Between the Bureau of Land Management and the U.S. Fish and Wildlife Service to Promote the Conservation of Migratory Birds
- Pima County MSCP
- Draft Post-Delisting Monitoring Plan for the Lesser Long-nosed Bat, 2019
- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan
- Western Monarch Butterfly Conservation Plan

Upland Sonoran Desertscrub
Habitat Profile



Upland Sonoran desertscrub occupies a relatively large portion of central and southern Arizona with a highly diverse composition and topography. Characteristic vegetation of the upland Sonoran desertscrub includes giant saguaro, cholla, prickly pear, and organ pipe cacti. Common tree and shrub species include palo verde, ironwood, catclaw acacia, mesquite, jojoba, and creosote bush (Dimmitt 2015).

This habitat type tends to receive more precipitation than other desertscrub habitat types (Bradley and Colodner 2019). Annual precipitation primarily comes in two distinct seasons, mid- to late-summer (monsoon) and winter, contributing to the habitat's rich biodiversity despite being a desert environment (Nabhan 2015). Annual plant species emerge in response to this seasonal precipitation pattern creating brief but remarkable changes to the landscape. If winter rains are hearty, fields of bright green grasses and forbs and beautiful arrays of wildflowers blanket the rocky slopes and valley floors during the spring season.

Arizona contains more Upland Sonoran desertscrub habitat than any other state in North America, putting Arizona in a position of great responsibility for conservation and protection of this unique habitat. Unfortunately, upland Sonoran desertscrub is highly susceptible to development with significant habitat losses occurring in recent decades due to urban expansion into desert environments. These desertscrub habitats are increasingly vanishing and becoming more fragmented, especially surrounding the growing urban areas around Phoenix and Tucson. However, approximately 44% of this habitat type is found in protected areas, mostly managed by federal agencies, such as NPS, USFS, and BLM (Hall et al. 2005). Several species are found in this habitat type that occur nowhere else in the state, including the Sonoran shovel-nosed snake, ferruginous (cactus) pygmy-owl, and three-lined boa (Turner 1994a).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Springs** often support endemic species, such as Bylas springsnail, Montezuma Well springsnail, Gila tryonia, Quitobaquito tryonia, and Sonoyta mud turtle.
- **Bedrock tinajas** in the mountains collect water during rare periods of rain and are critically important sources of water for desert bighorn sheep and other montane species.
- **Bajadas** are the coalescence of alluvial fans along a mountain front where fine sediment is deposited at the end of dry washes and other drainages. Because of this soil composition, bajadas can host a greater diversity of vegetation and more complex vertical structure compared to surrounding areas.
- **Ephemeral washes and pools** are critically important breeding habitats for a variety of desert anurans, including Sonoran green toad, Sonoran desert toad, Sinaloan narrow-mouthed toad, and Arizona toad (Brennen and Holycross 2009). Washes, despite their ephemeral nature, support higher densities of mesquite and ironwood than the surrounding plains. These linear woodlands (or xeric riparian corridors) serve as nesting and stopover sites for birds, provide browse and cover for ungulates, and act as movement corridors for a variety of wildlife species.
- **Caves and mines** are important roost sites for many species of bats. More than half (14) of the bat species that occur in the upland Sonoran desertscrub habitat use caves and mines at some point during the year. Many of the mines lack bat-friendly protections, leaving these species vulnerable to disturbances.
- **Saguaros, organ pipe cacti and multiple species of Agave** provide nectar, pollen, and fruit for two species of nectarivorous bats, as well as a host of other pollinator species, that occur across much of southern Arizona. Invasive buffelgrass and habitat loss is putting increased pressure on these iconic keystone species.
- **Riparian areas**, such as the Middle Gila and Lower Salt rivers are important for wildlife and support the only cottonwood and willow forests in upland Sonoran desertscrub. This riparian forest provides critically important habitat for a variety of species, including southwestern willow flycatcher, western yellow-billed cuckoo, and northern Mexican gartersnake. Additionally, these river systems provide some of the only perennial water found in these hyper-arid areas.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Sonoran green toad, Sonoran Desert toad, Sinaloan narrow-mouthed toad, lowland burrowing treefrog, lowland leopard frog, Arizona toad
Birds: Costa's hummingbird, Gila woodpecker, gilded flicker, ferruginous (cactus) pygmy-owl, elf owl, bald eagle, golden eagle, rufous-winged sparrow, black-throated sparrow, canyon towhee, cactus wren, western yellow-billed cuckoo, southwestern willow flycatcher, purple (western) martin

Invertebrates: Bylas springsnail, Gila tryonia, Montezuma Well springsnail, Phoenix (Squaw Peak) talussnail, Superstition talussnail, Quitobaquito tryonia
Mammals: Harris' antelope squirrel, Merriam's deermouse, Bailey's pocket mouse, desert pocket mouse, lesser long-nosed bat, Mexican long-tongued bat, California leaf-nosed bat, Mexican free-tailed bat, pale Townsend's big-eared bat, antelope jackrabbit, Sonoran pronghorn, pocketed free-tailed bat, Underwood's mastiff bat
Reptiles: Gila monster, northern Mexican gartersnake, regal horned lizard, Arizona night lizard, Bezy's night lizard, three-lined boa, rosy boa, variable sandsnake, Sonoran shovel-nosed snake, saddle leaf-nosed snake, black-necked gartersnake, tiger rattlesnake, Sonoran coralsnake, Sonora mud turtle, Sonoyta mud turtle, Sonoran desert tortoise
Fish: Sonoyta pupfish

Sensitive Plant Species

The following represents listed plant species that are known to occur in this habitat type:

Tonto Basin agave, Hohokam agave, Trelease agave, Page Springs agave, saiya, aquarius milkvetch, Pima pineapple cactus, Nichol Turk's Head cactus, Acuna cactus, Fish Creek fleabane, Arizona eryngo, Huachuca water-umbel, horseshoe deer vetch, seashore cactus, Chihuahua scurfpea, Verde breadroot, Ajo rock daisy, lace-leaf rockdaisy, Roosevelt Dam rockdaisy, whisk fern, parish alkali grass, Arizona cliff rose, Verde four-nerve daisy

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, such as altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Longfin dace, Couch's spadefoot, red-spotted toad, common chuckwalla, speckled rattlesnake, desert bighorn sheep, mule deer, javelina, coyote, bobcat, ringtail, common poorwill, curve-billed thrasher, Lucy's warbler, greater roadrunner, brown-crested flycatcher, song sparrow, desert cottontail, cave myotis, pallid bat, western yellow bat, canyon bat, California myotis, black-tailed jackrabbit, white-nosed coati, American bullfrog; plant species include giant saguaro, agave spp., acuña cactus, Nichol's turk's head cactus, buffelgrass, and tamarisk

Primary Threats to Upland Sonoran Desertscrub

The following describes the primary threats facing Upland Sonoran desertscrub woodlands, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see *Chapter 8: Threats and Conservation Actions**.*

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
2	Biological Resource Use	2.1 2.2	Unlawful take of terrestrial animals Unlawful take of terrestrial plants
3	Climate Change	3.1 3.2 3.3 3.4	Habitat shifting and alteration Droughts Changes in temperature regimes Storms and flooding
4	Residential and Commercial Development	4.1 4.2 4.3	Housing and urban areas Commercial and industrial areas Tourism and recreation areas
5	Disease, Pathogens, and Parasites	NA	NA
	Energy Production and Mining	6.2 6.3	Mining and quarrying Renewable energy
7	Human Intrusion and Disturbance	7.1 7.3	Recreational activities Work and other activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1 9.2	Fire and fire suppression Dams and water management
10	Pollution	10.1 10.2 10.3 10.4	Household sewage and urban wastewater Industrial and military effluents Agricultural and forestry effluents Garbage and solid waste
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Identify populations that could benefit from assisted migrations/translocation.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.
- Establish new wild and/or captive populations of climate vulnerable SGCN.

- Maintain existing and identify new wildlife waters for drought mitigation.
- Monitor for new populations of introduced and invasive species.
- Establish refugia for at-risk species (e.g. springsnail species, desert pupfish).

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles for each COA see Appendix H: Terrestrial COA Profiles.

COA Name	Site Owner/Manager(s)
Agua Fria National Monument	NPS
Bill Williams Complex	BLM, ASLD, AZGFD, USFWS, AZSP, USACE
Castle Dome Mountains	USFWS, DOD
Cave Creek Linkage	USFS, BLM, ASLD, Private
Estrella Maricopa Corridor	BLM
Garland Prairie	USFS, ASLD, Private
Gila River	BLM, Gila River Indian Community, Private
Hassayampa River	BLM, Private, Cities of Buckeye and Wickenburg
Ironwood National Monument	BLM
Joshua Tree IBA	BLM, ASLD, Private
King Valley	USFWS
Kofa Mountains	USFWS
Phoenix Area Snails	City of Phoenix, City of Glendale, City of Peoria, Maricopa County Parks, ASLD, AZGFD, USFS
McDowell Mountains - Superstition Mountains-Mazatzal Mountains	USFS, Maricopa County
McDowell Sonoran Preserve - Tonto National Forest	USFS
Porter Springs Wash and Cold Springs	BLM
Roosevelt Lake	USFS
Quitobaquito Spring	NPS
Salt-Verde Ecosystem	USFS
Sonoran Desert Borderlands	USFWS, NPS, BLM

COA Name	Site Owner/Manager(s)
Table Top Mountains	BLM
Telegraph Fire	USFS, ASLD
Tonto Creek	USFS
Ripsey Wash-Donnally Wash	ASLD, Private
Tortolita Mountains	NPS, Pima County
Weaver Mountains	BLM, ASLD

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

Arizona Center for Nature Conservation-Phoenix Zoo, Bat Conservation International, Desert Botanical Garden, Central Arizona Conservation Alliance (CAZCA), Arizona-Sonora Desert Museum, Tohono O'odham Nation, Gila River Indian Community, DOD Barry M. Goldwater Range, DOD Yuma Proving Ground, BLM, NPS, USFWS, USBR, Tucson Audubon Society, Audubon Southwest, Arizona Field Ornithologists, Sonoran Joint Venture, Sky Island Alliance, Sonoran Desert Comprehensive Weed Management Area, Pima County, Pinal County, Maricopa County, La Paz County, USACE, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

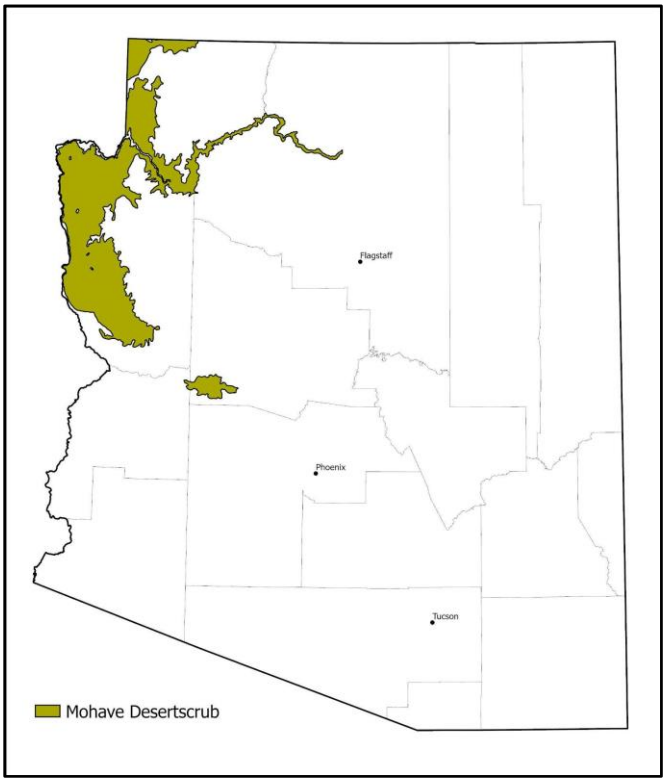
Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or of particular interest regarding SGCN in this habitat type:

- Candidate Conservation Agreement for the Sonoran Desert Tortoise (*Gopherus morafkai)* in Arizona
- CCAA - AZ Electric Power Co-op CCAA for the Sonoran Desert Tortoise
- Quitobaquito Tryonia Strategic Conservation Plan (CCA format; 2021 Draft)
- BLM Statewide Springsnail Strategic Conservation Plan (CCA format; 2022 Planned)
- Proposed Critical Habitat for Northern Mexican Gartersnake
- BLM Instruction Memorandum (IM) 2010-181, White Nose Syndrome
- Western Burrowing Owl Management Resources
- USFWS: A National Plan for Assisting States, Federal Agencies and Tribes in Managing White-Nose Syndrome in Bats, May 2011.
- Memorandum of Understanding Between the Bureau of Land Management and the U.S. Fish and Wildlife Service to Promote the Conservation of Migratory Birds
- Pima County MSCP
- Draft Post-Delisting Monitoring Plan for the Lesser Long-nosed Bat, 2019

- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan
- Western Monarch Butterfly Conservation Plan

Mohave Desertscrub
Habitat Profile



Mohave desertscrub occurs in northwestern Arizona, southern Nevada and southeastern California generally at elevations between 1,000 to 3,000 feet above sea level. Landscapes are typically quite barren and desolate in appearance with low, scattered shrubs. 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 1994c). Other predominant plant species include creosote bush, brittlebush, desert holly, and white bursage with smaller cacti present along slopes. Hot summers and cool winters are typical with the majority of the annual precipitation (5 to 11 inches) falling in the winter (USGS 2005). 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. Examples of these species include Mojave desert tortoise, relict leopard frog, Kingman springsnail, and Mohave talussnail.

In recent decades, the historical distribution of Mohave desertscrub in Arizona has been reduced through habitat loss and fragmentation due to agricultural operations and low-density development across the landscape (Averill-Murray et al. 2021). With this increase in habitat loss, habitat fragmentation has increased causing wildlife to become displaced and genetic diversity to decrease. A significant portion of Mohave desertscrub distribution is federally-managed. This offers some degree of protection from development on the landscape.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Riparian areas**, such as the Colorado River and Virgin River are extremely important for wildlife in Mohave desertscrub habitats. Riparian areas and associated marshlands provide

habitat for a variety of native species, including federally-listed species like Yuma Ridgway's rail, southwestern willow flycatcher, western yellow-billed cuckoo, and northern Mexican gartersnake.

- **Springs** exist on the landscape when water pressure in the aquifer pushes water through cracks or tunnels and flows naturally to the surface. These springs create isolated pockets of habitat and often support endemic species, such as Grand Wash springsnail, Kingman springsnail, desert springsnail, relict leopard frog, and lowland leopard frog.
- **Joshua tree forests** in Arizona are restricted to small areas of Mohave desertscrub in the northwest portion of the state. These habitats are an important part of the Mohave Desert ecosystem and are a host to unique species of yucca that provide resources for many pollinators, birds, mammals, and lizard species.
- **Caves and mines** are important roost sites for many species of bats. Many of the bat species that occur in the Mohave desertscrub habitat use caves and mines at some point during the year. Many of the mines lack bat-friendly protections, leaving these species vulnerable to disturbances.
- **Playas** occur in intermountain basins throughout the arid southwestern United States. Although playas may appear as featureless plains, they are rich in features and characteristics that can reveal information about climates, past and present (USGS 2009).

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Relict leopard frog, Arizona toad, lowland leopard frog
Birds: cactus wren, western burrowing owl, ferruginous hawk, bald eagle, golden eagle, American peregrine falcon, California condor, black-throated sparrow, Bendire's thrasher, loggerhead shrike, Swainson's hawk, LeConte's thrasher
Invertebrates: Grand Wash springsnail, Kingman springsnail, desert springsnail, Mohave talussnail
Mammals: Mexican free-tailed bat**,** pale Townsend's big-eared bat, American pronghorn, Allen's lappet-browed bat, California leaf-nosed bat
Reptiles: Mojave desert tortoise, Gila monster, Sonoran desert tortoise

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Arizona pricklypoppy, Holmgren (Paradox) milk-vetch, freckled milk-vetch, Kaibab suncup, Tabeau Peak wild buckwheat, Black Mountains monardella, Siler pincushion cactus, Higgins' phacelia, Arizona rose sage, Gierisch mallow

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Mule deer, coyote, black-tailed jackrabbit, desert bighorn sheep, common chuckwalla, javelina, Woodhouse's toad, red spotted toad, bobcat, greater roadrunner, black-tailed gnatcatcher, ash-throated flycatcher, desert cottontail, Yuma myotis, pallid bat, Joshua tree, Mohave yucca, creosote bush

Primary Threats to Mohave Desertscrub Habitat

The following describes the primary threats facing Mojave Desertscrub adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represents broad categories while second-level threats reflect more specific stressors to this habitat type. For detailed information on threats to lentic systems and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.3	Livestock farming and ranching
2	Biological Resource Use	2.1 2.2	Unlawful take of terrestrial animals Unlawful take of terrestrial plants
3	Climate Change	3.1 3.2	Habitat shifting and alteration Droughts
4	Residential and Commercial Development	4.1 4.2 4.3	Housing and urban areas Commercial and industrial areas Tourism and recreation areas
5	Disease, Pathogens, and Parasites	NA	NA
6	Energy Production and Mining	6.2 6.3	Mining and quarrying Renewable energy
7	Human Intrusion and Disturbance	7.1 7.3	Recreational activities Work and other activities
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species
9	Natural Systems Modifications	9.1 9.2 9.3	Fire and fire suppression Dams and water management Other ecosystem modifications
10	Pollution	10.1 10.4	Household sewage and urban wastewater Garbage and solid waste

Code	Level 1 Threats	Code	Level 2 Threats
11	Transportation and Service Corridors	11.1 11.2	Roads and railroads Utility and service lines

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Black Mountains	BLM, NPS, AZGFD, ASLD
Joshua Tree IBA	BLM, ASLD, Private
Grand Wash Cliffs North	BLM
Virgin River Springsnail	Private, BLM, ADOT
Black Mountains	BLM, NPS, AZGFD, ASLD

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFWS, BLM, NPS Grand Canyon-Parashant National Monument, Lake Mead National Recreation Area, Grand Canyon National Park, Hualapai Tribe, Havasupai Tribe, Big Sandy National Resource

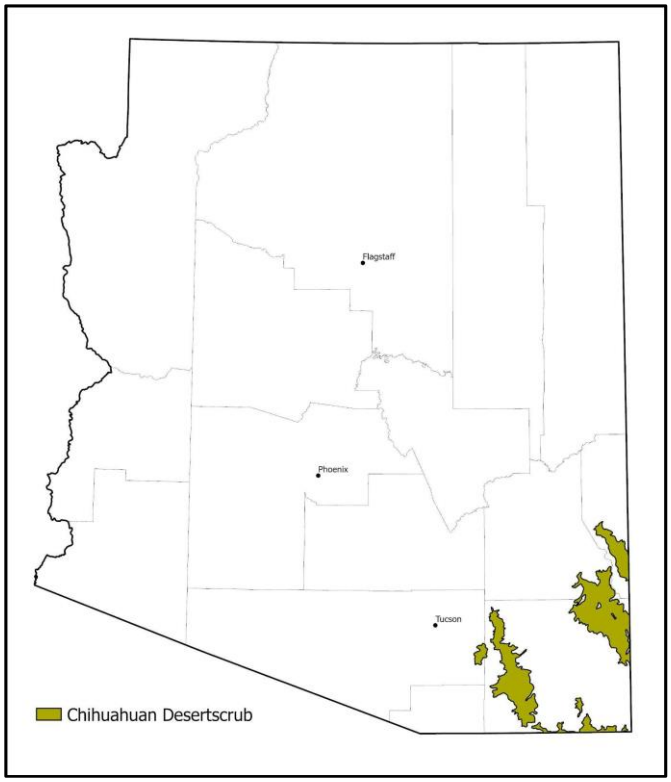
Conservation District, USDA NRCS, Mule Deer Foundation, Northern Arizona University, USGS, Nevada DOW, Nevada DOT, Utah DNR, Arizona Deer Association, Arizona Desert Bighorn Sheep Society, ADOT, Federal Highway Administration, Arizona Mule Deer Organization, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents of particular interest regarding SGCN in this habitat type:

- Western Burrowing Owl Management Resources
- CCAA - AZ Electric Power Co-op CCAA for the Sonoran Desert Tortoise
- Candidate Conservation Agreement for The Sonoran Desert Tortoise (*Gopherus morafkai*) in Arizona
- BLM Black Mountain Ecosystem Management Plan
- BLM Instruction Memorandum (IM) 2010-181, White Nose Syndrome
- A National Plan for Assisting States, Federal Agencies and Tribes in Managing White-Nose Syndrome in Bats, May 2011.
- Arizona Bighorn Sheep Management Plan
- MOU U.S. Department of Interior/BLM/USFWS, 2010: To promote the Conservation of Migratory Birds
- Grand Canyon — Parashant National Monument Resource Management Plan
- Mojave Desert Tortoise Recovery Plan
- Conservation Agreement and Assessment and Strategy for the Relict Leopard Frog
- BLM Statewide Springsnail Strategic Conservation Plan (CCA format; 2022 Planned)
- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan
- Western Monarch Butterfly Conservation Plan

Chihuahuan Desertscrub
Habitat Profile



In Arizona, Chihuahuan desertscrub covers only a relatively small area southeast of Tucson around Duncan, San Simon, and the San Pedro River Valley at elevations of approximately 3,500 to 5,000 feet above sea level. Chihuahuan desertscrub is more widespread in neighboring regions covering most of north-central Mexico, portions of West Texas, and southern New Mexico.

Chihuahuan desertscrub in Arizona typically receives less than nine inches of precipitation annually, mainly in the summer months (Brown 1994). Creosote, tarbush, and whitethorn acacia are characteristic shrubs. Additional characteristic plant species include ocotillo, mesquites, desert zinnias, agaves, and yuccas (Brown 1994). Trees are rare throughout this habitat type. The extent of Chihuahuan desertscrub in Arizona has expanded due to conversion from grasslands in areas experiencing suppression of natural fires and high grazing pressure combined with drought (Gori and Enquist 2003). This habitat type generally occurs on relatively flat areas of less than 10% slope making it attractive for agriculture operations and development. Several SGCN species occur in Chihuahuan desertscrub, including Gila monster, Harris' antelope squirrel, and banner-tailed kangaroo rat. However, no SGCN are limited to only this habitat type (AZGFD 2012).

Significant Habitat Features

The following describes habitat features or microhabitats in this habitat type that are of particular importance to certain species:

- **Springs** act as important water sources in an arid environment and often support endemic species that require aquatic habitats to support their life cycle, such as San Bernardino springsnail, Chiricahua leopard frog, and lowland leopard frog.
- **Ephemeral washes and pools** are critically important breeding habitats for a variety of desert anurans, including plains spadefoot, green toad, and Sonoran Desert toad (Brennen and

Holycross 2009). Washes, despite their ephemeral nature, support higher densities of mesquite and ironwood than the surrounding plains. These linear forests serve as nesting sites for birds, provide browse and cover for ungulates, and act as movement corridors for a variety of wildlife species.

- **Riparian areas**, such as the San Pedro River and Ciénega Creek, are important for wildlife. These waterways can support cottonwood and willow forests and provide critically-important habitat for a variety of species, including southwestern willow flycatcher, western yellow-billed cuckoo, and northern Mexican gartersnake. Besides providing some of the only perennial water in the region, these lush areas also act as important corridors for seasonal and annual movements for wildlife.

Key Conservation Species (SGCN)

The following list represents SGCN species found in this habitat type that AZGFD actively manages or is watching closely due to some level of concern:

Amphibians: Chiricahua leopard frog, plains leopard frog, lowland leopard frog, Sonoran Desert toad
Birds: southwestern willow flycatcher, western yellow-billed cuckoo, golden eagle, peregrine falcon, scaled quail, Chihuahuan raven, Cassin's sparrow, black-capped gnatcatcher, western burrowing owl
Invertebrates: San Bernardino springsnail
Mammals: lesser long-nosed bat, Harris' antelope squirrel, antelope jackrabbit, black-tailed prairie dog, yellow-nosed cotton rat, hispid pocket mouse, northern pygmy mouse, banner-tailed kangaroo rat, western red bat, cave myotis, greater western bonneted bat
Reptiles: northern Mexican gartersnake, Gila monster, ornate box turtle

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Cochise pincushion cactus, San Pedro River wild buckwheat, Arizona eryngo, Bartram stonecrop, Huachuca water-umbel, lace-leaf rockdaisy

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

White-nosed coati, curve-billed thrasher, greater roadrunner, kit fox, western yellow bat, Merriam's kangaroo rat, banner-tailed kangaroo rat, desert mule deer, desert cottontail, Gould's turkey, green toad, plains spadefoot, Mexican hognose snake, checkered gartersnake, western diamondback rattlesnake, Mohave rattlesnake, greater earless lizard, Texas horned lizard, roundtail horned lizard

Primary Threats to Chihuahuan Desertscrub

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
3	Climate Change	3.1 3.2 3.4	Habitat shifting and alteration Droughts Storms and flooding
6	Energy Production and Mining	6.3 6.3	Mining and quarrying Renewable energy
7	Human Intrusion and Disturbance	7.3	Work and other activities
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species
9	Natural Systems Modifications	9.1	Fire and fire suppression
10	Pollution	10.1	Household sewage and urban wastewater
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Monitor and mitigate for introduced/invasive species.
- Maintain existing and identify new wildlife waters for drought mitigation.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Dos Cabezas	BLM
Little Dragoons	ASLD, Private, BLM
Lower San Pedro River	AZGFD, TNC, BLM, ASLD, Private
Peloncillo Mountains	BLM
San Bernadino NWR	USFWS
San Pedro Riparian NCA	BLM

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

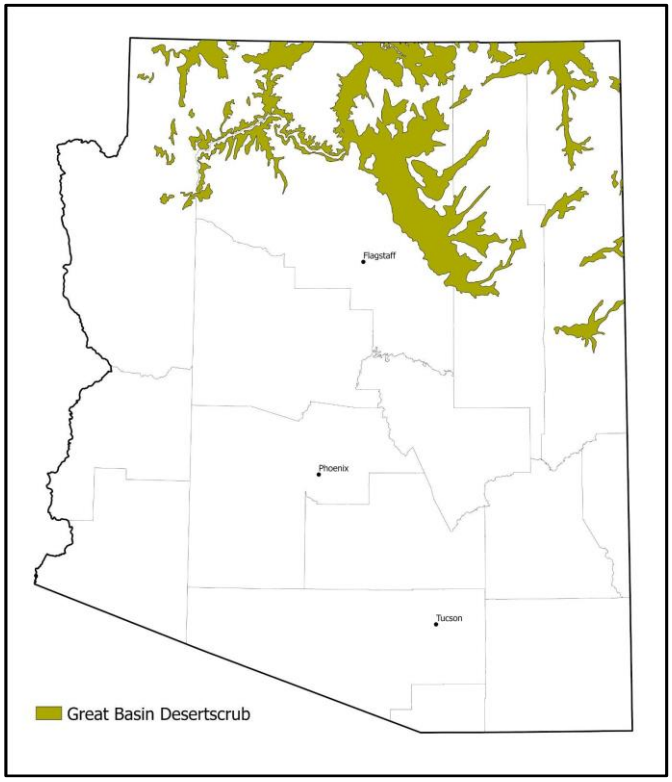
BLM (Safford and Tucson field offices), Malpais Borderlands Group, Borderlands Restoration Network, TNC, Arizona Field Ornithologists, Sonoran Joint Venture

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or of particular interest regarding SGCN in this habitat type.

- Chiricahua Leopard Frog Recovery Plan
- Southwestern Willow Flycatcher Recovery Plan
- Yellow-billed Cuckoo Species Profile Page
- Black-tailed Prairie Dog Multi-State Conservation Plan
- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan

Great Basin Desertscrub
Habitat Profile



The Great Basin Desert is the most northern and highest elevation of Arizona's deserts. This cold desert habitat occurs in northern Arizona's Colorado Plateau region. This shrub-dominated community occurs across the Arizona Strip and the Painted Desert of the Little Colorado River basin, generally at elevations between 4,000 to 7,000 feet above sea level (Brown 1982). The climate is arid, the growing season is short and freezing temperatures are common in all but the warmest summer months. Winters are dry, windy and cold. Plant diversity is relatively low with dominant shrub species including sagebrush, shadscale, blackbrush, Mormon tea, rabbitbrush, and winterfat. Cacti and succulents are limited to just a few low-stature species. Grasses include black grama, mutton grass, Indian rice and needle and thread. Historically, this was not a fire-adapted ecosystem, however with the invasion of annual grasses like cheatgrass, fire intervals have become more frequent to the detriment of native shrubs and herbaceous species such as blackbrush and winterfat (Turner 1994). Much of the area covered by Great Basin desertscrub has remained relatively unchanged. However, habitat degradation increased throughout the 20th Century, mostly due to intense grazing practices (Tuhy et al. 2002).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Springs and spring-fed wetlands** are generally scarce in this arid habitat but where they occur they provide essential habitat for native amphibians (e.g. northern leopard frog), a wide array of invertebrates, foraging grounds for bats and important stopover and sometimes breeding habitat for birds. They are also important watering sources for native ungulates (e.g. bighorn sheep, pronghorn, mule deer).
- **Cryptobiotic soil crusts** are created by living organisms (e.g., algae, cyanobacteria, and fungi). The bacteria release a gelatinous material that binds soil particles together in a dense matrix.

The result is a hardened surface layer made up of both living organisms and inorganic soil matter. This crust allows arid soils to resist erosion by wind and water. Many unusual and unique organisms occur in association with crusts, including rare and undescribed algal species and lichens. It is becoming increasingly clear that the older and better developed crusts support important levels of cryptogamic plant biodiversity. Cryptobiotic soil crusts are quite fragile, especially during the drier seasons. Footprints from hikers and livestock will crush cryptobiotic crusts and vehicle tires have the potential to damage large areas (NPS 2015). Some SGCN that occur in this habitats include Gunnison's prairie dog and chisel-toother kangaroo rat.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages in this habitat type or is watching closely due to some level of concern:

Amphibians: northern leopard frog
Birds: sagebrush sparrow, Brewer's sparrow, sage thrasher, golden eagle, ferruginous hawk, prairie falcon, scaled quail, common nighthawk
Invertebrates: Niobrara ambersnail
Mammals: House Rock Valley chisel-toothed kangaroo rat, chisel-toothed kangaroo rat, Gunnison's prairie dog, black-footed ferret, black-tailed jackrabbit, spotted bat, Mexican free-tailed bat, big free-tailed bat, greater western bonneted bat

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Cochise pincushion cactus, San Pedro River wild buckwheat, Arizona eryngo, Bartram stonecrop, Huachuca water-umbel, lace-leaf rockdaisy

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Great Basin spadefoot, American pronghorn, desert bighorn sheep, mule deer, American bison, northern mockingbird, lark sparrow, common raven, rock wren, common poorwill

Primary Threats to Great Basin Desertscrub

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). For detailed information on threats to this habitat type and the conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.3	Livestock farming and ranching
6	Energy Production and Mining	6.3	Renewable energy
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1	Fire and fire suppression

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Marble Canyon and Vermillion Cliffs	NPS
House Rock Valley	AZGFD
Lower Little Colorado River	ALSD, BLM, Private
Rim 2 River	AZGFD

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

Arizona Strip Habitat Working Group (AZSHWG), USFWS, USFS, BLM (Arizona Strip), NPS (Grand Canyon National Park, Petrified Forest National Park), Grand Canyon Trust, North Rim Ranches (adjoining grazing permittee), Babbitt Ranches LLC, Arizona Field Ornithologists, Intermountain West Joint Venture

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or of particular interest regarding SGCN in this habitat type.

- AGFD House Rock Wildlife Area Management Plan
- Bison Management Plan
- AGFD Chevelon Wildlife Area Management Plan
- Shivwits Plateau Landscape Restoration Project EA (in draft)
- BLM Resource Management Plans for the Arizona Strip, Vermilion Cliffs NM and Grand Canyon-Parashant NM
- Gunnison's Prairie Dog - Interagency Management Plan
- Gunnison's Prairie Dog - WAFWA Conservation Assessment
- White-tailed and Gunnison's Prairie Dog Conservation Strategy
- Black-footed Ferret Statewide Management Plan
- Black-footed Ferret Recovery Plan (USFWS 2013)
- Interim Conservation Plan for *Oxyloma (haydeni) kanabensis* complex and related ambersnails in Arizona and Utah (2002)
- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan

Grasslands Overview

North America's central grasslands are considered one of the most threatened ecosystems in the world (Gauthier et al. 2003, Askins 2007). It is estimated that Great Plains and desert grasslands once covered more than 500 million acres across North America. Although this acreage has been reduced in recent centuries thanks to human encroachment, grasslands still play a critical role on a continental scale. Nearly 200 wildlife species use this immense sea of grass, spanning 11 states and includes parts of Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming (WAFWA 2011). Conservation and sustainable use initiatives are becoming more strategic and comprehensive in nature, engaging multi-national focus between the United States, Mexico, and Canada.

Arizona's grasslands are ecologically- and economically-important areas, providing habitat for wildlife, forage for livestock, pollinator habitat, soil stabilization, and a host of additional ecosystem services that support healthy human populations. The vast, open grassland landscapes are aesthetically pleasing, offer outstanding wildlife viewing, and provide valuable educational, recreational, and research opportunities.

In Arizona, grasslands once occurred across an estimated 18.2 million acres, or approximately one quarter of the state (Hendricks et al. 1985). While significant grassland habitat still exists across southeastern and northeastern areas of the state, lack of regular fires, high grazing pressure, and extended drought conditions, have led to shrub encroachment in some areas and desertification in others. According to an interagency ecological assessment led by TNC (Gori and Enquist 2003), 31% of Arizona's former grasslands are in good condition with native perennial grasses and low shrub cover; 34% are shrub-invaded but have the potential to be restored; 26% have crossed a threshold where former grasslands have transitioned to shrubland; 9% are now dominated by exotic species; and 4% have low shrub cover but also little to no perennial grass.

Grasslands in Arizona occur primarily on State Trust, BLM, Tribal, and private lands, a significant portion of which is classified as working landscapes where livestock grazing is the primary land use. While grazing practices on many ranch lands and allotments have been modified in recent years to align with a more sustainable lands approach, overgrazing especially in arid environments can cause undesirable changes in the plant community, including 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). In the face of climate change and long-term drought, already stressed grasslands can be further impaired. In some places, introduced non-native plants (such as Lehmann lovegrass and cheatgrass) have invaded the natural vegetation and caused landscape-level changes that may be irreversible. In places where non-native grasses have

become established, a frequent and intense fire regime develops, which furthers the spread and dominance of the non-natives.

In addition to grazing pressures, Arizona's grasslands are at risk of loss to development, especially on private and State Trust lands which have no long-term conservation protection (Gori and Enquist 2003). This development not only results in habitat loss and fragmentation, but also prevents the use of fire in grasslands to maintain species diversity and prevent shrub encroachment (Gori and Enquist 2003).

Three types of grassland habitats occur in Arizona: semidesert grasslands, Plains and Great Basin grasslands, and subalpine grasslands.

Semidesert Grasslands

Semidesert grasslands occur in southeastern Arizona in areas with semi-arid soils associated with the Chihuahuan Desert ecoregion. They also occur in northwestern Arizona at the base of the Hualapai and Cerbat Mountains in the Kingman area, as well as in central Arizona along I-17 in Aqua Fria National Monument and the rolling hills outside of Camp Verde. Semidesert grasslands are the driest of any grassland habitat type in North America, receiving just 8 to 15 inches of precipitation annually. See the semidesert grassland habitat profile for further details.

Plains and Great Basin Grasslands

These grassland habitats are found mainly in northern Arizona in the Arizona/New Mexico Plateau ecoregion in shallow, mesic semi-arid soils. In the northeastern portion of the state, these grasslands cover relatively large areas east of Flagstaff, north and south of I-40. In north-central Arizona, Plains and Great Basin grasslands are found north of Williams on the Coconino Plateau as well as north of the Grand Canyon on the Kaibab Plateau. This habitat type receives an average of 17 inches of precipitation annually, the majority of which falls in the spring and summer. See the Plains and Great Basin grassland habitat profile for further details.

Subalpine Grasslands

Subalpine grasslands are limited in extent in Arizona, occurring in the White Mountains, on the Kaibab Plateau, and in a few areas in the sky islands region in southern Arizona. Supalpine grasslands are found in relatively flat areas, interspersed in mixed conifer and ponderosa pine forests. Forage value of grass species in this habitat type is high, making these grasslands an important resource for livestock as well as wildlife. See the subalpine grassland habitat profile for further details.

Conservation of Grasslands Systems

Restoring and enhancing grasslands in Arizona — and throughout much of North America — is challenging due to complex interactions among ecosystem components and cumulative effects of long-term stressors. However, in recent years, more and more research is providing valuable insights

from which land managers can develop landscape- and regional-scale grassland habitat conservation projects.

In 2004, the Western Association of Fish and Wildlife Agencies (WAFWA) recognized the need for an increased conservation focus on grassland ecosystems because of historical impacts (e.g., agricultural conversion, infrastructure development, and urbanization) as well as more recent and on-going impacts facing these habitats (e.g., invasive species, energy development, climate change, and urban sprawl).

Meanwhile, in Arizona, the concern with the ecological status and sustainability of the state's temperate grasslands has increased exponentially in recent years. In 2003, TNC completed a comprehensive grassland assessment for the Apache Highlands (APH) Ecoregion (U.S. and Mexico), an area that covers much of southeastern and central Arizona (Gori and Enquist 2003). Grasslands across the region were evaluated to characterize their condition, the extent of vegetation changes, and to identify the best remaining grasslands for restoration and conservation. The Nature Conservancy (TNC) concluded that changes to grassland vegetation have been extensive, due mostly to shrub encroachment and invasion of non-native grasses, emphasizing that grasslands are extremely vulnerable to development and most lack protective status.

Of the more significant findings in this report, most native grasslands within the U.S. portion of the APH Ecoregion with low shrub cover (the highest quality rating) are either private (44.3%) or State lands (23.3%). High quality native grasslands are less abundant on federal ownership (BLM and USFS), totaling only 17.1%. However, there is a very high percentage of native grasslands with restoration potential in public ownership (USFS 21.6% and BLM 15.4%), approximately 2.5 million acres. These lands represent the greatest opportunity for conservation efforts that will provide lasting benefits to future generations and wildlife populations. Lastly, there is a significant portion of native grassland with restoration potential on State Trust land (33.8%) that could be important if regional and statewide land use planning appropriated portions of these lands for conservation purposes.

Currently, AZGFD is working with several local, state, national and international initiatives that have implemented public/private partnerships to accomplish grassland conservation in Arizona:

- The High Plains Partnership (USFWS-Mountain-Prairie Region) is working towards conservation on private lands, including Arizona.
- The Malpai Borderlands Group, a nonprofit organization, works towards conservation and restoration of habitat and species through grass banking, conservation easements, prescribed fire, and outreach in southeastern Arizona and New Mexico.
- The Ciénega Watershed Partnership is composed of members from the general public, local property owners and ranchers, conservationists, recreationists, and representatives from various local, state, and federal agencies.
- In 2010, AZGFD helped initiate the Central Arizona Grasslands Conservation Strategy (CAGCS), along with partners from BLM, Prescott and Tonto national forests, and NRCS. This

effort seeks to unite the many disparate agency and non-governmental organization grassland conservation efforts that are currently taking place in central Arizona's grasslands.
- The North American Commission for Environmental Cooperation (NA-CEC) and TNC established a process to identify and map grasslands priority conservation areas (CEC and TNC 2005).
- Several national and international initiatives focus on the conservation of grasslands and associated species of concern including the North American Bird Conservation Initiative, TNC's Prairie Wings Program, Alliance for Grassland Conservation, Partners in Flight, Ducks Unlimited Grasslands for Tomorrow, and World Wildlife Fund's Northern Great Plains ecoregional assessment and initiatives to name a few.

Some of the broader and most relevant plans to grassland habitats or species (with web links) can be found in each of the grassland habitat profiles. Some examples include:

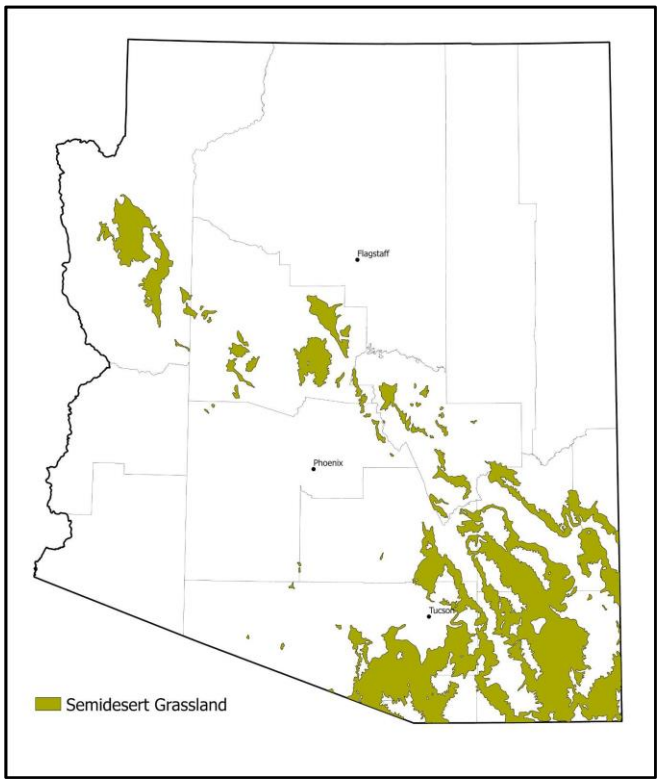
- Arizona Partners in Flight Bird Conservation Plan (Latta et al. 1999)
- Arizona Bat Conservation Strategic Plan (Hinman and Snow, eds. 2003)
- Black-footed Ferret Recovery Plan (USFWS 2013)
- American Peregrine Falcon, Rocky Mountain and Southwest Populations, Recovery Plan (USFWS and Rocky Mt/Southwestern Peregrine Falcon Recovery Team 1984)
- The White-tailed Prairie Dog and Gunnison's Prairie Dog Conservation Strategy (O'Neill 2006)

Arizona Game and Fish Department:
- Pronghorn Management Plan 2013
- Wildlife 20/20

U.S. Department of Agriculture Forest Service:
- Forest Service Handbook 2209.13, Southwestern Region (Region 3), Grazing Permit Administration Handbook, (Drought Guidelines), March 22, 2006
- Prescott National Forest Land and Resource Management Plan (Nov. 1986 as amended)
- Prescott National Forest Plan Amendment #16 Wildland Fire Use Amendment (August 6, 2007)
- Healthy Forest Restoration Act (USDA Forest Service R-3 Central Priority)
- Tonto Land and Resource Management Plan, Amendment #25, August 2006

U.S. Bureau of Land Management:
- Agua Fria National Monument and Bradshaw-Harquahala Proposed Resource Management Plan and Final Environmental Impact Statement (June 2008)
- Black Canyon Habitat Management Plan (1993; revised)
- Aqua Fria National Monument Current Management Guidance (2002)
- Arizona Statewide Land Use Plan Amendment for Fire, Fuels and Air Quality Management and Decision Record, September 28, 2004.
- Arizona Standards for Rangeland Health and Guidelines for Grazing Administration, 1997

Semidesert Grasslands
Habitat Profile



Semidesert grasslands are most extensive across southeastern Arizona, although they also occur in the northwestern part of the state. The semidesert grasslands habitat type can be described as perennial grass-scrub dominated, primarily located between desertscrub at lower elevations and evergreen woodland, chaparral, or plains grassland at higher elevations (Brown 1994, USFS 2021). Brown (1994) described semidesert grasslands in southeastern Arizona as essentially Chihuahuan semidesert grassland. In Arizona, this habitat type can be expected as low as 3,600 feet where it abuts Chihuahuan desertscrub or Sonoran Desertscrub and as high as 4,900 to 5,500 feet where it contacts Madrean Evergreen Woodland. Annual precipitation approaches 10 inches, with most rain falling during June through August. Winters are mild and summers are hot, with low relative humidity, except during the summer monsoon season (Brown 1994).

Typical warm season perennial grasses include black grama, slender grama, chino grama, spruce top grama, bush muhly, several three-awn species, Arizona cottontop, curly mesquite, slim tridens, pappus grass, tanglehead grass, vine mesquite grass, and others (Brown 1994).

Less than 10% of semidesert grasslands remain predominantly native with low shrub cover. Across the extent of Arizona's semidesert grasslands, significant departure from past native grassland conditions has occurred to the extent that the combination of non-native grasslands and former grasslands no longer considered restorable account for nearly half of all semidesert grasslands. The most common non-native grasses are Lehmann lovegrass and Boer lovegrass, both African species introduced into southeastern Arizona for erosion control (Uchytil 1992, Gucker 2009). According to Brown (1994), extensive areas of this habitat type have been replaced through competition with shrubs, trees, and cacti. To such an extent that "there now are extensive landscapes where shrubs, half-shrubs, cacti, and forbs greatly outnumber, and even completely replace the grasses." On a

positive note, however, over a third of the semidesert grasslands have restoration potential (Brown 1994; Gori and Enquist 2003).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to this habitat type:

- **Playas, wetlands, ciénegas, and springs** provide aquatic habitats that are critically important breeding habitats for a variety of desert anurans, including Sinaloan narrow-mouthed toad and Chiricahua and lowland leopard frogs. These habitats also provide important breeding and stopover habitats for bird species.
- **Prairie dog colonies** provide habitat diversity and other services to many grassland species. Black-tailed prairie dogs are considered keystone species, as their colonies can provide vegetation for grazers, burrows for other species, improve soil nutrients, and provide food for various predators (Hale et al. 2013).
- **Sacaton flats** are areas of dense grasslands often occurring in floodplains. These habitats provide important ecosystem functions, including absorbing flood flows, controlling soil erosion, and retaining sediments while also providing quality forage and wildlife habitat. Examples of SGCN that occur here are Botteri's sparrow and hispid cotton rat. Today, these habitats occupy about 5% of their original distribution in southern Arizona, resulting from habitat loss and encroachment from woody vegetation (Tiller et al. 2012).
- **Agave and yucca** are found throughout this habitat type and provide an important food source for lesser long-nosed and Mexican long-tongued bats, two pollinator bat species that are important to these ecosystems.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages in this habitat type or are watching closely due to some level of concern:

Amphibians: Sinaloan narrow-mouthed toad, Chiricahua leopard frog, plains leopard frog, lowland leopard frog, lowland burrowing treefrog
Birds: Aplomado falcon, grasshopper sparrow, Cassin's sparrow, pyrrhuloxia, Chihuahuan meadowlark, western meadowlark, Swainson's hawk, loggerhead shrike, western burrowing owl, golden eagle, prairie falcon, American kestrel, ferruginous (cactus) pygmy-owl, northern (masked) bobwhite, scaled quail
Invertebrates: Page springsnail
Mammals: black-tailed prairie dog, lesser long-nosed bat, antelope jackrabbit, Mexican long-tongued bat, Mexican free-tailed bat, cave myotis, greater western bonneted bat
Reptiles: milksnake, massasauga, northern Mexican gartersnake, Sonoran mud turtle, ornate box turtle

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Tonto Basin agave, Santa Cruz striped agave, Phillips agave, Trelease agave, Arizona agave, Page Springs agave, saiya, Kearney blue-star, coppermine milk-vetch, freckled milk-vetch, Santa Cruz beehive cactus, Cochise pincushion cactus, Pima pineapple cactus, Nichol Turk's head cactus, lemmon fleabane, Fish Creek fleabane, scepterbearing fleabane, San Pedro River wild buckwheat, Bartram stonecrop, Pinaleno Mountain rubberweed, Huachuca water-umbel, Lemmon's lupine, seashore cactus, beardless cinchweed, Chihuahua scurfpea, Verde breadroot, Catalina beardtongue, Maguire's penstemon, Ajo rock daisy, lace-leaf rockdaisy, Sonoita phacelia, Arizona cliff rose, Mexican skullcap, Canelo Hills ladies'-tresses, Verde four-nerve daisy, Goodding onion, White Mountains paintbrush

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

American pronghorn, coyote, Merriam's kangaroo rate, Ord's kangaroo rat, banner-tailed kangaroo rat, southern grasshopper mouse, badger, black-tailed jackrabbit, pallid bat, Gambel's quail, Say's phoebe, greater roadrunner, mule deer, Slevin's bunchgrass lizard, Texas horned lizard, Mexican hog-nosed snake, Mohave rattlesnake, desert kingsnake; invertebrates and plants include monarch butterfly, Huachuca water umbel, Pima pineapple cactus, Parry agave, small flower agave, Schott agave, Tusayan flameflower, and Rusby's milkwort

Primary Threats to Semidesert Grasslands

The following describes the primary threats facing this habitat type adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
3	Climate Change	3.1 3.2 3.3	Habitat shifting and alteration Droughts Temperature extremes
4	Residential and Commercial Development	4.1	Housing and urban areas
5	Disease, Pathogens, and Parasites	NA	NA

Code	Level 1 Threats	Code	Level 2 Threats
6	Energy Production and Mining	6.3	Renewable energy
7	Human Intrusion and Disturbance	7.3	Work and other activities
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species
9	Natural Systems Modifications	9.1	Fire and fire suppression
10	Pollution	10.1 10.3 10.4	Household sewage and urban wastewater Agricultural and forestry effluents Garbage and solid waste
11	Transportation and Service Corridors	11.1 11.2	Roads and railroads Utility and service lines

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Encourage and facilitate strategic planning for the renewable energy industry.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Agua Fria National Monument	NPS
Aravaipa Canyon	BLM
Appleton-Whittel and Las Ciénegas	Private, ASLD, USFWS
Backbone Fire	USFS
Buenos Aires NWR	USFWS

COA Name	Site Owner/Manager(s)
Chiricahua Mountains	USFS, NPS
Coal Mine Springs	AZGFD
Coyote-Baboquivari	BLM
Dragoon Mountains	USFS
Galiuro-Winchester	Coronado NF
Goodwin and Conteras Mesas	BLM, ASLD, Private
Gila Box	USFS
Hualapai Valley	BLM, ASLD, Private
Huachuca Mountains	DOD, USFS
Santa Rita Mountains	USFS
Pinaleño Mountains	USFS
San Pedro Riparian NCA	BLM
Little Dragoons	BLM, ASLD, Private
Lower Oak Creek	USFS, AZGFD
Patagonia Mountains	USFS
Peloncillo Mountains North	BLM
Peloncillo Mountains South	BLM
Sonoita Creek Patagonia TNC Preserve	TNC
Sonoita Creek SNA/Patagonia Lake	AZSP
Sulfur Springs Valley	ASLD, Private
Telegraph Fire	USFS, ASLD
Tonto Creek	USFS
Tucson Sky Islands	USFS, Pima County, NPS
Upper Santa Cruz River	Private
Whetstone Mountains	USFS
Whitewater Draw State Wildlife Area	AZGFD
Willcox Playa/Lake Cochise	DOD, ASLD, BLM, AZGFD

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

Malpais Borderlands Group, Altar Valley Conservation Alliance, BLM (Tucson, Safford, Hassayampa, and Kingman FOs), USFS (Coronado, Apache-Sitgreaves, Tonto, Prescott, Coconino NFs), USFWS, Buenos Aires NWR, Arizona Antelope Foundation, Mule Deer Foundation, Arizona Deer Association, National Wild Turkey Federation, Quail Forever/Pheasants Forever, Borderlands Restoration Network, Arizona Sportsmen for Wildlife Conservation, Arizona Wildlife Federation, Sonoran Desert Cooperative Weed Management Area, Sentinel Landscapes/Western Regional Partnership, Pima

County Natural Resources Parks and Recreation, Arizona Land and Water Trust, Trust for Public Land, Bat Conservation International, Arizona Field Ornithologists, Sonoran Joint Venture, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

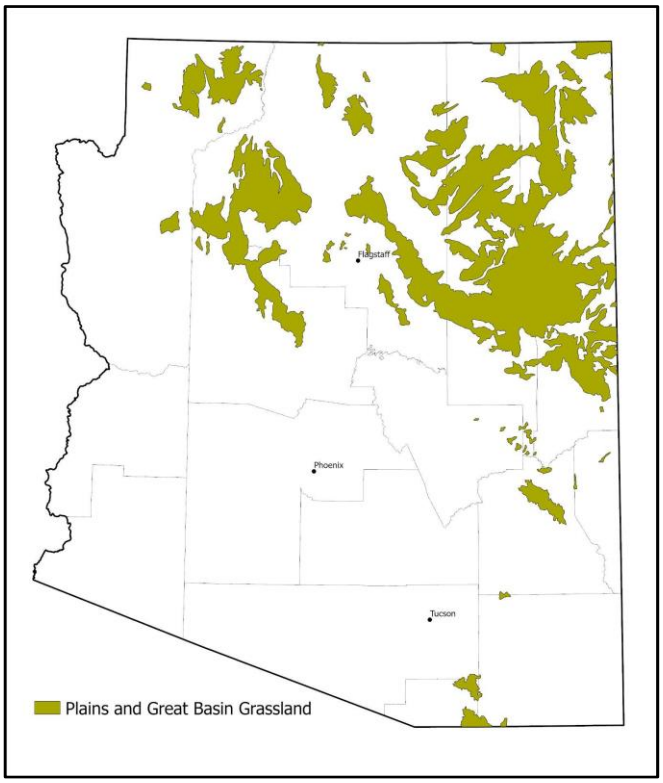
Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Western Burrowing Owl Management Resources
- Huachuca Water Umbel Recovery Plan
- Pima Pineapple Cactus Recovery Plan
- Black-tailed Prairie Dog Multi-state Recovery Plan
- Chiricahua Leopard Frog Recovery Plan
- Central Arizona Grasslands Conservation Strategy 2014
- Southeastern Arizona Grasslands Pronghorn Initiative, 2010-2019
- Sky Island Grassland Assessment: Identifying and Evaluating Priority Grassland Landscapes for Conservation and Restoration in the Borderlands
- An Assessment of the Spatial Extent and Condition of Grasslands in Central and Southern Arizona, Southwestern New Mexico and Northern Mexico
- Draft Post-Delisting Monitoring Plan for the Lesser Long-nosed Bat, 2019
- Page Springsnail Candidate Conservation Agreement with Assurances
- Central Arizona Springsnail Strategic Conservation Plan (In review)
- Arizona Partners in Flight Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan
- Bringing Birds Home: A Guide to Enhancing Grasslands for Birds and Other Wildlife
- Western Monarch Butterfly Conservation Plan

Plains and Great Basin Grasslands
Habitat Profile

Plains and Great Basin grasslands are found at elevations between 5,000 to 7,000 ft. Perennial, sod-forming grasses dominate this habitat type with blue, black, and sideoats gramas being the most abundant. Other important grasses include buffalo-grass, Indian rice grass, Galleta grass, prairie junegrass, plains lovegrass, vine mesquite grass, Texas timothy, and alkali sacaton. Common forbs are primrose, bahia, four-o'clock, gaura, mallow, aster, scurfpea, and coneflower (Brown 1994). Historically, this habitat type consisted of large areas of nearly uninterrupted grass and forb species with low shrub cover, and included most of the grasslands of the Colorado Plateau in northeastern Arizona. This habitat's distribution is limited in southeastern Arizona.



Plains and Great Basin grasslands in Arizona have changed significantly over the past century. The area occupied by these grasslands are in good condition across about 31% of their distribution. A high amount of the overall area, roughly 60%, has been invaded by shrubs with some potential to be restored or has transitioned into shrubland. The remaining 9% is dominated by shrubs or non-native grasses or suffers from severe erosion (TNC 2021; Schussman and Gori 2004). For example, when in close proximity to pinyon-juniper woodland, these grasslands are subject to encroachment and, in cases where essential ecosystem processes are not restored, conversion has resulted. Grazing pressures from livestock and wildlife can contribute to alterations in the vegetation composition and structure as well, though appropriate management may reduce negative impacts and even stimulate positive ecological responses (Finch 2004; Souther et al. 2019). Human encroachment is also adding pressure to these habitats as these low-lying valley bottoms are attractive for housing development, a rising trend that will only grow with increasing populations in Arizona.

Several SGCN occur in this habitat type that are not found elsewhere in the state or in only one or a few habitat types, such as Sonoran tiger salamander, eastern yellow-bellied racer, Arizona grasshopper sparrow, Gunnison's prairie dog, and black-footed ferret.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Ciénegas** and other small and shallow water bodies provide habitats for the reproduction and recruitment of amphibian and invertebrate species, including Chiracahua leopard frog and Sonoran tiger salamander. These vital habitat arealso an important water resource for other species. Ciénegas are particularly important in the grasslands of southeastern Arizona.
- **Springs** exist on the landscape when water pressure in the aquifer pushes water through cracks or tunnels and flows naturally to the surface. These springs create isolated pockets of habitat for a variety of aquatic species, such as the northern leopard frog found in Truxton Spring.
- **Temperate grasslands** are typically found between desert and forest habitat with grasses as the dominant vegetation type. Tree and shrub species can be found interspersed on the landscape. Examples of SGCN that occur in these habitat feautes include American pronghorn and plains leopard frog. Plains and Great Basin grasslands are the Aubrey Valley, Seventyfour Plains, north of the Great Basin conifer woodlands habitat in the White Mountains, Antelope Flat, and Cataract Ranch.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern.

Amphibians: Sonoran tiger salamander, northern leopard frog, Chiricahua leopard frog, lowland leopard frog, Arizona toad
Birds: ferruginous hawk, western burrowing owl, long-eared owl, Baird's sparrow, grasshopper sparrow, chestnut-collared longspur, horned lark, Sprague's pipit, golden eagle, loggerhead shrike, mountain plover, American peregrine falcon, prairie falcon, Swainson's hawk, southwestern willow flycatcher, western yellow-billed cuckoo
Invertebrates: Diablo mountainsnail
Mammals: Mexican gray wolf, Gunnison's prairie dog, black-footed ferret, ocelot, Mexican free-tailed bat, black-tailed prairie dog, spotted bat, big free-tailed bat, greater western bonneted bat
Reptiles: Slevin's bunchgrass lizard, northern Mexican gartersnake, Gila monster, Sonora mud turtle, ornate box turtle

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Holmgren (paradox) milk-vetch, Diamond Butte milkvetch, Sarah's wild buckwheat, Huachuca water-umbel, Holmgren's stickleaf, September 11 stickleaf, beardless cinchweed, Paradine (Kaibab) plains cactus, Fickeisen plains cactus, Peebles Navajo cactus, Siler pincushion cactus, Higgins' Phacelia,

Hughes' Phacelia, Huachuca Mountain milkwort, Arizona rose sage, Siler fishhook cactus, Canelo Hills ladies'-tresses

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Plains spadefoot, Mexican spadefoot, prairie rattlesnake, American pronghorn, mule deer, Rocky Mountain elk, western meadowlark, lark sparrow, rock wren, kit fox; invertebrates and plants include monarch butterfly, Tusayan flameflower, Rusby's milkwort, varied fishhook cactus

Primary Conservation Challenges

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.3	Livestock farming and ranching
2	Biological Resource Use	2.1 2.2	Unlawful take of terrestrial animals Unlawful take of terrestrial plants
3	Climate Change	3.1 3.2 3.3	Habitat shifting and alteration Drought Temperature extremes
4	Residential and Commercial Development	4.1 4.3	Housing and urban areas Tourism and recreation areas
5	Disease, Pathogens, and Parasites	NA	NA
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species
9	Natural Systems Modifications	9.1	Fire and fire suppression
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009):

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Maintain existing and identify new wildlife waters for drought mitigation.
- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Anderson Mesa	USFS
Coyote-Maimie	USFS, ASLD, Private
Grasslands Wildlife Area	AZGFD
Upper Verde River Wildlife Area	AZGFD, ASLD, USFS Yavapai County, Yavapai Prescott Indian Reservation, DOD
Lower Little Colorado River	ALSD, BLM, Private
Middle Lower Colorado River	USFS, Private, ASLD
Rim 2 River	AZGFD, Private
Petrified Forest - Puerco River	NPS
Aubrey Valley IBA	ASLD, USFS, Private
Grasslands Habitat Initiative	BLM, ASLD, Private

COA Name	Site Owner/Manager(s)
Raymond Wildlife Area	AZGFD
San Rafael Grasslands	USFS, private, AZSP
Silver Creek to LCR	BLM, ASLD, AZGFD, Private
Woolhouse	USFS

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFWS, USFS, BLM, NPS, Grand Canyon-Parashant National Monument, Lake Mead National Recreation Area, Grand Canyon National Park, Petrified Forest National Park, Navajo Nation, Hopi Tribe, Hualapai Tribe, Havasupai Tribe, Big Sandy National Resource Conservation District. USDA-NRCS, National Wild Turkey Federation, Quail Forever/Pheasants Forever, Private Landowners, Mule Deer Foundation, Arizona Antelope Foundation, NAU, USGS, Arizona Deer Association, Arizona Field Ornithologists, Arizona Mule Deer Organization, Appleton-Whittell Research Ranch (Audubon/BLM/USFS), Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

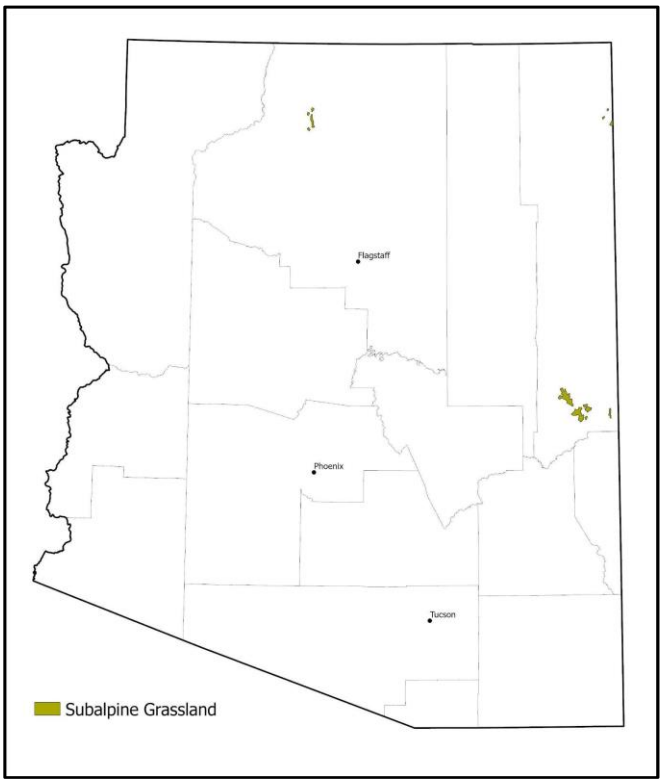
Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- An Assessment of the Spatial Extent and Condition of Grasslands in Central and Southern Arizona, Southwestern New Mexico and Northern Mexico
- Western Grassland Initiative Strategic Plan, A Plan for Conserving Grassland Habitat and Wildlife. July 2011
- Arizona Bat Conservation Strategic Plan
- Black-footed Ferret Statewide Management Plan
- Black-footed Ferret Recovery Plan (USFWS 2013)
- Black-tailed Prairie Dog - Multi-State Conservation Plan
- Chiricahua Leopard Frog Rocovery Plan
- Sonora Tiger Salamander Recovery Plan
- Gunnison's Prairie Dog - Interagency Management Plan
- Gunnison's Prairie Dog - WAFWA Conservation Assessment
- White-tailed and Gunnison's Prairie Dog Conservation Strategy
- Western Burrowing Owl Management Resources
- Southeastern Arizona Grasslands Pronghorn Initiative, 2010-2019
- Central Arizona Grasslands Conservation Strategy 2014
- Arizona Statewide Pronghorn Management Plan

- USFWS Sonoran Pronghorn Recovery Plan
- Western Monarch Butterfly Conservation Plan

Subalpine Grasslands
Habitat Profile



Found at elevations above 8,500 feet, this high-elevation lush grassland habitat is dominated by perennial bunchgrasses, including Arizona fescue, timothy, mountain muhly, pine dropseed, black dropseed, and mountain brome. Forbs are also abundant with cinquefoil, paintbrush, harebells, yarrow, fleabane daisy, aster, and vetch among the most common species.

Subalpine grassland habitats see an average annual precipitation of 20-35 inches, with nearly 50% occurring during the summer monsoon season, which occurs July through September (Brown and Makings 2014). subalpine grasslands occur as small meadows or large open parks in relatively flat, high-elevation areas surrounded by conifers. In Arizona, only the White Mountains, Kaibab Plateau, and a few isolated areas in the sky islands in the southern reaches of the state have well developed subalpine grassland habitats. Some subalpine grasslands have been affected by livestock grazing, invasive species such as Kentucky bluegrass, or fire, which occurs less commonly. These pressures can lead to changes in the vegetative communities, in particular reductions in native bunchgrasses and increases in shrubs and woody plants in some areas (Coop and Givnish 2007).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Ciénegas, springs, sinkholes, natural, and man-made shallow wetlands** are important as they can provide important sources of water and feeding and nesting habitat for many species of mammals, birds, reptiles, and amphibians in an otherwise xeric environment. Some of these habitats include sinkhole ponds and wetlands on the Kaibab Plateau and southern edge of the Mogollon Rim, ciénegas in the White Mountains, and collapse depression lakes on the Chuska Mountains. These features are especially important for migratory stopover habitat for wading birds and waterfowl.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Birds: Virginia rail, sora, savannah sparrow, Lincoln's sparrow, prairie falcon, bald eagle, American kestrel
Amphibians: Chiricahua leopard frog, northern leopard frog
Mammals, Mexican gray wolf, spotted bat, Allen's lappet-browed bat, hoary bat, fringed myotis, big free-tailed bat, greater western bonneted bat

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Goodding onion, White Mountains paintbrush, Blumer's dock

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Arizona tiger salamander, Rocky Mountain elk, coyote, bison, Merriam's turkey, American pronghorn, Arizona myotis, silver-haired bat, long-legged myotis; plant species include paintbrush (endemic to Kaibab)

Primary Threats to Subalpine Grasslands

The following describes the primary threats facing subalpine grassland systems, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions:

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.3	Livestock farming and ranching
3	Climate Change	3.1 3.2 3.3	Habitat shifting and alteration Drought Temperature extremes
6	Energy Production and Mining	6.3	Renewable energy
7	Human Intrusion and Disturbance	7.1	Recreational activities

Code	Level 1 Threats	Code	Level 2 Threats
8	Invasive and Problematic Species	8.1	Invasive non-native species
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009):

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Manager/Owner(s)
Kaibab Plateau	USFS
San Francisco Peaks	TNC, USFS

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFS, TNC (SF Peaks/ Hart Prairie), White Mountain Apache, San Carlos Apache, Navajo Nation, New Mexico State University, Grand Canyon NP, Arizona Field Ornithologists

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Four Forest Restoration Initiative
- Mexican Wolf Recovery Plan

Forest and Woodland Habitats

Overview

Although much of Arizona is dominated by arid, desert habitats, the state is also home to a diverse and extensive amount of forest and woodlands. From lower-elevation chaparral to higher-elevation Alpine forests and even tundra, this variety of forested habitats in Arizona contributes to the state's high biodiversity. These forest and woodland habitats cover approximately 18.6 million acres or roughly 25% of the state. Not only do these areas offer quality habitats for fish and wildlife, but they also play an important role as an economic driver, providing vast areas for recreational opportunities such as hiking, camping, fishing, and hunting. Meanwhile, forests and woodlands around the state provide essential ecological services, in particular helping to provide clean drinking water for the people of Arizona. The state hosts six distinct forest and woodland types that occur in a range of elevations:

Chaparral

Typically, a dense thicket of shrubs and small tree species, chaparral habitats occur at elevation of 4,000 to 6,000 feet. This habitat type is dominated by manzanita and shrub live oak. Chaparral thickets can be nearly impenetrable in certain areas. Because of the dense canopy that forms in chaparral, forbs and grasses are limited, except in scattered openings or immediately after fire events. Other plant species abundant in chaparral are birchleaf mountain-mahogany, skunkbush sumac, silktassels, and desert ceanothus. Prickly-pear cactus, agaves and yucca species commonly grow alongside chaparral shrubs. Most wildlife species that occur in chaparral are widespread and common. Since chaparral is a transitional habitat, the SGCN that are found here also occur in woodland or grassland habitats where chaparral meets those communities at its upper elevation limits, or in desertscrub at lower elevations (Brown and Makings 2014). Some SGCN found in chaparral include Arizona night lizard, Bezy's night lizard, and black-chinned sparrow.

The total area occupied by chaparral has remained largely unchanged over the past century, however, these systems were subjected to treatments such as mechanical manipulation and herbicides in the mid-20th Century in an effort to increase water yield and grazing potential. Because of their high accessibility and relatively gentle terrain, these ecosystems were heavily grazed by goats until 1940. This habitat is fire-adapted and quickly regenerates following fire events (Pase and Brown 1994). See the chaparral habitat profile for more details.

Madrean Woodland

Madrean woodland habitats typically occur at elevations between 5,000 and 7,000 ft. above sea level and are dominated by evergreen tree species such as oaks, juniper, and pine. In southern and central Arizona, Madrean woodlands dominate the sky islands, a loose network of mountain ranges

scattered throughout the arid desert environments. Common tree species found here include Emory oak, silverleaf oak, Mexican blue oak, alligator bark juniper, and Mexican pinyon pine. In some areas, open savannahs are common in Madrean woodland habitats. In addition, tall tree canopies allow for grasses to flourish in some areas. Several SGCN species are found in Madrean woodland habitats that are not found anywhere else in Arizona, including barking frog, brown vine snake, ridge-nosed rattlesnake, Montezuma quail, Mexican jay, bridled titmouse, southern pocket gopher, and Huachuca talussnail.

Total area occupied by Madrean woodlands has largely remained unchanged over the years, however this habitat type is experiencing alterations to community composition. About 77% of this habitat type has experienced moderate alterations with about 6% experiencing severe alterations. These changes are mostly attributed to fire and fire suppression (McPherson 1992). As a result Madrean woodlands have a moderate risk of losing key community components over time (USFS data; Schmidt et al. 2002). About 20% of Madrean woodlands are within areas managed with permanent protection (TNC 2004). See the Madrean woodland habitat profile for more details.

Great Basin Conifer Woodland

Great Basin conifer woodlands occur at elevations between 3,400 and 8,800 feet and is dominated by juniper and pinyon-pine species. Colorado pinyon-pine is the characteristic species throughout nearly the entire zone. North of the Mogollon Rim, Utah and one-seed juniper are intermixed with pinyon-pine. In the northwest portion of the state, singleleaf pinyon grows intermixed with Utah juniper. South of the Rim alligator juniper is commonly found. A tall canopy occasionally allows for other habitat types of habitats to grow beneath, such as grasslands, desertscrub, or chaparral. Several SGCN species are unique to this habitat, including juniper titmouse, gray flycatcher, and pinyon jay.

Over the past century, Great Basin conifer woodlands have been significantly altered by changes in fire regimes and fire suppression. Livestock grazing, along with mechanical and chemical treatments have also contributed to these changes over the years (Stevens and Monson 2004). Because of overgrown, dense tree canopies and the presence of invasive grass species, potential for devastating crown fires has increased dramatically in recent decades (Gruell 1999; Tausch 1999). Because of this Great Basin conifer woodlands have a moderate risk of losing key ecosystem components (Schmidt et al. 2002). Pinyon pines, which are a key component of this community, have recently experienced widespread mortality due to drought and insects (Breshears et al. 2005, USFS 2005). About 69% of this community is within areas managed with permanent protection for a primarily natural state (TNC 2004). See the Great Basin conifer woodland habitat profile for more details.

Petran Montane Conifer Forest

Found at elevations between 6,000 and 9,000 feet, Petran montane conifer forests are dominated by ponderosa pine, Douglas fir, and white fir. Other common tree species include southwestern white pine, Gambel oak, limber pine, bigtooth maple, and quaking aspen. High, dense canopies create open park-like understories, permitting a healthy understory of grasses, shrubs, forbs, and broadleaf trees.

In southern Arizona, Petran montane conifer is also found in the sky islands, the high-elevation habitats found atop scattered mountain ranges. Several SGCN species occur here, including: northern leopard frog, mountain treefrog, dusky grouse, Mexican spotted owl, evening grosbeak, red crossbill, New Mexico jumping mouse, and Wet Canyon talussnail.

Changes in fire regime and forest management have resulted in changes to community composition and structure. In some areas, well-spaced groups of mature trees are now dense thickets of younger trees, resulting in a reduced diversity of grasses, forbs, and the understory community. Disease, insect infestation, and high-intensity crown fires are also adversely affecting this forest habitat. According to USFS data, about 58% of Petran montane conifer forests have altered fire regimes that are contributing to these changes in community composition (Schmidt et al. 2002). The region's persistent drought, along with higher winter temperatures, have led to widespread die-off in ponderosa pines, affecting 1.3 million acres (27% of total distribution in Arizona) during 2002-2004 (USFS 2005). These standing dead trees increase fuel loads, contributing to more severe fires in the future. Only about 7.6% of Petran montane conifer area is within areas managed with permanent protection for a primarily natural state (TNC 2004). See the Petran montane conifer forest habitat profile for more details.

Petran Subalpine Conifer Forests

Petran subalpine conifer forests occur at elevations between 8,000 and 9,000 feet, and are usually a mix of coniferous and deciduous species. Dominant fir species include Engelmann spruce, blue spruce, corkbark fir, white fir, Douglas fir, bristlecone pine, and limber pine. Quaking aspen is the dominant deciduous species and can be found in dense stands intermixed with the fir species. Dense canopies mostly prevent the growth of grasses, forbs, and other understory vegetation. Some SGCN species found in Petran subalpine conifer habitats include northern pocket gopher, southern red-backed vole, Williamson's sapsucker, Canada jay, Lincoln's sparrow, and pine grosbeak.

Petran subalpine conifer forests are extremely limited in distribution. As such they have been disproportionately affected by human disturbance and development, including ski areas, communication towers and observatories (Patten and Stromberg 1995; Dahms and Geils 1997). Approximately 32% of the total Petran subalpine conifer habitat area found in Arizona (about 77,000 acres) is experiencing significant tree mortality, mostly due to drought conditions and insect infestation (USFS 2003, 2004, 2005).

Changes to fire regimes and fire suppression are also affecting Petran subalpine conifer habitats. Historically, these habitats were insulated from fire by the surrounding lower-elevation fire-resistant mixed conifer. However, a century of fire suppression has resulted in increased tree density. The fuel loads in mixed conifer habitats is leading to more frequent and intense wildfires. As a result, Petran subalpine conifer habitats are now also being lost to fire and disease. According to the USFS, approximately 79% of the Petran subalpine 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). See the Petran subalpine conifer forest habitat profile for more details.

Alpine Tundra

Alpine tundra habitats are extremely limited in Arizona and found only in highest elevations between 11,000 and 12,600 feet. Tundra habitats are found only on two mountain peaks, both in the San Francisco Mountains of northern Arizona. These high-elevation habitats are characterized by extreme cold temperatures, which prevent the establishment of most trees and succulent species. The dominant plants that are found in tundra habitats include low-lying woody shrubs and perennial herbs. Few SGCN inhabit this region that are not found elsewhere in the state, with the exception of the dwarf shrew that is often found in tundra and in nearby subalpine meadows (Hoffmeister 1986). This is also the only part of the state where white-crowned sparrows breed.

The only significant stressor to tundra habitats is human disturbance, mostly trampling and other disturbance by hikers. However, due to the tundra's limited range, climate change could lead to significant reductions in this community due to an upward shift in treeline (Bowman et al. 2002; Tuhy et al. 2002). See the alpine tundra habitat profile for more details.

Conservation of Forest and Woodland Systems

Approximately 46% of Arizona's forest and woodland systems are managed by the USFS in national forests such as the Coronado and Chiricahua national forests in the south to the Coconino and Apache-Sitgreaves forests in the north (TNC 2005). Meanwhile approximately 39% of forested lands in Arizona is in private lands (Shaw et al. 2018), emphasizing the importance of public-private partnerships to help conserve and protect forest and woodland habitats throughout the state.

Conserving Arizona's forest and woodland systems is becoming increasingly complicated. Prolonged drought, increasing frequency and intensity of forest fires, invasive species, and habitat alterations from both climate change and development, all have significant and long-lasting effects on these systems. More than ever before, inter-agency collaboration along with public/private partnerships will be critical to maintain a healthy future for our forest and woodland systems.

Four Forest Restoration Initiative (4FRI)
In an effort to address the escalating threat of wildfire, in 2003 then-Governor Janet Napolitano created the Forest Health Advisory Councils. One product of this effort was the Statewide Strategy for Restoring Arizona's Forests (2007) which focused on landscape-scale restoration that would protect communities and improve forest health. The Council's work led to establishing the landmark Four Forest Restoration Initiative (4FRI), an inter-agency collaboration and landscape-scale planning to restore our forests to a more healthy state. Staff at AZGFD are involved with the on-going 4FRI efforts in the Kaibab, Coconino, Apache-Sitgreaves, and Tonto national forests.

Much like USFS, the Arizona Department of Forestry and Fire Management (DFFM) helps manage multi-use forest systems to reduce fire risk to communities and wildlife areas. In 2010, DFFM produced the Arizona Forest Resource and Assessment, a comprehensive analysis of trends and threats to the state's forest resources. This was then followed by the Arizona Forest Action Plan, which detailed opportunities to conserve forests and reduce impacts of threats. (The plan was again updated in 2020.) Along with several other state and federal agencies, AZGFD played an integral role in shaping these plans.

Currently, there are several local, state, and national initiatives that have implemented public/private partnerships to accomplish forest and woodland conservation in Arizona:

- AZGFD has helped shape a coalition of hunter-focused NGOs that help conserve forest and woodland species and habitats. Some of the groups include the Mule Deer Foundation, Arizona Elk Society, and Arizona Mule Deer Organization.
- United States Forest Service, Four-Forest Restoration Initiative (USFS-4FRI) is working towards restoration of the ponderosa pine ecosystem across the Mogollon Rim in Arizona.
- White Mountain Stewardship has completed thousands of acres of cooperative projects to reduce fuel loading and improve forest health in the White Mountains of Arizona.
- AZGFD Habitat Partnership Committee funds projects through the sale of Special Big Tags and many of those projects are cooperative projects between AZGFD, land management agencies and private landowners.
- AZGFD Landowner Incentive Program works cooperatively with private landowners to improve forest health and restore grasslands in areas where woodlands have encroached.

Some of the more specific plans to forest and woodland species and their habitats can be found in each of the individual habitat profiles (with web links). Examples include:

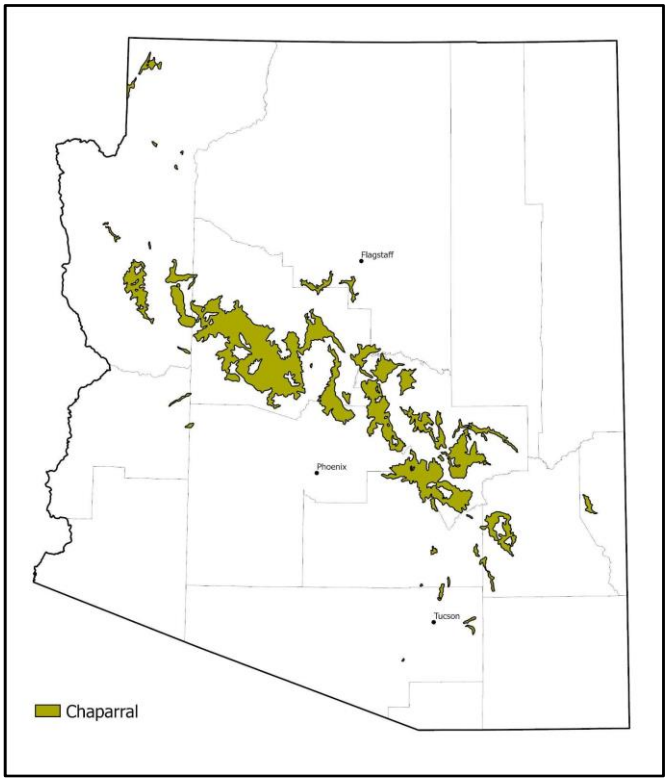
- Mountain Lion and Bear Conservation Strategy
- Mexican Wolf Recovery Plan
- Mule Deer Management Plan
- Mexican Spotted Owl Recovery Plan (1st Revision)

- Mt Graham Red Squirrel Recovery Plan (1st Revision)
- Huachuca Springsnail Candidate Conservation Agreement
- Pinaleño Mountain Land Snails Conservation Agreement

Some of the broader, regional or state-wide plans to protect forest and woodland habitats can also be found in each of the individual habitat profiles (with web links). Examples include:

- Arizona Partners in Flight Conservation Plan (Latta et al. 1999)
- Four Forest Restoration Initiative (4FRI)
- Arizona Forest Action Plan (2020)
- Southwest Mule Deer Habitat Guidelines

Chaparral
Habitat Profile



Chaparral describes a shrub-dominated plant community. In Arizona, this habitat covers approximately 3.5 million acres (Schalau 2008) and typically occurs at elevations between 3,200 and 5,700 feet. Chaparral is characterized by dense, nearly impenetrable thicket dominated by two species of manzanita, acacia, juniper, and shrub live oak. Forbs and grasses are not abundant, mostly due to the high percentage of crown cover. However, this understory vegetation can occur in the scattered interscrub openings or after a fire event. Other conspicuous species present in chaparral include birchleaf mountain-mahogany, skunkbush sumac, silktassels, hollyleaf buckhorn, cliffrose, desert olive, Palmer oak, Arizona white oak, Emory oak, pinyon pine, juniper 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. Some examples of SGCN include Arizona night lizard, Bezy's night lizard, and black-chinned sparrow.

The area occupied by chaparral has remained largely unchanged within historic times and stands of scrub oak present 100 years ago persist today (Brown and Makings 2014). However, over the past century, chaparral habitats were subjected to various management treatments. Until 1940, chaparral was heavily grazed by goats because of their high accessibility and relatively gentle terrain (Pase and Brown 1994). Many important range grasses were eliminated from most chaparral sites and, as a result, have been confined to rocky protected areas (ACERP 1995). Other management actions included mechanical manipulation and herbicides, practices that were common in the 1950s and 1960s in an effort to increase water yield and grazing potential in chaparral.

This habitat is fire adapted and quickly regenerates after a burning event (Pase and Brown 1994). Fire suppression has caused the frequency of wildfire to be lessened over time, allowing for dead wood to accumulate and increase the fire intensity when burned. Chaparral species tend to resprout from

their root crowns and are even stimulated to germinate by fires (Schalau 2008). There is typically an increase in invasive grasses that often establish post fire.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat and are of particular importance to certain species:

- **Springs** are vital water sources in an arid environment, and often support endemic species, such as springsnail as well as amphibians. Springs can also act as foraging grounds for several bat species and important stopover and sometimes breeding habitat for birds. There are approximately 1,360 springs in chaparral habitats throughout the state.
- **Rock outcrops** are unique habitats that lend topographic diversity to habitats that can be fairly dense and homogenous, such as chaparral. These habitats may only occupy a small percentage of the land base, but they are disproportionately important as wildlife habitat.
- **Lentic and lotic systems**, such as streams and rivers and lakes and ponds, play an out-sized role in most of Arizona's habitats, including chaparral. These aquatic systems are important breeding grounds for amphibians such a lowland leopard frogs and important foraging areas for many SGCN bat species. Parts of Roosevelt Lake is within this habitat.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern in this habitat type:

Amphibians: lowland leopard frog
Birds: golden eagle, ferruginous hawk, bald eagle, rufous-crowned sparrow, Woodhouse's scrub-jay, black-chinned sparrow
Invertebrates: Fossil springsnail
Mammals: kit fox, Mexican free-tailed bat, Arizona pocket mouse, pocketed free-tailed bat, Yuma myotis, cave myotis, Arizona myotis, Mexican vole, California leaf-nosed bat, antelope jackrabbit, lesser long-nosed bat, western red bat, greater western bonneted bat, spotted bat, fringed myotis, banner-tailed kangaroo rat, Mexican gray wolf, Harris' antelope squirrel
Reptiles: Arizona night lizard, Bezy's night lizard, Sonoran desert tortoise, Gila monster, Gila and giant spotted whiptail, variable sandsnake, Sonoran whipsnake, Sonoran coralsnake, Arizona black rattlesnake, regal horned lizard, Sonora mud turtle

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Arizona bugbane, Tonto Basin agave, Phillips agave, Arizona agave, Arizona hedgehog cactus, Hodgson's fleabane, Bartram stonecrop, Pinaleno Mountain rubberweed, broadleaf lupine, Lemmon's lupine, seashore cactus, Verde breadroot, Lyngholm's brakefern, Catalina beardtongue, Roosevelt Dam rockdaisy, Ertter's rose, Blumer's dock, Blackrock ground daisy

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Gilbert's skink, rosy boa, Sonoran lyre snake, black-tailed rattlesnake, American beaver, mule deer, javelina, Gambel's quail, bushtit, ladder-backed woodpecker, common poorwill, spotted towhee, gray vireo, wild turkey, white-tailed deer, Rocky Mountain bighorn sheep, mountain lion, Abert's squirrel, black bear, white-winged dove

Primary Threats

The following describes the primary threats to this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represents broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to this habitat type and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.2	Livestock farming and ranching
2	Biological Resource Use	2.3	Logging and wood harvesting
3	Climate Change	3.1 3.3 3.4	Habitat shifting and alteration Temperature extremes Storms and flooding
4	Residential and Commercial Development	4.1 4.3	Housing and urban areas Tourism and recreation areas
5	Disease, Pathogens, and Parasites	NA	NA
6	Energy Production and Mining	6.2 6.3	Mining and quarrying Renewable energy
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1	Fire and fire suppression

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Backbone Fire	USFS
4 FRI	USFS, Private
Upper Oak Creek	USFS
Telegraph Fire	USFS, ASLD
Weaver Mountains	BLM, ASLD
Tortolita Mountains	ASLD, Private
Central Arizona Springsnails	USFS, Private, AZGFD
Cave Creek Linkage	USFS, BLM, ASLD, Private
Salt-Verde Ecosystem	USFS
Tortolita Mountains	ASLD, Private, BLM, Pima County

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

Arizona Mule Deer Organization, Mule Deer Foundation, Arizona Elk Society, BLM, Arizona Field Ornithologists, USFS (Tonto National Forest, Prescott National Forest, Coconino National Forest),

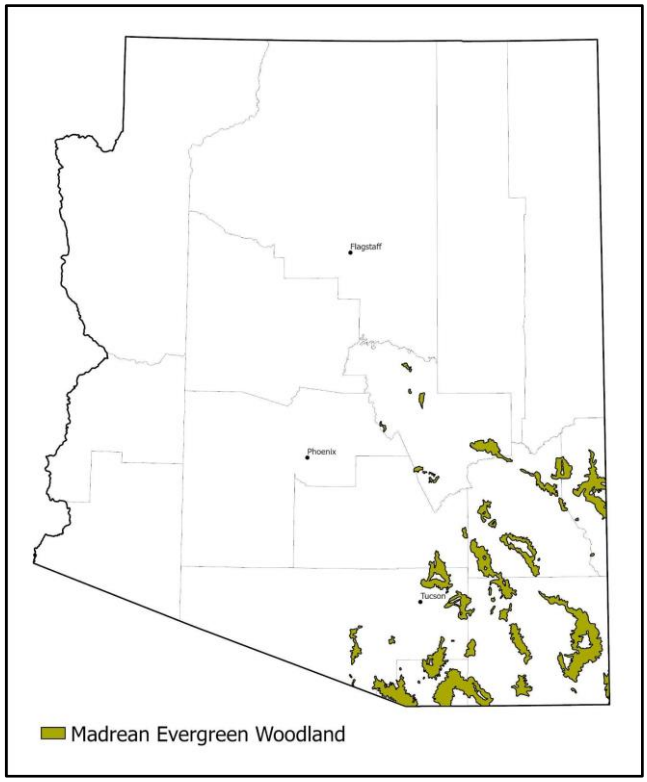
Northern Arizona University, University of Arizona, counties including Maricopa, Yavapai, Gila, Graham, Pinal, Coconino, and Mohave

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Mountain Lion Conservation Strategy
- Mexican Wolf Recovery Plan
- Arizona Bighorn Sheep Management Plan
- 4 Forest Restoration Initiative: Rim Country
- Mexican Spotted Owl Recovery Plan
- Elk Management Plan
- Pronghorn Management Plan
- Southwest Mule Deer Habitat Guidelines
- Arizona Bat Conservation Strategic Plan
- Arizona Partners in Flight Bird Conservation Plan

Madrean Woodlands
Habitat Profile



The Madrean woodlands habitat type comprises the majority of the sky islands of southeastern Arizona, and is found in elevations ranging between 5,000 and 7,600 feet. The term "sky island" refers to a mountain or mountain range surrounded by lowland desert or grassland, resulting in a habitat "island." Above 7,600 feet the habitat transitions to a higher-elevation Petran montane conifer habitat type.

Evergreen oaks dominate Madrean woodlands 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 oaks such as Emory, Mexican blue, Arizona, and silverleaf oaks. Alligator bark juniper and one-seed juniper are often mixed with Arizona, Apache, Southwestern white, and Chihuahuan pines, along with Mexican pinyon pine (NatureServe 2021).

Typical chaparral species comprise the subcanopy and shrub layers in Madrean woodlands (e.g. agaves, Arizona madrone, manzanita, silktassel, and beargrass). Other shrubs can include alderleaf mountain-mahogany, birchleaf buckthorn, Mearns' sumac and skunkbush sumac. Species more commonly affiliated with thornscrub may occur at lower elevations and on rocky south-facing slopes, such as southwestern coral bean, hopbush, and catclaw mimosa (Brown 1994). Grasses include several muhly grasses, bluestems, gramas, and lovegrasses (Dimmitt 2015).

Madrean woodlands support a rich assemblage of bird species, many of which are found only in this region of the state and are high sought after by birders. These species include the elegant trogon, violet-crowned hummingbird, white-eared hummingbird, Arizona woodpecker, black-throated gray warbler, Mexican jay, whiskered screech-owl, buff-breasted flycatcher, and Montezuma quail. In the higher elevations of the sky islands, Gould's turkey, band-tailed pigeon, Mexican chickadee, and hepatic tanager can be found (Brown 1994).

Amphibians and reptiles of the Madrean woodland habitats include barking frogs, Tarahumara frogs, Chiricahua leopard frogs, banded rock, ridge-nosed, and twin-spotted rattlesnakes, green ratsnakes, mountain skinks, and Slevin's bunchgrass lizards (Ivanyi et al. 2015).

Common mammals include large herbivores such as Coues white-tailed and mule deer, javelina, rodents such as yellow-nosed cotton rat, white-throated woodrat, southern pocket gopher, and Arizona gray squirrel. Porcupine, Bailey's pocket mouse, and eastern cottontail also occur (NatureServe 2021).

The area occupied by Madrean woodlands has remained largely unchanged within historical times, although 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 that are severely altered from their historical condition, 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 2004).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Ciénegas** provide important habitat for Huachuca springsnail, Gila topminnow and desert pupfish, Sonoran tiger salamander and Chiricahua leopard frog, and northern Mexican gartersnake. Each of these species is reliant on permanent, spring-fed waters for shelter and forage.
- **Talus slopes and boulder piles** along hillsides and canyon drainages provide essential sheltering habitat for native land snails like talussnails, mountainsnails, and woodlandsnails during hot, dry periods of the year. These mollusks aestivate for months in the cool and damp interstitial spaces in talus, under boulders, and deep rock crevices. Bat species including fringed myotis, have been found roosting in talus and boulder piles and may use these features to a greater extent than has been documented. Twin-spotted and banded-rock rattlesnakes are also found in these unique microhabitats.
- **Limestone and rhyolite outcrops** greatly increase the diversity of plants throughout the sky islands and can also provide habitat for amphibians such as the barking frog (Warshall 1995).

Key Conservation Species (SGCN)

The following list represents species in this habitat type that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Sonoran tiger salamander, Sinaloan narrow-mouthed toad, barking frog, Arizona treefrog, Chiricahua leopard frog, Tarahumara frog

Birds: Mexican jay, Arizona woodpecker, whiskered screech-owl, dusky-capped flycatcher, sulphur-bellied flycatcher, elegant trogon, Montezuma quail, eastern (azure) bluebird
Invertebrates: Pinaleño talussnail, Wet Canyon talussnail, Pinaleño mountainsnail, Ramsey Canyon talussnail, Huachuca mountainsnail, Huachuca woodlandsnail, Huachuca springsnail
Mammals: ocelot, jaguar, Chiricahua fox squirrel, white-bellied long-tailed vole, long-tailed weasel, Arizona shrew, southern pocket gopher, hoary bat, Mexican long-tongued bat, pale Townsend's big-eared bat, fringed myotis
Reptiles: mountain skink, Yarrow's spiny lizard, striped plateau lizard, Madrean alligator lizard, brown vinesnake, green ratsnake, northern Mexican gartersnake, black-necked gartersnake, Yaqui black-headed snake, Chihuahuan black-headed snake, Sonoran whipsnake, tiger rattlesnake, banded rock rattlesnake, New Mexico ridge-nosed rattlesnake, thornscrub hook-nosed snake

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Santa Cruz striped agave, trelease agave, Goodding onion, saiya, Kearney blue-star, coppermine milk-vetch, Huachuca milkvetch, Santa Cruz beehive cactus, Los Pinitos dodder, pine flatsedge, Gentry's indigo bush, Pinalenos fleabane, Chiricahua fleabane, Lemmon fleabane, Fish Creek fleabane, scepterbearing fleabane, Bartram stonecrop, Texas purple spike, Pinaleno Mountain rubberweed, Dragoon Mountains rubberweed, Huachuca water-umbel, Chiricahua mudwort, Lemmon's lupine, beardless cinchweed, Chihuahua scurfpea, Chiricahua rock cress, Catalina beardtongue, Chiricahua rock daisy, Huachuca Mountain milkwort, Huachuca cinquefoil, whisk fern, Blumer's Dock, Huachuca groundsel, Canelo Hills ladies'-tresses

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Gould's turkey, Bewick's wren, Coues white-tailed deer, white-nosed coati, American black bear, eastern cottontail, southern pocket gopher, mountain lion, javelina, western spotted skunk, red-spotted toad, Mexican spadefoot, black-tailed rattlesnake, western patch-nosed snake, Sonoran mountain kingsnake, Clark's spiny lizard, and Canelo Hills ladies' tresses

Primary Threats to Madrean Woodlands

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to Madrean woodlands and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.2	Livestock farming and ranching
3	Climate Change	3.1 3.2 3.3	Habitat shifting and alteration Droughts Changes in temperature regimes
6	Energy Production and Mining	6.2	Mining and quarrying
7	Human Intrusion and Disturbance	7.3	Work and other activities
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species
9	Natural Systems Modifications	9.1 9.2	Fire and fire suppression Dams and water management and use
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009):

- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Atascosa Highlands	USFS

COA Name	Site Owner/Manager(s)
Bush Fire	USFS, Private
Chiricahua Mountains	NPS, USFS
Coyote-Baboquivari	BLM
Dos Cabezas	BLM
Dragoon Mountains	USFS, Private, ASLD
East Verde River	USFS, Private
Galiuro-Winchester	USFS
Gila Box	USFS
Huachuca Mountains	USFS, DOD
Little Dragoons	ASLD, Private, BLM
Patagonia Mountains	USFS
Peloncillo Mountains North	BLM
Pinaleño Mountains	USFS
San Francisco Blue	USFS, Private
San Rafael Grasslands	USFS, Private, AZSP
Santa Rita Mountains	USFS
Santa Theresa Wilderness	USFS, BLM
Telegraph Fire	USFS, ASLD
Tucson Sky Islands	USFS, Pima County, NPS
Tucson Mountains	NPS, Pima County
Whetstone Mountains	USFS

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

DOD-Fort Huachuca, USFS, USFWS, NPS Chiricahua National Monument, Coronado National Memorial, Malpais Borderlands Group, Southwestern Research Station (American Museum of Natural History), Sky Island Alliance, Appleton-Whittell Research Ranch (Audubon), TNC, Arizona Center for Nature Conservation-Phoenix Zoo, Borderlands Restoration Network, Southern Arizona

Quail Forever, Huachuca Gould's NWTF Chapter, University of Arizona, Bat Conservation International, Arizona Field Ornithologists, Tucson Audubon Society, Sonoran Joint Venture

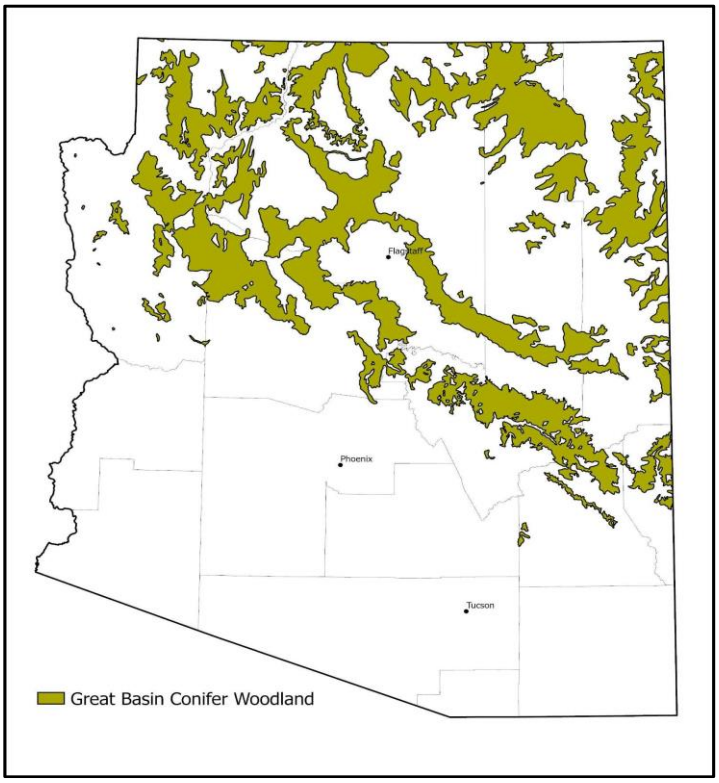
Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Chiricahua Leopard Frog Recovery Plan
- A proposal to re-establish Tarahumara frogs (*Rana tarahumarae*) into southcentral Arizona.
- Sonora Tiger Salamander Recovery Plan
- New Mexico Ridge-nosed Rattlesnake Recovery Plan
- Ocelot Recovery Plan
- Jaguar Recovery Plan
- Huachuca Springsnail Candidate Conservation Agreement
- Pinaleño Mountain Land Snails Conservation Agreement
- Arizona Bat Conservation Strategic Plan
- Arizona Partners in Flight Bird Conservation Plan

Great Basin Conifer Woodlands
Habitat Profile

Great Basin conifer woodlands are found throughout northern Arizona, mostly north of the Mogollon Rim at elevations between 3,400 and 8,800 feet. These habitats are dominated by up to 40% juniper and pinyon pine to the north due to winter rainfall. Pinyon pine, and Utah, Rocky Mountain and one-seed juniper are the dominant canopy species. Gambel oak can be intermixed with mountain mahogany (Bennet et al. 2013). Depending on the area, other habitat types such as grassland, desertscrub, and chaparral woodland may form beneath the canopy of mature conifer woodlands. Several avian species are endemic to this habitat type in Arizona, including pinyon jay, juniper titmouse, and gray vireo.



Over the past century, Great Basin conifer woodlands have been significantly affected by human activities, including livestock grazing, mechanical and chemical treatments, and perhaps most notably, fire suppression, which results in changes to natural fire regimes (Monsen and Stevens 1999; Stevens and Monson 2004) and increased tree cover. Today, 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 risk of losing key ecosystem components (Schmidt et al. 2002). Other factors have influenced diversity and function, including introduced plant species, historic overgrazing, and extended drought. Introduced forbs and grasses, such as cheatgrass, can increase wildfire risk and lead to reductions in plant composition and diversity. The combination of reduced plant diversity, fire suppression, and livestock grazing can result in increased densities of pinyon pine and juniper (Wright et al. 1979). These denser woodlands, combined with climate change, are expected to experience more frequent and extensive crown fires, potentially resulting in a decline of woodland tree species and entire communities eventually being replaced by shrublands or grasslands (Gruell 1999). Recent wildfires have decreased the reliability of water at some springs which can impact local wildlife. Monitoring of habitat and wildlife will continue to determine overall effects of large-scale fires (Ketcham and Koprowski 2013).

Invasive insect species are also contributing to significant changes in Great Basin conifer woodlands. Prolonged drought throughout the region is causing additional stress to trees. 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 2005). Epidemics of pinyon ips beetle, a type of bark beetle, have been occurring during drought periods when the mature trees are weak, resulting in stands of dead trees. The partial overstory of dead material changes the characteristics of the stands, altering the probability of fire starts and how it will then be carried (Clifford et al 2008).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat and are of particular importance to certain species:

- **Wet meadows** can occur in low lying areas with poorly drained soils, including shallow, ephemeral lakes. For most of the year wet meadows are without standing water, though the high water table allows the soil to remain wet. A variety of water-loving grasses, sedges, rushes, and wetland wildflowers proliferate in the highly fertile soil of wet meadows. Amphibians such as Great Basin spadefoot will breed in these temporary wetlands, and the wetland wildflowers provide a critical source of nectar for many pollinator species.
- **Springs** are vital water sources in an arid environment, and often support endemic species, such as Verde Rim springsnail and an undescribed *Pyrgulopsis* springsnail. Amphibians that rely on these water sources include Chiricahua leopard frog, northern leopard frog, lowland leopard frog, and Arizona toad. Springs can also act as foraging grounds for bats and important stopover and sometimes breeding habitat for birds. There are approximately 1,240 springs in this habitat type statewide.
- **Rock outcrops** are unique habitats that lend topographic diversity to habitats that can be fairly dense and homogenous, such as chaparral. These habitats may only occupy a small percentage of the land base, but they are disproportionately important as wildlife habitat.
- **Hanging gardens** are associated with seeps and springs and usually emerge from perched, unconfined aquifers in aeolian sandstone formations. In Arizona, hanging gardens support unique ecosystems with wetland, riparian and desert plants, including various amphibian species that rely on aquatic systems. In this habitat type, hanging gardens can be found at Little Green Valley Fen, Horseshoe, and Mesquite washes.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Chiricahua leopard frog, northern leopard frog, lowland leopard frog, Arizona toad
Birds: gray flycatcher, pinyon jay, black-throated gray warbler, Scott's oriole, juniper titmouse, bald eagle, golden eagle, northern goshawk
Invertebrates: Verde Rim springsnail, an undescribed *Pyrgulopsis* springsnail

Mammals: spotted bat, greater western bonneted bat, big free-tailed bat, Gunnison's prairie dog, black-footed ferret
Reptiles: Arizona black rattlesnake, Sonoran mud turtle, Sonoran whipsnake, black-necked gartersnake, northern Mexican gartersnake, narrow-headed gartersnake

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Arizona bugbane, Tonto Basin agave, Phillips agave, Page Springs agave, Goodding onion, Arizona pricklypoppy, Welsh's milkweed, sentry milk-vetch, Cliff milk-vetch, freckled milk-vetch, Duane's milkvetch, Navajo sedge, clustered leather flower, Jones cycladenia, Fish Creek fleabane, broadleaf lupine, Lemmon's lupine, Holmgren's stickleaf, September 11 stickleaf, seashore cactus, Brady pincushion cactus, Paradine (Kaibab) plains cactus, Fickeisen plains cactus, Siler pincushion cactus, Poverty Mountain breadroot, Verde breadroot, Lyngholm's brakefern, Cronquist's phacelia, Furniss' phacelia, Higgins' phacelia, Hughes' phacelia, Siler fishhook cactus, Mexican skullcap, Grand Canyon catchfly, Blackrock ground daisy

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, including altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Black bear, mule deer, white-tailed deer, javelina, mountain lion, bighorn sheep, Rocky Mountain elk, pinyon mouse, gray vireo, spotted towhee, Merriam's turkey, American pronghorn, Pinon mouse; plant species include Tusayan flameflower, Rusby's milkwort, varied fishhook cactus

Primary Threats to Great Basin Conifer Habitats

The following describes the primary threats facing lentic systems adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to lentic systems and conservation actions being taken, see *Chapter 8: Threats and Conservation Actions.*

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.2	Livestock farming and ranching
3	Climate Change	3.1 3.3	Habitat shifting and alteration Changes in temperature regimes
6	Energy Production and Mining	6.2	Mining and quarrying
7	Human Intrusion and Disturbance	7.1	Recreational activities

Code	Level 1 Threats	Code	Level 2 Threats
8	Invasive and Problematic Species	8.1 8.2	Invasive non-native species Problematic native species

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Monitor and mitigate for introduced/invasive species.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Manager/Owner(s)
Aubrey Valley	
4 FRI	USFS, Private
Anderson Mesa	USFS
Backbone Fire	USFS
Central Arizona Springsnails	USFS, NPS, Private, AZGFD
Coyote-Maimie	USFS, ASLD, Private
Eagle Creek Restoration Project	USFS
Escudilla	USFS
Grand and Marble Canyons	NPS
Grand Wash Cliffs North	BLM, NPS, Hualapai Indian Reservation, Private
Grasslands Wildlife Area	AZGFD
Joshua Tree IBA	BLM, ASLD, Private

COA Name	Site Manager/Owner(s)
Lower Little Colorado River	ALSD, BLM, Private
Lower Oak Creek	USFS, AZGFD, Private
Nutrioso Road	USFS
Raymond Wildlife Area	AZGFD
Rim 2 River	AZGFD, Private
Salt-Verde Ecosystem	USFS
San Francisco Blue	USFS, AZSP, Private
Silver Creek to LCR	BLM, ASLD, AZGFD, Private
White Mountains	AZGFD, USFS, Private
Woolhouse	USFS

Potential Partnerships

The following is a list of the organizations and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

BLM, Arizona State Land Department, Hualapai Tribe, USFS-Tonto and Prescott National Forest, Mule Deer Foundation, Arizona Elk Society, Upper Agua Fria Watershed Partnership, Payson Habitat Partnership Committee, Gila County, Yavapai County, Mohave County, Coconino County, Graham County, Greenlee County, Navajo Nation, White Mountain Apache, NRCS, Theodore Roosevelt Conservation Partnership, Northern Arizona Forest Foundation, Salt River Project, Trout Unlimited, Arizona Field Ornithologists, Intermountain West Joint Venture, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Important Conservation Resources

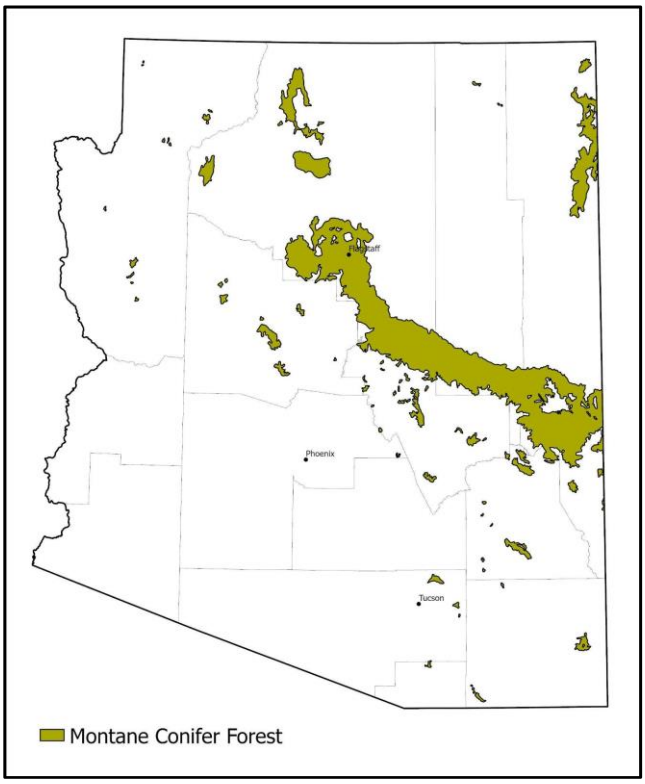
The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type.

- Mexican Wolf Recovery Plan
- Chiricahua Leopard Frog Recovery Plan
- Arizona Bighorn Sheep Management Plan
- Mogollon Rim EIS
- 4 Forest Restoration Initiative: Rim Country
- Mexican Spotted Owl Recovery Plan
- Black-footed Ferret Statewide Management Plan
- Management Focus Area Unit 22, 23
- Elk Management Plan

- Regional Elk Operational Plans
- Predation Management Plans: Unit 21
- Mule Deer Management Plan
- Pronghorn Management Plan
- Southwest Mule Deer Habitat Guidelines
- GMU- Management Focus Area Plans
- Gunnison's Prairie Dog - Interagency Management Plan
- Gunnison's Prairie Dog - WAFWA Conservation Assessment
- White-tailed and Gunnison's Prairie Dog Conservation Strategy
- Arizona Bat Conservation Strategic Plan
- Central Arizona Springsnail Strategic Conservation Plan (In review)
- Arizona Partners in Flight Bird Conservation Plan
- Conservation Strategy for the Pinyon Jay (*Gymnorhinus cyanocephalus*)
- Western Monarch Butterfly Conservation Plan

Petran Montane Conifer Forests
Habitat Profile

In Petran montane conifer forests, ponderosa pine dominates, with Douglas fir and white fir growing in varying proportions, particularly in cooler microhabitats. 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 can permit and understory of grasses, forbs, shrubs, and broadleaf trees. The largest contiguous block of Petran montane conifer forest is located along the southern edge of the Colorado Plateau in central Arizona as an unbroken ponderosa pine forest. In southern Arizona, Petran montane conifer forest grows primarily on the larger sky islands, a set of high-elevation mountains.



Changes in natural fire regimes and in forest management have altered 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. Approximately 58% of the Petran montane conifer forests have fire regimes which are severely altered from their historical state, creating a high risk of losing key ecosystem components (Schmidt et al. 2002). In addition, insect outbreaks during 2002-2004, 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) increasing risk of large, intense wildfire events (USFS 2004, 2005).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Small and ephemeral aquatic habitats** are important as they provide important sources of water and feeding and nesting habitat for many species, inlcuding dusky grouse, northern leopard frog, and Arizona toad. Some of these habitats include sinkhole ponds and wetlands on the Kaibab Plateau and southern edge of the Mogollon Rim, ciénegas in the White

Mountains, collapse depression lakes on the Chuska Mountains, and crater lakes in San Francisco volcanic field (e.g., Walker Lake).

- **Talus slopes and boulder piles** along hillsides and canyon drainages provide essential sheltering habitat for native land snails like talussnails and mountainsnails during hot, dry periods of the year. These mollusks aestivate for months in the cool and damp interstitial spaces in talus, under boulders, and deep rock crevices.
- **Snags** are found in mature and old-growth stands of ponderosa pine and are important for cavity nesting birds and as hunting perches for many other bird species. Tree-roosting bats such as Allen's lappet-browed bat and Southwestern myotis may use cavities, crevices, exfoliating bark, or roost in the snag itself.
- **Maple draws** on the Mogollon Rim provide important breeding and foraging habitats for many neotropical migrant bird species.
- **Caves and lava tubes** provide important habitat for summer roosting and hibernating bats, such as hoary bat and southwestern myotis, as well as many cave dwelling invertebrates.
- **High elevation riparian areas** are important habitats for small mammals, such as water shrew and New Mexico jumping mouse, which require saturated soils with tall dense herbaceous vegetation but also dry soils which may extend into adjacent upland habitat within 100m of these riparian areas (USFWS 2020). Herpetofauna that occur in these habitat features include Arizona treefrog, northern leopard frog, and narrow-headed gartersnake.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Chiricahua leopard frog, northern leopard frog, Arizona toad
Birds: flammulated owl, Mexican spotted owl, northern (mountain) pygmy-owl, northern goshawk, dusky grouse, band-tailed pigeon, bald eagle, thick-billed parrot (extirpated), pine grosbeak, red crossbill, Virginia's warbler, olive warbler, olive-sided flycatcher,
Invertebrates: Pinaleño talussnail, Pinaleño mountainsnail, mimic talussnail, Wet Canyon talussnail, Clark Peak talussnail, Sierra Ancha talussnail, Ancha mountainsnail, Three Forks springsnail
Mammals: Mt. Graham red squirrel, New Mexico jumping mouse, white-bellied long-tailed vole, Arizona montane vole, Abert's chuska squirrel, Kaibab squirrel, Arizona shrew, dwarf shrew, western water shrew, gray-collared chipmunk, least chipmunk, Unita chipmunk, southern red-backed vole, long-tailed vole, Mexican vole, long-tailed weasel, Merriam's shrew, southwestern cottontail, Colorado chipmunk, Mexican wolf, American pronghorn, pale Townsend's big-eared bat, Allen's lappet-browed bat, big free-tailed bat, hoary bat, southwestern myotis
Reptiles: Yarrow's spiny lizard, striped plateau lizard, Slevin's bunchgrass lizard, narrow-headed gartersnake, Arizona black rattlesnake, twin-spotted rattlesnake

Sensitive Plant Species

The following list represents plant species that are known to occur in this habitat type:

Arizona bugbane, Tonto Basin agave, Goodding onion, Arizona pricklypoppy, coppermine milk-vetch, sentry milk-vetch, Kaibab Indian paintbrush, White Mountains paintbrush, clustered leather flower, yellow lady's-slipper, Arizona hedgehog cactus, Pinalenos fleabane, Chiricahua fleabane, Bartram stonecrop, Pinaleno Mountain rubberweed, Huachuca water-umbel, broadleaf lupine, Lemmon's lupine, Holmgren's stickleaf, seashore catus, Chiricahua rock cress, Catalina beardtongue, Garland Prairie cinquefoil, Hualapai cinquefoil, Chiricahua cinquefoil, Flagstaff cinquefoil, Blumer's dock, Arizona willow, Huachuca groundsel, Grand Canyon catchfly, Porsild's starwort, Arizona monkshood, Goodding onion, Kaibab Indian paintbrush, White Mountains paintbrush, clustered leather flower, yellow lady's-slipper, Pinalenos fleabane, San Francisco Peaks ragwort, Blumer's dock, Arizona willow, Mexican skullcap, Porsild's starwort

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Rocky Mountain elk, mule deer, Coues white-tailed deer, Rocky Mountain bighorn sheep, black bear, mountain lion, Merriam's and Gould's turkey, red-faced warbler, orange-crowned warbler, Williamson's sapsucker, hairy woodpecker, Arizona tiger salamander, Arizona treefrog, western chorus frog, terrestrial gartersnake, long-legged myotis, silver-haired bat, and greater bladderwort

Primary Threats to Petran Montane Conifer Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represents broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to Petran montane conifer forest systems and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.2	Livestock farming and ranching
2	Biological Resource Use	2.3	Logging and wood harvesting
3	Climate Change	3.1 3.3 3.4	Habitat shifting and alteration Changes in temperature regimes Storms and flooding
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1	Fire and fire suppression

Code	Level 1 Threats	Code	Level 2 Threats
11	Transportation and Service Corridors	11.1	Roads and railroads

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Identify and improve the connectivity of natural landscapes to better link wildlife populations and allow for range shifts.
- Restore and/or improve diverse habitats to support a broad range of species assemblages that account for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Anderson Mesa	USFS
Central Arizona Springsnails	USFS, Private, AZGFD
Cottonwood Seep	USFS
Coyote-Maimie	USFS, ASLD, Private
Marble Canyon and Vermillion Cliffs	NPS
Grand Wash Cliffs	BLM
Rim 2 River	AZGFD
Black River	AZGFD, USFS
Telegraph Fire	USFS, ASLD
Woolhouse	USFS
San Francisco Blue	USFS, AZSP, Private

COA Name	Site Owner/Manager(s)
Mogollon Rim Snow Melt Draws IBA	USFS
Nutrioso Rudd	USFS
Old Hatchery	AZGFD

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

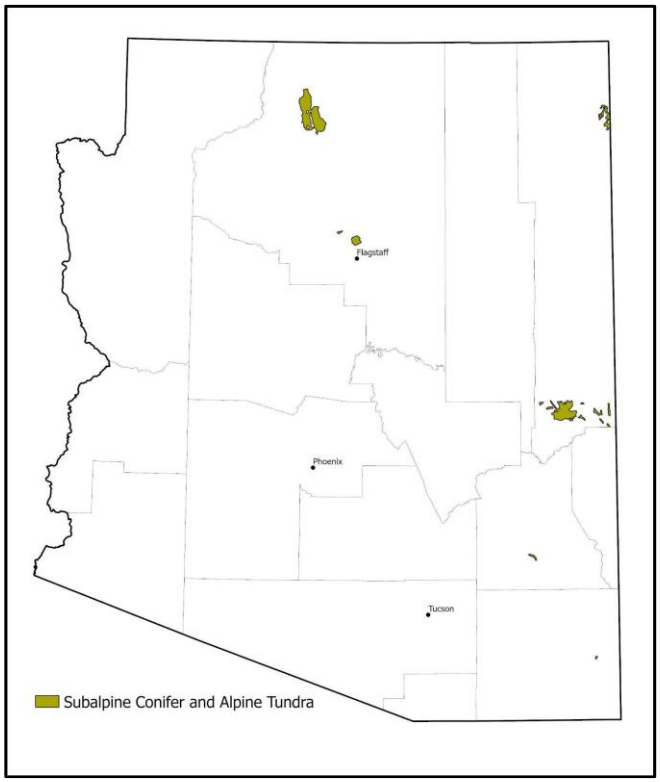
USFS, NPS (Grand Canyon), Phoenix Zoo, TNC (SF Peaks/ Hart Prairie), White Mountain Apache, San Carlos Apache, Navajo Nation, Hualapai Tribe, Northern Arizona University, New Mexico State University, University of Arizona, Arizona Mule Deer Organization, Mule Deer Foundation, Arizona Elk Society, Intermountain West Joint Venture, Arizona Field Ornithologists, Sonoran Joint Venture, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- USFWS Mexican Spotted Owl Recovery Plan
- Draft Mount Graham Red Squirrel Recovery Plan, First Revision
- New Mexico Meadow Jumping Mouse Recovery Outline
- Four Forest Restoration Initiative
- Pinaleño Mountain Land Snails Conservation Agreement
- Chiricahua Leopard Frog Recovery Plan
- Arizona Partners in Flight Bird Conservation Plan
- Western Monarch Butterfly Conservation Plan

Petran Subalpine Conifer Forests and Alpine Tundra
Habitat Profile



Petran subalpine conifer forests are at the southern end of their range in Arizona. Typically above 8,500 ft above sea level, these forests are variable and complex. They occur at the highest elevations of plateaus and mountain ranges in northern Arizona (e.g., Kaibab Plateau, San Francisco Mountain, White Mountains) as well as in the southern reaches of the state (e.g., Pinaleño, Chiricahua and Santa Catalina mountains).

A number of coniferous and deciduous species characterize these forests. At higher elevations and on north facing slopes the dominant conifers are usually Engelmann spruce and subalpine fir. On drier and more exposed sites, limber and bristle-cone pines may dominate. At lower elevations these forests are composed of a broad mix of coniferous species including blue spruce, white fir, and Douglas fir. This elevational band is often referred to as the cool/moist mixed conifer forest (Margolis et al. 2013). Quaking aspen is the dominant deciduous species and is found intermixed with the conifers, however pure aspen stands may be found post-fire. Dense overstories limit or prevent growth of herbaceous vegetation except in aspen stands and along forest edges where bunchgrasses are common. Otherwise, understory vegetation is limited to mosses, lichens, and prostrate junipers (Brown et al. 2020; Margolis et al. 2013).

Historically, Petran subalpine conifer forests were subject to a high-severity fire regime where fires were infrequent and stand-replacing. Patch sizes varied from as small as 74 acres to greater than 2,400 acres. After a high-severity fire, these forests followed a fairly predictable successional pathway beginning with aspen regeneration, followed by shade-tolerant conifer regeneration, and eventually forming an aspen/mixed conifer forest. Due to the patchiness of high-severity fires, irregular forest structures were common across stands and at landscape scales. Stands were multi-storied due to the shade tolerance of mixed-conifer tree species and the infrequency of high-severity

fires that did not have the effect of "thinning from below." While high-severity fire patches from recent fires may be larger than historical ones, the fire regime and resulting forest structures have not changed as dramatically in these forests as they have in drier forest communities at lower elevations (e.g., ponderosa pine-dominated forests). Petran subalpine conifer forests may be within their natural range of variability and do not necessarily indicate a need for restoration (Margolis et al. 2011; Margolis et al. 2013).

However, due to their limited distribution in Arizona, Petran subalpine 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 have also been degraded by a century of livestock grazing and fire suppression and have experienced significant tree mortality due to drought and insect infestation. In 2019, beetle-caused tree mortality in Douglas fir, white fir, and subalpine fir increased in Arizona and affected about 35,000 acres, primarily on the Apache-Sitgreaves and Coconino national forests and on the Navajo Nation. However, spruce beetle mortality has been consistently low in Arizona (120 acres in 2019) with most of the activity observed on White Mountain Apache lands (USFS 2020). In addition, invasive pests affect Engelmann and blue spruce (spruce aphid) and more recently aspen (oystershell scale). Recent monitoring indicates the emergent oystershell scale is widespread in northern Arizona and is contributing to aspen mortality on the Coconino, Kaibab, Apache-Sitgreaves, and Prescott national forests. A new effort to evaluate aspen decline was initiated in 2019 (USFS 2020).

Alpine tundra is found above 11,500 ft above sea level. Restricted to a few thousand acres above timberline on the highest peaks of San Francisco Mountain and on Mount Baldy, it is one of the rarest biotic communities in Arizona. This community is extremely isolated from any other alpine tundra, with the closest being in central New Mexico. Extreme cold temperatures exclude trees. Dominant plants are ground-hugging forbs and grasses (Brown 1990). Some recreational activity and past sheep grazing have affected this community. However, the largest threat is climate change which could lead to the elimination of alpine tundra habitats in Arizona.

Significant Habitat Features

The following describes habitat features or microhabitats in this habitat type that are of particular importance to certain species:

- **Sinkholes** are important as they can provide important sources of water and feeding and nesting habitat for many species of mammals, birds, reptiles, and amphibians in an otherwise xeric environment.
- **Wet meadows and vernal pools** typically have surface water only during the wetter periods of the year and do not usually support fish unless they are connected to perennial water. These habitats are important for amphibians such as leopard frogs and tiger salamanders, because their early life stages can thrive free of fish and other predators.
- **Talus slopes and boulder piles** along hillsides and canyon drainages provide essential sheltering habitat for native land snails like talussnails and mountainsnails during hot, dry

periods of the year. These mollusks aestivate for months in the cool and damp interstitial spaces in talus, under boulders, and deep rock crevices.

- **Aspen stands** provide important habitats for many species at these high altitudes, including mule deer and red-naped sapsucker. Many aspen stands are in decline thanks to fire-suppression, conifer encroachment, and over-browsing by elk.
- **Maple draws** provide important breeding and foraging habitats for many neotropical migrant bird species, such as red-faced warbler and hermit thrush.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or is watching closely in this habitat type due to some level of concern:

Amphibians: Chiricahua leopard frog, northern leopard frog
Birds: white-crowned (mountain west) sparrow, evening grosbeak, pine grosbeak, American pipit, golden-crowned kinglet, Canada jay, Swainson's thrush, American three-toed woodpecker, northern goshawk, Clark's nutcracker, red-faced warbler, hermit thrush
Invertebrates: Pinaleño talussnail, Pinaleño mountainsnail, mimic talussnail, Wet Canyon talussnail, Clark Peak talussnail
Mammals: dwarf shrew, northern pocket gopher, southern red-backed vole, Mt. Graham red squirrel, hoary bat
Reptiles: Yarrow's spiny lizard

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Arizona tiger salamander, Rocky Mountain elk, black bear, dusky grouse, ruby-crowned kinglet, red-naped sapsucker, northern saw-whet owl, red-breasted nuthatch, Williamson's sapsucker, red squirrel, San Francisco Peaks ragwort (*Packera franciscana*), silver-haired bat, long-legged myotis

Primary Threats to Petran Subalpine Conifer Forest and Alpine Tundra Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). For detailed information on threats to this habitat type and the conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
3	Climate Change	3.1 3.2	Habitat shifting and alteration Droughts
5	Disease, Pathogens, and Parasites	NA	NA
7	Human Intrusion and Disturbance	7.1	Recreational activities
9	Natural Systems Modifications	9.1 9.3	Fire and fire suppression Other ecosystem modifications
11	Transportation and Service Corridors	11.2	Utility and service lines

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.
- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Test novel husbandry techniques, new technology, and/or life history research on native aquatic wildlife to improve survival, growth, production, health, condition, transportation, release, and post-release performance of captive progeny.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix H: Terrestrial COA Profiles:

COA Name	Site Owner/Manager(s)
Kaibab Plateau	USFS
San Francisco Peaks	USFS
Lamar Haines Wildlife Area	AZGFD

COA Name	Site Owner/Manager(s)
Tucson Sky Islands	USFS, NPS, Pima County
Pinaleño Mountains	USFS
Chiricahua Mountains	USFS

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFS, USFWS, private landowners and grazing permittees, NGOs, White Mountain Apache Tribe, University of Arizona, Arizona Field Ornithologists

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type.

- Mexican Spotted Owl Recovery Plan (1st Revision)
- Draft Mt Graham Red Squirrel Recovery Plan (1st Revision)
- Four Forest Restoration Initiative (4FRI) , First Environmental Impact Statement (2015)
- Four Forest Restoration Initiative Rim Country Project, Draft EIS (2020)
- Pinaleño Mountain Land Snails Conservation Agreement
- Arizona Bat Conservation Strategic Plan
- Arizona Partners in Flight Bird Conservation Plan

Aquatic Systems
Overview

Although occupying only approximately 0.3% of the total surface area of Arizona (U.S. Census Bureau 2010), aquatic systems play an outsized role in supporting the biodiversity of our state's flora and fauna. Many of Arizona's SGCN are only found in aquatic systems while many more species utilize the associated riparian areas during at least a portion of their life cycle (Ffolliot et al. 2004; Zaines 2007).

Aquatic systems are bodies of water that support water-dependent communities of plants and animals. These systems occur as rivers and streams, ponds and lakes, wetlands and springs. Aquatic systems are home to fishes, many invertebrates, some mammals (e.g., beaver and muskrat), amphibians and reptiles, waterbirds, algas and aquatic plants. These systems also act as important habitat for early life stages of amphibians and many insects. Arizona's aquatic systems support 34 native fish species and numerous non-native fishes including sport fish. Depending on life stage and species, these fishes play multiple roles in the aquatic food web (Bunn et al. 2007). Meanwhile, sport fish support recreational opportunities while contributing to local economies throughout the state. Aquatic invertebrates are important parts of the food web, and are eaten by predatory invertebrates, fishes, amphibians, birds, and even a few mammals. Those species that metamorphose into winged adults are important food sources for a variety of birds, bats, and other wildlife. A wide variety of Arizona's wildlife utilize aquatic systems for water sources, and many plants would not exist without this surface or subsurface water source. The AWCS identifies four main categories of aquatic systems in Arizona:

Lentic and Lotic Systems

Lentic systems are areas that possess stationary surface water, such as a lake or pond. Lotic systems have flowing surface water, such as a river or stream (Zaimes et al. 2007). In Arizona, lotic systems can be perennial (surface water present year-round), intermittent (surface water present seasonally), or ephemeral (surface water present only following precipitation events). Both lentic and lotic systems possess unique hydrologic regimes as well as hosting communities of plants and animals. See the lentic and lotic systems habitat profiles for more details.

Wetlands

Wetlands are areas where frequent and prolonged presence of water at or near the surface, creates an ecosystem with unique hydrology and soil composition as well as an obligate community of plants and wildlife species. We separated wetlands from lentic systems to focus attention on them. In Arizona, wetlands include ciénegas (marshes) as well as ephemeral and intermittent pools, sites that hold water seasonally (e.g., after snow melt) or only following rain events. Wetlands, whether perennial or intermittent, provide water for all wildlife and important habitat for migrating waterfowl

as well as some species of amphibians, reptiles, and invertebrates (Minckely et al. 2013). These increasingly rare wetland habitats also support riparian vegetation which is often more diverse and lush than surrounding vegetation. See the wetlands habitat profile for more details.

Springs

Springs are points at which a groundwater aquifer intersects the surface (Stevens et al. 2016). A spring might flow continuously or respond to precipitation events, and can range from simple seeps to flows of thousands of gallons each day. Spring ecosystems typically have shallow flowing water with flora and fauna quite distinct from the surrounding terrestrial environment. They often play an important role in arid environments, providing a critical source of water not only for plants and animals, but for humans as well. Arizona has more than 10,200 mapped springs, but many have been degraded and reduced due to groundwater pumping, diversion, livestock and wildlife grazing, development, and invasive species (SSI 2020). Extended drought and climate change threaten the remaining functional spring ecosystems. See the springs habitat profile for more details.

Riparian Areas and Aquatic Systems

Riparian areas are terrestrial habitats that are closely associated with aquatic systems and play a critical role in supporting a large portion of Arizona's wildlife. Riparian areas are defined as vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage (Arizona Riparian Council 1994). Riparian areas serve as transition zones between aquatic ecosystems and the surrounding upland terrestrial environment.

Riparian areas exist within all major terrestrial habitat types in Arizona, however vegetation composition and structure varies based on region, elevation, climatic conditions, flow patterns, and water levels and quality. Common tree species in riparian areas include: Fremont cottonwood, Goodding's willow, Arizona sycamore, velvet ash, Arizona walnut, red willow, Arizona alder, boxelder, and mesquite. Rushes, sedges, and cattails are a few of the common herbaceous plants found in the riparian zone. Non-native species like salt cedar and Russian olive tree have invaded many of the lower-elevation riparian areas in Arizona, oftentimes at the expense of native species.

Riparian areas provide essential habitats for wildlife and are also some of the most degraded, altered, and threatened habitats in Arizona (Stomberg and Tellman 2009). Because of the high moisture content of riparian areas, vegetation and wildlife abundance and diversity is exceedingly high within and directly adjacent to these habitats (Levick et al. 2008). Up to 80% percent of Arizona wildlife species are dependent on riparian areas for breeding, migration, shelter, and seasonal forage during some part of their life cycle (Chaney et al. 1990). Wildlife also rely on riparian areas for a dependable water source. Many species unique to the Southwest rely solely on riparian areas for breeding, including the endangered southwestern willow flycatcher, the threatened western yellow-billed cuckoo, and northern Mexican gartersnake. Other SGCN of note include gray hawk, common black hawk, and white-nosed coati. Game species such as Gambel's quail, mule deer, and javelina also rely on riparian areas.

Whether endangered or common, game species or not, many of Arizona's wildlife rely on riparian areas to facilitate movement from habitat to habitat (Zaines 2007). From dry washes to flowing rivers, these riparian areas act as wildlife corridors — the landscape linkages which provide habitats and allow for species to safely move from habitat to habitat throughout the year as conditions change. Riparian areas act as important linkages in the landscape to facilitate daily, seasonal, and annual movements of individuals and populations of species. Keeping these connections intact ensures the long-term viability of all wildlife species, as well as plants, by promoting genetic exchange between individuals and populations.

Balancing Angler Opportunity with Native Aquatic Species Conservation
Maintaining and enhancing sport fishing opportunities while simultaneously conserving and restoring Arizona's native aquatic wildlife resources is a complex and challenging mission for AZGFD. To address this challenge, AZGFD is working with partners to develop watershed management plans for each of the 11 major watersheds in Arizona. These plans establish management prescriptions intended to reduce conflicts between sport fish and native aquatic species. The plans provide an integrated management strategy whereby all fish management activities within the watershed work toward meeting long-term goals. Examples of goals include proactively managing to improve the status of native fish within the watershed, promoting the delisting of ESA-listed species, preventing the need for future federal listings, and achieving no net loss of sport fishing opportunity and/or angler use. To achieve these goals, the plans divide waters within a watershed into management units and identify management objectives and target species for each unit.

Many of these watershed management plans were used to identify the Aquatic COAs (See Appendix G). More information about the watershed management plan development process and the plans themselves can be found on the AZGFD website.

Conservation of Aquatic Systems and Riparian Areas

Water resources throughout the state are currently over-allocated such that conflicts are increasing between societal needs and maintenance of functioning ecosystems (ADWR 2018; Tiller et al. 2012). Active land and water management planning is critical to accommodating the anticipated human population growth while maintaining biological diversity. Thankfully, these richly diverse and extremely valuable areas are a primary focus of much of the conservation and restoration efforts by agencies, organizations, and private landowners throughout the state. These partners all help monitor, conserve, restore, and protect riparian areas and aquatic systems in Arizona. Here are just a few examples:

- TNC, ADEQ, BLM, and Pima County annually monitor the wet-dry extent (wet-dry mapping) of stream courses. This information can be used to track the effects of natural processes and human impacts of surface water in streams.
- The Arizona Land and Water Trust launched its Desert Rivers and Riparian Heritage Initiative to develop and implement water stewardship tools that will sustain the rural livelihoods and riparian habitats that enrich Arizona's natural and cultural landscapes.
- Pima County protects riparian habitat for future generations by ensuring the long-term stability of natural floodplains, allowing for the survival of native plants and animals, while also helping to maintain the area's quality of life for County residents.
- Nonprofit organizations, such as Arizona Riparian Council, Verde Watershed Restoration Coalition, the Community Watershed Coalition of Southern Arizona, and others, provide for the exchange of information on the status, protection, and management of riparian systems in Arizona. Membership is open to any person or organization interested in the conservation, restoration, or scientific study of riparian systems.
- The Spring Stewardship Institute (SSI) was established in 2013 through the Museum of Northern Arizona to improve our collective understanding of spring ecology and to increase stewardship of these valuable and vulnerable resources. In addition to a central hub and collaboration platform for sharing information on springs and spring ecosystems, SSI developed a searchable database to make this information easily accessible for researchers and land managers.

These partnerships and collaborations are guided by dedicated staff and organizations that have been instrumental in conserving and protecting these valuable resources. However, aquatic and riparian systems have been and continue to be highly impacted and altered by diversion, impoundment, dewatering, erosion, sedimentation, non-native and invasive species, and prolonged drought. These, and many other challenges facing Arizona's wildlife and habitats, are summarized in Chapter 3: Conservation Challenges of the AWCS. Specific threats facing riparian areas and aquatic systems — along with conservation actions — can be found in the individual habitat profiles for lentic, lotic, wetland, and spring systems found in Chapter 8: Threats and Conservation Actions.

Lentic Systems
Habitat Profile

Lentic systems include natural lakes or ponds, small man-made lakes, isolated or connected backwaters of rivers, large reservoirs, and their associated riparian habitats. Arizona has about 492 square miles covered with water, mostly in man-made reservoirs (Tellman et al. 1997). Most of the natural ponds in Arizona are not perennial, and even the two natural lakes (Mormon Lake and Stoneman Lake) can dry up during extended droughts (Hereford and Amoroso 2021). Following the settlement of the Arizona Territory and, later, the State of Arizona, the need to manage water resources for safety and human uses increased. In response to these changes, more than 400 dams were constructed around the state (USGS 2017). The larger reservoirs were created in the early to mid-20th century, beginning with construction of Roosevelt Dam in 1911 (Blanchard 1911). Damming of rivers immediately altered downstream flows and habitat in the streams/river systems in which they were built, thus affecting native aquatic wildlife (Garcia 2009). Humans also introduced non-native fish, crayfish, and mollusks to many of these reservoirs, which negatively-affected native aquatic species in these lentic systems as well as the connected lotic systems (Johnson et al. 2008).

Hundreds of smaller human-created impoundments, including stock tanks, local community/ranch ponds, and small lakes are dispersed throughout Arizona and provide habitat for aquatic and terrestrial wildlife (USGS 2017). Most of these small impoundments have limited or no riparian areas, nor do they support populations of native fishes. Fish that do occur in these smaller lentic systems are typically non-native species (Olden and Poff 2005). These ponds provide locally-important sources of drinking water for many wildlife species, and maybe the only sources of standing water over significant areas.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Ponds and tanks** smaller than two surface acres and shallower than 10 feet are often temporary and may only provide water for less than a year at a time. However, the temporal availability of these ponded habitats is very important for the reproduction and recruitment of amphibian and invertebrate species. Thanks to the ephemeral nature of these lentic systems, they preclude the occupation of non-native fishes that may prey or compete with native species. Many species of game and nongame wildlife will also use these temporary water sources as a drinking water source.
- **Moderate-sized ponds** may persist for one or more years, except during the longest drought periods. These lentic systems provide more reliable drinking water sources for game and nongame wildlife. However, these ponds may require active management to maintain a desirable aquatic species assemblage and native habitat that reflects AZGFD's management

goals for the area, whether they be a sportfishing opportunity or for native species conservation.

- **Larger reservoirs** have converted many miles of flowing river to standing water habitats that can be used by a variety of waterfowl and piscivorous birds such as bald eagle and osprey. These larger lentic systems also provide suitable habitat for the fish species that support the majority of recreational sport fishing opportunities in the state.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern in this habitat type:

Amphibians: Sonora tiger salamander, Chiricahua leopard frog, northern leopard frog, lowland leopard frog
Birds: Yuma Ridgway's rail, California black rail, American bittern, Virginia rail, least (western) bittern, sora, southwestern willow flycatcher, western yellow-billed cuckoo, western grebe, Clark's grebe, common gallinule, bald eagle, peregrine falcon
Fish: Sonoyta pupfish, desert pupfish, bonytail, Gila chub, Yaqui chub, roundtail chub, Yaqui catfish, Apache trout, Gila trout, Gila topminnow, Yaqui topminnow, razorback sucker
Invertebrates: California floater
Reptiles: northern Mexican gartersnake, Sonora mud turtle, Sonoyta mud turtle
Mammals: western red bat, greater western bonneted bat, Mexican free-tailed bat, pocketed free-tailed bat, spotted bat, Allen's lappet-browed bat

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Arizona tiger salamander, western chorus frog, American beaver, river otter, Yuma myotis, American pronghorn, Rocky Mountain elk, Rocky Mountain bighorn sheep, desert bighorn sheep, Mexican gray wolf, Merriam's wild turkey, mule deer, Coues' white-tailed deer, osprey, American coot, common yellowthroat, song sparrow, American bullfrog, rainbow trout, brown trout, brook trout, cutthroat trout, channel catfish, flathead catfish, yellow bullhead, black bullhead, largemouth bass, striped bass, green sunfish, common carp; invertebrates include northern crayfish, red swamp crayfish, western mosquitofish, quagga mussels, Asian clams, New Zealand mudsnail, applesnail

Primary Threats to Lentic Systems

The following describes the primary threats facing lentic systems adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represents broad categories while second-level threats reflect more specific stressors to the system. For detailed information on threats to lentic systems and conservation actions being taken, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
3	Climate Change	3.1 3.2	Habitat shifting and alteration Droughts
5	Disease, Pathogens, and Parasites	NA	NA
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native/alien species
9	Natural Systems Modifications	9.1	Fire and fire suppression

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix G: Aquatic COA Profiles.

Currently, AZGFD manages 85 lentic systems statewide with a management emphasis on native aquatic species conservation. These lentic systems are scattered throughout the various watersheds across the state. Most of these COAs were identified using AZGFD's watershed management plans.

Watershed Name	Number of COAs in Watershed
Agua Fria	10
Little Colorado River	11
Lower and Middle Gila River	2

Watershed Name	Number of COAs in Watershed
Lower Colorado River	9
Lower Colorado-Lake Mead	1
Salt River	12
San Pedro River and Wilcox Playa	23
Santa Cruz River	3
Upper Gila River	11
Verde River	3

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in lentic systems:

USFS (all AZ Forests), BLM (all AZ districts), USFWS Arizona Ecological Services, USFWS Arizona Fish and Wildlife Conservation offices, USFWS National Wildlife refuges, White Mountain Apache Tribe, San Carlos Apache Tribe, Gila River Indian Community, Navajo Nation, Hopi Nation, Hualapai Nation, Salt River Maricopa Indian Community, Fort McDowell Yavapai Nation, SRP, USBR, ADEQ, ADWR, ASPT, ASLD, ASU, UA, NAU, Maricopa County Parks and Recreation, Pima County Natural Resources, Parks and Recreation, Mesa Community College, Scottsdale Community College, Black Canyon City Heritage Park, Deer Valley High School, Ciénega High School, Lake Havasu High School, Palo Verde High School, Apache Elementary School, Hermosa Montessori Elementary School, Tohono Chul Park, Arizona-Sonora Desert Museum, Phoenix Zoo, Desert Botanical Garden, TNC, Audubon Southwest, Safari Club International Wildlife Museum, Amerind Museum, Arizona Historical Society, Trout Unlimited, Arizona Field Ornithologists

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in lentic systems.

- Arizona Bald Eagle Conservation Assessment and Strategy
- Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan (2007)
- Safe Harbor Agreement for the Chiricahua Leopard Frog in Arizona (2006)
- Rangewide Conservation Agreement for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker (2006)
- Arizona Statewide Conservation Agreement for Roundtail Chub (*Gila robusta)*, Headwater chub (*Gila nigra*), Flannelmouth Sucker (*Catostomus latipinnis*), Little Colorado River Sucker (*Catostomus* spp.), Bluehead Sucker (*Catostomus discobolus*), and Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*) (2006)

- Razorback sucker (*Xyrauchen texanus*) Recovery Goals: Amendment and Supplement to the Razorback Sucker Recovery Plan (2002)
- Razorback Sucker (*Xyrauchen texanus*) Recovery Plan (1998)
- Yaqui Fishes Recovery Plan (1994)
- Desert Pupfish Recovery Plan (1993)
- Sonora Chub Recovery Plan (1992)
- Gila and Yaqui Topminnow Recovery Plan (1984)
- Safe Harbor Agreement for the Gila Topminnow and Desert Pupfish in Aravaipa Canyon Preserve (2005)
- Safe Harbor Agreement for Topminnows and Pupfish in Arizona (2007)
- Pima County's Multi-species Conservation Plan: Final
- Habitat Conservation Plan Horseshoe and Bartlett Reservoirs (2008)
- San Rafael Ranch Low-Effect Habitat Conservation Plan, Santa Cruz County, Arizona (2015)
- Lower Colorado River Multi-species Conservation Program
- Arizona Partners in Flight Bird Conservation Plan
- Sonoran Joint Venture Bird Conservation Plan
- Arizona Bat Conservation Strategic Plan

Lotic Systems
Habitat Profile

Lotic ecosystems have flowing water that can be perennial, intermittent, or ephemeral (Zaines 2007). These systems include associated riparian corridors and connecting ephemeral channels. In Arizona, lotic systems range in size, from the large, free-flowing Colorado River to small stream channels that only contain water following rain events. All of these lotic systems are extremely fragile and provide important habitat for native fish, birds, aquatic organisms, and other riparian-dependent wildlife species (Bunn et al. 2007).

The Colorado River is Arizona's largest river, with an annual discharge that ranks 25th largest in the United States (lseri and Langbein 1974). Meanwhile, the Gila, Salt, and Verde — which are considered large rivers for Arizona — have discharges considerably less than the Colorado. Arizona's moderate-sized rivers include the San Pedro, Santa Cruz, Little Colorado, White, Black, Blue, San Francisco, Bill Williams, Agua Fria, and Babocomari. Additionally, there are hundreds of smaller perennial, intermittent, and ephemeral streams that are tributaries to these larger systems (Goodrich et al. 2018).

Geology and hydrology shape lotic systems through fluvial processes, or the interaction between flowing water and the river channel (Hereford 1984). These interactions create a variety of macro- and microhabitat types, including cascades, riffles, runs, glides, pools, and others. Aquatic wildlife and organisms inhabit these macro- and micro-habitats depending on their adaptations (Wood and Bain 1995).

Arizona has a bimodal pattern of annual precipitation that drives these fluvial processes. Intense but short-term precipitation during the summer often results in localized flash floods, making lotic systems turbid with suspended sediments (Graf et al. 1981). Native aquatic wildlife are adapted to these rapid changes in flows and turbidity (Brouder 2001). Conversely, winter precipitation can be less intense and more prolonged, providing opportunity for interconnectedness between perennial reaches that are otherwise disconnected during drier periods (Jager et al. 2014).

Lotic systems in Arizona are occupied by a variety of algae and submerged aquatic plants that form the base of the food web while also providing habitat for aquatic invertebrates and vertebrates. The biomass of algae and submersed plants in lotic systems is highly dependent upon the amount of sunlight reaching the stream, which is affected by the geologic setting, riparian vegetation, and suspended sediments (Bunn et al. 2006).

Primary threats affecting lotic systems include drying, sedimentation, non-native species, and pollution (Stromberg and Tellman 2009). Drought, climate change, water diversions, and groundwater pumping contribute to stream drying, resulting in habitat loss and reduced diversity of aquatic wildlife (Rinne et al. 2005). Sedimentation is caused by overgrazing, timber harvest, excessive OHV

use, runoff from roadways, and precipitation events following wildfire. The spread and invasion of non-native species can also alter the native lotic community composition, replacing some assemblages entirely and increasing degradation of native riparian habitats (Olden and Poff 2005). Finally, pollution is a much more localized stressor to lotic systems. Effluent from mines, agriculture, and urban areas can transport a variety of pollutants that can severely degrade lotic communities (Singh 2010; Dolan and Mannan 2009).

All of these stressors can disrupt lotic food webs and negatively-affect aquatic wildlife (Tellman et al. 2009). A focused and collective effort is necessary to reduce these threats where possible, conserve and protect the remaining functioning lotic systems, and restore riparian habitat in key areas where species benefit is maximized.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to lotic systems and are of particular importance to certain species:

- **Low-gradient riffles** with pebbles and cobbles that are not embedded in fine substrates are required for loach minnow which lay eggs on the underside of these rocks (Propst and Bestgen 1991).
- **Edgewaters below riffles and cascades** are important for spikedace where they school and feed on drifting insects (Rinne 1991).
- **Sand to gravel sized substrates** are needed for spawning habitat for Gila trout, Apache trout, spikedace, speckled dace, longfin dace, chub species, and all of the native suckers (Rinne 2001; Minckley and Marsh 2009).
- Apache and Gila trout prefer **non-turbid streams with a mix of pools and riffles** that have instream and overhead cover, as well as larger sediments that are not embedded (Cantrell et al. 2005).
- Apache and Gila trout generally require **mean daily water temperatures** of less than 68°F (20°C) year-round (Lee and Rinne 1980; Petre and Bonar 2017).
- **Large- and moderate-sized connected rivers** are preferred by many of the big river fish species, including razorback sucker, Colorado River pikeminnow, flannelmouth sucker, and bonytail, where they can complete their reproductive cycles and migrate up and down the river corridors. However, these habitat types no longer exist within Arizona due to damming of rivers (Minckley and Marsh 2009).

Key Conservation Species (SGCN)

The following list represents lotic-dependent species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Arizona toad, northern leopard frog, relict leopard frog, Chiricahua leopard frog, lowland leopard frog, Tarahumara frog

Birds: yellow-billed (western) cuckoo, California black rail, Yuma Ridgway's rail, least (western) bittern, southwestern willow flycatcher, elegant trogon, painted redstart, hooded oriole, Bullock's oriole, Abert's towhee, American dipper, bald eagle, peregrine falcon, golden eagle, MacGillivray's warbler, osprey
Fish: longfin dace, Mexican stoneroller, Yaqui sucker, desert sucker, bluehead sucker, Zuni bluehead sucker, Sonora sucker, flannelmouth sucker, Little Colorado sucker, beautiful shiner, Sonoyta pupfish, desert pupfish, humpback chub, Sonora chub, bonytail, Gila chub, Yaqui chub, roundtail chub, Virgin River chub, Yaqui catfish, spikedace, Virgin River spinedace, Little Colorado spinedace, Apache trout, Gila trout, woundfin, Gila topminnow, Yaqui topminnow, Colorado pikeminnow, loach minnow, razorback sucker
Invertebrates: California floater
Mammals: western red bat, New Mexico jumping mouse
Reptiles: black-necked gartersnake, northern Mexican gartersnake, narrow-headed gartersnake, Sonoran mud turtle

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

American beaver, common black hawk, gray hawk, zone-tailed hawk, cordilleran flycatcher, vermilion flycatcher, yellow warbler, summer tanager, Lucy's warbler, Bell's vireo, yellow-breasted chat, green-tailed towhee, red-faced warbler, Yuma myotis, Huachuca water umbel, Rocky Mountain elk, Rocky Mountain bighorn sheep, rainbow trout, brown trout, brook trout, cutthroat trout, channel catfish, flathead catfish, yellow bullhead, black bullhead, smallmouth bass, coosa bass, largemouth bass, striped bass, green sunfish, common carp, red shiner, blue tilapia, American bullfrog; invertebrates include western mosquitofish, New Zealand mudsnail, applesnail, Asian clam, quagga mussel, northern crayfish

Primary Threats to Lotic Systems

The following are the primary threats facing lotic systems and are adapted from standardized lexicon described in Salafsky et al. (2008). For detailed descriptions of threats and conservation actions being taken to address these threats, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
3	Climate Change	3.1 3.2 3.2	Habitat shifting and alteration Drought Temperature extremes

Code	Level 1 Threats	Code	Level 2 Threats
5	Disease, Pathogens, and Parasites	NA	NA
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1 9.2	Fire and fire suppression Dams and water management/use
10	Pollution	10.2 10.3	Industrial and military effluents Agricultural and forestry effluents

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix G: Aquatic COA Profiles.

Currently, AZGFD manages 329 lotic systems statewide with a management emphasis on native aquatic species conservation. These lotic systems are scattered throughout the various watersheds across the state. Most of these COAs were identified using AZGFD's watershed management plans.

Watershed Name	Number of COAs within Watershed
Agua Fria	36
Bill Williams River	11
Little Colorado River	48
Lower and Middle Gila River	6
Lower Colorado River	4

Watershed Name	Number of COAs within Watershed
Lower Colorado-Lake Mead	17
Salt River	62
San Pedro River and Wilcox Playa	38
Santa Cruz River	27
Upper Gila River	26
Verde River	54

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFS (all AZ Forests), BLM (all AZ districts), USFWS Arizona Ecological Services, USFWS Arizona Fish and Wildlife Conservation offices, USFWS National Wildlife refuges, USBR, USBIA, White Mountain Apache Tribe, San Carlos Apache Tribe, Navajo Nation, Hopi Nation, Hualapai Nation, Salt River Pima-Maricopa Indian Community, Fort McDowell Yavapai Nation, Gila River Indian Community, SRP, ADEQ, ADWR, ASPT, ASLD, Arizona State University, University of Arizona, Northern Arizona University, Pima County, Arizona-Sonora Desert Museum, Phoenix Zoo, Desert Botanical Garden, TNC, Trout Unlimited, various Flycaster groups, Sonoran Joint Venture, Audubon Southwest, Tucson Audubon Society, Arizona Field Ornithologists, Maricopa County Parks, Intermountain West Joint Venture, Arizona Field Ornithologists, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in lotic systems.

- Arizona Bald Eagle Conservation Assessment and Strategy.
- Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan (2007)
- Safe Harbor Agreement for the Chiricahua Leopard Frog in Arizona (2006)
- Rangewide Conservation Agreement for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker (2006)
- Arizona Statewide Conservation Agreement for Roundtail Chub (*Gila robusta*), Flannelmouth Sucker (*Catostomus latipinnis*), Little Colorado River Sucker (*Catostomus* spp.), Bluehead Sucker (*Catostomus discobolus*), and Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*) (2006)
- Apache Trout (*Oncorhynchus gilae apache*) Recovery Plan, second revision; (2009)
- Gila Trout (*Oncorhynchus gilae*) Recovery Plan, third revision (2003)

- Bonytail Chub Recovery Plan (1990)
- Bonytail (*Gila elegans*) Recovery Goals: amendment and supplement to the Bonytail Chub Recovery Plan (2002)
- Colorado Pikeminnow (*Ptychocheilus lucius*) Recovery Goals: amendment and supplement to the Colorado Squawfish Recovery Plan: (2002)
- Humpback Chub Recovery Plan (1990)
- Humpback Chub (*Gila cypha*) Recovery Goals: amendment and supplement to the Humpback Chub Recovery Plan (2002)
- Razorback Sucker (*Xyrauchen texanus*) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan (2002)
- Razorback Sucker (*Xyrauchen texanus*) Recovery Plan (1998)
- Little Colorado River Spinedace, *Lepidomeda vitatta*, Recovery Plan (1998)
- Yaqui Fishes Recovery Plan (1994)
- Virgin River Fishes Recovery Plan (1994)
- Desert Pupfish Recovery Plan (1993)
- Sonora Chub Recovery Plan (1992)
- Loach Minnow Recovery Plan (1990)
- Spikedace Recovery Plan (1990)
- Gila and Yaqui Topminnow Recovery Plan (1984)
- Safe Harbor Agreement for the Gila Topminnow and Desert Pupfish in Aravaipa Canyon Preserve (2005)
- Safe Harbor Agreement for Topminnows and Pupfish in Arizona (2007)
- Virgin Spinedace Conservation Strategy (2002)
- Pima County's Multi-Species Conservation Plan: Final
- Habitat Conservation Plan Horseshoe and Bartlett Reservoirs (2008)
- San Rafael Ranch Low-Effect Habitat Conservation Plan, Santa Cruz County, Arizona (2015)
- Lower Colorado River Multi-species Conservation Program
- Southwestern Willow Flycatcher Recovery Plan (2002)
- New Mexico Meadow Jumping Mouse Recovery Outline
- Arizona Bat Conservation Strategic Plan
- Arizona Partners in Flight Bird Conservation Plan
- Bring Birds Back Home: A Guide to Enhancing Rivers, Streams and Desert Washes for Birds and Other Wildlife
- Western Monarch Butterfly Conservation Plan

Wetlands
Habitat Profile

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year. Wetlands are scattered throughout Arizona and can be categorized into various forms, including wet meadows, vernal pools, and ciénegas (marshes). Wetlands typically have emergent aquatic vegetation such as rushes, cattails, and sedges. Wetlands with perennial water also tend to have a variety of submersed and floating aquatic vegetation. These increasingly rare wetland habitats can also support riparian vegetation which is often more diverse than surrounding vegetation. Wetlands, whether perennial or intermittent, provide water for all wildlife. Vegetation associated with wetlands provides food and habitat for a wide variety of wildlife including birds, mammals, amphibians, reptiles, and invertebrates. Some of the deeper and perennial ciénegas are inhabited by fish (Minckley et al. 2013).

The statewide status of wetlands is not well documented, but most are thought to be greatly reduced from their pre-settlement conditions (Trombalak and Frissel 2000). The distribution of ciénegas has shrunk from formerly widespread to small, scattered remnants due to grazing and streambed modifications (Hendrickson and Minckley 1984). A follow-up study reported more than 20% of known/named ciénegas had lost their ecological function, in that they no longer provide any provisioning, critical habitat, or other original services. In addition, groundwater withdrawals for agriculture, and the sinking water table that results, has been identified as another stressor to wetlands (Minckley 2013). The remaining wetlands are often subject to intensive utilization.

Vernal pools are temporary wetlands that occur seasonally. These habitats are covered by shallow water during wet periods of the year but may completely dry out during other periods. These intermittent pools support wildlife that would not be successful in permanent waters where predators such as fish occur. Many of Arizona's amphibians utilize these temporary aquatic habitats for reproduction and development of their young. A variety of invertebrates, such as fairy shrimp, clam shrimp, tadpole shrimp, water fleas, and insects also utilize these pools. These pools also provide temporary local water sources for a variety of wildlife.

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Wet meadows and vernal pools** typically have surface water only during the wetter periods of the year and do not usually support fish unless they are connected to perennial water. These habitats are important for amphibians such as leopard frogs and tiger salamanders, because their early life stages can thrive when free of fish and other predators.

- **Emergent vegetation** found in and around ciénegas provides important nesting habitat for a wide variety of nesting birds, such as waterfowl, rails, redwing blackbirds, and marsh wrens. Foods for these species are also found in the vegetation or in the water. Mammals such as muskrat, also find food and shelter in ciénegas.
- **Ciénegas** provide still or slow-moving water with abundant vegetative cover that can support a variety of native fish species such as Gila topminnow, desert pupfish, Sonoyta pupfish, and Gila chub.

Key Conservation Species (SGCN)

The following list represents species that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Sonoran tiger salamander, Chiricahua leopard frog, lowland leopard frog
Birds: American bittern, California black rail, black-bellied whistling duck, common gallinule, least (western) bittern, Yuma Ridgway's rail, snowy egret, sora, Virginia rail
Invertebrates: Huachuca springsnail
Mammals: Arizona cotton rat, western harvest mouse, New Mexico jumping mouse, Arizona montane vole, water shrew
Reptiles: northern Mexican gartersnake, painted turtle, Sonora mud turtle, Sonoyta mud turtle, yellow mud turtle
Fish: Gila topminnow, Yaqui topminnow, desert pupfish, Sonoyta pupfish, Gila chub, Yaqui chub, Yaqui catfish, beautiful shiner

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

western mosquitofish, muskrat, elk, crayfish, Physa pond snail, marsh wren, common yellowthroat

Primary Threats to Wetlands

The following are the primary threats facing lotic systems and are adapted from standardized lexicon described in Salafsky et al. (2008). For detailed descriptions of threats and conservation actions being taken to address these threats, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.3	Livestock farming and ranching
3	Climate Change	3.1 3.2	Habitat shifting and alteration Droughts
5	Disease, Pathogens, and Parasites	NA	NA

Code	Level 1 Threats	Code	Level 2 Threats
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native species
9	Natural Systems Modifications	9.1 9.3	Fire and fire suppression Other systems modifications

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Conserve a variety of habitats that support healthy populations of fish and wildlife as climate changes.
- Restore and maintain diverse habitats to support broad species assemblages that account for range shifts.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.
- Implement long-term monitoring protocols for vulnerable species and habitats to inform adaptive management.

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFS (all AZ Forests), BLM (all AZ districts), NPS, USFWS Arizona Ecological Services, USFWS Arizona Fish and Wildlife Conservation offices, USFWS National Wildlife refuges, USBR, SRP, ADEQ, ADWR, ASPT, ASLD, ASU, UA, NAU, Pima County, Arizona-Sonoran Desert Museum, Phoenix Zoo, Arizona Field Ornithologists, Arizona Monarch Collaborative, Southwest Monarch Study, Gila Watershed Partnership

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix G: Aquatic COA Profiles.

COA Name	Site Own/Manager(s)
San Rafael Grasslands	USFS, AZGFD, Private
Central Arizona Springsnails	AZGFD, USFS
Lower Salt and Gila Rivers	BLM, USBR, ASLD, USACE, AZGFD
Quigley-Achee Wildlife Area	AZGFD
Nutriosos Rudd	USFS, AZGFD
Lower Gila River	USBR, BLM, Yuma Crossing Heritage Area
Rim 2 River	USFS, ASLD, Private
Appleton-Whittell & Las Cienagas	BLM, ASLD, USFWS, Private
San Pedro Riparian National Conservation Area	BLM
Tuzigoot	NPS
Lake Havasu	USFWS, USBR, BLM

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Chiricahua Leopard Frog (Rana chiricahuensis) Recovery Plan (2007)
- Safe Harbor Agreement for the Chiricahua Leopard Frog in Arizona (2006)
- Yaqui Fishes Recovery Plan (1994)
- Desert Pupfish Recovery Plan (1993)
- Gila and Yaqui Topminnow Recovery Plan (1984)
- Safe Harbor Agreement for Topminnows and Pupfish in Arizona (2007)
- Arizona Partners in Flight Bird Conservation Plan
- Sonoran Joint Venture Bird Conservation Plan
- New Mexico Meadow Jumping Mouse Recovery Outline
- Huachuca Springsnail Candidate Conservation Agreement
- Arizona Bat Conservation Strategic Plan
- Western Monarch Butterfly Conservation Plan

Springs
Habitat Profile

Springs are places where groundwater comes to the Earth's surface. Springs emerge into both aquatic and terrestrial environments and have been categorized into 12 types (Stevens et al. 2016). This habitat profile focuses on three types of springs that occur in Arizona, including gushet, hanging garden, and hill slope. (Other types of springs are described in separate profiles for lotic, lentic, and wetland systems where they occur.) Springs vary greatly in flow, water chemistry, geomorphic form, ecological significance, and cultural and economic importance (Springer et al. 2008). Seeps are simply small springs, usually with immeasurably diffuse or small seepage or flow (Stevens et al. 2016).

Arizona, the nation's second driest state, has the highest known density of springs, with more than 10,000, according to the Springs Stewardship Institute's (SSI) online database (Stevens et al. 2016). Arizona springs are most abundant in montane and canyon-bound areas, such as the Mogollon Rim, the Grand Canyon, and the sky islands region in the southern reaches of the state. Springs are less common in flatlands, such as the southwestern quarter of the state. Springs are unique in that they can have profound influences on surrounding ecosystems and provide water for wildlife, human, and livestock use throughout Arizona. The three types of springs covered in this habitat profile support many rare and unique wetland plants, invertebrates, and animals, and influence and attract surrounding terrestrial species (Stevens et al. 2016).

Significant Habitat Features

The following describes habitat features or microhabitats that are unique to this habitat type and are of particular importance to certain species:

- **Gushet springs** typically discharge from perched, unconfined aquifers, often along fractures in cliff faces (Springer et al. 2008). Gushets often result in thin sheets of water flowing over rock faces and they frequently contain many different microhabitats, supporting diverse ecosystems (Hynes 1970). Although they typically occur along steep escarpments, such as the Grand Canyon, they are also found in regions with more modest topographic relief (Stevens et al. 2016).
- **Hanging gardens** emerge along geologic contacts and seep, drip, or pour onto underlying walls (Stevens et al. 2016). In Arizona, these complex springs usually emerge from perched, unconfined aquifers in wind-created sandstone formations. There are three primary types of hanging gardens: alcoves, window-blinds, and terraces (Welsh and Toft 1981). In the United States, hanging gardens support unique ecosystems with wetland, riparian, and desert plants, including some species (e.g., *Primula* spp.) that occur in indirect light on wet backwalls (Welsh and Toft 1981; Wong 1999, Spence 2008).

- **Hillslope springs** emerge from confined or unconfined aquifers on a hillslope with 30-to-60-degree slope. Oftentimes they originate from indistinct or multiple sources and they support a diverse array of microhabitats (Springer et al. 2008). The slope gradient is usually negatively related to floral diversity, and slope aspect strongly influences diversity (Stevens et al. 2016).

Key Conservation Species (SGCN)

The following list represents species in this habitat type that AZGFD actively manages or are watching closely due to some level of concern:

Amphibians: Sonoran tiger salamander
Invertebrates: Page springsnail, Fossil springsnail, Montezuma Well springsnail, Verde Rim springsnail, Brown springsnail, desert springsnail, Grand Wash springsnail, Kingman springsnail, Hualapai springsnail, Three Forks springsnail, Bylas springsnail, Huachuca springsnail, Gila tryonia, Quitobaquito tryonia, three undescribed *Pyrgulopsis* springsnail species

Additional Influential Species

The following are other wildlife species, native and non-native, that can have particular influence in this habitat type. Influential species can affect SGCN and their habitats directly and indirectly, for example altering predator/prey interactions, overgrazing, outcompeting natives, creating microhabitats, and others.

Rocky Mountain elk, feral burros and horses, crayfish, New Zealand mudsnail

Primary Threats to Springs Systems

The following are the primary threats facing springs systems and are adapted from standardized lexicon described in Salafsky et al. (2008). For detailed descriptions of threats and conservation actions being taken to address these threats, see Chapter 8: Threats and Conservation Actions.

Code	Level 1 Threats	Code	Level 2 Threats
1	Agriculture	1.1 1.3	Annual and perennial non-timber crops Livestock farming and ranching
3	Climate Change	3.1 3.2	Habitat shifting and alteration Droughts
5	Disease, Pathogens, and Parasites	NA	NA
7	Human Intrusion and Disturbance	7.1	Recreational activities
8	Invasive and Problematic Species	8.1	Invasive non-native species

Conservation in the Context of Climate Change

The following describes some of the conservation strategies that may mitigate the effects of a changing climate for this habitat type. Strategies have been adapted from guidelines by the Association of Fish and Wildlife Agencies (AFWA 2009).

- Establish new wild and/or captive populations of climate vulnerable SGCN.
- Conserve a variety of habitats that support healthy populations of wildlife as the climate changes.
- Conduct research targeting species and habitat types likely to be vulnerable to climate change impacts.

Conservation Opportunity Areas (COAs)

The following represents identified COAs where conservation efforts would benefit SGCN and their habitats. For detailed profiles on for each COA see Appendix G: Aquatic COA Profiles.

COA Name	Site Owner/Manager(s)
Lamar Haines Wildlife Area	AZGFD
Central Arizona Springsnails	AZGFD, USFS, NPS, Private
Huachuca Mountains	USFS, DOD, Private
White Mountains	USFS, AZGFD, Private
Black Mountains	BLM

Potential Partnerships

The following is a list of the organization and agencies that AZGFD regularly partners with on conservation efforts in this habitat type:

USFS (all AZ Forests), BLM (all AZ districts), USFWS Arizona Ecological Services, USFWS Arizona Fish and Wildlife Conservation offices, USFWS National Wildlife refuges, NPS, USBR, SRP, ADEQ, ADWR, Arizona State Parks, ASU, UA, NAU, Pima County Natural Resources, Parks and Recreation, Arizona-Sonora Desert Museum, Phoenix Zoo

Important Conservation Resources

The following are links to relevant conservation agreements, plans, and other documents or particular interest regarding SGCN in this habitat type:

- Huachuca Springsnail Candidate Conservation Agreement
- Page Springsnail Candidate Conservation Agreement with Assurances

- Central Arizona Springsnail Strategic Conservation Plan (In review)
- Quitobaquito Tryonia Strategic Conservation Plan (In review)

Chapter 8:
Threats and Conservation Actions

From climate change to invasive species and from development to agricultural practices, Arizona's native species and their habitats are facing unprecedented challenges today. As a comprehensive conservation strategy, the AWCS is intended to not only identify these threats, but also recommend conservation actions that can reduce or eliminate them altogether. In Chapter 3: Conservation Challenges we detailed the myriad of threats facing Arizona's SGCN and their habitats. In this chapter we place those threats within the context of each habitat type and the associated species.

Following recommendations from AFWA (2012) the AWCS utilizes a standardized lexicon for threats and conservation actions. Threats and conservation actions described here have been modified slightly from Salafsky et al (2008). This standardized lexicon uses a hierarchical system with different levels, similar to the Linnaean System of taxonomy. Level 1 Threats (Table 5) are broad categories, such as Agriculture (1) and Natural Systems Modifications (9), while Level 2 Threats are more narrow and detailed, including Annual and Perennial Non-timber Crops (2.1) and Fire and Fire Suppression (9.1). We made slight revisions to the standardized lexicon to tailor to the needs in Arizona. For example, we dropped Geological Events — a level 1 category in Salafsky — since it has little relevance to Arizona. Likewise, we added a new level 1 category (Disease, Pathogens, and Parasites) as it better reflects the primary threats to be addressed in our state.

Threats to Arizona's Wildlife and Their Habitats

Threats are defined as "natural processes or human activities that may cause destruction, degradation, and/or impairment of biodiversity and/or habitats." Unfortunately, these threats rarely occur independently, rather, they act in a cumulative manner (Paine et al. 1998). For example, agricultural practices may increase habitat fragmentation and these practices may also introduce invasive species and reduce water quality. Likewise, drought and other climatological changes may impair resources for wildlife while contributing to insect outbreaks and increasing the likelihood of wildfire. By identifying and describing the suite of primary threats facing each of Arizona's habitat types we can approach our conservation efforts in a holistic manner by implementing conservation actions to reduce and eliminate various threats.

Chapter 7: Habitat Profiles briefly lists the various threats facing each habitat type using the standardized lexicon. This chapter gets into more detail about these threats as well as the conservation actions that can be taken to reduce or eliminate these threats to wildlife and their habitats. Table 5 below describes the Level 1 and Level 2 threats as modified from Salafsky et al. (2008). Also included are brief descriptions of each threat.

Table 5: *Lexicon of threats and definitions adapted from Salafsky et al. (2008).*

Level 1 Threat	Level 2 Threat
1. Agriculture Threats from farming and ranching as a result of agricultural expansion and intensification, including silviculture, mariculture, and aquaculture	**1.1 Annual and perennial nontimber crops** Crops planted for food, fodder, fiber, fuel, or other uses **1.2 Wood and pulp plantations** Stands of trees planted for timber or fiber outside of natural forests, often with non-native species **1.3 Livestock farming and ranching** Domestic terrestrial animals raised in one location on farmed or nonlocal resources (farming); also domestic or semi-domesticated animals allowed to roam in the wild and supported by natural habitats (ranching)
2. Biological Resource Use Threats from consumptive use of "wild" biological resources including deliberate and unintentional harvesting effects; also persecution or control of specific species	**2.1 Unlawful collection of terrestrial animals** Killing or trapping terrestrial wild animals or animal products for commercial, recreation, subsistence, research or cultural purposes, or for control/persecution reasons; includes accidental mortality/bycatch **2.2 Unlawful collection of terrestrial plants** Harvesting plants, fungi, and other nontimber/nonanimal products for commercial, recreation, subsistence, research or cultural purposes, or for control reasons **2.3 Logging and wood harvesting** Harvesting trees and other woody vegetation for timber, fiber, or fuel **2.4 Fishing and harvesting aquatic resources** Harvesting aquatic wild animals or plants for commercial, recreation, subsistence, research, or cultural purposes, or for control/persecution reasons; includes accidental mortality/bycatch
3. Climate Change and Severe Weather Long-term climatic changes that may be linked to global warming and other severe climatic or weather events outside the natural range of variation could lead to habitat shifts and local extinctions of vulnerable species	**3.1 Habitat shifting and alteration** Major changes in habitat composition and location **3.2 Droughts** Periods in which rainfall falls below the normal range of variation **3.3 Temperature extremes** Periods in which temperatures exceed or go below the normal range of variation **3.4 Storms and flooding** Extreme precipitation and/or wind events or major shifts in seasonality of storms
4. Residential and Commercial Development Human settlements or other nonagricultural land uses with a substantial footprint	**4.1 Housing and urban areas** Human cities, towns, and settlements including nonhousing development typically integrated with housing **4.2 Commercial and industrial areas** Factories and other commercial centers **4.3 Tourism and recreation areas** Tourism and recreation sites with a substantial footprint
5. Disease, Pathogens, and Parasites Threats from pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on biodiversity following their introduction, spread and/or increase in abundance	**No Level 2 categories (NA)**
6. Energy Production and Mining	**6.1 Oil and gas drilling**

Level 1 Threat	Level 2 Threat
Threats from production of nonbiological resources	Exploring for, developing, and producing petroleum and other liquid hydrocarbons **6.2 Mining and quarrying** Exploring for, developing, and producing minerals and rocks **6.3 Renewable energy** Exploring, developing, and producing renewable energy
7. Human Intrusions and Disturbance Threats from human activities that alter, destroy and disturb habitats and species associated with nonconsumptive uses of biological resources	**7.1 Recreational activities** People spending time in nature or traveling in vehicles outside of established transport corridors, usually for recreational reasons **7.2 War, civil unrest and military exercises** Actions by formal or paramilitary forces without a permanent footprint **7.3 Work and other activities** People spending time in or traveling in natural environments for reasons other than recreation or military activities
8. Invasive and Other Problematic Species Threats from non-native and native plants, animals, that have or are predicted to have harmful effects on biodiversity following their introduction, spread and/or increase in abundance	**8.1 Invasive non-native species** Harmful plants, animals, pathogens and other microbes not originally found within the ecosystem(s) in question and directly or indirectly introduced and spread into it by human activities **8.2 Problematic native species** Harmful plants, animals, or pathogens and other microbes that are originally found within the ecosystem(s) in question, but have become "out of balance" or "released" directly or indirectly due to human activities
9. Natural System Modifications Threats from actions that convert or degrade habitat in service of "managing" natural or seminatural systems, often to improve human welfare	**9.1 Fire and fire suppression** Suppression or increase in fire frequency and/or intensity outside of its natural range of variation **9.2 Dams and water management** Changing water flow patterns from their natural range of variation either deliberately or as a result of other activities **9.3 Other ecosystem modifications** Other actions that convert or degrade habitat in service of "managing" natural systems to improve human welfare
10. Pollution Threats from introduction of exotic and/or excess materials or energy from point and nonpoint sources	**10.1 Household sewage and urban waste water** Water-borne sewage and nonpoint runoff from housing and urban areas that include nutrients, toxic chemicals and/or sediments **10.2 Industrial and military effluents** Water-borne pollutants from industrial and military sources including mining, energy production, and other resource extraction industries that include nutrients, toxic chemicals and/or sediments **10.3 Agricultural and forestry effluents** Water-borne pollutants from agricultural, silvicultural, and aquaculture systems that include nutrients, toxic chemicals and/or sediments including the effects of these pollutants on the site where they are applied **10.4 Garbage and solid waste** Rubbish and other solid materials including those that entangle wildlife

Level 1 Threat	Level 2 Threat
	10.5 Air-borne pollutants Atmospheric pollutants from point and nonpoint sources **10.6 Excess energy** Inputs of heat, sound, or light that disturb wildlife or ecosystems
11. Transportation and Service Corridors Threats from long, narrow transport corridors and the vehicles that use them including associated wildlife mortality	**11.1 Roads and railroads** Surface transport on roadways and dedicated tracks **11.2 Utility and service lines** Transport of energy and resources **11.3 Flight paths** Air and space transport

Conservation Actions for Arizona's Wildlife and Their Habitats

Conservation actions are defined as "activities that can be implemented to reach conservation goals and counteract adverse effects from threats" (Salafsky et al. 2008). With a more habitat-based approach, the AWCS provides 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 and protect ecosystems is to reduce or eliminate threats to habitats and their associated species. Hence, the AWCS provides numerous conservation actions specifically aimed at removing or alleviating the effect of the threats.

This chapter provides specific conservation actions per habitat type in response to the threats identified. These conservation actions were developed by AZGFD staff and partners to help meet recovery goals for ESA-listed species, priority nongame species (SGCN), conservation and research needs, to maintain habitat and populations, and to reduce or remove threats. The conservation actions identified here are feasible to implement, at least at some scale on the landscape or site of interest. These do not represent actions that only AZGFD will undertake to meet conservation goals, rather, the conservation actions listed represent the best recommendations for *all* of our conservation partners to consider when implementing conservation efforts. Table 6 below describes the various conservation actions to be implemented. Level 1 is a broad category of actions while level 2 is more focused and detailed.

Table 6: *Lexicon of conservation actions and adapted from Salafsky et al. (2008).*

Level 1 Conservation Action	Level 2 Conservation Action
1. Land and Water Protection Actions to identify, establish or expand parks and other legally protected areas, and to protect resource rights	**1. 1 Site/area protection** Establishing or expanding public or private parks, reserves, and other protected areas roughly equivalent to IUCN categories I-VI **1.2 Resource and habitat protection** Establishing protection or easements of some specific aspect of the resource on public or private lands outside of IUCN categories I-VI

Level 1 Conservation Action	Level 2 Conservation Action
2. Land and Water Management Actions directed at conserving or restoring sites, habitats and the wider environment	**2.1 Site/area management** Management of protected areas and other resource lands for conservation **2.2 Invasive/problematic species control** Eradicating, controlling and/or preventing invasive and/or other problematic plants, animals, and pathogens **2.3 Habitat and natural process restoration** Enhancing degraded or restoring missing habitats and ecosystem functions; dealing with pollution
3. Species Management Actions directed at managing or restoring species, focused on the species of concern itself	**3.1 Management of specific species of concern** Managing specific plant and animal populations of concern **3.2 Species recovery** Manipulating, enhancing or restoring specific plant and animal populations, vaccination programs **3.3 Species reintroduction** Reintroducing species to places where they formally occurred or benign introductions **3.4 Ex situ conservation** Protecting biodiversity out of its native habitats
4. Education and Awareness Actions directed at people to improve understanding and skills, and influence behavior	**4.1 Formal education** Enhancing knowledge and skills of students in a formal degree program **4.2 Training** Enhancing knowledge, skills and information exchange for practitioners, stakeholders, and other relevant individuals in structured settings outside of degree programs **4.3 Awareness and communication** Raising environmental awareness and providing information through watchable wildlife programs, wildlife-related recreation, or various forms of media
5. Law and Policy Actions to develop, change, influence, and help implement formal legislation, regulations, and voluntary standards	**5.1 Legislation** Making, implementing, changing, influencing, or providing input into formal government sector legislation or policies at all levels: international, national, state/provincial, local, tribal **5.2 Policies and regulations** Making, implementing, changing, influencing, or providing input into policies and regulations affecting the implementation of laws at all levels: international, national, state/provincial, local/community, tribal **5.3 Private sector standards and codes** Setting, implementing, changing, influencing, or providing input into voluntary standards and professional codes that govern private sector practice **5.4 Compliance and enforcement** Monitoring and enforcing compliance with laws, policies and regulations, and standards and codes at all levels
6. Livelihood, Economic and Other Incentives Actions to use economic and other incentives to influence behavior	**6.1 Linked enterprises and livelihood alternatives (i.e. ecotourism)** Developing enterprises that directly depend on the maintenance of natural resources or provide substitute livelihoods as a means of changing behaviors and attitudes **6.2 Substitution with environmentally-friendly goods and services**

Level 1 Conservation Action	Level 2 Conservation Action
	Promoting alternative products and services that substitute for environmentally damaging ones **6.3 Market forces** Using market mechanisms to change behaviors and attitudes **6.4 Conservation payments and programs** Using direct or indirect payments to change behaviors and attitudes **6.5 Non-monetary values** Using intangible values to change behaviors and attitudes
7. External Capacity Building Actions to build the infrastructure to do better conservation	**7.1 Institutional and civil society development (i.e. land trusts)** Creating or providing non-financial support and capacity building for nonprofits, government agencies, communities, and for-profits **7.2 Alliance and partnership development** Forming and facilitating partnerships, alliances, and networks of organizations **7.3 Conservation finance (i.e. raising funds)** Raising and providing funds for conservation work

Threats to Lower Sonoran Desertscrub Habitats

The following describes the primary threats facing this habitat type and the associated species, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial non-timber crops

1.3 Livestock farming and ranching

Historical and current overgrazing on the landscape has affected native plant populations. With overgrazing and drought prevalent, non-native plant species have taken over areas once dominated by native vegetation. Agriculture operations in a drought-driven environment have contributed to a decreased water table, exacerbating the difficult balance between wildlife conservation and working lands.

2. Biological Resource Use

2.1 Unlawful collection of terrestrial animals

2.2 Unlawful collection of terrestrial plants

Unlawful take of terrestrial animals or plants can be detrimental to populations that have slow recruitment. Excess harvest can substantially impact populations of species with small populations and reduce their ability to recover from stochastic events, such as drought or wildfire.

3. Climate Change

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

3.4 Storms and Flooding

Warmer ambient temperatures may surpass species' temperature tolerances, causing local extinctions or changing the distribution of less heat-tolerant species. Altered precipitation patterns may affect hydrological regimes (more droughts and floods) which can adversely influence terrestrial plant and wildlife distributions.

4. Residential and Commercial Development

4.1 Housing and urban areas

4.2 Commercial and industrial areas

4.3 Tourism and recreation areas

With the human population increasing in Arizona, habitat loss is becoming more widespread due to the rate of housing and commercial development. Additionally, unlawful/unmanaged recreational use by OHV users may degrade habitats, leading to increased levels of soil erosion, vegetation loss, and habitat degradation.

5. Disease, Pathogens, and Parasites

With the increase in transport of both people and wildlife, emerging infectious diseases are being spread to naive wildlife populations. Infectious diseases have been linked to wildlife declines throughout Arizona and the rest of the United States. In many cases, wildlife populations are unable to adapt immune or behavioral defenses to these diseases to avoid severe population declines. Populations then face genetic bottlenecks and decreased population connectivity, further impacting their ability to recover.

6. Energy Production and Mining

6.2 Mining and quarrying

6.3 Renewable energy

Many areas within lower Sonoran desertscrub have been utilized both historically and contemporarily for mineral extraction. Many of these mines are still in operation and can have major impacts on the habitat. A major increase in solar energy development throughout the southwestern portion of the state is impacting large swaths of habitat previously available for wildlife use.

7. Human Intrusion and Disturbance

7.1 Recreational activities

7.2 War, civil unrest, and military exercises

Poorly-managed recreational activities, such as illegal OHV use, can degrade desertscrub habitats by damaging habitats, increasing erosion, harming delicate vegetation, and altering wildlife behavior. Military installations and the resulting activities can impact wildlife habitats and populations. Fortunately, many of these lands have robust conservation measures to avoid and mitigate for these activities. Recent border wall construction has also severely impacted many critically-important habitats along the southern border.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and introduced species may compete with native fauna, over-utilize native species, affect native species populations through hybridization, and cause habitat damage. Invasive species, such as salt cedar (tamarisk), reduce habitat diversity in the delicate riparian habitats found in upper Sonoran desertscrub.

9. Natural Systems Modifications

9.1 Fire and fire suppression

9.2 Dams and water management

Many invasive plant species are adapted to wildfire regimes. Post-fire, invasive species such as buffelgrass may outcompete native species and quickly displace native communities. Meanwhile, fire suppression can allow for the establishment of woody plants, such as mesquite, that can greatly alter the desertscrub community. Dams and water management activities convert lotic systems into lentic systems, and alter or completely dry downstream lotic stretches of waterways.

10. Pollution

10.1 Household sewage and urban wastewater

10.2 Industrial and military effluents

10.3 Agricultural and forestry effluents

10.4 Garbage and solid waste

Pollution can lead to habitat degradation, behavioral modification from noise, direct mortality/reduced fecundity, and loss of food and water. Sources of pollution include leaking septic and fuel tanks, untreated sewage, oil or sediment on roads, lawn and agricultural fertilizers and herbicides, illegal dump sites, mine tailings, roadside litter, construction-site debris, military effluents, and solid garbage and waste.

11. Transportation and Service Corridors

11.1 Roads and railroads

11.2 Utility and service lines

The creation of new roads, as well as current travel corridors, can be both a direct and indirect threat to species in the area. Vehicle traffic can create noise and visual disturbance, altering the behavior of wildlife species and leading to direct mortality due to vehicle strikes. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Lower Sonoran Desertscrub Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

1.2 Resource and habitat protection

- Identify wildlife corridors essential to the movement of species between high-quality habitat blocks. **(Threats 4.1, 4.2)**
- Engage communities to incorporate natural resource values and open spaces into long-term planning. Acquire land and water rights, pursue conservation agreements and easements, especially in critical wildlife corridors. **(Threats 4.1, 4.3, 6.2, 6.3, 7.1)**
- Continue maintenance of wildlife waters to mitigate drought and the effects of temperature extremes. **(Threats 3.2, 3.3)**

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife. Actively seek opportunities to partner with Arizona agricultural producers, private landowners, and land management agencies on a

variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.1, 1.3, 3.1, 4.1, 4.2, 4.3, 6.2, 6.3, 7.1, 7.2, 9.1)**

- Continue disease monitoring efforts for impacted species. Avoid inadvertent spread of disease by following the proper disinfectant protocols. **(Threat 5)**
- Conduct monitoring and targeted removal efforts to limit establishment and spread of invasive species, especially in COAs or other important wildlife areas. Continue removal activities for trespass livestock, burros, and feral horses on managed lands. **(Threats 1.3, 8.1, 9.1)**

4. Education and Awareness

4.2 Training

4.3 Awareness and communication

- Engage communities to incorporate natural resource values and open spaces into long-term planning. **(Threats 1.1, 1.3, 4.1, 4.2, 4.3, 6.3, 7.1, 10.1, 10.2, 10.3, 10.4, 11.1)**
- Conduct emerging disease education and outreach to user groups who potentially come into contact with affected species. Provide education on methods for avoiding the spread of diseases, pathogens, and parasites into novel populations of wildlife (i.e. bats and white-nose syndrome). **(Threat 5)**
- Provide extensive educational outreach through public events, social media messaging, billboards, and partnering with AZ State Parks, OHV dealers, OHV rental companies as well as off-road clubs and organizations. Educate new outdoor enthusiasts on safe, ethical practices and proper behavior in natural settings and in proximity to wildlife. **(Threats 4.3, 7.1, 11.1)**
- Work with developers, federal permitting agencies, the Arizona Corporation Commission (ACC), and state and local governments to raise awareness of impacts to wildlife and habitat from renewable and nonrenewable energy development. **(Threats 6.3, 11.2)**
- Develop outreach programs for the public on impacts to wildlife, agriculture, and recreation from introduced species. Incorporate citizen science programs to identify distribution of invasives (such as iMapInvasives.org). **(Threat 8.1)**

5. Law and Policy

5.2 Policies and regulations

5.4 Compliance and enforcement

- Conduct statewide law enforcement patrols targeting illegal OHV use as well as targeted saturation patrols in areas identified as critical habitat that are being adversely impacted by OHV and other recreational activities. **(Threats 7.1)**
- Inform federal and state agencies of critical need for wildlife movement across the international border with Mexico, and help design any necessary border barriers to allow wildlife movement. **(Threats 7.2)**
- Conduct statewide law enforcement patrols targeting illegal take of wildlife, especially during scheduled hunts. **(Threat 2.1)**

6. Livelihood, Economic, and Other Incentives

6.2 Substitution with environmentally-friendly goods and services

6.3 Market forces

- Collaborate with the development and renewable energy industries to incorporate BMPs and other measures to reduce impacts to wildlife and habitats. Identify ways for incentivizing incorporation of recommendations. **(Threats 4.1, 4.2, 6.3)**
- Work with local governments to incorporate wildlife protections and habitat connectivity into general plans. **(Threats 4.1, 4.2, 6.3)**
- Share information and discuss the benefits of participating in species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements with Assurances, and Candidate Conservation Agreements with interested landowners. **(Threats 1.1, 1.3, 3.1, 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts for long-term conservation of SCGN wildlife. **(Threat 3.1, 3.2, 3.3, 3.4, 5, 8.1)**

Other Conservation Actions that Benefit Lower Sonoran Desertscrub Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Implement conservation actions to promote populations of SGCN species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of desertscrub habitat to minimize negative impacts to habitat and associated species.

Threats to Upland Sonoran Desertscrub Habitats

The following describes the primary threats facing this habitat type and the associated species, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial non-timber crops

1.3 Livestock farming and ranching

Historical and current overgrazing on the landscape has affected native plant populations. With overgrazing and drought prevalent, non-native plant species have taken over areas once dominated by native vegetation. Agriculture operations in a drought-driven environment have contributed to a decreased water table, exacerbating the difficult balance between wildlife conservation and working lands.

2. Biological Resource Use

2.1 Unlawful collection of terrestrial animals

2.2 Unlawful collection of terrestrial plants

Unlawful take of terrestrial animals or plants can be detrimental to populations that have slow recruitment. Excess harvest can substantially impact populations of species with small populations and reduce their ability to recover from stochastic events, such as drought or wildfire.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

3.4 Storms and Flooding

Warmer ambient temperatures may surpass species' temperature tolerances, causing local extinctions or changing the distribution of less heat-tolerant species. Altered precipitation patterns may affect hydrological regimes (more droughts and floods) which can adversely influence terrestrial plant and wildlife distributions.

4. Residential and Commercial Development

4.1 Housing and urban areas

4.2 Commercial and industrial areas

4.3 Tourism and recreation areas

With the human population increasing in Arizona, habitat loss is becoming more widespread due to the rate of housing and commercial development. Additionally, heavy recreational use by unlawful OHV users are degrading habitats and leading to increased levels of soil erosion, vegetation loss, and habitat degradation.

5. Disease, Pathogens, and Parasites

With the increase in transport of both people and wildlife, emerging infectious diseases are being spread to naive wildlife populations. Infectious diseases have been linked to wildlife declines throughout Arizona and the rest of the United States. In many cases, wildlife populations are unable to adapt immune or behavioral defenses to these diseases to avoid severe population declines. Populations then face genetic bottlenecks and decreased population connectivity, further impacting their ability to recover.

6. Energy Production and Mining

6.2 Mining and quarrying

6.3 Renewable energy

Many areas within upper Sonoran desertscrub have been utilized both historically and contemporarily for mineral extraction. Many of these mines are still in operation and can have major impacts on the habitat. A major increase in solar energy development throughout the southwestern portion of the state is impacting large swaths of habitat previously available for wildlife use.

7. Human Intrusion and Disturbance

7.1 Recreational activities

7.3 Work and other activities

Poorly-managed recreational activities, such as illegal OHV use, can degrade desertscrub habitats by altering habitats, increasing erosion, harming delicate vegetation, and altering wildlife behavior. Military installations and the resulting activities can impact wildlife habitats and populations. Fortunately, many of these lands have robust conservation measures to avoid and mitigate for these activities. Recent border wall construction has also severely impacted many important habitats along the southern border.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and introduced species may compete with native fauna, over-utilize native species, affect native species populations through hybridization, and cause habitat damage. Invasive species, such as tamarisk, reduce habitat diversity in the delicate riparian habitats found in upper Sonoran desertscrub.

9. Natural Systems Modifications

9.1 Fire and fire suppression

9.2 Dams and water management

Many invasive plant species are adapted to wildfire regimes. Post-fire, invasive species such as buffelgrass may outcompete native species and quickly displace native communities. Meanwhile, fire suppression can allow for the establishment of woody plants, such as mesquite, that can greatly alter the desertscrub community. Dams and water management activities convert lotic systems into lentic systems, and alter or completely dry downstream lotic stretches of waterways.

10. Pollution

10.1 Household sewage and urban wastewater

10.2 Industrial and military effluents

10.3 Agricultural and forestry effluents

10.4 Garbage and solid waste

Pollution can lead to habitat degradation, behavioral modification from noise, direct mortality/reduced fecundity, and loss of food and water. Sources of pollution include leaking septic and fuel tanks, untreated sewage, oil or sediment on roads, lawn and agricultural fertilizers and herbicides, illegal dump sites, mine tailings, road-side litter, construction-site debris, military effluents, and solid garbage and waste.

11. Transportation and Service Corridors

11.1 Roads and railroads

The creation of new roads, as well as current travel corridors, can be both a direct and indirect threat to species in the area. Vehicle traffic can create noise and visual disturbance, altering the behavior of wildlife species and leading to direct mortality due to vehicle collisions. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Upland Sonoran Desertscrub Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. "Land and Water Protection") represent broad categories of potential actions, while the Level 2 conservation actions (i.e. "Resource and habitat protection") are more specific.

1. Land and Water Protection

1.1 Site/area protection

1.2 Resource and habitat protection

- Identify wildlife corridors essential to the movement of species between high-quality habitat blocks. **(Threats 4.1, 4.2)**
- Engage communities to incorporate natural resource values and open spaces into long-term planning. Acquire land and water rights, pursue conservation agreements and easements, especially in critical wildlife corridors. **(Threats 4.1, 4.3, 6.2, 6.3, 7.1)**
- Continue maintenance of wildlife waters to mitigate drought and the effects of temperature extremes. **(Threats 3.2, 3.3)**

2. Land and Water Management

2.1 Site/area management

2.3 Invasive/problematic species control

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife. Actively seek opportunities to partner with Arizona agricultural producers, private landowners, and land management agencies on a

variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.1, 1.3, 4.1, 4.2, 4.3, 6.2 ,6.3, 7.1, 7.3, 9.1)**

- Continue disease monitoring efforts for impacted species. Avoid inadvertent spread of disease by following the proper disinfectant protocols. **(Threat 5)**
- Conduct monitoring and targeted removal efforts to limit establishment and spread of invasive species, especially in COAs or other important wildlife areas. Continue removal activities for trespass livestock, burros, and feral horses on managed lands. **(Threats 1.1, 1.3, 8.1, 9.1)**

4. Education and Awareness

4.2 Training

4.3 Awareness and communication

- Engage communities to incorporate natural resource values and open spaces into long-term planning. **(Threats 1.1, 1.3, 4.1, 4.2, 4.3, 6.3, 7.1, 7.3, 10.1, 10.2, 10.3, 10.4, 11.1)**
- Conduct emerging disease education and outreach to user groups who potentially come into contact with affected species. Provide education on methods for avoiding the spread of diseases, pathogens, and parasites into novel populations of wildlife (i.e. bats and white-nose syndrome). **(Threat 5)**
- Provide extensive educational outreach through public events, social media messaging, billboards, and partnering with AZ State Parks, OHV dealers, OHV rental companies as well as off-road clubs and organizations. Educate new outdoor enthusiasts on safe, ethical practices and proper behavior in natural settings and in proximity to wildlife. **(Threats 4.3, 7.1, 11.1)**
- Work with developers, federal permitting agencies, the Arizona Corporation Commission, and state and local governments to raise awareness of impacts to wildlife and habitat from renewable and nonrenewable energy development. **(Threats 6.3, 11.2)**
- Develop outreach programs for the public on impacts to wildlife, agriculture, and recreation from introduced species. Incorporate citizen science programs to identify distribution of invasives (such as iMapInvasives.org). **(Threat 8.1)**

5. Law and Policy

5.2 Policies and regulations

5.4 Compliance and enforcement

- Conduct statewide law enforcement patrols targeting illegal OHV use as well as targeted saturation patrols in areas identified as critical habitat that are being adversely impacted by OHV and recreational activities. **(Threats 7.1)**
- Inform federal and state agencies of critical need for wildlife movement across the international border with Mexico, and help design any necessary border barriers to allow wildlife movement. **(Threats 7.3)**
- Conduct statewide law enforcement patrols targeting illegal take of wildlife, especially during scheduled hunts. **(Threat 2.1)**

6. Livelihood, Economic, and Other Incentives

6.2 Substitution with environmentally-friendly goods and services

6.3 Market forces

- Collaborate with the development and renewable energy industries to incorporate BMPs and other measures to reduce impacts to wildlife and habitats. Identify ways for incentivizing incorporation of recommendations. **(Threats 4.1, 4.2, 6.3)**
- Work with local governments to incorporate wildlife protections and habitat connectivity into general plans. **(Threats 4.1, 4.2, 6.3)**
- Share information and discuss the benefits of participating in species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements with Assurances, and Candidate Conservation Agreements with interested landowners. **(Threats 1.3, 4.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts for long-term conservation of SCGN wildlife. **(Threat 3.1, 3.2, 3.3, 3.4, 5, 8.1)**

Other Conservation Actions that Benefit Upland Sonoran Desertscrub Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Implement conservation actions to promote populations of SGCN species, including translocations and insurance populations when necessary.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Fund or work with partners to conduct conservation-related species research.

Threats to Chihuahuan Desertscrub Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial nontimber crops

1.3 Livestock farming and ranching

Historical and current overgrazing on the landscape has affected the native plant populations. With overgrazing and drought prevalent, non-native plant species have taken over areas once dominated by native vegetation. Agriculture operations in a drought driven environment have contributed to a decreased water table, exacerbating the difficult balance between conservation and working lands.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.4 Storms and flooding

Warmer ambient temperatures may surpass species' temperature tolerances, causing local extinctions or changing the distribution of less heat-tolerant species. Altered precipitation patterns may affect hydrological regimes (more droughts and floods) which can adversely influence terrestrial plant and wildlife distributions.

6. Energy Production and Mining

6.2 Mining and quarrying

6.3 Renewable energy

Mining operations can cause significant habitat loss/fragmentation, draw down of water tables, and general disturbance through increased human activities. Renewable energies also contribute to habitat loss/fragmentation and can lead to direct mortality from collisions with wind turbines or impacts with solar mirrors.

7. Human Intrusions and Disturbance

7.3 Work and other activities

Infrastructure development and activities associated with the international border with Mexico, such as construction of roadways and lighting and increased human presence, can adversely affect wildlife through altering behavior and habitat fragmentation.

8. Invasive and Problematic Species

8.1 Invasive non-native species

8.2 Problematic native species

Invasive and problematic species compete with native fauna, over-utilize native species, affect native species' gene pool through hybridization, and cause habitat damage. Invasive species, such as tamarisk, reduces habitat diversity in the delicate riparian habitats found in Chihuahuan desertscrub.

9. Natural Systems Modifications

9.1 Fire and fire suppression

Post-fire periods allow invasive vegetation, such as buffelgrass, to become established and outcompete native flora. Meanwhile, fire suppression can allow for the establishment of woody plants, such as mesquite, that can greatly alter the desertscrub community.

10. Pollution

10.2 Industrial and military effluents

Pollution can lead to habitat degradation, behavior modification from noise, direct mortality/reduced fecundity, and loss of food and water. Industrial sources of pollution include leaking septic and fuel tanks, oil or sediment on roads, and mine tailings.

11. Transportation and Service Corridors

11.1 Roads and railroads

The creation of new roads and current travel corridors can be both a direct and indirect threat to species in the area. Vehicle traffic can create noise and visual disturbance, altering behavior of wildlife species. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors. The construction of new roads is also in coordination with new utility and service lines on the landscape.

Conservation Actions for Chihuahuan Desertscrub Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Maintain native desertscrub through chemical and manual treatments of invasive and problematic species; protect native flora through appropriate stocking rates and to address soil erosion from grazing. **(Threats 1.1, 1.3, 8.2)**
- Increase connectivity by removing barriers and impediments to species movement. Modify pasture and boundary fences to meet wildlife-friendly criteria to allow safe wildlife movement. **(Threats 1.3, 3.1, 7.3, 11.1)**

5. Law and Policy

5.2 Policies and regulations

5.4 Compliance and enforcement

- Work with federal and state agencies to address the critical need for wildlife movement across the international border with Mexico, and help design any necessary border barriers to allow wildlife movement. **(Threat 7.3)**

6. Livelihood, Economic, and Other Incentives

6.1 Linked enterprises and livelihood alternatives

6.4 Conservation payments and programs

- Partner with agricultural producers and private landowners on a variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.1, 1.3, 4.1**)
- Perform outreach with interested landowners on species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, and Candidate Conservation Agreements. **(Threats 1.1, 1.3, 3.1 8.1)**

Other Conservation Actions that Benefit Chihuahuan Desertscrub Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey other influential species within the habitat to inform adaptive management strategies in order to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of desertscrub habitat to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Mohave Desertscrub Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). First-level threats (i.e. Agriculture, Climate Change) represent broad categories while second-level threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Historical and current overgrazing on the landscape has affected the native plant populations. With overgrazing and drought prevalent, non-native plant species, such as cheatgrass, have taken over areas once dominated by native vegetation. Agriculture operations in a drought driven environment have contributed to a decreased water table.

2. Biological Resource Use

2.1 Unlawful collection of terrestrial animals

2.2 Unlawful collection of terrestrial plants

Unlawful take of terrestrial animals or plants can be detrimental to populations that have slow recruitment. Excess harvest can substantially impact populations of species with small populations and reduce their ability to recover from stochastic events, such as drought or wildfire.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

With climate change, warmer ambient temperatures may surpass species' temperature tolerances, causing local extinctions or changing the distribution of less heat-tolerant species. Climate change also results in altered precipitation patterns, affecting hydrological regimes (more droughts and floods) which can adversely influence terrestrial plant and wildlife distributions.

4. Residential and Commercial Development

4.1 Housing and urban areas

4.2 Commercial and industrial areas

4.3 Tourism and recreation areas

With the human population increasing in Arizona, the expansion of development on the landscape is having direct and indirect effects on wildlife. Direct effects are on habitat loss, degradation, and fragmentation, while indirect effects are pollution from light and noise.

5. Disease, Pathogens, and Parasites

Species in the desertscrub habitat can be affected by a variety of diseases, including rabies, hantavirus, West Nile virus, rabbit hemorrhagic disease, and white-nose syndrome. These diseases can have detrimental impacts on wildlife populations, causing significant mortalities and drastic population declines as well as decreased reproduction and recruitment of young. When a species encounters a new disease, it can take years for the recovery of the population to take place.

6. Energy Production and Mining

6.2 Mining and quarrying

6.3 Renewable energy

Mohave desertscrub is home to several old, new, and proposed mining claims and to several solar farms and wind farms. These mining operations can cause habitat loss/fragmentation, draw down of water and general disturbance. Renewable energies can cause direct mortality from collisions with wind turbines or impacts with solar mirrors.

7. Human Intrusion and Disturbance

7.1 Recreational activities

7.3 Work and other activities

Poorly-managed recreational activities, such as illegal OHV use, can degrade desertscrub by damaging habitats, increasing erosion, harming delicate vegetation, and altering wildlife behavior. These types of alterations can negatively-affect desertscrub species abundance and distributions due to the lack of quick regeneration of native plant species.

8. Invasive and Problematic Species

8.1 Invasive non-native species

8.2 Problematic native species

Invasive and problematic species — such as feral burros, unrestrained pets, non-native mussels, non-native grasses — compete with native fauna, over-utilize native species, affect native species' gene pool through hybridization, and cause habitat damage. This can alter the structure of these habitats and communities making them less desirable or unusable to native species.

9. Natural Systems Modifications

9.1 Fire and Fire Suppression

9.2 Dams and water management

9.3 Other ecosystem modifications

Increase in wildfires fueled by invasive annual grasses has resulted in the overgrowth of non-native plant species that offer little to no nutritional value for wildlife. Dams and water management activities change lotic systems to lentic systems, and alter or completely dry downstream lotic systems. Other ecosystem modifications for the Mohave desertscrub include the destruction of riparian areas, overgrazing, and dusting wallows.

10. Pollution

10.1 Household sewage and urban wastewater

10.4 Garbage and solid waste

Pollution can lead to habitat degradation, behavior modification from noise, direct mortality/reduced fecundity, and loss of food and water. Sources of pollution include leaking septic and fuel tanks, untreated sewage, oil or sediment on roads, lawn and agricultural fertilizers and herbicides, illegal dump sites, mine tailings, road-side litter, construction-site debris, and solid garbage and waste.

11. Transportation and service corridors

11.1 Roads and railroads

11.2 Utility and service lines

The creation of new roads and current travel corridors can be both a direct and indirect threat to species in the area. Vehicle traffic can create noise and visual disturbance, altering behavior of wildlife species. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors. The construction of new roads is also in coordination with new utility and service lines on the landscape.

Conservation Actions for Mohave Desertscrub Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Identify wildlife corridors essential to the movement of species between high-quality habitat blocks. **(Threat 4.1)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Improve rangeland health by creating suitable habitat and/or habitat features for wildlife; partner with agricultural producers and private landowners on a variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.3, 10.1)**
- To reduce adverse effects to habitat, control the spread of and remove non-native, undesirable, and/or invasive wildlife and plant species, including unauthorized livestock, burros, and feral horses; remove these species where they are not managed at appropriate levels. **(Threat 8.1)**

4. Education and Awareness

4.3 Awareness and communication

- Engage communities to incorporate natural resource values and open spaces into long-term planning; increase public awareness of AZGFD's nongame conservation efforts to gain the support of non-traditional constituencies. **(Threat 4.1)**
- Work with developers, federal permitting agencies, the Arizona Corporation Commission, and state and local governments to raise awareness of impacts to wildlife and habitat from renewable and non-renewable energy development. **(Threats 6.2, 6.3)**
- Increase educational outreach through public events, social media messaging, and partnering with AZ State Parks, OHV dealers, and off-road clubs and organizations; improve

coordination with partners to discuss priorities and how the AWCS can be used to facilitate project planning and implementation. **(Threat 7.1)**

- Improve coordination with partners to identify priorities and how the AWCS can be used to facilitate project planning and implementation; mitigate transportation impacts by constructing wildlife crossing structures, avoiding wildlife corridors, and signage, etc., when major roadway/highway construction will be occurring. **(Threat 11.1)**

5. Law and Policy

5.2 Policies and regulations

5.4 Compliance and enforcement

- Partner with NGOs and OHV user groups to track OHV use and damage of cross-country travel; improve coordination with partners through multi-agency regional to discuss priorities; conduct statewide law enforcement patrols targeting illegal OHV use as well as targeted saturation patrols in areas identified as critical habitat that are being adversely impacted by recreational activities. **(Threat 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners at different scales (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and determine specific management efforts to improve and coordinate landscape-scale efforts for long-term conservation of SCGN wildlife. **(Threats 3.1, 3.2, 3.3)**

Other Conservation Actions that Benefit Mohave Desertscrub Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Monitor white-nose syndrome on BLM-administered lands with various funding sources. Mines/caves are gated or closed dependent on the bat resources found.
- Monitor for epizootic pneumonia disease in the Black Mountain desert bighorn sheep population.
- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements. Survey other influential species within the habitat to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of desertscrub habitat to minimize negative impacts to habitat and associated species.
- Collect samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Great Basin Desertscrub Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Historical and current grazing practices have led to reduced forage for herbivores and granivores, reduced cover for many species including pronghorn, increased erosion and water infiltration, and facilitated invasive annual grasses such as cheatgrass.

6. Energy Production and Mining

6.3 Renewable energy

This habitat type hosts many mining claims as well as proposed solar and wind farms. Renewable energy operations can lead to increased road densities, habitat loss, and draw down of water tables. Infrastructure can cause direct mortality to wildlife such as bats, songbirds, and raptors from collisions with turbines and solar mirrors.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Annual grasses such as cheatgrass have increased the fire interval in this ecosystem, leading to detrimental effects on native shrubs such as blackbrush and winterfat as well as on herbaceous species.

9. Natural Systems Modifications

9.1 Fire and fire suppression

Great Basin desertscrub is not a fire-adapted ecosystem. However, invasive annual grasses such as cheatgrass have increased the fire frequency and intensity to the detriment of native shrubs and herbaceous species.

Conservation Actions for Great Basin Desertscrub Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Implement projects to improve the quality of altered systems and increase connectivity by removing barriers (e.g., fence modifications and removals). **(Threats 1.3, 6.3, 8.1, 9.1)**
- Control the spread of invasive species using manual, mechanical, and chemical methods, as needed. **(Threats 1.3, 6.3, 8.1, 9.1)**
- Seek opportunities to work with land management agencies and grazing permittees on habitat enhancements that benefit both livestock and wildlife. Encourage land management agencies to reduce stocking levels during drought conditions, to implement adequate range monitoring and respond to thresholds by adjusting stocking levels. **(Threats 1.3, 8.1, 9.1)**

4. Education and Awareness

4.3 Awareness and communication

- Raise awareness among the public and legislators regarding impacts of renewable energy sources on wildlife — particularly on migratory raptors, songbirds, and bats — but also other wildlife as well as on water resources (e.g., solar farms). **(Threat 6.3)**

5. Law and Policy

5.1 Legislation

5.2 Policies and regulations

5.4 Compliance and enforcement

- Provide input into the implementation of laws, monitoring programs, and compliance with laws and policies. **(Threats 1.3, 6.3, 7.1)**

6. Livelihood, Economic, and Other Incentives

6.1 Linked enterprises and livelihood alternatives

6.2 Substitution with environmentally-friendly goods and services

- Work with land management agencies and grazing permittees on habitat enhancements that benefit both livestock and wildlife. **(Threats 1.3, 3.1, 8.1)**
- Collaborate with renewable energy interests to avoid migration corridors and reduce hazards to wildlife from wind turbines. **(Threat 6.3)**
- Share information and discuss the benefits of participating in species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements with Assurances, and Candidate Conservation Agreements with interested landowners. **(Threats 1.3, 4.1)**

Other Conservation Actions that Benefit Great Basin Desertscrub Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.

- Survey the influential species (when possible) to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Semidesert Grassland Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial crops

1.3 Livestock farming and ranching

Many agricultural practices adversely impact natural semidesert grasslands systems through loss of plant cover, biotic diversity, erosion, and dewatering. Vegetation is degraded directly through livestock grazing and clearing for farming, and indirectly through modified water levels as a result of diversions and groundwater pumping. Historically, excessive stocking rates in combination with fire suppression have led to decreased plant diversity and cover for wildlife.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

A warming climate favors shrub species over perennial grasses and also results in altered precipitation patterns which change hydrological regimes and affect species distribution. Warmer ambient temperatures may surpass species temperature tolerances, causing local extirpations, or changes in distributions. Phenological changes can result in misalignment in the timing of food resource availability and the arrival of migratory birds.

4. Residential and Commercial Development

4.1 Housing and urban areas

As Arizona's population continues to expand, demand for housing and employment centers pose threats to habitat through direct loss of habitat, and indirect impacts such as habitat fragmentation, loss of wildlife resources, light and noise pollution, and disturbance to wildlife from human and pet recreation outside the built environment.

6. Energy Production and Mining

6.3 Renewable energy

As the need for renewable energy sources increases, grassland habitats are the likely location for wind farm development. The impacts include direct mortality, loss of habitat from infrastructure development, and introduction of non-native species.

7. Human Intrusions and Disturbance

7.3 Work and other activities

Infrastructure development and human activities associated with the international border with Mexico, such as construction of roadways and lighting and increased human presence, can adversely affect wildlife through altering behavior and habitat fragmentation.

8. Invasive and Problematic Species

8.1 Invasive and non-native species

8.2 Problematic native species

Native semidesert grasses are highly susceptible to displacement by problematic species including Lehmann's lovegrass and buffelgrass. Meanwhile, fire suppression is allowing for the establishment of problematic native woody plants, including mesquite and juniper. Encroachment from these species can greatly alter the composition of wildlife communities that depend on this habitat type.

9. Natural System Modifications

9.1 Fire and Fire Suppression

Post-fire periods allow invasive vegetation, such as buffelgrass, to become established and outcompete native grasses. Meanwhile, fire suppression can allow for the establishment of woody plants, such as mesquite, that can greatly alter the grassland community.

10. Pollution

10.1 Household sewage and urban wastewater

10.3 Agricultural and forestry effluents

10.4 Garbage and solid waste

Pollution can lead to habitat degradation, behavior modification from noise, direct mortality/reduced fecundity, and loss of food and water. Sources of pollution include leaking septic and fuel tanks, untreated sewage, oil or sediment on roads, lawn and agricultural fertilizers and herbicides, illegal dump sites, mine tailings, road-side litter, construction-site debris, and solid garbage and waste.

11. Transportation and Service Corridors

11.1 Roads and Railroads

11.2 Utility and Service Lines

The creation of new roads and current travel corridors can be both a direct and indirect threat to species in the area. Vehicle traffic can create noise and visual disturbance, altering behavior of wildlife species. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors. The construction of new roads is also in coordination with new utility and service lines on the landscape.

Conservation Actions for Semidesert Grassland Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas. **(Threats 1.1, 1.3, 3.1, 3.3, 9.1)**

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive wildlife and plant species. Monitor the success of removal efforts. **(Threats 5, 8.1)**
- Improve, restore, or maintain high quality aquatic habitat to support SCGN aquatic species. Develop and maintain refuge habitats. **(Threats 1.3, 3.2, 9.2)**
- Improve the quality of altered ecosystems by restoring and maintaining native plant species. This can be done by utilizing fire, improving diversity, eradication of invasive species, coordinating with partners to protect and maintain native grassland characteristics and wildlife habitat requirements, research, and maintenance once work is performed. **(Threats 1.3, 3.1, 8.1, 9.2)**

3. Species Management

3.1 Management of specific species of concern

3.2 Species recovery

3.4 Ex situ conservation

- Develop and implement projects for repatriation of wildlife species populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range (including refuge populations). For the listed species with recovery plans, reintroductions will be done as specified in recovery plans. **(Threats 3.1, 5, 8.1, 9.1)**
- Rescue (salvage) native aquatic wildlife at risk from imminent threats, and return salvaged wildlife when conditions are appropriate. **(Threats 3.1, 9.1)**

4. Education and Awareness

4.3 Awareness and communication

- Make presentations at scientific conferences, training workshops, and other professional meetings, field trips, wildlife fairs, media events, educational presentations, workshops, and public events, to increase awareness of effects of threats to aquatic and riparian wildlife species and habitats with an emphasis on how the threats can be reduced. **(Threats 1.3, 3.1, 3.3, 5, 7.1, 8.1, 9.1)**

5. Law and Policy

5.1 Legislation

5.2 Policies and regulation

5.4 Compliance and enforcement

- Provide input into formal government sector legislation or policies, influencing, or providing input into policies and regulations affecting the implementation of laws at all levels, monitoring and enforcing compliance with laws, policies and regulations, and standards and codes at all levels. **(Threats 1.3, 7.1, 8.1, 9.1)**
- Partner with NGOs and OHV user groups to track OHV use and damage of cross-country travel; improve coordination with partners through multi-agency regional to discuss priorities; conduct statewide law enforcement patrols targeting illegal OHV use as well as targeted saturation patrols in areas identified as critical habitat that are being adversely impacted by recreational activities. **(Threats 4.3, 7.1)**

6. Livelihood, Economic and Other Incentives

6.2 Conservation payments and programs

- Engage landowners and partners to participate in Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements (CCA), and Candidate Conservation Agreements with Assurances (CCAA). **(Threats 1.3, 3.1, 9.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts. **(Threats 1.3, 3.1, 7.1, 9.1)**

Other Conservation Actions that Benefit Semidesert Grassland Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when there is survey and management direction and protocols) within the semidesert grassland to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of grassland habitat to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Plains and Great Basin Grassland Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Agricultural practices (primarily livestock grazing) can adversely affect grasslands through loss of plant cover, erosion, and conversion to non-native species. Excessive stocking rates in combination with fire suppression have led to decreased plant diversity and cover for wildlife. Groundwater pumping is also affecting water levels.

2. Biological Resource Use

2.1 Unlawful collection of terrestrial animals

2.2 Unlawful collection of terrestrial plants

Unlawful collection of terrestrial animals or plants can be detrimental to populations that have slow recruitment. When healthy, mature wildlife are taken out of season, population numbers are reduced due to the loss of the viable reproductive animal(s).

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

Climatological warming trends favor shrub species over perennial grasses and desert grasslands are likely to transition to desertscrub. Changes in precipitation, hydrological, and temperature regimes may result in increased frequency, magnitude, and intensity of droughts, dust storms, floods, and other extreme weather events which have the potential to impact wildlife populations through changes to suitable habitat.

4. Residential and Commercial Development

4.1 Housing and urban areas

4.3 Tourism and recreation areas

As Arizona's population continues to expand, demand for housing and employment centers pose threats to habitat through direct loss of habitat, and indirect impacts such as habitat fragmentation, loss of wildlife resources, light and noise pollution, and disturbance to wildlife from human and pet recreation outside the built environment.

5. Disease, Pathogens, and Parasites

Species in this habitat can be affected by a variety of diseases, including plague, rabies, hantavirus, rabbit hemorrhagic disease which can cause significant mortalities and drastic population declines to keystone species. There is also the threat of decreased reproduction and recruitment of young.

7. Human Intrusion and Disturbance

7.1 Recreation activities

Recreational activities, such as unlawful OHV use, can damage habitats by altering or damaging vegetation. In upland areas poorly-managed OHV use can cause erosion. These types of alterations can negatively affect species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

8.2 Problematic native species

Invasive and problematic species compete with native fauna, over-utilize native species, and cause habitat damage. Overgrazing and invasive insects also impact this habitat type, resulting in increased woody debris, decrease in diversity of species, and increasing the potential for large and severe fires.

9. Natural Systems Modifications

9.1 Fire and fire suppression

The lack of wildfires on the plains and great basin grassland landscape has resulted in the encroachment of pinyon pine and juniper tree species. Where fire has occurred, non-native plant species are competing with natives.

11. Transportation and Service Corridors

11.1 Roads and railroads

Transportation corridors through grasslands can be a direct threat to species. Vehicles traveling those roads can be a significant cause of mortality while also creating noise and visual disturbance which alters wildlife behavior. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Plains and Great Basin Grassland Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.2 Resource and habitat protection

- Identify wildlife corridors essential to the movement of species between high-quality habitat blocks. Create wildlife corridors that are identified via acquisition and/or conservation easements. Identify new wildlife corridors essential to movements between high quality habitat blocks. **(Threats 1.3, 4.1, 11.1)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Improve the quality of altered ecosystems by restoring and maintaining native plant species. This can be done by utilizing fire, improving diversity, eradication of invasive species, coordinating with partners to protect and maintain native grassland characteristics and wildlife habitat requirements, research, and maintenance once work is performed. (**Threats 1.3, 3.1, 8.1, 9.1)**
- Increase habitat connectivity by removing barriers and impediments to species movement. **(Threats 1.3, 4.1)**
- Control the spread of invasive and problematic species by implementing biological, mechanical, and chemical methods. **(Threat 8.1)**

3. Species Management

3.1 Management of specific species of concern

3.2 Species recovery

3.3 Species reintroduction

- Survey and monitor species and habitats to determine status and conditions so that resources can be appropriately allocated. Evaluate the effectiveness of management actions, adapting the approach as necessary. Develop predator control strategies to enhance fawn recruitment. **(Threats 8.2)**
- Ensure viable populations of at-risk species (prairie dogs and black-footed ferrets) through captive breeding, artificial propagation and/or gene banking. **(Threat 5)**
- Conduct research with new methods to help lower the spread of plague on the landscape. Reduce the prevalence of external parasites carrying plague on the landscape to bolster prairie dog and ferret populations. **(Threat 5)**

4. Education and Awareness

4.3 Awareness and communication

- Engage communities to incorporate natural resource values and open spaces into long-term planning; increase public awareness of AZGFD's nongame conservation efforts to gain the support of non-traditional constituencies. **(Threat 4.1)**
- Collaborate with developers, the Arizona Corporation Commission, and federal state, and local governments to raise awareness of impacts to wildlife and habitat from renewable and non-renewable energy development. (**Threats 6.2, 6.3**)
- Partner with NGOs and OHV user groups to raise awareness about damages to sensitive habitats resulting from recreational activities. (**Threat 7.1**)
- Mitigate transportation impacts by constructing wildlife crossing structures, avoiding wildlife corridors, and signage, etc., when major roadway/highway construction will be occurring. (**Threat 11.1**)

5. Law and Policy

5.2 Policies and regulations

5.4 Compliance and enforcement

- Partner with NGOs and OHV user groups to track OHV use and damage of cross-country travel; improve coordination with partners through multi-agency regional to discuss priorities; conduct statewide law enforcement patrols targeting illegal OHV use as well as targeted saturation patrols in areas identified as critical habitat that are being adversely impacted by recreational activities **(Threat 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners at different scales (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and determine specific management efforts to improve and coordinate landscape-scale efforts for long-term conservation of SCGN wildlife. **(Threats 3.2, 3.3)**
- Improve coordination with partners to identify priorities and how the AWCS can be used to facilitate project planning and implementation. **(Threats 1.3, 4.1, 11.1)**

Other Conservation Actions that Benefit Plains and Great Basin Grassland Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Monitor pronghorn movements and wildlife connectivity in Big Chino Valley.
- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements. Survey other influential species within the habitat to minimize negative impacts to habitat and species.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of grassland habitat to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Subalpine Grasslands Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock Farming & Ranching

Agricultural practices (primarily livestock grazing) can adversely affect the subalpine grasslands through loss of plant cover, erosion, and conversion to non-native species.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

Climate change is leading to warmer ambient temperatures which may exceed species' temperature tolerances, causing local extirpations, or changing the distribution of less heat-tolerant species towards cooler climates. Climate change also results in altered precipitation patterns which alter hydrological regimes and affect species distribution.

6. Energy Production and Mining

6.3 Renewable energy

As the need for renewable energy sources increases, grassland habitats are the likely location for wind farm development. The impacts from wind development include loss of habitat from road construction, pad construction, and introduction of non-native species.

7. Human Intrusion and Disturbance

7.1 Recreational activities

Recreational activities, such as illegal OHV use, can damage habitats by altering or damaging vegetation. In upland areas, poorly-managed OHV use can cause erosion. These types of alterations can negatively affect species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species, such as feral horses, can compete with native fauna, over-utilize native grassland species and cause habitat damage similar to livestock. This can alter the structure of these habitats making them less desirable or unusable to native species and change food availability for native species.

11. Transportation and Service Corridors

11.1 Roads and railroads

Transportation corridors through subalpine grasslands can be a direct threat to species. Vehicles traveling those roads can be a significant cause of mortality while also creating noise and visual

disturbance which alters wildlife behavior. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Subalpine Grassland Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive species. Monitor the success of removal efforts. **(Threats 5, 8.1)**
- Implement projects focused on improving the quality of altered habitats and/or habitat features that are not degraded by livestock grazing. **(Threat 1.3)**

3. Species Management

3.1 Management of specific species of concern

3.3 Species reintroduction

3.4 Ex situ conservation

- Develop and implement projects for repatriation of wildlife populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range (including refuge populations). **(Threats 1.3, 3.1, 5, 7.1, 8.2, 9.1)**
- Establish and maintain captive populations and provide progeny to meet conservation needs. **(Threats 1.3, 3.1, 5, 7.1, 8.2, 9.1)**

4. Education and Awareness

4.3 Awareness and training

- Increase education and outreach efforts and partner with NGOs and OHV user groups to reduce damage to sensitive habitats through recreational use. **(Threat 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, and to determine the effectiveness of specific management efforts. **(Threats 1.3, 3.1, 3.2, 9.1)**

Other Conservation Actions that Benefit Subalpine Grassland Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when there is survey and management direction and protocols) within the subalpine grasslands to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related species research.
- Manage recreational activities and OHV use of grassland habitat to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Chaparral Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Agricultural practices (primarily livestock grazing) can adversely affect chaparral habitats through loss of plant cover, erosion, and conversion to non-native species.

2. Biological Resource Use

2.3 Logging and wood harvesting

Logging and wood harvesting can alter chaparral habitats. Mechanical removal of trees often results in disturbance to soils and ground vegetation and the loss of snags and nesting habitat, resulting in the direct mortality or displacement of species.

3. Climate change

3.1 Habitat shifting and alteration

3.3 Temperature extremes

3.4 Storms and flooding

Climate change is leading to warmer ambient temperatures which may exceed species temperature tolerances, causing local exterpations, or changing the distribution of less heat-tolerant species towards cooler climates. Climate change is also leading to changes in precipitation patterns which alter hydrological regimes and affect species distribution.

4. Development

4.1 Housing and urban areas

4.3 Tourism and recreation areas

With the human population increasing in Arizona, the expansion of development on the landscape is having direct and indirect effects on wildlife. Direct effects are on habitat loss, degradation, and fragmentation, while indirect effects are pollution from light and noise. In addition, open space planning does not always guarantee permeability for wildlife or connectivity and it comes down to the design level for each community and landscape for consideration.

6. Energy and mining

6.2 Mining and quarrying

6.3 Renewable energy

These mining operations can cause habitat loss/fragmentation, draw down of water and general disturbance. Renewable energy operations can cause direct mortality from collisions with wind turbines, impacts with solar mirrors or injury from solar flux.

7. Human intrusions and disturbances

7.1 Recreational activities

Recreational activities, such as illegal OHV use, can damage habitats by altering or damaging vegetation. In upland areas poorly-managed OHV use can cause erosion. These types of alterations can negatively affect species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species compete with native fauna, over-utilize native species, and cause habitat damage. Overgrazing and invasive insects have also impacted the habitat, resulting in increased woody debris, decrease in diversity of species, and increasing the potential for large and severe fires.

9. Natural systems modifications

9.1 Fire and fire suppression

Fire suppression in the 20th Century created forests that are susceptible to more frequent and more intense wildfires which can cause direct mortality to individuals and result in habitat loss. In addition, drought conditions since the 1990s initiated bark beetle outbreaks in 2003 and has resulted in increased snags and accumulations of coarse woody debris, increasing fuel loads.

11. Transportation and Service Corridors

11.1 Roads

11.2 Utility and service lines

Transportation corridors through chaparral can be a direct threat to species. Vehicular traffic can be a significant cause of mortality while noise and visual disturbance can alter behavior. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Chaparral Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife. Manage for thinning, prescribed burns to create healthy habitats that are less prone to catastrophic wildfires and resilient to drought and insect infestations. **(Threats 2.3, 9.1)**

- Manage unauthorized livestock, including removal and managed at appropriate levels to minimize ecological impacts where allowed. **(Threat 1.3)**
- Control the spread of invasive and problematic species by implementing invasive species management plans that may include herbicide, mechanical removal, and other methods. **(Threats 8.1, 8.2)**
- Perform maintenance as needed to all the AZGFD water catchments used by wildlife to maintain functionality. Meet with federal land ownership agencies staff annually to identify and plan future water projects. **(Threats 3.1, 3.2)**
- Collaborate with local land management agencies to ensure that recreational use is not negatively impacting habitats. Continue to provide signs to private property landowners to discourage trespassing. Ensure that all illegal roads are properly posted to avoid habitat degradation. **(Threat 7.1)**
- To improve habitat connectivity for large ungulates, identify specific areas of chaparral and juniper encroachment and implement habitat improvement projects such as prescribed burns and/or juniper thinning. **(Threats 8.1, 8.2, 9.1)**

Other Conservation Actions that Benefit Chaparral Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when possible) within the chaparral habitat to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use in chaparral habitats to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Madrean Woodland Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Agricultural practices (primarily livestock grazing) can adversely affect Madrean woodlands through loss of plant cover, erosion, and conversion to non-native species.

3. Climate Changes

3.1 Habitat shifting and alteration

3.2 Droughts

3.4 Storms and flooding

Climate change is leading to warmer ambient temperatures which may exceed species' temperature tolerances, causing local extirpations, or changing the distribution of less heat-tolerant species towards cooler climates. Climate change also results in altered precipitation patterns which change hydrological regimes and affect species distribution.

6. Energy Production and Mining

6.2 Mining and quarrying

Mining activities in the Madrean woodlands result in complete and permanent loss of habitat, alterations to groundwater quantity and flow, and loss of recreation areas. Indirect effects may include pollution of water resources via toxic mine spills, disturbance to wildlife from noise and lighting, and fragmentation of wildlife habitat.

7. Human Intrusion and Disturbance

7.1 Recreational activities

7.3 Work and other activities

Recreational activities, such as illegal OHV use, can damage habitats by altering or damaging vegetation. In upland areas, poorly-managed OHV use can cause erosion. These types of alterations can negatively-affect species abundance and distributions. Illegal activities associated with the international border with Mexico (e.g. drug trafficking, undocumented migrants) and associated law enforcement activities can disturb wildlife, and create "wildcat" trails and roads which can lead to damage to vegetation and erosion. Recent border wall construction has also severely impacted many important habitats along the southern border.

8. Invasive and Problematic Species

8.1 Invasive non-native species

8.2 Problematic native species

Invasive and problematic species compete with native fauna, over-utilize native species, and cause habitat damage. Overgrazing and invasive insects have also impacted the habitat, resulting in

increased woody debris, decrease in diversity of species, while increasing the potential for large and severe fires.

9. Natural Systems Modifications

9.1 Fire and fire suppression

Fire suppression during the past century created decadent forests that are susceptible to more frequent and more intense wildfires. This can cause direct mortality to wildlife and can result in habitat loss or significant alteration. These changes, combined with a warming and drying climate in the desert southwest, has led to unprecedented fire severity.

11. Transportation and Service Corridors

11.1 Roads and railroads

The disjunct sky island mountains are natural north-south corridors for wildlife movement. Interstate 10 bisects movement between the Pinaleños and Chiricahuas, the Galiuros/Winchesters/Little Dragoons and the Dragoons, and the Rincons and the Whetstones/Santa Ritas. There are no wildlife crossings along the interstate throughout the Madrean woodlands, although wildlife are able to safely cross the highway at times beneath bridges and occasionally through culverts.

Conservation Actions for Madrean Woodland Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

1.2 Resource and habitat protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas to mitigate adverse effects of some agricultural practices. **(Threats 1.1, 6.2)**
- Identify wildlife corridors essential to the movement of species between high-quality habitat blocks. **(Threats 1.3, 6.2, 7.1, 7.3, 11.1)**

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife. Manage for thinning, prescribed burns to create

healthy habitats that are less prone to catastrophic wildfires and resilient to drought and insect infestations. **(Threats 1.3, 2.3, 9.1)**

- Increase connectivity by removing barriers and impediments to species movement. Modify pasture and boundary fences to meet wildlife-friendly criteria to allow safe wildlife movement or provide wildlife crossing structures to minimize wildlife/vehicle collisions. **(Threats 1.3, 11.1)**
- Maintain native woodland vegetation through chemical and manual treatments of invasive and/or problematic plant species. **(Threats 8.1, 8.2)**
- Protect native brush species from livestock overgrazing through appropriate stocking rates. **(Threat 1.3)**

4. Education and Awareness

4.3 Awareness and communication

- Increase education and outreach efforts and partner with NGOs and OHV user groups to reduce damage to sensitive habitats through recreational use. **(Threat 7.1)**

6. Livelihood, Economic, and Other Incentives

6.1 Linked enterprises and livelihood alternatives

6.4 Conservation payments and programs

- Actively seek opportunities to partner with Arizona agricultural producers and private landowners on a variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.3, 3.1, 3.2, 3.3, 3.4, 8.1, 9.1)**
- Share information and discuss the benefits of participating in species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements with Assurances, and Candidate Conservation Agreements with interested landowners. **(Threats 1.3, 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners at different scales (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and determine specific management efforts to improve and coordinate landscape-scale efforts for long-term conservation of SCGN wildlife. **(Threats 1.3, 3.1, 3.2, 3.4, 7.1, 7.3, 8.1, 8.2, 9.1)**

Other Conservation Actions that Benefit Madrean Woodland Habitats

The following describes other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when possible) to minimize negative impacts to habitat and associated species.

- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Great Basin Conifer Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Agricultural practices (primarily livestock grazing) can adversely affect great basin conifer habitats through loss of plant cover, erosion, and conversion to non-native species.

2. Biological Resource Use

2.3 Logging and wood harvesting

Logging and wood harvesting can alter the seral stage of conifer habitats. Mechanical removal of trees often results in disturbance to soils and ground vegetation and the loss of snags and nesting habitat, resulting in the direct mortality or displacement of species.

3. Climate Change

3.1 Habitat shifting and alteration

3.3 Temperature extremes

3.4 Storms and flooding

Climate change is leading to warmer ambient temperatures which may exceed species temperature tolerances, causing local extirpations, or changing the distribution of less heat-tolerant species towards cooler climates. Climate change also results in altered precipitation patterns which alter hydrological regimes and affect species distribution. In addition, invasive species have an advantage over native species and have started monocultures in many areas due to extended drought and climate change.

4. Development

4.1 Housing and urban areas

4.3 Tourism and recreation areas

With the human population increasing in Arizona, the expansion of development on the landscape is having direct and indirect effects on wildlife. Direct effects are on habitat loss, degradation, and fragmentation, while indirect effects are pollution from light and noise. In addition, open space planning does not guarantee the permeability and connectivity of wildlife as those are considerations at the design level.

6. Energy and mining

6.2 Mining and quarrying

6.3 Renewable energy

Mining operations can cause habitat loss/fragmentation, draw down of groundwater and general disturbance. Renewable energy operations can cause direct mortality from collisions with wind turbines, impacts with solar mirrors or injuries from solar flux.

7. Human intrusions and disturbances

7.1 Recreational activities

Recreational activities, such as illegal OHV use, can damage habitats by altering or damaging vegetation. In upland areas, poorly-managed OHV use can cause erosion. These types of alterations can negatively affect species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

8.2 Problematic native species

Invasive and problematic species compete with native fauna, over-utilize native species and cause habitat damage. Overgrazing and invasive insects have also impacted the habitat, resulting in increased woody debris, decrease in diversity of species, and increasing the potential for large and severe fires.

9. Natural systems modifications

9.1 Fire and fire suppression

Fire suppression in the 20th Century created forests that are susceptible to more frequent and more intense wildfires which can cause direct mortality to individuals and result in habitat loss. Drought conditions since the 1990s initiated bark beetle outbreaks in 2003 and has resulted in increased snags and accumulations of coarse woody debris which increase fuel loads. Recent wildfires have increased the populations of native non-invasive vegetation (e.g. oak and manzanita) resulting in encroachments into pinyon and juniper habitat types. Herbaceous biomass has also decreased.

10. Pollution

10.1 Household sewage and urban wastewater

10.4 Garbage and solid waste

Pollution can lead to habitat degradation, behavior modification from noise, direct mortality/reduced fecundity, and loss of food and water. Sources of pollution include leaking septic and fuel tanks, untreated sewage, oil or sediment on roads, lawn and agricultural fertilizers and herbicides, illegal dump sites, mine tailings, road-side litter, construction-site debris, and solid garbage and waste.

11. Transportation and Service Corridors

11.1 Roads

11.2 Utility and service lines

Transportation corridors through montane forests can be a direct threat to species. Vehicular traffic can be a significant cause of mortality while noise and visual disturbance can alter behavior. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Great Basin Conifer Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife and pollinator species. Manage for thinning, prescribed burns to create healthy habitats that are less prone to catastrophic wildfires and resilient to drought and insect infestations. **(Threats 1.3, 2.3, 3.1, 8.1, 9.1)**
- Control the spread of invasive and problematic species by implementing invasive species management plans that may include herbicide, mechanical removal, and other methods. **(Threats 8.1, 8.2)**
- Manage unauthorized livestock and feral horses, including removal, and managed at appropriate levels to minimize ecological impacts where allowed. (**Threat 8.1**)
- Perform maintenance as needed to all the AZGFD water catchments used by wildlife to maintain functionality. Meet with federal land ownership agencies staff annually to identify and plan future water projects. **(Threats 3.1, 3.2, 3.3)**
- Collaborate with local land managing agencies to ensure that recreational use is not negatively impacting habitats. Continue to provide signs to private property landowners to discourage trespassing. Ensure that all illegal roads are properly posted to avoid habitat degradation. **(Threats 4.3, 7.1, 10.4)**
- To improve habitat connectivity for large ungulates, identify specific areas of chaparral and juniper encroachment and implement habitat improvement projects such as prescribed burns and/or juniper thinning. **(Threats 4.1, 8.1, 8.2, 11.1, 11.2)**

4. Education and Awareness

4. 3 Awareness and communication

- Increase awareness of the effects of specific threats (e.g. climate change, invasive species, illegal collection of reptiles and amphibians) on wildlife and habitats with an emphasis on how the threats can be reduced. **(Threats 3.1, 3.3, 5, 8.1)**
- Inform local sportsman groups of the need to reduce chaparral and juniper encroachment that negatively impact wildlife movements. **(Threat 8.2)**

5. Law and Policy

5.1 Legislation

5.2 Policies and regulations

- Provide input into formal government sector legislation or policies, influencing, or providing input into policies and regulations affecting the implementation of laws at all levels, monitoring and enforcing compliance with laws, policies and regulations, and standards and codes at all levels. **(Threats 3.1, 3.2, 3.3, 3.4, 4.3, 6.3, 7.1, 8.1, 9.1)**

6. Livelihood, Economic and Other Incentives

6.1 Linked enterprises and livelihood alternatives

- Actively seek opportunities to partner with Arizona agricultural producers and private landowners on a variety of habitat enhancements that benefit both livestock and wildlife. **(Threats 1.1, 1.3, 3.1, 3.2, 3.3, 3.4, 8.1, 9.1)**
- Share information and discuss the benefits of participating in species recovery programs such as Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements with Assurances, and Candidate Conservation Agreements with interested landowners. **(Threats 1.3, 3.1)**

Other Conservation Actions that Benefit Great Basin Conifer Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when possible) within the Great Basin conifer habitat to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use of conifer habitats to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Petran Montane Conifer Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.3 Livestock farming and ranching

Agricultural practices (primarily livestock grazing) can adversely affect the Petran montane conifer forests through loss of plant cover, erosion, and conversion to non-native species.

2. Biological Resource Use

2.3 Logging and wood harvesting

Logging and wood harvesting can alter the seral stage of conifer habitats. Mechanical removal of trees often results in disturbance to soils and ground vegetation and the loss of snags and nesting habitat, resulting in the direct mortality or displacement of species.

3. Climate Change

3.1 Habitat shifting and alteration

3.3 Temperature extremes

3.4 Storms and flooding

Climate change is leading to warmer ambient temperatures which may exceed species' temperature tolerances, causing local extirpations, or changing the distribution of less heat-tolerant species towards cooler climates. Climate change also results in altered precipitation patterns which alter hydrological regimes and affect species distribution.

7. Human Intrusion and Disturbance

7.1 Recreational activities

Recreational activities, such as Illegal OHV use, can damage habitats by altering or damaging vegetation. In upland areas poorly-managed OHV use can cause erosion. These types of alterations can negatively affect species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species compete with native fauna, over-utilize native species and cause habitat damage. Overgrazing and invasive insects have also impacted the habitat, resulting in increased woody debris and decreased species diversity, while increasing the potential for large and severe fires.

9. Natural Systems Modifications

9.1 Fire and fire suppression

Fire suppression in the 20th Century created decadent forests that are susceptible to more frequent and more intense wildfires which can cause direct mortality to individuals and can result in habitat loss or significant alteration.

11. Transportation and service corridors

11.1 Roads and railroads

Transportation corridors through montane forests can be a direct threat to species. Vehicular traffic can be a significant cause of mortality while noise and visual disturbance can alter behavior. Road construction and maintenance may result in the direct loss of habitat and disrupt migration corridors.

Conservation Actions for Petran Montane Conifer Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

2. Land and Water Management

2.1 Site/area management

2.2 Invasive/problematic species control

- Implement projects focused on improving the quality of altered systems creating suitable habitat and/or habitat features for wildlife and pollinator species. Implement forest thinning and prescribed burns to create healthy forests that are less prone to catastrophic wildfires and resilient to drought and insect infestations. **(Threats 1.3, 2.3, 3.1, 8.1, 9.1)**
- Manage unauthorized livestock and feral horses, including through removal, and manage at appropriate levels to minimize ecological impacts where allowed. **(Threat 8.1)**

4. Education and Awareness

4.3 Awareness and communication

- Increase education and outreach efforts and partner with NGOs and OHV user groups to reduce damage to sensitive habitats through recreational use. **(Threat 7.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, and to determine the effectiveness of specific management efforts. **(Threats 1.3, 3.1, 3.2, 9.1)**

Other Actions that Benefit Petran Montane Conifer Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in Petran montane conifer habitats:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when possible) within the Petran montane conifer habitat to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use of conifer habitats to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Subalpine Conifer Forests and Alpine Tundra Habitats

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

3. Climate Change

3.1 Habitat shifting and alteration

3.2 Droughts

As our highest-elevation biotic communities, these habitats and species are naturally limited in distribution and more susceptible to changes in the environment. Warmer ambient temperatures may exceed species' temperature tolerances, causing local extinctions, or changing the distribution of less heat-tolerant species. Climate change also results in altered precipitation patterns which affects species distribution.

5. Disease, Pathogens and Parasites

Beetles, aphids and oystershell scale all threaten Petran subalpine conifer forests. Increasing drought can exacerbate the effects of these threats.

7. Human Intrusion and Disturbance

7.1 Recreational activities

Due to their limited distribution in Arizona, Petran subalpine conifer forests and alpine tundra have been disproportionately affected by a small number of hiking trails and ski runs. Infrastructure (e.g., roads) associated with these projects can further fragment and degrade these habitats.

11. Transportation and Service Corridors

11.2 Utility and service lines

Due to their limited distribution in Arizona, Petran subalpine conifer forests have been disproportionately affected by a small number of development projects such as communication towers and observatories. Infrastructure (e.g., roads) associated with these projects can fragment this limited habitat.

Conservation Actions for Petran Subalpine Conifer Forests and Alpine Tundra Habitats

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al (2008). Level 1 conservation actions (i.e. "Land and Water Protection") represent broad categories of potential actions, while the Level 2 conservation actions (i.e. "Resource and habitat protection") are more specific.

2. Land and Water Management

2.1 Site/area management

2.3 Habitat and natural process restoration

- Collaborate with local land management agencies and utility companies to ensure that recreational use and transportation and service corridors do not further negatively impact habitats. **(Threats 7.1, 11.2)**
- Support the USFS effort to evaluate aspen decline. **(Threat 5)**

4. Education and Awareness

4.3 Awareness and communication

- Develop public understanding and support for ecosystem services provided by healthy natural communities (e.g., clean water, clean air). **(Threats 3.1, 7.1, 11.2)**
- Develop public understanding and support for limited and unique communities that provide essential wildlife habitats. **(Threats 3.1, 7.1, 11.2)**

5. Law and Policy

5.1 Legislation

- Support ongoing efforts to better understand diseases, pathogens and parasites in Petran subalpine conifer forests. **(Threat 5)**

Other Conservation Actions that Benefit Petran Subalpine Conifer Forests and Alpine Tundra Habitats

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Survey the influential species (when possible) within these habitats to minimize negative impacts to habitat and associated species.
- Fund or work with partners to conduct conservation-related research.
- Manage recreational activities and OHV use of conifer habitats to minimize negative impacts to habitat and associated species.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.

Threats to Lotic Systems

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial crops

1.3 Livestock farming and ranching

Agricultural practices adversely affect lotic systems through loss of plant cover, erosion, and dewatering caused by livestock grazing and clearing for farming. Diversions and groundwater pumping can alter habitat quality and aquatic food webs.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

Climate change is leading to warmer lotic water temperatures which may surpass species' temperature tolerances, causing local extinctions or distributions to shift towards colder water. The drying of streams can cause local extinctions or greatly reduce species distributions.

5. Disease, Pathogens, and Parasites

Diseases, pathogens, and parasites can spread through a variety of human-mediated mechanisms, natural processes, and movement of native and non-native fauna and can severely alter aquatic communities. Introduction of these harmful elements can also slow or end species reintroduction efforts.

7. Human Intrusions and Disturbance

7.1 Recreational activities

Recreational activities, such as illegal OHV use, are degrading lotic habitats by altering habitat, damaging instream and riparian vegetation, causing erosion in upland areas. These alterations can negatively-affect aquatic species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species such as non-native fish, amphibians (bullfrogs), and crustaceans (crayfish), can compete with or prey upon native fauna. Invasive aquatic plants can completely cover lotic habitats. Invasive riparian area plant species, especially tamarisk and Russian olive, alter flow patterns, reduce habitat diversity, and increase shading of aquatic habitats, thereby changing food availability for native species.

9. Natural System Modifications

9.1 Fire and fire suppression

9.2 Dams and water management use

Wildfire and other modifications to natural systems are resulting in silt and ash runoff, erosion that leads to increased sedimentation, and reduced water quality in lotic systems. Dams and water management activities change lotic systems to lentic systems and alter or completely dry downstream lotic systems.

10. Pollution

10.2 Industrial and military effluents

10.3 Agricultural and forestry effluents

Pollution is a mostly localized stressor to lotic systems. Effluent from mines, agriculture, and urban areas can transport a variety of pollutants that can severely degrade lotic communities.

Conservation Actions for Lotic Systems

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas. **(Threats 1.1, 1.3, 3.1, 9.1)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive wildlife and plant species. Monitor the success of removal efforts. **(Threats 5, 8.1)**
- Install fish passage barriers to prevent upstream movement of non-native fishes into reaches with native aquatic species management emphasis. **(Threats 8.1)**
- Improve, restore, or maintain high-quality aquatic habitat to support SCGN aquatic species. Develop and maintain refuge habitats. **(Threats 1.3, 3.1, 9.1)**

3. Species Management

3.1 Management of specific species of concern

3.2 Species recovery

3.3 Species reintroduction

- Develop and implement projects for repatriation of wildlife species populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range (including refuge populations). **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1, 9.2)**

- Establish and maintain hatchery or other captive populations and provide progeny to meet conservation needs. **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1, 9.2)**
- Rescue (salvage) native aquatic wildlife at risk from imminent threats and return salvaged wildlife when conditions are appropriate. **(Threats 3.1, 3.2, 3.3, 5, 9.1)**

6. Livelihood, Economic and Other Incentives

6.4 Conservation payments and programs

- Engage landowners and partners to participate in Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements (CCA), and Candidate Conservation Agreements with Assurances (CCAA). **(Threats 1.1, 1.3, 3.1, 9.1)**

4. Education and Awareness

4.3 Awareness and communication

- Make presentations at scientific conferences, training workshops, and other professional meetings, field trips, wildlife fairs, media events, educational presentations, workshops, and public events, to increase awareness of effects of threats to aquatic and riparian wildlife species and habitats with an emphasis on how the threats can be reduced. **(Threats 1.1, 1.3, 3.1, 5, 7.1, 8.1, 9.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts. **(Threats 1.2, 3.1, 9.1)**

Other Conservation Actions that Benefit Lotic Systems

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Manage recreational activities and OHV use of riparian and aquatic habitat to minimize negative impacts to habitat and associated species.
- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Identify the suitability of aquatic and riparian habitats for potential reintroduction or release.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Test novel husbandry techniques, new technology, and/or life history research on native aquatic wildlife to improve survival, growth, production, health, condition, transportation, release and post-release performance of captive progeny.
- Fund or work with partners to conduct conservation-related aquatic species research.

- Engage in water management public processes, such as certificated water rights and severe and transfer review and protest processes. Collaborate with partners on instream flow studies and support partner applications for instream flow water rights through sharing of species occurrence data and science.

Threats to Lentic Systems

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial non-timber crops

1.3 Livestock farming and ranching

Livestock farming and ranching practices can adversely affect lentic systems through loss of plant cover, erosion, and dewatering. Livestock also alter water quality in lentic systems through excrement and trampling which mixes sediments into the water.

3. Climate Change

3.1 Habitat shifting and alteration

3.2 Droughts

Climate change is leading to warmer water temperatures which may exceed species' temperature tolerances, causing local extinctions. Climate change can also increase drought frequency and severity which can lead to reduction or complete habitats.

5. Disease, Pathogens, and Parasites

In closed lentic systems, harmful diseases, pathogens, or parasites can spread throughout these populations causing declines or even local extinctions. Introduction of these harmful organisms can also slow or end species reintroduction efforts.

7. Human Intrusions and Disturbance

7.1 Recreational activities

Recreational activities, such as illegal OHV use, can degrade lentic habitats through altering habitats or destroying submersed and emergent vegetation. Also OHV use on shores and in upland areas can cause erosion which leads to more sedimentation in lentic systems.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species such as non-native fish, amphibians (bullfrogs), and crustaceans (crayfish), can compete with or prey upon native fauna. Invasive aquatic plants can outcompete native plants, and cover lentic habitats, resulting in increased shading and alteration of nutrient inputs.

9. Natural Systems Modifications

9.1 Fire and fire suppression

Wildfire can result in silt, sediment, and ash inputs to lentic systems, leading to reduction in habitat and water quality. Wildfires can also directly burn riparian and aquatic vegetation, and alter the aquatic ecosystem by decreasing aquatic species abundances.

Conservation Actions for Lentic Systems

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas. **(Threats 1.32, 3.1)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive wildlife and plant species. Monitor the effectiveness and maintenance for the success of removal efforts. **(Threat 8.1)**
- Improve, restore, or maintain high-quality aquatic habitat to support SCGN aquatic species. Develop and maintain refuge habitats. **(Threats 1.3, 3.1)**
- Improve, restore, or maintain high-quality riparian habitat to support pollinator species. **(Threats 1.1, 1.3, 3.1, 8.1, 9.1)**

3. Species Management

3.2 Species recovery

3.3 Species reintroduction

3.4 Ex situ conservation

- Develop and implement projects for repatriation of aquatic wildlife species populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range, including refugia populations. **(Threats 1.1, 1.3, 3.1, 3.2, 5, 7.1, 8.1, 9.1)**
- Establish and maintain hatchery or other captive populations and provide progeny to meet conservation needs. **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1)**
- Rescue (salvage) native aquatic wildlife at risk from imminent threats, and return salvaged wildlife when appropriate. **(Threats 3.1, 3.2, 5, 8.1)**

4. Education and Awareness

4.3 Awareness and communication

- Make presentations at professional meetings and public events to increase awareness of effects of threats to aquatic wildlife species and habitats with an emphasis on how the threats can be reduced. **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1)**

6. Livelihood, Economic and Other Incentives

6.4 Conservation payments and programs

- Engage landowners and partners to participate in Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements (CCA), and Candidate Conservation Agreements with Assurances (CCAA). **(Threats 1.1, 1.3, 3.1)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with various partners (e.g., statewide, regional, national, and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts. **(Threats 1.3, 3.1)**

Other Conservation Actions that Benefit Lentic Systems

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Implement conservation actions to promote populations of SGCN species.
- Identify suitable habitat and assess the quality of lentic habitat for potential reintroduction or release.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Investigate the use of novel husbandry techniques, new technology, and/or life history research on native aquatic wildlife to improve survival, growth, production, health, condition, transportation, release and post-release performance of captive progeny into the wild.
- Fund or work with partners to conduct conservation-related aquatic species research.
- Manage recreational activities within lentic systems to minimize negative impacts to habitat and associated species.

Threats to Springs Systems

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represent broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial crops

1.3 Livestock farming and ranching

Water diverted from springs or pumped from shallow wells can decrease or eliminate surface water in springs, thus negatively-affecting the native species that rely on these habitats. Livestock also alter water quality in spring systems through excreting waste and trampling which mixes sediments into the water.

3. Climate Change

3.1 Habitat shifting and alteration

3.2 Droughts

Climate change is leading to warmer water temperatures which may cause population declines or if temperatures surpass species tolerances, cause local extinctions. Climate change can also increase drought frequency and severity which can lead to reduction or complete loss of springs and the aquatic species that inhabit them.

5. Disease, Pathogens, and Parasites

In springs where aquatic wildlife populations are dense, harmful diseases, pathogens, or parasites can spread throughout spring populations, causing declines or even local extinctions. These harmful organisms can also slow or end species reintroduction efforts.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species can compete with or prey upon native fauna. Invasive aquatic plants can outcompete native plants, alter nutrient inputs, and change food availability for native species.

9. Natural Systems Modifications

9.2 Dams and water management and use

Spring boxes divert water from the source spring for human and livestock use and may lead to reduction or elimination of surface water.

Conservation Actions for Springs Systems

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas. **(Threats 1.1, 1.3, 3.1, 9.2)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive wildlife and plant species. Monitor the success of removal efforts**. (Threats 5, 8.1)**
- Improve, restore, or maintain high quality aquatic habitat to support SCGN aquatic species. Develop and maintain refuge habitats. (**Threats 1.3, 3.1, 3.2, 9.1)**

3. Species Management

3.2 Species recovery

3.3 Species reintroduction

3.4 Ex situ conservation

- Develop and implement projects for repatriation of wildlife species populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range (including refuge populations). For the listed species with recovery plans, reintroductions will be done as specified in recovery plans. **(Threats 1.3, 3.1, 5, 8.1, 9.2)**
- Establish and maintain captive populations and provide progeny to meet conservation needs. **(Threats 1.3, 3.1, 5, 8.1, 9.2)**
- Rescue (salvage) native aquatic wildlife at risk from imminent threats, and return salvaged wildlife when conditions are appropriate. **(Threats 3.1, 3.2, 5, 9.2)**

4. Education and Awareness

4.3 Awareness and communication

- Make presentations at scientific conferences, training workshops, and other professional meetings, field trips, wildlife fairs, media events, educational presentations, workshops, and public events, to increase awareness of effects of threats to aquatic species and habitats with an emphasis on how the threats can be reduced. **(Threats 1.1, 1.3, 3.1, 3.2, 5, 8.1, 9.2)**

6. Livelihood, Economic and Other Incentives

6.4 Conservation payments and programs

- Engage landowners and partners to participate in Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements (CCA), and Candidate Conservation Agreements with Assurances (CCAA). **(Threats 1.3, 3.1, 9.2)**

7. External Capacity Building

7.2 Alliance and partnership development

- Collaborate with partners across different geographies (e.g., statewide, regional, national and international) to develop and implement management plans, conservation agreements, recovery actions, research, management recommendations, and to determine the effectiveness of specific management efforts. **(Threats 1.3, 3.1, 9.2)**

Other Actions that Benefit Spring Systems

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Implement conservation actions to promote populations of SGCN species.
- Identify suitable habitat and assess the quality of spring habitat for potential reintroduction or release.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Investigate the use of novel husbandry techniques, new technology, and/or life history research on native aquatic wildlife to improve survival, growth, production, health, condition, transportation, release and post-release performance of captive progeny into the wild.
- Fund or work with partners to conduct conservation-related aquatic species research.
- Manage recreational activities within spring systems to minimize negative impacts to habitat and associated species.

Threats to Wetland Systems

The following describes the primary threats facing this habitat type, adapted from Salafsky et al. (2008). Level 1 threats (i.e. Agriculture, Climate Change) represents broad categories while Level 2 threats reflect more specific stressors to the system.

1. Agriculture

1.1 Annual and perennial crops

1.3 Livestock farming and ranching

Agricultural practices adversely affect wetland systems through loss of plant cover, erosion, and dewatering caused by livestock grazing and clearing for farming. Diversions and groundwater pumping can alter habitat quality and aquatic food webs.

3. Climate Change and Severe Weather

3.1 Habitat shifting and alteration

3.2 Droughts

3.3 Temperature extremes

Climate change is leading to warmer water temperatures which may exceed species' temperature tolerances, causing local extinctions or distributions to shift towards colder water. The drying of wetlands can cause local extinctions or reduce species distributions.

5. Disease, Pathogens, and Parasites

Diseases, pathogens, and parasites can spread through a variety of human-mediated mechanisms, natural processes, and movement of native and non-native fauna and can severely alter aquatic communities. Introduction of these harmful elements can also slow or end species reintroduction efforts.

7. Human Intrusions and Disturbance

7.1 Recreational activities

Recreational activities, such as illegal OHV use, are degrading wetland habitats by altering habitat, damaging instream and riparian vegetation, causing erosion in upland areas. These alterations can negatively-affect aquatic species abundance and distributions.

8. Invasive and Problematic Species

8.1 Invasive non-native species

Invasive and problematic species such as non-native fish, amphibians (bullfrogs), and crustaceans (crayfish), can compete with or prey upon native fauna. Invasive aquatic plants can completely cover wetland habitats. Invasive riparian area plant species, especially tamarisk and Russian olive, alter flow patterns, reduce habitat diversity, and increase shading of aquatic habitats, thereby changing food availability for native species.

9. Natural System Modifications

9.1 Fire and fire suppression

9.2 Dams and water management use

Wildfire and other modifications to natural systems are resulting in silt and ash runoff, erosion that leads to increased sedimentation, and reduced water quality in wetland systems. Dams and water management activities change wetland systems to lentic systems and alter or completely dry downstream wetland systems.

Conservation Actions for Wetlands Systems

The following describes specific conservation actions that can be taken to reduce or eliminate threats to this habitat type, adapted from Salafsky et al. (2008). Level 1 conservation actions (i.e. Land and Water Protection) represent broad categories of potential actions, while the Level 2 conservation actions (i.e. Resource and habitat protection) are more specific.

1. Land and Water Protection

1.1 Site/area protection

- Acquire land and water rights and pursue conservation agreements and easements in and around COAs and other priority areas. **(Threats 1.3, 3.1, 9.1)**

2. Land and Water Management

2.2 Invasive/problematic species control

2.3 Habitat and natural process restoration

- Remove non-native, undesirable, and/or invasive wildlife and plant species. Monitor the success of removal efforts. **(Threats 5, 8.1)**
- Improve, restore, or maintain high-quality aquatic habitat to support SCGN aquatic species. Develop and maintain refuge habitats. **(Threats 1.3, 3.1, 3.2, 9.1)**
- Improve, restore, or maintain high-quality emergent wetland habitat to support wildlife and pollinator species. **(Threats 1.3, 3.1, 3.2, 3.3, 8.1, 9.1)**

3. Species Management

3.2 Species recovery

3.3 Species reintroduction

3.4 Ex situ conservation

- Develop and implement projects for repatriation of wildlife species populations that are currently unsustainable or extirpated, or to improve genetic resilience throughout their historical range (including refuge populations). **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1, 9.2)**
- Establish and maintain hatchery or other captive populations and provide progeny to meet conservation needs. **(Threats 1.3, 3.1, 5, 7.1, 8.1, 9.1, 9.2)**
- Rescue (salvage) native aquatic wildlife at risk from imminent threats and return salvaged wildlife when conditions are appropriate. **(Threats 3.1, 3.2, 5, 9.1)**

4. Education and Awareness

4.3 Awareness and communication

- Make presentations at scientific conferences, training workshops, and other professional meetings, field trips, wildlife fairs, media events, educational presentations, workshops, and public events, to increase awareness of effects of threats to aquatic and riparian wildlife species and habitats with an emphasis on how the threats can be reduced. **(Threats 1.1, 1.3, 3.1, 5, 7.1, 8.1, 9.1)**

6. Livelihood, Economic and Other Incentives

6.4 Conservation payments and programs

- Engage landowners and partners to participate in Safe Harbor Agreements, Habitat Conservation Plans, Candidate Conservation Agreements (CCA), and Candidate Conservation Agreements with Assurances (CCAA). **(Threats 1.2, 3.1, 9.1)**

Other Conservation Actions that Benefit Wetland Systems

The following describe other routine or on-going conservation actions AZGFD regularly performs in this habitat type:

- Manage recreational activities and OHV use of wetlands to minimize negative impacts to habitat and associated species.
- Conduct surveys and monitor populations of SGCN as specified in work plans and job statements.
- Identify the suitability of wetlands for potential reintroduction or release.
- Collect specimens or samples for taxonomic analysis, genetics, research, and/or disease testing.
- Test novel husbandry techniques, new technology, and/or life history research on native aquatic wildlife to improve survival, growth, production, health, condition, transportation, release and post-release performance of captive progeny.
- Fund or work with partners to conduct conservation-related aquatic species research.
- Engage in water management public processes, such as certificated water rights and severe and transfer review and protest processes.

Chapter 9: Monitoring

Monitoring is a critical element of any conservation effort and is at the heart of AZGFD's mission to "conserve, enhance, and restore Arizona's diverse wildlife resources and habitats." Monitoring should be a systematic and repeated activity, i.e., not simply an inventory. These efforts are often associated with and designed to assess the effects of a management action, using scientifically-defensible methods. Useful references that have informed our monitoring efforts include Elzinga et al. (2001), Atkinson et al. (2004), Stem et al. (2005), and The Heinz Center (2009).

Species Monitoring

It is not practical to monitor all SGCN, therefore AZGFD prioritizes monitoring efforts for species or habitats of highest conservation concern, such as those species listed under the ESA, covered under signed conservation agreements or strategies, or species that are the subject of reintroduction efforts. Monitoring is conducted at various hierarchical scales, depending on the particular questions being addressed. As such, AZGFD monitors both at the habitat level and at the species level, depending on project goals and priorities. For reference, these correspond fairly closely with TNC's "course-filter" and "fine-filter" biodiversity conservation targets (TNC 1982).

Monitoring at local scales includes projects that target individual SGCN, such as Chiricahua leopard frog, Huachuca springsnail, black-tailed prairie dog, and others. Monitoring at the landscape scale includes regularly-scheduled bird monitoring projects including Riparian, Grassland, and Sonoran Desert monitoring (data are archived in the Avian Knowledge Network), regularly-scheduled Gunnison's prairie dog occupancy and productivity surveys, or working with our partners on projects such as the Pima County Multi-Species Conservation Plan. In addition to species or habitat-focused monitoring, AZGFD also monitors various diseases that affect SGCN, including chytridiomycosis, snake fungal disease, avian influenza, bubonic plague, and white-nosed syndrome, among others.

For some SGCN, inventory is our only practical option. This inventory entails collecting as much information as possible regarding a species' distribution, status, and threats. Information from species inventories provide important baseline data from which other studies and monitoring efforts can be developed. We collect and archive large amounts of these data, most of which are housed either in the Wildlife Data Warehouse (WDW), or in the interactive HDMS Dashboard. The WDW, which is scheduled to launch in fall 2022, will include information explicitly collected by AZGFD staff for targeted conservation and management efforts (including monitoring). Meanwhile, the HDMS Dashboard combines point data archived in HDMS (i.e. element occurrences, point observation database, Arizona Breeding Bird Atlas), with observation data from Scientific Activities Licenses, and citizen science crowdsourcing applications, including HerpMapper, eBird, and iNaturalist, and others.

Habitat Monitoring

Throughout the state, most habitat monitoring is done by land management agency partners and formalized in their resource management plans. Clearly, much of the habitat manipulation and monitoring can only be done with our partners. Most habitat monitoring done by AZGFD staff is done in concert with species-level projects. For example, since 2012, AZGFD and partners have restored, improved, or secured about 30 springs, ponds, or stream sections intended to support SGCN Chiricahua leopard frogs, for which monitoring includes measuring the success of subsequent leopard frog translocation or reoccupation. In southern Arizona, AZGFD staff work closely with BLM and private landowners to remove mesquites and other woody vegetation in order to restore grasslands for SGCN prairie dogs and other grassland-dependent species. Project success is then measured through black-tailed prairie dog monitoring. In a slightly different example of a landscape habitat manipulation project (pinyon pine removal to improve grasslands), we also monitor SGCN pinyon jays to evaluate possible unintended consequences of pinyon removal.

Monitoring the effects of management manipulations is a high priority for SGCN conservation. Existing monitoring plans or efforts are outlined in Table 7 below. These plans are utilized by AZGFD and our partners on a regular or semi-regular basis to monitor single species, multiple species, and/or their habitats. Monitoring plans and other documents listed are organized by taxa/species the plan covers (if applicable). Other information includes habitat types where these monitoring efforts occur (with primary habitat listed first followed by other habitat types the plan covers), the document citation with web links (if applicable), and the lead agency and partners associated with implementing the monitoring plan.

Table 7: *Monitoring and planning documents utilized by AZGFD and partners.*

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
American bison	Great Basin Conifer Woodland, Petran montane conifer Forest, Plains and Great Basin Grasslands	AZGFD. 2020. Arizona Bison Management Plan	AZGFD
American pronghorn	Semidesert Grassland, Petran montane conifer Forest, Plains and Great Basin Grasslands, Upland Sonoran Desertscrub, Great Basin Conifer Woodland	(1) AZGFD. 2013. Arizona Statewide Pronghorn Management Plan. 96pp. (2) Arizona Antelope Foundation. 2020. National Fish and Wildlife Foundation Grant Report "Southeastern Arizona Grasslands Pronghorn Initiative" 2010-2019.	AZGFD
Bald eagle	Various	Driscoll, JT, KV Jacobson, GL Beatty, JS Canaca, and JG Koloszar. 2006. Conservation assessment and strategy for the bald eagle in Arizona. Nongame and Endangered Wildlife Program Technical Report 173. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD Lead; Various State, Federal, Tribal, and private entities.
Bat species	Various	(1) BLM Instruction Memorandum (IM) 2010-181, White Nose Syndrome.	BLM, various

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
		(2) Whitenose Syndrome Response Team. 2014. Implementation of The National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats. WNS Response Plans. (3) Hinman, KE, and TK Snow, eds. 2003. Arizona Bat Conservation Strategic Plan. Nongame and Endangered Wildlife Program Technical Report 2013. Arizona Game and Fish Department, Phoenix, Arizona.	
Bendire's thrasher	Upland Sonoran Desertscrub	Ammon, EM, DM Fletcher, LB Harter, CC Borgman, E Duvuvuei, G Geupel, D Jongsomjit, E Juarez, CL Kondrat, E Masters, and R Norvell. 2020. Survey methods, habitat models, and future directions for conservation of Bendire's and LeConte's Thrashers: A comprehensive report of region-wide surveys in 2017-2018. GBBO Gen. Tech. Report 2019-1.Great Basin Observatory, Reno, NV.1.	Desert Thrasher Working Group
Bighorn sheep	Various	WAFWA Wildlife Health Committee. 2015. Bighorn Sheep Herd Health Monitoring Recommendations.	AZGFD
Black-footed ferret	Plains and Great Basin Grasslands	AZGFD. 2016. Management Plan for the Black-footed Ferret in Arizona. Nongame and Endangered Wildlife Program Technical Report 301. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD
Black-tailed prairie dog	Semidesert Grassland, Plains and Great Basin Grasslands, Chihuahuan Desertscrub, Upland Sonoran Desertscrub	Luce, RJ. 2003. A Multi-State Conservation Plan for the Black-tailed Prairie Dog, *Cynomys ludovicianus*, in the United States - An addendum to the Black-tailed Prairie Dog Conservation Assessment and Strategy, November 3, 1999.	11 state fish and wildlife agencies within the range of the black-tailed prairie dog
California floater	Lotic	AZGFD Nongame and Endangered Wildlife Conservation Plan, July 1, 2022-June 30, 2032	AZGFD, ACNC-Phoenix Zoo
Cervids	Various	(1) Gillin, CM, and Mawdsley, JR (eds.). 2018. AFWA Technical Report on Best Management Practices for Surveillance, Management and Control of Chronic Wasting Disease. Association of Fish and Wildlife Agencies, Washington, D. C.. (2) Gillin, CM, and Mawdsley, JR (eds.) 2019. AFWA Best Management Practices for Surveillance, Management and Control of Chronic Wasting Disease (CWD): First Supplement. Association of Fish and Wildlife Agencies (AFWA), Washington, D. C..	AZGFD

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
Chiricahua leopard frog	Various	USFWS. 2007. Chiricahua Leopard Frog (*Rana chiricahuaensis*) Recovery Plan. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, NM. Jones, TR. 2013. A survey/monitoring plan for bullfrogs and native ranid frogs in the Peña Blanca Lake region, Santa Cruz County, Arizona. Nongame and Endangered Wildlife Program Technical Report 337. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD lead; USFS and USFWS
Colonial waterbird nest survey	Wetland, Lentic, Lotic	Corman, TE, and EA Juarez. 2017. Arizona Coordinated Bird Monitoring Program – Project Progress Report: 2006-2012. Nongame and Endangered Wildlife Program Technical Report 296.Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD lead; various State, Federal, Tribal, and private entities.
Desert pupfish	Lotic, Lentic	Marsh, PC and DW Sada. 1993. Desert Pupfish (*Cyprinodon macularius*) Recovery Plan. US Fish and Wildlife Service. Phoenix, Arizona.	AZGFD, USFWS
Flat-tailed horned lizard	Lower Sonoran Desertscrub	Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision.	AZGFD, DOD, USBR
Golden eagle	Various	McCarty, KM, JK Presler, and KV Jacobson. 2020. Arizona golden eagle nest survey 2020. Nongame and Endangered Wildlife Program Technical Report 334. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD lead; various State, Federal, Tribal, and private entities.
Gunninson's prairie dog	Plains and Great Basin Grasslands	Seglund, AE, AE Ernst, and DM O'Neill. 2005. Gunnison's prairie dog conservation assessment. Western Association of Fish and Wildlife Agencies. Laramie, Wyoming. Unpublished Report.	WAFWA, AZGFD, USFWS
Huachuca springsnail	Springs, Wetlands, Madrean Woodlands	USFWS. 2016. Candidate Conservation Agreement for the Huachuca Springsnail (*Pyrgulopsis thompsoni*).	AZGFD, USFWS, USFS, DOD, ACNC-Phoenix Zoo, TNC
LeConte's thrasher	Upland Sonoran Desertscrub	Ammon, EM, DM Fletcher, LB Harter, CC Borgman, E Duvuvuei, G Geupel, D Jongsomjit, E Juarez, CL Kondrat, E Masters, and R Norvell. 2020. Survey methods, habitat models, and future directions for conservation of Bendire's and LeConte's Thrashers: A comprehensive report of region-wide surveys in 2017-2018. GBBO General Technical Report 2019-1.Great Basin Observatory, Reno, NV.	Desert Thrasher Working Group

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
Lesser long-nosed bat	Upland Sonoran Desert, Lower Sonoran Desert	USFWS. 2019. Draft post-delisting monitoring plan for the lesser long-nosed bat (*Leptonycteris yerbabuenae*). Region 2 USFWS, Arizona Ecological Services Field Office, Phoenix, Arizona.	USFWS
Mexican spotted owl	Petran montane conifer Forest, Petran subalpine conifer Forest	USFWS. 2012. Final Recovery Plan for the Mexican Spotted Owl (*Strix occidentalis lucida*), First Revision. U.S. Fish and Wildlife Service. Albuquerque, New Mexico, USA.	USFS Lead, USFWS
Mexican wolf	Subalpine Grasslands, Petran montane conifer Forest	USFWS. 2017. Mexican Wolf Recovery Plan, First Revision. Region 2, Albuquerque, New Mexico, USA.	AZGFD, USFWS
Monarch butterfly	Various	Western Association of Fish and Wildlife Agencies. 2019. Western monarch butterfly conservation plan, 2019–2069. Version 1.0.	WAFWA Monarch and Native Pollinator Working Group, Arizona Monarch Collaborative
Mt. Graham red squirrel	Petran montane conifer	USFWS. 2011. Draft Recovery Plan for the Mount Graham Red Squirrel (*Tamiasciurus hudsonicus grahamensis*), First Revision. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, NM..	AZGFD, USFWS
Narrow-headed gartersnake	Semidesert Grassland, Great Basin Conifer Woodland, Petran montane conifer Forest, Chaparral	Ryan, MJ, AB Smith, S Lashway, KK Smith, SB Riddle, CM Akins, BR Blais, and KT Krahn. 2019. A five-year narrow-headed gartersnake (*Thamnophis rufipunctatus*) survey summary from Canyon Creek, Arizona-Revised. Nongame and Endangered Wildlife Program Technical Report 323. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD, USFWS, USFS
New Mexico jumping mouse	Subalpine Grasslands, Petran montane conifer Forest, Petran subalpine conifer Forest	USFWS. 2014. Recovery Outline: New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*) U.S. Fish and Wildlife Service New Mexico Ecological Services Field Office, Albuquerque, New Mexico.	AZGFD, USFWS, USFS
New Mexico ridge-nosed rattlesnake	Madrean Woodland, Montaine Conifer Forest	USFWS. 1985. New Mexico Ridgenose Rattlesnake Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.	USFWS, NMGFD, AZGFD
Nightjars	Various	Nightjar Survey Network. Center for Conservation Biology.	AZGFD, The College of William and Mary
Niobrara ambersnail (includes populations formerly called Kanab ambersnail)	Springs, Great Basin Desertscrub	Sorensen, JA and CB Nelson. 2002. Interim Conservation Plan for *Oxyloma (haydeni) kanabensis* complex and related ambersnails in Arizona and Utah. Nongame and Endangered Wildlife Program Technical Report 192. Arizona Game and Fish Department, Phoenix, Arizona. AZGFD. 2017.	AZGFD, USFWS, NPS, UDWR, Best Friends Animal Sanctuary

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
		Ambersnail Survey Protocol - April 2017. Arizona Game and Fish Department..	
Northern leopard frog	Great Basin Desertscrub, Great Basin Woodland, Petran montane conifer Forest, Lentic, Lotic, Wetlands	USFWS. 2007. Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan. USFWS, Southwest Region, Albuquerque, NM.	AZGFD lead; USFS, USFWS
Northern Mexican gartersnake	Semidesert Grassland, Plains and Great Basin Grasslands, Upland Sonoran Desertscrub, Great Basin Conifer Woodland, Petran montane conifer Forest	Boyarski, VL, MJ Ryan, and TB Cotten. 2019. Monitoring Program for Northern Mexican Gartersnakes (*Thamnophis eques megalops*) at Page Springs and Bubbling Ponds Fish Hatcheries. Nongame and Endangered Wildlife Program Technical Report 317. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD, USFWS
Page springsnail	Springs	USFWS and AZGFD. 2009. Candidate Conservation Agreement with Assurances for the Page springsnail (*Pyrgulopsis morrisoni*). Sorensen, JA. 2021. Monitoring program for Page springsnail. Version 9/16/2021	AZGFD, USFWS
Quitobaquito Tryonia	Springs	Quitobaquito Tryonia Working Group. 2021 (Draft). Monitoring program for Quitobaquito tryonia springsnails.	AZGFD, USFWS, NPS, ASDM
Relict leopard frog	Various lentic and lotic systems	Relict Leopard Frog Conservation Team. 2016. Conservation Agreement and Conservation Assessment and Strategy for the Relict Leopard Frog (*Rana onca* [=*Lithobates onca*]).	AZGFD, BLM, USFWS, BOR, NDOW, NPS, UDWR, UNLV
San Bernardino springsnail	Springs	AZGFD Nongame and Endangered Wildlife Conservation Plan July 1, 2022 – June 30, 2032.	AZGFD, USFWS, ACNC-Phoenix Zoo, private
San Xavier talussnail	Upland Sonoran Desertscrub	Cooperating Partners of the San Xavier Talussnail Working Group. 2018. Strategic Conservation Plan for San Xavier talussnail in Pima County, Arizona.	AZGFD, USFWS, KinderMorgan (El Paso Natural Gas Company, LLC), Arizona G&T Cooperatives, Pima County
Sonoran desert tortoise	Upland Sonoran Desertscrub, Mohave Desertscrub, Semidesert Grasslands	Averill-Murray, RC. 2000. Survey protocol for Sonoran desert tortoise monitoring plots: Reviewed and revised. Arizona Interagency Desert Tortoise Team.	AZGFD, USFWS, BLM, NPS, DOD, CBP, USFS, NRCS, ADOT
Sonoran pronghorn	Lower Sonoran Desertscrub	USFWS. 2016. Recovery Plan for the Sonoran pronghorn (*Antilocapra americana sonoriensis*), Second Revision. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico, USA.	USFWS, AZGFD

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
Sonoran tiger salamander	Plains and Great Basin Grassland, Madrean Woodlands	USFWS. 2002. Sonora tiger salamander (A*mbystoma tigrinum stebbinsi*) recovery plan. U.S. Fish and Wildlife Service, Phoenix, Arizona.	USFWS, AZGFD
Southwestern willow flycatcher	Riparian areas within most habitat types found in Arizona	U.S. Fish and Wildlife Service. 2002. Southwestern Willow Flycatcher Recovery Plan. Albuquerque, New Mexico..	USFWS
Three Forks springsnail	Springs	AZGFD Springsnail Survey Protocol - October 2016. Arizona Game and Fish Department.	AZGFD, USFWS, USFS, ACNC-Phoenix Zoo
Various bird species (Sonoran Desert)	Upland Sonoran Desertscrub	Corman, TE, EA Juarez, JE Arnett, Jr., and CJ Beardmore (Eds.). 2018. Sonoran Desert breeding bird monitoring: 2012-2014 Summary Report. Nongame and Endangered Wildlife Program Technical Report 298. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD
Various	Lower Sonoran Desertscrub, Lentic, Lotic, Wetlands	Lower Colorado River Multi-Species Conservation Program. 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Final. December 17. (J&S 00450.00.) Sacramento, CA	BOR
Various	Lower Sonoran Desertscrub, Upland Sonoran Desertscrub, Semidesert Grasslands, Lentic, Lotic, Wetlands, Springs	Pima County. 2016. Multi-species Conservation Plan for Pima County, Arizona: Final. Submitted to the Arizona Ecological Services office of the U.S. Fish and Wildlife Service, Tucson, Arizona.	Pima County, USFWS
Various	Semidesert Grasslands, Plains and Great Basin Grasslands	Gori, D, GS Bodner, K Sartor, P Warren, and S Bassett. 2012. Sky Island Grassland Assessment: Identifying and Evaluating Priority Grassland Landscapes for Conservation and Restoration in the Borderlands. Report prepared by The Nature Conservancy in New Mexico and Arizona.	TNC, NFWF
Various	Semidesert Grasslands, Plains and Great Basin Grasslands	Gori, DF, and CAF 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.	TNC, NFWF
Various bird species (breeding birds)	Various	USGS Patuxent Wildlife Research Center. North American Breeding Bird Survey.	USGS, AZGFD lead, various State, Federal, and private entities.
Various bird species (grasslands)	Semidesert Grasslands, Plains and Great Basin Grasslands	Sparks, RA , DC Pavlacky, JP Beason, and E Juarez. 2017. Monitoring Grassland Birds in BCR 34, Arizona: 2016 Field Season Report. Bird Conservancy of the Rockies, Brighton, Colorado.	AZGFD

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
Various bird species (riparian areas)	Riparian	Corman, TE, EA Juarez, JE Arnett., and CJ Beardmore. 2018. Riparian habitats breeding bird Monitoring: 2009-2012 Summary Report. Nongame and Endangered Wildlife Program Technical Report 297. Arizona Game and Fish Department, Phoenix, Arizona.	AZGFD
Various snail species: Huachuca woodlandsnail, Huachuca mountainsnail, Huachuca talussnail, Bear Canyon talussnail, Garden Canyon talussnail, Ramsey Canyon talussnail	Petran montane conifer Forest	AZGFD. 2016. AZGFD Land Snail Survey Protocol - October 2016. Arizona Game and Fish Department.	AZGFD, USFWS, Maricopa County, City of Phoenix, City of Glendale
Various snail species: Phoenix (Squaw Peak) talussnail, Superstition talussnail, Eastern desertsnail, undescribed Sonorella species	Upland Sonoran Desertscrub	AZGFD. 2016. AZGFD Land Snail Survey Protocol - October 2016. Arizona Game and Fish Department..	AZGFD, USFWS, Maricopa County Parks, City of Phoenix Parks and Recreation, City of Glendale Parks and Recreation
Various snail species: Pinaleño talussnail, Wet Canyon talussnail, Mimic talussnail, Clark Peak talussnail, Pinaleño mountainsnail, Cross snaggletooth, Shortneck snaggletooth	Petran montane conifer Forest	Pinaleño Land Snail Working Group. 2018. Conservation Agreement for Land Snails in the Pinaleño Mountain on the Coronado National Forest in Arizona.	AZGFD, USFWS, USFS
Various snail species: Kingman springsnail, Grand Wash springsnail, Virgin (Desert) springsnail, Bylas springsnail, and Gila Tryonia	Springs	AZGFD. 2018 (Draft). Monitoring Program for Springsnails on BLM Lands in Arizona.	AZGFD, USFWS, BLM
Various snail species: Page springsnail, Verde Rim springsnail, Fossil springsnail, Montezuma Well springsnail, Brown springsnail, and two undescribed *Pyrgulopsis* species	Springs	Central Arizona Springsnails Strategic Conservation Plan (2021, in review) AZGFD. 2021 (Draft). Monitoring Program for Central Arizona Springsnails.	AZGFD, USFWS, USFS, NPS
Western burrowing owl	Various	AZGFD Western Burrowing Owl Management website	AZGFD, BLM, USFWS
Yellow-billed cuckoo	Riparian areas within most habitat types found in Arizona	Halterman, M, MJ Johnson, JA Holmes, and SA Laymon. 2015. A Natural History Summary and Survey Protocol for the Western Distinct Population Segment of the Yellow-billed Cuckoo: U.S. Fish and Wildlife Techniques and Methods.	USFWS, Pima County

Taxa/Species	Habitat Type	Document Citation	Lead or Partners
Yuma Ridgway's rail, other marsh birds	Wetlands	Conway, CJ. 2015. National protocol framework for the inventory and monitoring of secretive marsh birds. Inventory and Monitoring, National Wildlife Refuge System, U.S. Fish and Wildlife Service, Fort Collins, Colorado.	USFWS, AZGFD

Literature Cited

Agee, JK. 1993. Fire ecology of Pacific Northwest Forests. Island Press, Washington, DC.

Allender, M. 2019. Ranaviral disease in reptiles and amphibians. In RE Miller, N Lamberski, and P Calle (eds.) Fowler's zoo and wild animal medicine, Elsevier, St. Louis, MO.

Arizona Comprehensive Environmental Risk Project (ACERP). 1995. The Arizona comprehensive environmental risk project report. ACERP Steering Committee, Phoenix, Arizona. http://earthvision.asu.edu/acerp/ (accessed January 2020).

Arizona Conservation Science. Arizona's grasslands. The Nature Conservancy. http://azconservation.org/projects/grasslands (accessed January 2020).

Arizona Department of Agriculture (AZDA). 2018. Guide to Arizona agriculture. https://agriculture.az.gov/ (accessed January 2021).

Arizona Department of Water Resources (ADWR). Arizona water facts. 2018. http://www.arizonawaterfacts.com/water-your-facts (accessed January 2020).

ADWR. 2021. Water your facts. http://www.arizonawaterfacts.com/water-your-facts (accessed January 2021).

ADWR. Arizona Department of Water Resources. Conservation: Agriculture. https://new.azwater.gov/conservation/agriculture (accessed January 2020).

Arizona Commerce Authority. 2020. Labor market. https://www.azcommerce.com/oeo/labor-market/ (accessed December 20210).

Arizona Game and Fish Department (AZGFD). 2012. Arizona's state wildlife action plan: 2012-2022. Arizona Game and Fish Department, Phoenix, Arizona. https://s3.amazonaws.com/azgfd-portal-wordpress/PortalImages/files/wildlife/2012-2022_Arizona_State_Wildlife_Action_Plan.pdf

AZGFD. 2016. State of Arizona Aquatic Invasive Species Program, Vision for 2016-2025. https://s3.amazonaws.com/azgfd-portal-wordpress/PortalImages/files/fishing/InvasiveSpecies/AISProgramVision7-28-16.pdf (accessed January 2020).

Arizona Riparian Council (ARC). 1994. Riparian. Fact Sheet.

Arizona State Climate Office. Arizona climate. Tempe, AZ. https://azclimate.asu.edu/climate/. (accessed February 2020).

Arizona State Energy Profile. 2020. U.S. Energy Information Administration. https://www.eia.gov/ (accessed February 2020).

Association of Fish and Wildlife Agencies (AFWA). 2009. Voluntary guidance for states to incorporate climate change into state wildlife action plans & other management plans. Climate Change Wildlife Action Plan Work Group. Association of Fish & Wildlife Agencies, Washington, DC.

AFWA. 2012. Best practices for state wildlife action plans—voluntary guidance to states for revision and implementation. State Wildlife Action Plan (SWAP) Best Practices Working Group. Teaming With Wildlife Committee. Association of Fish and Wildlife Agencies. Washington, DC.

Anderson, M.G., Barnett, A., Clark, M., Prince, J., Olivero Sheldon, A. and Vickery B. 2016. Resilient and Connected Landscapes for Terrestrial Conservation. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA.

Askins, RA, F Chávez-Ramírez, BC Dale, CA Haas, JR Herkert, FL Knopf, and PD Vickery. 2007. Conservation of grassland birds in North America: Understanding ecological processes in different regions. Report of the AOU Committee on Conservation. Ornithological Monographs 64. https://doi.org/10.2307/40166905.

Atkinson, AJ, PC Trenham, RN Fisher, SA Hathaway, BS Johnson, SG Torres and YC Moore. 2004. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. Technical Report. U.S. Geological Survey, Western Ecological Research Center, Sacramento, CA.

Audubon. 2020. Appleton-Whittell Research Ranch of Audubon. The National Audubon Society. https://researchranch.audubon.org/ (accessed January 2020).

Averill-Murray, RC, TC Esque, LJ Allison, S Bassett, SK Carter, KE Dutcher, SJ Hromada, KE Nussear, and K Shoemaker. 2021, Connectivity of Mojave Desert tortoise populations—Management implications for maintaining a viable recovery network: U.S. Geological Survey Open-File Report 2021–1033. https://doi.org/10.3133/ofr20211033.

Avian Power Line Interaction Committee (APLIC). 2006. Suggested practices for avian protection on power lines: The state of the art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission, Washington, D.C. and Sacramento, CA.

Barnes, ME and ML Brown. 2011. A review of *Flavobacterium psychrophilum* biology, clinical signs, and bacterial cold water disease prevention and treatment.The Open Fish Science Journal 4:40-48.

Bender, LC, LA Lomas, and J Browning. 2007. Condition, survival, and cause-specific mortality of adult female mule deer in north-central New Mexico. The Journal of Wildlife Management 71:1118-1124.

Bennett, PS, M Kunzmann, LA Graham. 2013. Descriptions of Arizona vegetation represented on the GAP vegetation map. Version 5.2. U.S. Geological Survey.

Bernardet JF, P Segers, M Vancanneyt, F Berthe, K Kersters, P Vandamme. 1996. Cutting a Gordian knot: Emended classification and description of the genus *Flavobacterium*, emended description of the family *Flavobacteriaceae*, and proposal of *Flavobacterium hydatis nom. nov.* (basonym, *Cytophaga aquatilis* Strohl and Tait 1978). International Journal of Systematic Bacteriology 46:128-148.

Beschta, RL, JJ Rhodes, JB Kauffman, RE Gresswell, GW Minshall, JR. Karr, DA Perry, FR. Hauer, and CA Frissell. 2004. Postfire management on forested public lands of the western United States. Conservation Biology 18:957-967.

Bikel, AK, D Duval, G Frisvold. 2017. Arizona's agribusiness system: Contributions to the state economy. University of Arizona, Department of Agricultural and Resource Economics, Tucson, Arizona.https://economics.arizona.edu/arizonas-agribusiness-system-contributions-state-economy (accessed June 2021).

Bird Studies Canada and NABCI. 2014. Bird conservation regions. Published by Bird Studies Canada on behalf of the North American Bird Conservation Initiative. https://www.birdscanada.org/bird-science/nabci-bird-conservation-regions (accessed March 2020).

Blanchard, CJ. 1911. The dedication of Roosevelt Dam. Scientific American 104:271-272.

Boarman WI, Sazaki M. 2006. A highway's road-effect zone for desert tortoises (*Gopherus agassizii*). Journal of Arid Environments 65:94-101.

Bolin, B, BR Doos, J Jager, and RA Warrick. 1986. The Greenhouse Effect, Climate Change, and Ecosystems. John Wiley and Sons, New York, NY.

Bötsch, Y, Z Tablado, and L Jenni. 2017. Experimental evidence of human recreational disturbance effects on bird-territory establishment. Proceedings of the Royal Society 284:20170846. https://doi.org/10.1098/rspb.2017.0846

Bowman, WD, DM Cairns, JS Baron, and TR Seastedt. 2002. Islands in the sky: Alpine and treeline ecosystems of the Rockies. Pp 183-202 In JS Baron (ed.) Rocky Mountain Futures: An Ecological Perspective. Island Press, Washington, DC.

Boyarski, VL, MJ Ryan, and TB Cotten. 2019. Monitoring Program for Northern Mexican Gartersnakes (*Thamnophis eques megalops*) at Page Springs and Bubbling Ponds Fish Hatcheries. Nongame and Endangered Wildlife Program Technical Report 317. Arizona Game and Fish Department, Phoenix, Arizona.

Boyle, S, Samson, F. 1985. Effects of nonconsumptive recreation on wildlife: A Review. Wildlife Society Bulletin (1973-2006). 13:110-116. http://www.jstor.org/stable/3781422 (accessed March 2020).

Bradley, C and D. Colodner. 2019. The Sonoran Desert. Pp. 110-125 In. MI Goldstein and DA DellaSala (eds.) Encyclopedia of the World's Biomes. Elsevier.

Bradley, GA, PC Rosen, MJ Sredl, TR Jones, and JE Longcore. 2002. Chytridiomycosis in native Arizona frogs. Journal of Wildlife Diseases 38:206-212.

Brand, LA, JC Stromberg, and BR Noon. 2010. Avian density and nest survival on the San Pedro River: Importance of vegetation type and hydrologic regime. The Journal of Wildlife Management. 74:739-754.

Brennen, TC and AT Holycross. 2009. A field guide to the amphibians and reptiles in Arizona. Arizona Game and Fish Department, Phoenix, AZ.

Breshears, DD, NS Cobb, PM Rich, KP Price, CD Allen, RG Balice, WH Romme, JH Kastensf, ML Floyd, J Belnap, JJ Anderson, OB Myers, and CW Meyer. 2005. Regional vegetation die-off in response to global-change-type drought. Proceedings of the National Academy of Sciences 102:15144-15148.

Briggs, MK, EA Lozano-Cavazos, HM Poulos, J Ochoa-Espinoza, JA Rodriguez-Pineda. 2019. The Chihuahuan Desert: A binational conservation response to protect a global treasure. Pp. 126-138 In. MI Goldstein and DA DellaSala (eds.) Encyclopedia of the World's Biomes. Elsevier.

Bristow, KD, LE Harding, SR Boe, ML Crabb, and ES Rubin. 2013. Pronghorn (*Antilocapra americana*) movements and habitat use in the Big Chino Valley, Arizona. Arizona Game and Fish Department Technical Guidance Bulletin 15. Phoenix, AZ.

Brooks, ML. 1999. Alien annual grasses and fire in the Mojave Desert. Madroño 46:13-19.

Brooks, ML and JR Matchett. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980–2004. Journal of Arid Environments 67:148-164.

Brooks, ML and DA Pyke. 2001. Invasive plants and fire in the deserts of North America. Pages 1-14 In KEM Galley and TP 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, FL.

Brooks, ML and JC Chambers. 2011. Resistance to invasion and resilience to fire in desert shrublands of North America. Rangeland Ecology & Management 64:431-438.

Brouder, MJ. 2001. Effects of flooding on recruitment of roundtail chub, *Gila robusta*, in a southwestern river. The Southwestern Naturalist 46:302-310.

Brown, DE. 1982. Great Basin Conifer Woodlands. In. DE Brown (ed.) Desert Plants. Biotic communities of the American southwest United States and Mexico. Desert Plants 4.

Brown. DE. 1984. Arizona tree squirrels. Arizona Game and Fish Department, Phoenix, AZ.

Brown. DE. 1989. Arizona game birds. University of Arizona Press, Tucson, AZ.

Brown, DE (ed). 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City, UT.

Brown, D, E Makings, A Neils, D Jenness, RL Glinski, RD Babb, and M Traphagen. 2017. Biotic resources of the Lower Santa Cruz River Flats, Pinal County, Arizona. Desert Plants 32:3-52.

Brown, DE, RD Babb and CH Lowe, Jr. 2020. Biotic Communities, Pp 9-30 In AT Holycross and JC Mitchell (eds.) Snakes of Arizona. ECO Publishing, Rodeo, NM.

Brown, DE, and C Lowe. 1980. Biotic Communities – Southwestern United States and Northwestern Mexico [Map]. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service General Technical Report RM-78.

Brown, D and E Makings. 2014. A guide to North American grasslands. Desert Plants 29:1-158.

Brown, JH, TJ Valone, and CG Curtin. 1997. Reorganization of an arid ecosystem in response to recent climate change. Proceedings of the National Academy of Sciences 94:9729-9733.

Bunn, SE, SR Balcombe, PM Davies, CS Fellows, FJ McKenzie-Smith. 2006. Aquatic productivity and food webs of desert river ecosystems. Pp. 76-99 In. R. Kingsford (ed.) Ecology of Desert Rivers. Cambridge Press, Cambridge, UK.

Bureau of Land Management (BLM). 2020. U.S. Department of the Interior. Wild horse and burro program. https://www.blm.gov/programs/wild-horse-and-burro (accessed January 2020).

Burrell, AL, JP Evans, and MG De Kauwe. 2020. Anthropogenic climate change has driven over 5 million km2 of drylands towards desertification. Nature Communications 11:3853.

Cantrel, CJ, AT Robinson, and LD Avenetti. 2005. Habitat selection by Apache trout in six east-central Arizona streams. Transactions of the American Fisheries Society 134:1382-1388.

Center for the Future of Arizona. 2020. Young talent, 2020 Survey Report.

Chaney, E, W Elmore, and WS Platt. 1990. Livestock grazing on western riparian areas. U.S. Environmental Protection Agency, Washington, D.C.

Chhabra D, C Yoshioka, E Kim, and N Stevenson. 2018. Economic Impact of off-highway recreation in the state of Arizona. School of Community Resources and Development Arizona State University.

Cipriano, R. 2005. Intraovum infection caused by *Flavobacterium psychrophilum* among eggs from captive Atlantic salmon broodfish. Journal of Aquatic Animal Health 17:275-283.

Clement, JM, LE Harding, RW Lucas, ES Rubin. 2019. The Relative Imortance of Biotic and Abiotic Factors Influencing Aspen Recruitment in Arizona. Forest and Ecology Management 441 (2019) 32-41.

Clifford, MH, ME Rocca, R Delph, PL Ford, and NS Cobb. 2008. Drought induced tree mortality and ensuing bark beetle outbreaks in southwestern pinyon-juniper woodlands. Pp. 39-51 In. GJ Gottfried, JD Shaw, PL Ford (compilers) Ecology, management, and restoration of pinon-juniper and ponderosa pine ecosystems. USDA Forest Service, Rocky Mountain Research Station P-51. Fort Collins, CO.

Commission for Environmental Cooperation (CEC) and The Nature Conservancy (TNC). 2005. North American central grasslands priority conservation areas: Technical report and documentation. Eds. J.W. Karl and J. Hoth. Commission for Environmental Cooperation and The Nature Conservancy. Montreal, Quebec.

Coop, JD and TJ Givnish. 2007. Spatial and temporal patterns of recent forest encroachment in montane grasslands of the Valles Caldera, New Mexico, USA. Journal of Biogeography 34:914-927.

Coop, JD, SA Parks, CS Stevens-Rumann, SD Crausbay, PE Higuera, MD Hurteau, A Tepley, E Whitman, T Assal, BM Collins, KT Davis, S Dobrowski, DA Falk, PJ Fornwalt, PZ Fulé, BJ Harvey, VR Kane, CE Littlefield, EQ Margolis, M North, M-A Parisien, S Prichard, and KC Rodman. 2020. Wildfire-driven forest conversion in western North American landscapes. BioScience 70:659–673.

Corman, TE and C Wise-Gervais. 2005. Arizona Breeding Bird Atlas. University of New Mexico Press, Albuquerque.

Dahms, CW and BW Geils. 1997. An assessment of forest ecosystem health in the Southwest. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station RM-GTR-295. Fort Collins, CO.

Dimmit, MA and MH Fusari. 2015. Conservation issues in the Sonoran Desert region. Pp 1-2 In: MA Dimmitt, PW Comus, and LM Brewer (eds.) A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, AZ.

Dimmitt MA. 2015. Biomes and communities of the Sonoran Desert region. Pp 5-19 In: MA Dimmitt, PW Comus, and LM Brewer (eds.) A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, AZ.

Dolan, C and B Mannan. 2009. Invasive wildlife. University of Arizona College of Agriculture and Life Sciences, Cooperative Extension. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1481e.pdf (accessed February 2021).

Duval D, G Frisvold, and A Bickel. 2020. The economic value of trails in Arizona: A travel cost method study. Department of Agricultural and Resource Economics, University of Arizona Cooperative Extension.

Dykstra, BL, MA Rumble, LD Flake. 1997. Effects of timber harvesting on birds in the Black Hills of South Dakota and Wyoming, USA. Pp. 16-26 In: JE Cook and BP Oswald (compilers) First Biennial North American Forest Ecology Workshop: June 24-26, 1997, North Carolina State University, Raleigh, NC.

Eccleston DT. and RE Harness. 2018. Raptor electrocutions and power line collisions. Pp. 273-302 In: JH Sarasola, JM Grande, and JJ Negro (eds). Birds of Prey. Springer International Publishing, Cham, Switzerland.

Efroymson, RA, S Nemeth, and GW Suter. 2001. Ecological risk assessment framework for low altitude overflights by fixed-wing and rotary-wing military aircraft. U.S. Department of Defense. Publication No 5010, Environmental Sciences Division ORNL. DOI: 10.2172/777698.

Eigenbrod F, SJ Hecnar, and L Fahrig. 2009. Quantifying the road-effect zone: Threshold effects of a motorway on anuran populations in Ontario, Canada. Ecology and Society 14:24. http://www.ecologyandsociety.org/vol14/iss1/art24/ (accessed May 2020).

Eissa, E and E Elsayed. 2006. An overview on bacterial kidney disease. Life Science Journal 3:58-78.

Elliott, D, R Pascho, and G Bullock. 1989. Developments in the control of bacterial kidney disease of salmonid fishes. Diseases of Aquatic Organisms. 6:201-215.

Elzinga, CL, DW Salzer, JW Willoughby, and JP Gibbs. 2001. Monitoring plant and animal populations. Blackwell Science, Inc., Malden, MA.

Evelyn, T. 1993. Bacterial kidney disease - BKD. Pp. 177-195 In: V Inglis, RJ Roberts, and NR Bromage (eds.) Bacterial diseases of fish. Halsted Press, New York.

Esque, TC, and CR Schwalbe. 2002. Alien annual grasses and their relationships to fire and biotic change in Sonoran Desertscrub. Pages 165-194 In. B Tellman (ed.). Invasive exotic species in the Sonoran Desert. University of Arizona Press, Tucson.

Falk, DA, AC Watts, and AE Thode. 2019. Scaling ecological resilience. Frontiers in Ecology and Evolution. https://doi.org/10.3389/fevo.2019.00275.

Federal Aviation Association (FAA). 2021. FAA Wildlife Strike Database. https://wildlife.faa.gov/search (accessed December 2021).

Felger, RS, DS Turner, and MF Wilson. 2003. Flora and vegetation of the Mohawk Dunes, Arizona. SIDA 2:1155-1187.

Finch, DM, editor. 2012. Climate change in grasslands, shrublands, and deserts of the interior American West: A review and needs assessment. USDA Forest Service, Rocky Mountain Research Station RMRS-GTR-285. Fort Collins, CO.

Ffolliott, PF, MB Baker, Jr., LF DeBano, and DG Neary. 2004. Introduction. Pp. 1-9 In. MB Baker, Jr, PF Ffolliott, LF DeBano, and DG Neary(eds.), Riparian areas of the Southwestern United States: Hydrology, ecology and management. CRC Press. Boca Raton, FL.

Flesch, AD, CW Epps, JW Cain, M Clark, PR Krausman, and JR Morgart. Potential effects of the United States-Mexico border fence on wildlife. Conservation Biology 24:171–181.

Forman, RTT, and LE Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology Evolution and Systematics 29:207–231.

Frissel, CA. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California. Conservation Biology 8:629-644.

Furniss, MJ, TD Roeloffs, and CS Lee. 1991. Road construction and maintenance. Pp 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, MD.

Ganey JL, and Balda RP. 1989. Distribution and habitat use of Mexican spotted owls in Arizona. The Condor 91:355-361.

Garcia, K. 2009. Roosevelt Dam. Arcadia Publishing, Arizona.

Garfin G, G Franco, H Blanco, A Comrie, P Gonzalez, T Piechota, R Smyth, and R Waskom. 2014. Climate change impacts in the United States: The Third National Climate Assessment. Pp 462-486 In. JM Melillo, TC Richmond, and GW Yohe (eds.) U.S. Global Change Research Program. doi:10.7930/J08G8HMN.

Garfin, G, A Jardine, R Meredith, M Black, and S LeRoy, editors. 2013. Assessment of climate change in the southwest United States: A report prepared for the National Climate Assessment. A report by the Southwest Climate Alliance. Island Press, Washington, DC.

Garland, T, and WG Bradley. 1984. Effects of a highway on Mohave desert rodent populations. American Midland Naturalist 111:47-56.

Gauthier, DA, A Lafon, TP Toombs, J Hoth, and E Wiken. 2003. Grasslands: Toward a North American conservation strategy. Commission for Environmental Cooperation and Canadian Plains Research Center, University of Regina, Saskatchewan, Canada.

Geiger, E, G McPherson. 2005. Response of semi-desert grasslands invaded by non-native grasses to altered disturbance regimes. Journal of Biogeography 32:895-902.

Goodrich, DC, WG Kepner, LR Levick, and P J Wigington. 2018. Southwestern intermittent and ephemeral stream connectivity. Journal of the American Water Resources Association 54:400-422.

Gori, DF and CAF 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.

Governor's Forest Health Councils, State of Arizona. 2007. The statewide strategy for restoring Arizona's forests. Aumack, E, T Sisk, and J Palumbo, eds. Published by Arizona Public Service, Phoenix, AZ.

Graf, JB, R Webb, and R Hereford. 1991. Relation of sediment load and flood-plain formation to climatic variability, Paria River drainage basin, Utah and Arizona. GSA Bulletin 103:1405–1415.

Grant, EC, KR Inendino, WJ Love, and T Goldberg. 2005. Effects of practices related to catch-and-release angling on mortality and viral transmission in juvenile largemouth bass Infected with largemouth bass virus. Journal of Aquatic Animal Health 17:315-322.

Griffith, GE, JM Omernik, CB Johnson, and DS Turner. 2014. Ecoregions of Arizona (poster): U.S. Geological Survey Open-File Report 2014–1141, with map, scale 1:1,325,000, http://dx.doi.org/10.3133/ofr20141141.

Grizzle, JM and CJ Brunner. 2003. Review of largemouth bass virus. Fisheries 28:10-14.

Gruell, GE. 1999. Historical and modern roles of fire in pinyon-juniper. Pp 24-28 In SB Monsen and R Stevens (eds.). Ecology and management of pinyon-juniper communities within the Interior West. USDA Forest Service, Rocky Mountain Research Station RMRS-P-9., Ogden, UT.

Gucker, CL. 2009. *Eragrostis curvula*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us /database/feis/plants/graminoid/eracur/all.html (accessed July 2020).

Guide to North American Birds: Bronzed cowbird. National Audubon Society. [online] URL: https://www.audubon.org/field-guide/bird/bronzed-cowbird (accessed February 2020).

Guiterman, CH, EQ Margolis, CD Allen, DA Falk, and TW Swetnam. 2018. Long-term persistence and fire resilience of oak shrubfields in dry conifer forests of Northern New Mexico. Ecosystems 21:943–959.

Haack, RA, and JW Byler. 1993. Insects and pathogens: Regulators of forest ecosystems. Journal of Forestry 91:32-37.

Hale, SL, JL Koprowski, and H Hicks. 2013. Review of black-tailed prairie dog reintroduction strategies and site selection: Arizona reintroduction. Pp. 310-315 In. GJ Gottfried, PF Ffolliott, BS Gebow, LG Eskew, G Lane, and LC Collins (comps.) Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts. USDA Forest Service, Rocky Mountain Research Station RMRS-P-67. Fort Collins, CO.

Hall, JA, S Weinstein, and CL McIntyre. 2005. The impacts of livestock grazing in the Sonoran Desert. A literature review and synthesis. The Nature Conservancy in Arizona, Tucson.

Heinz Center. 2009. Measuring the results of wildlife conservation activities. Washington, DC.

Hendricks, DM, PR Krausman, RW Mannan, FD Hole, HW Peirce, SJ Levine, DF Post, CW Guernsey, YH Havens, JE Jay, ML Richardson, and PR Krausman. 1985. Arizona soils. College of Agriculture, University of Arizona.

Hendrickson, DA, and WL Minckley. 1984. Ciénegas - vanishing climax communities of the American Southwest. Desert Plants 6:131-175.

Hereford, R. 1984. Climate and ephemeral-stream processes: Twentieth-century geomorphology and alluvial stratigraphy of the Little Colorado River, Arizona. GSA Bulletin 95:654–668.

Hereford, R and L Amoroso. 2021. Historical and prehistorical water levels of Mormon Lake, Arizona as a measure of climate change on the southwest Colorado Plateau, USA. Quaternary Research 100:32-51.

Hessburg, PF and JK Agee. 2003. An environmental narrative of inland northwest United States forests, 1800-2000. Forest Ecology and Management 178:23-59.

Hoffmeister, DF. 1986. Mammals of Arizona. University of Arizona Press, Tucson.

Hruska, T, D Toledo, R Sierra-Corona, V Solis-Gracia. 2017. Social-ecological dynamics of change and restoration attempts in the Chihuahuan Desert grasslands of Janos Biosphere Reserve, Mexico. Plant Ecology 218:67-80.

Huijser, MPJ, W Duffield, AP Clevenger, RJ Ament, and PT McGowen. 2009. Cost–benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada; a decision support tool. Ecology and Society 14:15. http://www.ecologyandsociety.org/vol14/iss2/art15/ (accessed January 2020).

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, Pachauri RK and Meyer LA [eds.]). IPCC, Geneva, Switzerland.

Invasive Mussel Collaborative, Great Lakes Commission. 2018. Strategy to advance management of invasive zebra and quagga mussels. https://invasivemusselcollaborative.net/wp-content/uploads/2018/11/IMC-Strategy-Nov-2018-final.pdf (accessed February 2020).

lseri, KT, and WB Langbein. 1974. Large rivers of the United States. Geological Survey Circular 686. U.S. Geological Survey, Reston, VA.

Ivanyi CI, J Johnson, T Van Devender, and H Lawler. 2015. Sonoran Desert reptiles and amphibians. Pp. 454-489 In: MA Dimmitt, PW Comus, and LM Brewer (eds.) A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, AZ.

Jaeger, KL, JD Olden, and NA Pelland. 2014. Climate change poised to threaten hydrologic connectivity and endemic fishes in dryland streams. Proceedings of the National Academy of Sciences of the United States of America 111:13894-13899.

Jansen, BD, PR Krausman, JR Heffelfinger, and JC Devos. 2010. Bighorn sheep selection of landscape features in an active copper mine. Wildlife Society Bulletin 34:1121-1126

Johnson, PT, Olden, JD, and MJ Vander Zanden. 2008. Dam invaders: impoundments facilitate biological invasions into freshwaters. Frontiers in Ecology and the Environment 6:357-363.

Jonathan DC, SA Parks, CS Stevens-Rumann, SD Crausbay, PE Higuera, MD Hurteau, A Tepley, E Whitman, T Assal, BM Collins, KT Davis, S Dobrowski, DA Falk, PJ Fornwalt, PZ Fulé, BJ Harvey, VR Kane, CE Littlefield, EQ Margolis, M North, M-A Parisien, S Prichard, KC Rodman. 2020. Wildfire-driven forest conversion in western North American landscapes. BioScience 70:659–673.

Jones, AS, JJ Anderson, BG Dickson, S Boe, and ES Rubin. 2017. Off-highway vehicle road networks and kit fox space use. The Journal of Wildlife Management 81:230-237.

Jones, TR. 2013. A survey/monitoring plan for bullfrogs and native ranid frogs in the Peña Blanca Lake region, Santa Cruz County, Arizona. Nongame and Endangered Wildlife Program Technical Report 337. Arizona Game and Fish Department, Phoenix, Arizona.

Jones TR, and M Goode. 2020. Conservation. Pages 33–51 In AT Holycross and JC Mitchell (eds.). Snakes of Arizona. ECO Publishing, Rodeo, NM.

Kagan, RA, TC Viner, PW Trail, and EO Espinoza. 2014. Avian mortality at solar energy facilities in southern California: A preliminary analysis. National Fish and Wildlife Forensics Laboratory.

Ketcham, SL, and JL Koprowski. 2013. Impacts of wildfire on wildlife in Arizona: A synthesis. Pp. 345-350 In. J Gottfried, J Gerald, PF Ffolliott, BS Gebow, LG Eskew, and LC Collins (comps) Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts. USDA Forest Service, Rocky Mountain Research Station RMRS-P-67. Fort Collins, CO.

Knight, RL and DN Cole. 1995. Wildlife responses to recreationists. Pp. 54-69 In. RL Knight and KJ Gutzwiller (eds.) Wildlife and recreationists: coexistence through management and research. Island Press, Washington DC.

Koloszar, JG and TK Snow. 1999. Subalpine grassland bat survey on the Apache-Sitgreaves National Forest. Nongame and Endangered Wildlife Program Technical Report 145. Arizona Game and Fish Department, Phoenix, Arizona.

Kosciuch K, D Riser-Espinoza, M Gerringer, and W Erickson. 2020. A summary of bird mortality at photovoltaic utility scale solar facilities in the Southwestern U.S. PLoS ONE 15: e0232034. https://doi.org/10.1371/journal.pone.0232034.

Kunz, TH, EB Arnett, BM Cooper, WP Erickson, RP Larkin, T Mabee, ML Morrison, MD Strickland, and JM Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document. Journal of Wildlife Management 71:2449-2486.

Lee, RM and JN Rinne. 1980. Critical thermal maxima of five trout species in the southwestern United States. Transactions of the American Fisheries Society 109:632-635.

Levick, L, J Fonseca, D Goodrich, M Hernandez, D Semmens, R Leidy, M Scianni, P Guertin, M Tluczek, and W Kepner. 2008. The ecological and hydrological significance of ephemeral and intermittent streams in the arid and semi-arid American Southwest. EPA/600/R-08/134 and ARS/233046. Washington, D.C.: U.S. Environmental Protection Agency, Office of Research & Development and USDA/ARS Southwest Watershed Research Center.

Loeser, MR, TD Sisk, TE Crews, K Olsen, C Moran, and C Hudenko. 2012. Reframing the grazing debate: Evaluating ecological sustainability and bioregional food production. Center for Environmental Sciences and Education Northern Arizona University.

Loss, SR, Will, T, and Marra, PP. 2014. Refining estimates of bird collision and electrocution mortality at power lines in the United States. PloS one 9: e101565. https://doi.org/10.1371/journal.pone.0101565. (Accessed June 2021).

Lovich, JE, JR. Ennen. 2011. Wildlife conservation and solar energy development in the Desert Southwest, United States. BioScience 61:982–992.

Lytle CM, BN Smith, and CZ McKinnon. 1995. Manganese accumulation along Utah roadways: a possible indicator of motor vehicle exhaust pollution. The Science of the Total Environment 162:105-109.

MacConnell E and ER Vincent. 2002. Review: the effects of *Myxobolus cerebralis* on the salmonid host. Pp. 95-107. In JL Bartholomew and JC Wilson (eds.) Whirling disease: reviews and current topics. American Fisheries Society Symposium 29, Bethesda, MD.

Maceina, MJ and JM Grizzle. 2006. The relation of largemouth bass virus to largemouth bass population metrics in five Alabama reservoirs. Transactions of the American Fisheries Society 135:545-555.

Malcolm, JR, L Canran, RP Neilson, L Hansen, and L Hannah. 2006. Global warming and extinctions of endemic species from biodiversity hotspots. Conservation Biology 20: 538–548.

Margolis, EQ, EW Huffman and JM Iniguez. 2013. Southwestern mixed conifer forests: Evaluating reference conditions to guide ecological restoration treatments. Working Paper 28, Ecological Restoration Institute, Northern Arizona University, Flagstaff, AZ.

Margolis, EQ, TW Swetnam, and CD Allen. 2011. Historical stand-replacing fire in upper montane forests of the Madrean Sky Islands and Mogollon Plateau, southwestern USA. Fire Ecology 7:88-107.

Master, LL, D Faber-Langendoen, R Bittman, GA Hammerson, B Heidel, L Ramsay, K Snow, A Teucher, and A Tomaino. 2012. NatureServe conservation status assessments: factors for evaluating species and ecosystem risk. NatureServe, Arlington, VA.

Mattson, WJ and RA Haack. 1987. The role of drought in outbreaks of plant-eating insects. Bioscience 37:110-118.

Mawdsley, JR, Scott, DP, Johansen, PR, and Mason, JR (eds.), 2020. AFWA President's task force on shared science and landscape conservation priorities: Final report. Association of Fish and Wildlife Agencies, Washington, DC.

McLaughlin, SP and JE Bowers. 1982. Effects of wildfire on a Sonoran Desert plant community. Ecology 63:246-248.

McIntosh, BA, JR Sedell, JE Smith, RC Wissmar, SE Clarke, GH Reeves, and LA Brown. 1994. Management history of east-side ecosystems: Changes in fish habitats over 50 years, 1935-1992. USDA Forest Service Pacific Northwest Research Station PNW-GTR-321, Portland, OR.

McPherson, GR. 1992. Ecology of oak woodlands in Arizona. Pp 24-33 In PF Ffolliott, GJ Gottfried, DA Bennett, VM Hernandez, A Ortega-Rubio, and RH Hamre (tech. coords.) Ecology and management of oak and associated woodlands: perspectives in the southwestern United States and northern Mexico. USDA Forest Service RM-GTR-218. Fort Collins, CO.

Melillo, JM, TC Richmond, and GW Yohe (eds). 2014: Climate change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program.

Milchunas, DG. 2006. Responses of plant communities to grazing in the southwestern United States. USDA Forest Service, Rocky Mountain Research Station, RMRS-GTR-169. Fort Collins, CO.

Millennium Ecosystem Assessment, 2005. Ecosystems and human well-being: Synthesis. Island Press, Washington, DC.

Miller D, M Gray, and A Storfer. 2011. Ecopathology of ranaviruses infecting amphibians. Viruses 3:2351-2373.

Minckley, TA, DS Turner, and SR Weinstein. 2013. The relevance of wetland conservation in arid regions: A re-examination of vanishing communities in the American Southwest. Journal of Arid Environments 88:213-221.

Minckley, WL and PC Marsh. 2009. Inland fishes of the greater Southwest: Chronicle of a vanishing biota. University of Arizona Press, Tucson.

Mock CJ. 1996. Climatic controls and spatial variations of precipitation in the western United States. Journal of Climate 9:1111–1125.

Moir, WH and JH Dieterich. 1988. Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico. Natural Areas Journal 8:17-24.

Monsen, SB and R Stevens. 1999. Symposium on pinyon and juniper ecology, restoration, and management: introduction. Pp 3-4 In SB Monsen and R Stevens (eds.). Ecology and management of pinyon-juniper communities within the Interior West. USDA Forest Service, Rocky Mountain Research Station, RMRS-P-9. Ogden, UT.

Murcia, C. 1995. Edge effects in fragmented forests: Implications for conservation. Trends in Ecology and Evolution 10:58-62.

Nabhan, GP. 2015. Welcome to the Sonoran Desert. Pp. 1-2 In: MA Dimmitt, PW Comus, and LM Brewer (eds.) A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, AZ.

National Park Service (NPS). 2015. Glen Canyon. https://www.nps.gov/glca/learn/nature/soils.htm. Accessed July 2021.

NatureServe.2022. NatureServe Network Biodiversity Location Data. NatureServe, Arlington, Virginia. NatureServe. 2022.

NatureServe. 2021. Madrean lower montane pine-oak forest and woodland. https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.722877/Madrean_Lower_Montane_Pine-Oak_Forest_and_Woodland (accessed March 2020).

Negron, JF, JD McMillin, JA Anhold, and D Coulson. 2009. Bark beetle-caused mortality in a drought-affected ponderosa pine landscape in Arizona, USA. Forest ecology and management 257:1353–1362.

New Census Report Ranks Arizona Third In Percentage Growth Rate. Office of the Governor, Doug Ducey. News Release. December 19, 2019. https://azgovernor.gov/governor/news/2019/12/new-census-report-ranks-arizona-third-percentage-growth-rate (accessed January 2020).

NOAA National Centers for Environmental Information, 2016. State summaries: 149 Arizona. https://statesummaries.ncics.org/downloads/AZ-print-2016.pdf (accessed January 2020).

North American Bird Conservation Initiative (NABCI). 2020. Bird conservation regions. https://nabci-us.org/resources/bird-conservation-regions/ (accessed February 2020).

Olden, JD and NL Poff. 2005. Long-term trends of native and non-native fish faunas in the American Southwest. Animal Biodiversity and Conservation 28:75-89.

Omernik, JM. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118-125.

Ouren, DS, C Haas, CP Melcher, SC Stewart, PD Ponds, NR Sexton, L Burris, T Fancher and ZH Bowen. 2007. Environmental effects of off-highway vehicles on Bureau of Land Management lands: A literature synthesis, annotated bibliographies, extensive bibliographies, and internet resources: U.S. Geological Survey, Open-File Report 2007-1353.

Paine, RT, MJ Tegner, and EA Johnson. 1998. Compounded perturbations yield ecological surprises. Ecosystems 1:535–545.

Parendes LA, and JA Jones. 2000. Role of light availability and dispersal in exotic plant invasion along roads and streams in the H.J. Andrews Experimental Forest, Oregon. Conservation Biology 14:64–75.

Parris KM, and A Schneider. 2009. Impacts of traffic noise and traffic volume on birds of roadside habitats. Ecology and Society 14:29. http://www.ecologyandsociety.org/vol14/iss1/art29 (accessed January 2020).

Pase, CP and DE 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, UT.

Patten, DT and JC Stromberg. 1995. Dynamics of the landscape patches in the old growth forest on Mt. Graham (Pinaleño Mountains), Arizona. Pp. 174-179 In LF DeBano, PF Folliott, A Ortega-Rubio, GJ Gottfried, RH Hamre, and CB Edminster (eds.). Biodiversity and management of the Madrean Archipelago: The sky

islands of southwestern United States and northwestern Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, RM-GTR-264. Fort Collins, CO.

Peet, PK. 1988. Forests of the Rocky Mountains. Pp. 64-101 In. MG Barbour and WD Billings (eds.). North American terrestrial vegetation. Cambridge University Press, New York.

Petre, SJ, and SA Bonar. 2017. Determination of habitat requirements for Apache Trout. Transactions of the American Fisheries Society 146:1-15.

Phillips, A, J Marshall and G Monson. 1964. The birds of Arizona. University of Arizona Press, Tucson.

Pimentel, D, L Lach, R Zuniga, and D Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. Bioscience. 50:53-65.

Poulos H, JV Díaz, JC Paredes, A Camp, and RG Gatewood. 2013. Human influences on fire regimes and forest structure in the Chihuahuan Desert borderlands. Forest Ecology and Management 298:1–11.

Propst, DL and KR Bestgen. 1991. Habitat and biology of the loach minnow, *Tiaroga cobitis*, in New Mexico. Copeia 1991:29–38.

Pyne, SJ. 1984. Introduction to wildland fire: Fire management in the United States. Wiley, New York.

Reno PW. 1999. Infectious pancreatic necrosis and associated aquatic birnaviruses. Pp. 1-54 In. PTK Woo and DW Bruno (eds.) Fish Diseases and Disorders, Vol. 3. CABI, New York.

Reijnen R, R Foppen, CT Braak, and J Thissen. 1995. The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. Journal of Applied Ecology 32:187-202.

Right-Of-Way Stewardship Council. 2016. Accreditation standards for assessing IVM excellence. http://www.rowstewardship.org/resource_pdfs/2016_rowsc_accreditation_standards.pdf (accessed January 2020).

Rinne, JN. 1980. Spawning habitat and behavior of Gila trout, a rare salmonid of the southwestern United States. Transactions of the American Fisheries Society 109:83-91.

Rinne, JN. 1991. Habitat use by spikedace, *Meda fulgida* (Pisces: Cyprinidate) in southwestern streams with reference to probable habitat competition by red shiner, *Notropis lutrensis* (Pisces: Cyprinidae). The Southwestern Naturalist 36:7-13.

Rinne, JN. 2001. Effects of substrate composition on Apache trout fry emergence. Journal of Freshwater Ecology 16:355-365.

Rinne, JN, JR Simms, and H Blasius. 2005. Changes in hydrology and fish fauna in the Gila River, Arizona-New Mexico: Epitaph for a native fish fauna? American Fisheries Society symposium 45:127–137.

Rubin, ES, WM Boyce, and VC Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81:769-786.

Ryan, MJ, AB Smith, S Lashway, KK Smith, SB Riddle, CM Akins, BR Blais, and KT Krahn. 2019. A five-year narrow-headed gartersnake (*Thamnophis rufipunctatus*) survey summary from Canyon Creek, Arizona-Revised. Nongame and Endangered Wildlife Program Technical Report 323. Arizona Game and Fish Department, Phoenix, Arizona.

Salafsky N, D Salzer, AJ Stattersfield, C Hilton-Taylor, R Neugarten, SH Butchart, B Collen, N Cox, LL Master, S O'Connor, and D Wilkie. 2008. A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. Conservation Biology 22:897-911.

Sallabanks, R, and EB Arnett, 2005. Accommodating Birds in Managed Forests of North America: A Review of Bird-Forestry Relationships. Pp. 345-372 In. C Ralph, R John, and D Terrell (eds.) Bird conservation implementation and integration in the Americas: Proceedings of the third international Partners in Flight conference. USDA Forest Service, Pacific Southwest Research Station PSW-GTR-191. Albany, CA.

Scarborough R and RC Brusca. 2015. Geologic origin of the Sonoran Desert. Pp. 71–84 In. MA Dimmitt, PW Comus, and LM Brewer (eds.) A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, AZ.

Schalau, J. 2008. Arizona's interior chaparral. University of Arizona, Cooperative Extension, Yavapai County.

Schmidt, KM, JP Menakis, CC Hardy, WJ Hann, and DL Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. USDA Forest Service, Rocky Mountain Research Station RMRS-GTR-87. Fort Collins, CO.

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.

Scotter, G. W. 1980. Management of wild ungulate habitat in the western United States and Canada: A review. Journal of Range Management, 33(1), 16-27.

Severson, KE and AL Medina. 1983. Deer and elk habitat management in the southwest. Journal of Range Management Monograph 2:1-64.

Shaw, JD, J Menlove, C Witt, TA Morgan, MC Amacher, SA Goeking, and CE Werstak. 2018. Arizona's forest resources, 2001–2014. USDA Forest Service, Rocky Mountain Research Station RMRS-RB-25. Fort Collins, CO.

Simons, LH. 1989. Vertebrates killed by desert fire. The Southwestern Naturalist 34:144-145.

Singh, M. 2010. Water consumption at copper mines in Arizona. State of Arizona Department of Mines & Mineral Resources Special Report 29.

Sleeman, JM, T DeLiberto, and N Nguyen. 2017. Optimization of human, animal, and environmental health by using the One Health approach. Journal of Veterinary Science 18(S1):263-268.

Souther, S, M Loeser, TE Crews, and T Sisk. 2019. Complex response of vegetation to grazing suggests need for coordinated, landscape-level approaches to grazing management. Global Ecology and Conservation 20:e00770. https://doi.org/10.1016/j.gecco.2019.e00770

Southwest Climate Adaptation Science Center (SWCASC) and Center for Climate Adaptation Science and Solutions (CCASS). 2020. Ecosystem Transformation After Large-scale Disturbance (Webinar). https://www.swcasc.arizona.edu/ecosystem-resilience-2-ecosystem-transformation-after-large-scale-disturbance (accessed March 2020).

Spence, JR. 2008. Spring supported vegetation along the Colorado River on the Colorado Plateau: Floristics, vegetation structure, and environment. Pp. 185-210 In. LE Stevens and VJ Meretsky (eds.). Aridland Springs in North America: Ecology and Conservation. University of Arizona Press, Tucson.

Spring Stewardship Institute (SSI). 2020. Museum of Northern Arizona. https://springstewardshipinstitute.org/ (accessed January 2020).

Springer, AE, LE Stevens, D Anderson, RA Parnell, D Kreamer, and S Flora. 2008. A comprehensive springs classification system: integrating geomorphic, hydrogeochemical, and ecological criteria. Pp. 49-75 In LE Stevens and VJ Meretsky (eds.) Aridland Springs in North America: Ecology and Conservation. University of Arizona Press, Tucson.

Steidl, RJ, Andrea R. Litt, and WJ Matter. 2013. Effects of plant invasions on wildlife in desert grasslands. Wildlife Society Bulletin 37: 527-536.

Stein, Bruce A. 2002. States of the Union: Ranking America's biodiversity. Arlington, Virginia: NatureServe.

Stem, CR, N Margoulis, N Salafsky, and M Brown. 2005. Monitoring and evaluation in conservation: A review of trends and approaches. Conservation Biology 19:295-309.

Stevens, LE, JD Ledbetter, AE Springer, C Campbell, L Misztal, M Joyce, and G Hardwick. 2016. Arizona springs restoration handbook. Spring Stewardship Institute, Museum of Northern Arizona, Flagstaff, and Sky Island Alliance, Tucson, AZ.

Stevens, R and SB Monson. 2004. Guidelines for restoration and rehabilitation of principal plant communities. Pp. 199-294 In SB Monson, R Stevens and NL Shaw (comps.). Restoring western ranges and wildlands. USDA Forest Service, Rocky Mountain Research Station RMRS-GTR-136-V1. Fort Collins, CO.

Stringer, CE, KW Krauss, JS Latimer, eds. 2016. Headwaters to estuaries: Advances in watershed science and management. Proceedings of the Fifth Interagency Conference on Research in the Watersheds. USDA Forest Service, Southern Research Station, e-GTR-SRS-211. Asheville, NC.

Stromberg JC and BJ Tellman. 2009. Ecology and conservation of the San Pedro River. University of Arizona Press, Tucson.

Superfund Research Program. Copper mining and processing: copper mining in Arizona and Tribal Lands. University of Arizona. https://www.superfund.arizona.edu/learning-modules/tribal-modules/copper/AZ-tribal (accessed March 2020).

Tausch, RJ. 1999. Historic pinyon and juniper woodland development. Pp. 12-19 In. SB Monsen and R Stevens (comps). Proceedings: Ecology and management of pinyon-juniper communities within the Interior West. USDA Forest Service, Rocky Mountain Research Station, RMRS-P-9. Ogden, UT.

Tellman, B, R Yarde, and MG Wallace. 1997. Arizona's changing rivers: How people have affected the rivers. Water Resources Research Center, College of Agriculture, The University of Arizona, Tucson.

Thompson JR, Rutter AJ, and Ridout PS. 1986. The salinity of motorway soils. II. Distance from the carriageway and other sources of local variation in salinity. Journal of Applied Ecology 23:269-280.

Tiller, R, M Hughes, and G Bodner. 2012. Sacaton riparian grasslands: Mapping distribution and ecological condition using state-and-transition models in the Upper Cienega Creek Watershed. The Nature Conservancy, Tucson, AZ.

The Nature Conservancy (TNC). 1982. Natural heritage program operations manual. The Nature Conservancy, Arlington, Virginia (Unpublished).

TNC. 2004. Arizona forest legacy program: Assessment of need. Report to Arizona State Land Department, Fire Management Division, Phoenix, Arizona..

TNC. 2021. Grassland status and diversity. https://azconservation.org/projects/grasslands (accessed July 2021).

Trombulak SC, and Frissell CA. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

Tuhy, JS, 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, UT.

Turner, RM. 1994a. Sonoran Desertscrub. Pp. 181-221. In DE Brown (ed.). Biotic Communities: Southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City.

Turner, RM. 1994b. Cold-temperate desertlands. Great Basin desertscrub Pp. 144-155 In DE Brown, ed. Biotic communities: Southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City.

Turner, R. M. 1994c. 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.

Teaming With Wildlife Committee (TWW). 2003. State wildlife conservation strategies: Defining a vision for conservation success. International Association of Fish and Wildlife Agencies, Washington DC.

Uchytil, RJ. 1992. *Eragrostis lehmanniana*. In: Fire effects information system. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). https://www.fs.fed.us/database/feis/plants/graminoid/eraleh/all.html (accessed July 2021).

University of Arizona (UA) Cooperative Extension College of Agriculture and Life Sciences. 2007. Invasive plants in Arizona's forests and woodlands. https://www.fs.fed.us/rm/pubs_other/rmrs_2007_rogstad_a001.pdf (accessed January 2020).

Updike, RG, EG Ellis, WR Page, MJ Parker, JB Hestbeck, and WF Horak (eds.). 2013. United States–Mexican Borderlands: Facing tomorrow's challenges through USGS science: U.S. Geological Survey Circular 1380.

U.S. Census Bureau, Geography: State Area Measurements, 2010. https://www.usgs.gov/special-topic/water-science-school/science/how-wet-your-state-water-area-each-state?qt-science_center_objects=0#qt-science_center_objects (accessed June 2020).

U.S. Census Bureau. 2020. Quick Facts - Arizona. https://www.census.gov/quickfacts/fact/table/AZ# (accessed February 2020).

U.S. Department of Agriculture (USDA). 2010. A guide for addressing climate change in forest plan Revisions for Southwestern national forests and national grasslands: Southwestern region climate change trends and forest planning. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5181242.pdf (accessed February 2021).

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011. 2011 national survey of fishing, hunting, and wildlife-associated recreation.

U.S. Environmental Protection Agency (USEPA). Harmful Algae Blooms. 2019. Nutrient Pollution. https://www.epa.gov/nutrientpollution/harmful-algal-blooms (accessed January 2020).

USEPA. 2012. Climate and land use change effects on ecological resources in three watersheds: A synthesis report (final report), 17-27. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-07/086F, 2012.

U.S. Fish and Wildlife Service (USFWS). 2012. The Cost of Invasive Species. https://www.fws.gov/verobeach/PythonPDF/CostofInvasivesFactSheet.pdf (accessed January 2020).

USFWS. 2019. Examining the impacts of disease on wildlife conservation and management. testimony of Stephen Guertin, deputy director for policy. Department of the Interior. https://www.doi.gov/ocl/disease-and-wildlife-management (accessed May 2020).

USFWS. 2020. Species status assessment report for the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), 1st revision. January 2020. Albuquerque, NM. 160pp.

U.S. Forest Service (USFS). 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.

USFS. 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 (accessed January 2020).

USFS. 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 (accessed February 2020).

USFS. 2020. Forest insect and disease conditions in the Southwestern Region, 2019. Forest Health PR-R3-16-19.

USFS. 2021. Grasslands: General Information from Rocky Mountain Research Station Air, Water, & Aquatic Environments Program. fs.fed.us/rm/boise/AWAE/labs/awae_flagstaff/highlands/vegetation/grasslands/glgeneral.html (accessed July 2020).

USFS. 2010. Southwest region climate change trends and forest planning, United States Department of Agriculture, Forest Service, Southwestern Region.

U.S. Geological Survey (USGS). 2005. Precipitation History of the Mojave Desert Region, 1893–2001. https://pubs.usgs.gov/fs/fs117-03/. (accessed July 2021).

USGS, Southwest Biological Science Center. 2016. Dryland forest sustainability. https://www.usgs.gov/centers/sbsc/science/terrestrial-ecosystems-and-restoration (accessed May 2020).

USGS. 2017. National anthropogenic barrier dataset. http://sciencebas.gov/catalog (accessed September 2020).

USGS. 2018. Mineral commodity summaries 2018: U.S. Geological Survey, https://doi.org/10.3133/70194932 (accessed May 2020).

USGS. 2021. Mineral commodity summaries 2021: U.S. Geological Survey, https://doi.org/10.3133/mcs2021.

U.S. Energy Information Administration. Washington, D.C. Available from https://www.eia.gov/state/?sid=AZ (accessed June 2021).

Van Riper, C, III., and R Ockenfels. 1998. The influence of transportation corridors on the movement of pronghorn antelope over a fragmented landscape in northern Arizona. Pp. 241-248 In. GL Evink, D Ziegler, and J Berry (eds.) Proceedings of international conference on wildlife ecology and transportation, February 10-12, 1998, Fort Myers, FL. US Department of Transportation.

Walsh, J, D Wuebbles, K Hayhoe, J Kossin, K Kunkel, G Stephens, P Thorne, R Vose, M. Wehner, J Willis, D Anderson, S Doney, R Feely, P Hennon, V Kharin, T Knutson, F Landerer, T Lenton, J Kennedy, and R Somerville. 2014. Our changing climate. Pp. 19-67 In. JM Melillo, T Richmond, and GW Yohe (eds.) Climate Change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program. doi:10.7930/J0KW5CXT.

Walstad, JD, SR Radosevich, and DV Sandberg (eds). 1990. Natural and prescribed fire in Pacific Northwest forests. Oregon State University Press, Corvalis, OR.

Walther, GR, E Post, P Convey, A Mensel, C Parmesan, TJC Beebee, J Fromentin, O Hoegh-Gulberg, and F Bairlein. 2002. Ecological responses to recent climate change. Nature 416:389-395.

Warshall, P. 1995. The Madrean Sky Island Archipelago: A planetary overview. Pp.6-18 in LF DeBano, PF Ffolliott, RH Hamre, CB Edminster, PF Ffolliott, and A Ortega-Rubio. Biodiversity and management of the Madrean Archipelago: The Sky Islands of Southwestern United States and Northwestern Mexico. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station RM-GTR-264. Fort Collins, CO.

Welsh, SL, and CA Toft. 1981. Biotic communities of hanging gardens in southeastern Utah. National Geographic Society Research Reports 13:663-681.

Wemple, BC, JA Jones, and GE Grant. 1996. Channel network extension by logging roads in two basins, western Cascades, Oregon. Water Resources Bulletin 32:1195-1207.

Western Association of Fish and Wildlife Agencies. 2019. Western monarch butterfly conservation plan, 2019–2069. Version 1.0. https://wafwa.org/wpdm-package/western-monarch-butterfly-conservation-plan-20192069/?wpdmdl=13048&refresh=61f7bf8e887281643626382&ind=1602171186650&filename=WAFWA_Monarch_Conservation_Plan.pdf (accessed January 2022)

Whitbeck, DC and JS Fehmi. 2016. Variables influencing law enforcement off-road route proliferation on an arid site. Remote Sensing Applications: Society and Environment 3:45-52.

Wolf, K. 1988. Fish viruses and fish viral diseases. Cornell University Press, Ithaca, NY.

Wong, D.1999. Community analysis of hanging gardens at Zion National Park, Utah and the Colorado Plateau. Northern Arizona University, Flagstaff, AZ.

Wood, BM and MB Bain. 1995. Morphology and microhabitat use in stream fish. Canadian Journal of Fisheries and Aquatic Sciences 52:1287-1498.

Zaimes, G, MA Crimmins, D Green, and M Nichols. 2006. Understanding Arizona's Riparian Areas. [online] URL: https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1432.pdf

Zuliani, M, N Ghazian, CJ Lortie. 2021. Shrub density effects on the community structure and composition of a desert animal community. Wildlife Biology 2021:wlb.00774. doi:10.2981/wlb.00774

Appendices

Appendix A: Acronyms in the AWCS

4FRI Four Forest Restoration Initiative
ABBA Arizona Breeding Bird Atlas
ABCI Arizona Bird Conservation Initiative
ACC Arizona Corporation Commission
ADEQ Arizona Dept of Environmental Quality
ADOT Arizona Dept of Transportation
ADWR Arizona Dept of Water Resources
AFWA Association of Fish and Wildlife Agencies
AIDTT Arizona Interagency Desert Tortoise Team
AMA Active Management Area
APH Apache Highlands Ecoregion
APLIC Avian Power Line Interaction Committee
ARCC Aquatics Research and Conservation Center
ASLD Arizona State Land Department
ASP Arizona State Parks
ATV All-Terrain Vehicle
AUD Angler Use Days
AWCS Arizona Wildlife Conservation Strategy
AZCBM Arizona Coordinated Bird Monitoring Program
AZFWCO Arizona Fish and Wildlife Conservation Office
AZGFD Arizona Game and Fish Department
BCR Bird Conservation Region
BLM Bureau of Land Management
CAGCS Central Arizona Grassland Conservation Strategy
CAP Central Arizona Project
CAT Conservation Analysis Tool
CCA Candidate Conservation Agreements
CCAA Candidate Conservation Agreements with Assurances
CCAS Climate Change Adaptation Strategies
CEC Commission for Environmental Cooperation
CFA Center for the Future of Arizona
CHAT Critical Habitat Assessment Tool
CMA Conservation Management Area
COA Conservation Opportunity Area
CWCS Comprehensive Wildlife Conservation Strategy
CWD Chronic Wasting Disease
DEM Digital Elevation Model
DOD Department of Defense
EPA Environmental Protection Agency
ESA Endangered Species Act
FAA Federal Aviation Administration
FHWA Federal Highway Administration
FTHL Flat-tailed Horned Lizard
GIS Geographic Information System
HCP Habitat Conservation Plan
HDMS Heritage Database Management System
HMA Herd Management Area
HMN Hummingbird Monitoring Network
HUC Hydrologic Unit Code
IBA Important Bird Area
IPCC International Panel on Climate Change
IUCN International Union for the Conservation of Nature
LCRB Lower Colorado River Basin
LRP Landowner Relations Program
LTMP Long Term Monitoring Plot
NABCI North American Birds Conservation Initiative
NA-CEN North American Commission for Environmental Cooperation
NMGFD New Mexico Game and Fish Department
NDOW Nevada Department of Wildlife
NF National Forest
NGO Non-Government Organizations
NHS National Historic Site
NM National Monument
NPS National Park Service
NRCS Natural Resource Conservation Service
NWR National Wildlife Refuge
OHV Off Highway Vehicle
PACS Protected Activity Areas
PARC Partners in Amphibian and Reptile Conservation
PIF Partners in Flight
RF Random Forests
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
STWG State and Tribal Wildlife Grants Program
SWAP State Wildlife Action Plan
SWG State Wildlife Grants
SWReGAP Southwest Regional Gap Analysis Project
TNC The Nature Conservancy
TWW Teaming With Wildlife Committee
UA University of Arizona
USACE US Army Corps of Engineers
URTD Upper Respiratory Tract Disease
USBR US Bureau of Reclamation
USDA US Dept of Agriculture
UDWR Utah Division of Wildlife Resources
USFWS US Fish and Wildlife Service (also FWS)
USGS US Geological Survey
WAFWA Western Association of Fish and Wildlife Agencies
WDW Wildlife Data Warehouse
WFMP Watershed-based Fish Management Process
WHR Wildlife Habitat Relationship
WMP Watershed Management Plan
WNS White-nose syndrome
WSCA Wildlife of Special Concern in Arizona
WUI Wildland-Urban Interface
WVP Wildlife Viewing Program

Appendix B: Acknowledgements

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Appendix C: Master Species List

Amphibians			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Ambystoma mavortium nebulosum	Arizona Tiger Salamander	*Rana yavapaiensis*	Lowland Leopard Frog
Anaxyrus microscaphus	Arizona Toad	*Spea multiplicata*	Mexican Spadefoot
Hyla wrightorum	Arizona Treefrog	*Rana pipiens*	Northern Leopard Frog
Hyla wrightorum (Huachuca-Canelo Hills Population)	Arizona Treefrog (Huachuca-Canelo Hills Population)	*Rana blairi*	Plains Leopard Frog
Craugastor augusti	Barking Frog	*Spea bombifrons*	Plains Spadefoot Toad
Hyla arenicolor	Canyon Treefrog	*Anaxyrus punctatus*	Red-spotted Toad
Rana chiricahuensis	Chiricahua Leopard Frog	*Rana onca*	Relict Leopard Frog
Scaphiopus couchii	Couch's Spadefoot Toad	*Incilius alvarius*	Sonoran Desert Toad
Pseudacris regilla	Desert Pacific Treefrog	*Anaxyrus retiformis*	Sonoran Green Toad
Spea intermontana	Great Basin Spadefoot Toad	*Ambystoma mavortium stebbinsi*	Sonoran Tiger Salamander
Gastrophryne mazatlanensis	Sinaloan Narrow-mouthed Toad	*Rana tarahumarae*	Tarahumara Frog
Anaxyrus cognatus	Great Plains Toad	*Pseudacris maculata*	Western Chorus Frog
Anaxyrus debilis	Green Toad	*Anaxyrus woodhousii*	Woodhouse's Toad

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Melozone aberti	Abert's Towhee	*Chondestes grammacus*	Lark Sparrow
Melanerpes formicivorus	Acorn Woodpecker	*Passerina amoena*	Lazuli Bunting
Recurvirostra americana	American Avocet	*Ixobrychus exilis hesperis*	Western Least Bittern
Botaurus lentiginosus	American Bittern	*Calidris minutilla*	Least Sandpiper
Fulica americana	American Coot	*Toxostoma lecontei*	LeConte's Thrasher
Corvus brachyrhynchos	American Crow	*Spinus psaltria*	Lesser Goldfinch
Cinclus mexicanus	American Dipper	*Chordeiles acutipennis*	Lesser Nighthawk

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Falco sparverius	American Kestrel	*Aythya affinis*	Lesser Scaup
Anthus rubescens	American Pipit	*Melanerpes lewis*	Lewis's Woodpecker
Turdus migratorius	American Robin	*Melospiza lincolnii*	Lincoln's Sparrow
Picoides dorsalis	American Three-toed Woodpecker	*Lanius ludovicianus*	Loggerhead Shrike
Pelecanus erythrorhynchos	American White Pelican	*Numenius americanus*	Long-billed Curlew
Mareca americana	American Wigeon	*Limnodromus scolopaceus*	Long-billed Dowitcher
Calypte anna	Anna's Hummingbird	*Asio otus*	Long-eared Owl
Ammodramus savannarum ammolegus	Arizona Grasshopper Sparrow	*Calothorax lucifer*	Lucifer Hummingbird
Peucaea botterii arizonae	Arizona Botteri's Sparrow	*Oreothlypis luciae*	Lucy's Warbler
Dryobades arizonae	Arizona Woodpecker	*Geothlypis tolmiei*	MacGillivray's Warbler
Myiarchus cinerascens	Ash-throated Flycatcher	*Anas platyrhynchos*	Mallard
Sialia sialis fulva	Azure Bluebird	*Cistothorus palustris*	Marsh Wren
Ammodramus bairdii	Baird's Sparrow	*Rhynchophanes mccownii*	Thick-billed Longspur
Haliaeetus leucocephalus	Bald Eagle	*Meleagris gallopavo merriami*	Merriam's Turkey
Patagioenas fasciata	Band-tailed Pigeon	*Poecile sclateri*	Mexican Chickadee
Tyto alba	Barn Owl	*Aphelocoma wollweberi*	Mexican Jay
Hirundo rustica	Barn Swallow	*Antrostomus arizonae*	Mexican Whip-poor-will
Vireo bellii arizonae	Arizona's Bell Vireo	*Ictinia mississippiensis*	Mississippi Kite
Megaceryle alcyon	Belted Kingfisher	*Cyrtonyx montezumae*	Montezuma Quail
Toxostoma bendirei	Bendire's Thrasher	*Sialia currucoides*	Mountain Bluebird
Thryomanes bewickii	Bewick's Wren	*Poecile gambeli*	Mountain Chickadee
Laterallus jamaicensis coturnic	California Black Rail	*Charadrius montanus*	Mountain Plover
Sayornis nigricans	Black Phoebe	*Zonotrichia leucophrys oriantha*	Mountain West White-crowned Sparrow
Melanitta americana	Black Scoter	*Zenaida macroura*	Mourning Dove
Coragyps atratus	Black Vulture	*Phalacrocorax brasilianus*	Neotropic Cormorant

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Dendrocygna autumnalis	Black-bellied Whistling-Duck	*Colinus virginianus ridgwayi*	Masked Bobwhite
Pica hudsonia	Black-billed Magpie	*Glaucidium gnoma gnoma*	Mountain Pygmy-owl
Polioptila nigriceps	Black-capped Gnatcatcher	*Falco femoralis septentrionalis*	Northern Aplomado Falcon
Archilochus alexandri	Black-chinned Hummingbird	*Camptostoma imberbe*	Northern Beardless-Tyrannulet
Spizella atrogularis	Black-chinned Sparrow	*Empidonax fulvifrons pygmaeus*	Northern Buff-breasted Flycatcher
Nycticorax nycticorax	Black-crowned Night-heron	*Cardinalis cardinalis*	Northern Cardinal
Pheucticus melanocephalus	Black-headed Grosbeak	*Colaptes auratus*	Northern Flicker
Himantopus mexicanus	Black-necked Stilt	*Accipiter gentilis*	Northern Goshawk
Polioptila melanura	Black-tailed Gnatcatcher	*Circus hudsonius*	Northern Harrier
Setophaga nigrescens	Black-throated Gray Warbler	*Mimus polyglottos*	Northern Mockingbird
Amphispiza bilineata	Black-throated Sparrow	*Anas acuta*	Northern Pintail
Passerina caerulea	Blue Grosbeak	*Glaucidium gnoma californicum*	Northern Pygmy-owl
Polioptila caerulea	Blue-gray Gnatcatcher	*Stelgidopteryx serripennis*	Northern Rough-winged Swallow
Lampornis clemenciae	Blue-throated Mountain-gem	*Aegolius acadicus*	Northern Saw-whet Owl
Spatula discors	Blue-winged Teal	*Spatula clypeata*	Northern Shoveler
Euphagus cyanocephalus	Brewer's Blackbird	*Lanius borealis*	Northern Shrike
Spizella breweri	Brewer's Sparrow	*Peucedramus taeniatus*	Olive Warbler
Baeolophus wollweberi	Bridled Titmouse	*Contopus cooperi*	Olive-sided Flycatcher
Cynanthus latirostris	Broad-billed Hummingbird	*Oreothlypis celata*	Orange-crowned Warbler
Selasphorus platycercus	Broad-tailed Hummingbird	*Pandion haliaetus*	Osprey
Molothrus aeneus	Bronzed Cowbird	*Troglodytes pacificus*	Pacific Wren
Certhia americana	Brown Creeper	*Myioborus pictus*	Painted Redstart
Myiarchus tyrannulus	Brown-crested Flycatcher	*Falco peregrinus anatum*	American Peregrine Falcon

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Molothrus ater	Brown-headed Cowbird	*Phainopepla nitens*	Phainopepla
Antrostomus ridgwayi	Buff-collared Nightjar	*Podilymbus podiceps*	Pied-billed Grebe
Icterus bullockii	Bullock's Oriole	*Pinicola enucleator*	Pine Grosbeak
Psaltriparus minimus	Bushtit	*Spinus pinus*	Pine Siskin
Glaucidium brasilianum cactorum	Cactus Ferruginous Pygmy-Owl	*Gymnorhinus cyanocephalus*	Pinyon Jay
Campylorhynchus brunneicapillus	Cactus Wren	*Vireo plumbeus*	Plumbeous Vireo
Gymnogyps californianus	California Condor	*Falco mexicanus*	Prairie Falcon
Branta canadensis	Canada Goose	*Progne subis hesperia*	Desert Purple Martin
Perisoreus canadensis	Canada Jay	*Progne subis arboricola*	Western Purple Martin
Aythya valisineria	Canvasback	*Sitta pygmaea*	Pygmy Nuthatch
Melozone fusca	Canyon Towhee	*Cardinalis sinuatus*	Pyrrhuloxia
Catherpes mexicanus	Canyon Wren	*Loxia curvirostra*	Red Crossbill
Haemorhous cassinii	Cassin's Finch	*Sitta canadensis*	Red-breasted Nuthatch
Tyrannus vociferans	Cassin's Kingbird	*Cardellina rubrifrons*	Red-faced Warbler
Peucaea cassinii	Cassin's Sparrow	*Sphyrapicus nuchalis*	Red-naped Sapsucker
Bubulcus ibis	Cattle Egret	*Buteo jamaicensis*	Red-tailed Hawk
Calcarius ornatus	Chestnut-collared Longspur	*Agelaius phoeniceus*	Red-winged Blackbird
Corvus cryptoleucus	Chihuahuan Raven	*Aythya americana*	Redhead
Spizella passerina	Chipping Sparrow	*Rallus obsoletus yumanensis*	Ridgway's Rail
Spatula cyanoptera	Cinnamon Teal	*Aythya collaris*	Ring-necked Duck
Aechmophorus clarkii	Clark's Grebe	*Eugenes fulgens*	Rivoli's Hummingbird
Nucifraga columbiana	Clark's Nutcracker	*Salpinctes obsoletus*	Rock Wren
Petrochelidon pyrrhonota	Cliff Swallow	*Pachyramphus aglaiae*	Rose-throated Becard
Buteogallus anthracinus	Common Black Hawk	*Anser rossii*	Ross's Goose
Gallinula galeata	Common Gallinule	*Regulus calendula*	Ruby-crowned Kinglet
Columbina passerina	Common Ground Dove	*Oxyura jamaicensis*	Ruddy Duck

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Mergus merganser	Common Merganser	*Aimophila ruficeps*	Rufous-crowned Sparrow
Chordeiles minor	Common Nighthawk	*Peucaea carpalis*	Rufous-winged Sparrow
Phalaenoptilus nuttallii	Common Poorwill	*Oreoscoptes montanus*	Sage Thrasher
Corvus corax	Common Raven	*Artemisiospiza nevadensis*	Sagebrush Sparrow
Geothlypis trichas	Common Yellowthroat	*Antigone canadensis*	Sandhill Crane
Accipiter cooperii	Cooper's Hawk	*Passerculus sandwichensis*	Savannah Sparrow
Empidonax occidentalis	Cordilleran Flycatcher	*Sayornis saya*	Say's Phoebe
Calypte costae	Costa's Hummingbird	*Callipepla squamata*	Scaled Quail
Caracara cheriway	Crested Caracara	*Icterus parisorum*	Scott's Oriole
Toxostoma crissale	Crissal Thrasher	*Accipiter striatus*	Sharp-shinned Hawk
Toxostoma curvirostre	Curve-billed Thrasher	*Buteo brachyurus*	Short-tailed Hawk
Junco hyemalis	Dark-eyed Junco	*Anser caerulescens*	Snow Goose
Phalacrocorax auritus albociliatus	Double-crested Cormorant	*Charadrius nivosus nivosus*	Western Snowy Plover
Dryobates pubescens	Downy Woodpecker	*Egretta thula*	Snowy Egret
Empidonax oberholseri	Dusky Flycatcher	*Melospiza melodia*	Song Sparrow
Dendragapus obscurus	Dusky Grouse	*Porzana carolina*	Sora
Myiarchus tuberculifer	Dusky-capped Flycatcher	*Strix occidentalis lucida*	Mexican Spotted Owl
Podiceps nigricollis	Eared Grebe	*Actitis macularius*	Spotted Sandpiper
Sturnella lilianae	Chihuahan Meadowlark	*Pipilo maculatus*	Spotted Towhee
Trogon elegans	Elegant Trogon	*Anthus spragueii*	Sprague's Pipit
Micrathene whitneyi	Elf Owl	*Cyanocitta stelleri*	Steller's Jay
Coccothraustes vespertinus	Evening Grosbeak	*Myiodynastes luteiventris*	Sulphur-bellied Flycatcher
Buteo regalis	Ferruginous Hawk	*Piranga rubra*	Summer Tanager
Amphispizopsis quinquestriata	Five-striped Sparrow	*Buteo swainsoni*	Swainson's Hawk
Psiloscops flammeolus	Flammulated Owl	*Catharus ustulatus*	Swainson's Thrush
Mareca strepera	Gadwall	*Tyrannus crassirostris*	Thick-billed Kingbird

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Callipepla gambelii	Gambel's Quail	*Rhynchopsitta pachyrhyncha*	Thick-billed Parrot
Melanerpes uropygialis	Gila Woodpecker	*Myadestes townsendi*	Townsend's Solitaire
Colaptes chrysoides	Gilded Flicker	*Tachycineta bicolor*	Tree Swallow
Aquila chrysaetos	Golden Eagle	*Tyrannus melancholicus*	Tropical Kingbird
Regulus satrapa	Golden-crowned Kinglet	*Cathartes aura*	Turkey Vulture
Setophaga graciae	Grace's Warbler	*Passerina versicolor*	Varied Bunting
Dumetella carolinensis	Gray Catbird	*Auriparus flaviceps*	Verdin
Empidonax wrightii	Gray Flycatcher	*Pyrocephalus rubinus*	Vermilion Flycatcher
Buteo plagiatus	Gray Hawk	*Pooecetes gramineus*	Vesper Sparrow
Vireo vicinior	Gray Vireo	*Amazilia violiceps*	Violet-crowned Hummingbird
Ardea herodias	Great Blue Heron	*Tachycineta thalassina*	Violet-green Swallow
Ardea alba	Great Egret	*Rallus limicola*	Virginia Rail
Bubo virginianus	Great Horned Owl	*Leithlypis virginiae*	Virginia's Warbler
Quiscalus mexicanus	Great-tailed Grackle	*Vireo gilvus*	Warbling Vireo
Contopus pertinax	Greater Pewee	*Sialia mexicana*	Western Bluebird
Geococcyx californianus	Greater Roadrunner	*Athene cunicularia hypugaea*	Western Burrowing Owl
Butorides virescens	Green Heron	*Ammodramus savannarum perpallidus*	Western Grasshopper Sparrow
Chloroceryle americana	Green Kingfisher	*Aechmophorus occidentalis*	Western Grebe
Pipilo chlorurus	Green-tailed Towhee	*Tyrannus verticalis*	Western Kingbird
Anas crecca	Green-winged Teal	*Sturnella neglecta*	Western Meadowlark
Dryobates villosus	Hairy Woodpecker	*Megascops kennicottii*	Western Screech-Owl
Parabuteo unicinctus	Harris's Hawk	*Piranga ludoviciana*	Western Tanager
Piranga flava	Hepatic Tanager	*Contopus sordidulus*	Western Wood-Pewee
Catharus guttatus	Hermit Thrush	*Megascops trichopsis*	Whiskered Screech-Owl
Icterus cucullatus	Hooded Oriole	*Sitta carolinensis*	White-breasted Nuthatch

Birds			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Eremophila alpestris	Horned Lark	*Plegadis chihi*	White-faced Ibis
Haemorhous mexicanus	House Finch	*Aeronautes saxatalis*	White-throated Swift
Troglodytes aedon	House Wren	*Zenaida asiatica*	White-winged Dove
Vireo huttoni	Hutton's Vireo	*Melanitta deglandi*	White-winged Scoter
Columbina inca	Inca Dove	*Meleagris gallopavo mexicana*	Gould's Turkey
Passerina cyanea	Indigo Bunting	*Sphyrapicus thyroideus*	Williamson's Sapsucker
Baeolophus ridgwayi	Juniper Titmouse	*Empidonax traillii extimus*	Southwestern Willow Flycatcher
Charadrius vociferus	Killdeer	*Gallinago delicata*	Wilson's Snipe
Dryobates scalaris	Ladder-backed Woodpecker	*Aix sponsa*	Wood Duck
Calamospiza melanocorys	Lark Bunting	*Aphelocoma woodhouseii*	Woodhouse's Scrub-Jay
Junco phaeonotus	Yellow-eyed Junco	*Setophaga petechia*	Yellow Warbler
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	*Coccyzus americanus occidentalis*	Western Yellow-billed Cuckoo
Setophaga coronata	Yellow-rumped Warbler	*Icteria virens*	Yellow-breasted Chat
Buteo albonotatus	Zone-tailed Hawk		

Fish			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Oncorhynchus apache	Apache Trout	*Campostoma ornatum*	Mexican Stoneroller
Cyprinella formosa	Beautiful Shiner	*Cyprinodon eremus*	Sonoyta Pupfish
Catostomus discobolus	Bluehead Sucker	*Xyrauchen texanus*	Razorback Sucker
Gila elegans	Bonytail Chub	*Gila robusta*	Roundtail Chub
Ptychocheilus lucius	Colorado Pikeminnow	*Gila ditaenia*	Sonora Chub
Cyprinodon macularius	Desert Pupfish	*Catostomus insignis*	Sonora Sucker
Catostomus clarkii	Desert Sucker	*Rhinichthys osculus*	Speckled Dace
Catostomus latipinnis	Flannelmouth Sucker	*Meda fulgida*	Spikedace
Gila intermedia	Gila Chub	*Mugil cephalus*	Striped Mullet
Poeciliopsis occidentalis occidentalis	Gila Topminnow	*Gila seminuda*	Virgin River Chub
Oncorhynchus gilae	Gila Trout	*Lepidomeda mollispinis mollispinis*	Virgin Spinedace
Gila cypha	Humpback Chub	*Plagopterus argentissimus*	Woundfin
Lepidomeda vittata	Little Colorado Spinedace	*Ictalurus pricei*	Yaqui Catfish
Catostomus sp. 3	Little Colorado Sucker	*Gila purpurea*	Yaqui Chub
Tiaroga cobitis	Loach Minnow	*Catostomus bernardini*	Yaqui Sucker
Agosia chrysogaster	Longfin Dace	*Poeciliopsis occidentalis sonoriensis*	Yaqui Topminnow
Elops affinis	Machete	*Catostomus discobolus yarrowi*	Zuni Bluehead Sucker

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Vallonia perspectiva	(no common name)	*Lucilla (Helicodiscus) eigenmanni*	Mexican Coil
Galba (Fossaria) cockerelli	(no common name)	*Planorbella tenuis*	Mexican Rams-horn
Lymnaea humilis	(no common name)	*Succinea luteola*	Mexico Ambersnail
Oreohelix sp. 32	(no common name)	*Sonorella micromphala*	Milk Ranch Talussnail
Sonorella sp. 1	(no common name)	*Otala lactea*	Milk Snail

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Vertigo arizonensis	(no common name)	*Sonorella imitator*	Mimic Talussnail
Vertigo coloradensis	(no common name)	*Hawaiia minuscula*	Minute Gem
Sonorella santaritana	Agua Caliente Talussnail	*Ashmunella mogollonensis*	Mogollon Woodlandsnail
Nesovitrea electrina	Amber Glass	*Gastrocopta pilsbryana*	Montane Snaggletooth
Hyalella azteca	(no common name)	*Hyalella montezuma*	Montezuma Well Amphipod
Oreohelix anchana	Ancha Mountainsnail	*Pyrgulopsis montezumensis*	Montezuma Well Springsnail
Gastrocopta cochisensis	Apache Snaggletooth	*Sonorella mustang*	Mustang Talussnail
Sonorella apache	Apache Talussnail	*Streptocephalus dorothae*	New Mexico Fairy Shrimp
Sonorella meadi	Aqua Dulce Talussnail	*Oxyloma haydeni haydeni*	Niobrara Ambersnail
Stygobromus arizonensis	Arizona Cave Amphipod	*Discus whitneyi*	(no common name)
Holospira arizonensis	Arizona Holospira	*Sonorella compar*	Oak Creek Talussnail
Pallifera pilsbryi	Arizona mantleslug	*Vertigo ovata*	Ovate Vertigo
Gyraulus parvus	Ash Gyro	*Pyrgulopsis morrisoni*	Page Springsnail
Sonorella baboquivariensis	Baboquivari Talussnail	*Sonorella ambigua*	Papago Talussnail
Sonorella danielsi	Bear Canyon Talussnail	*Sonorella ambigua ambigua*	Papago Talussnail
Oreohelix barbata	Bearded Mountainsnail	*Sonorella ambigua verdensis*	Papago Verde Talussnail
Thamnocephalus platyurus	Beavertail Fairy Shrimp	*Sonorella simmonsi*	Picacho Talussnail
Sonorella optata	Big Emigrant Talussnail	*Oreohelix grahamensis*	Pinaleño Mountainsnail
Sonorella russelli	Black Mesa Talussnail	*Sonorella grahamensis*	Pinaleño Talussnail
Naesiotus (Rabdotus) nigromontanus	Black Mountain Rabdotus	*Paralaoma caputspinulae*	Pinhead Spot
Sonorella papagorum	Black Mountain Talussnail	*Sonorella neglecta*	Portal Talussnail
Vertigo milium	Blade Vertigo	*Sonorella rinconensis*	Posta Quemada Talussnail
Ashmunella pilsbryana	Blue Mountain Woodlandsnail	*Physella virgata*	Protean Physa
*Sonorella caeruliflumini*s	Blue Talussnail	*Sonorella odorata*	Pungent Talussnail

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Sonorella bradshaveana	Bradshaw Talussnail	*Galba (Fossaria) parva*	Pygmy Fossaria
Cyzicus setosa	Bristletail Clam Shrimp	*Sonorella micra*	Pygmy Sonorella
Pyrgulopsis sola	Brown Springsnail	*Sonorella bowiensis*	Quartzite Hill Talussnail
Pyrgulopsis arizonae	Bylas Springsnail	*Zonitoides arboreus*	Quick Gloss
Anodonta californiensis	California Floater	*Tryonia quitobaquitae*	Quitobaquito Tryonia
Glyphyalinia indentata	Carved Glyph	*Sonorella reederi*	Rampart Talussnail
Holospira chiricahuana	Cave Creek Holospira	*Sonorella granulatissima*	Ramsey Canyon Talussnail
Radiocentrum clappi	Cave Creek Mountainsnail	*Ashmunella ferrissi*	Reed's Mountain Woodlandsnail
Ashmunella chiricahuana	Cave Creek Woodlandsnail	*Pupoides hordaceus*	Ribbed Dagger
Physella osculans	Cayuse Physa	*Radiodiscus millecostatus*	Ribbed Pinwheel
Streptocephalus mackini	Chihuahuan Desert Fairy Shrimp	*Punctum californicum*	Ribbed Spot
Radiocentrum chiricahuana	Chiricahua Mountainsnail	*Sonorella ashmuni*	Richinbar Talussnail
Sonorella virilis	Chiricahua Talussnail	*Sonorella bagnarai*	Rincon Talussnail
Ashmunella proxima	Chiricahua Woodlandsnail	*Galba (Fossaria) modicella*	Rock Fossaria
Sonorella christenseni	Clark Peak Talussnail	*Branchinecta packardi*	Rock Pool Fairy Shrimp
Discus shimekii cockerelli	Cockerell's Striate Disc (Snail)	*Pupilla blandii*	Rocky Mountain Column
Branchinecta coloradensis	Colorado Fairy Shrimp	*Oreohelix strigosa*	Rocky Mountainsnail
Physella humerosa	Corkscrew Physa	*Sonorella (Myotophallus) rooseveltiana*	Roosevelt Talussnail
Gastrocopta cristata	Crested Snaggletooth	*Vertigo berryi*	Rotund Vertigo
Pupilla hebes	Crestless Column	*Pyrgulopsis bernardina*	San Bernardino Springsnail
Gastrocopta quadridens	Cross Snaggletooth	*Artemia franciscana*	San Francisco Brine Shrimp
Oreohelix yavapai cummingsi	Cummings Mountainsnail	*Sonorella eremita*	San Xavier Talussnail
Pyrgulopsis deserta	Desert Springsnail	*Sonorella tryoniana*	Sanford Talussnail

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Triops newberryi	Desert Tadpole Shrimp	*Sonorella sabinoensis*	Santa Catalina Talussnail
Tryonia porrecta	Desert Tryonia	*Succinea grosvenori*	Santa Rita Ambersnail
Oreohelix houghi	Diablo Mountainsnail	*Naesiotus (Rabdotus) christenseni*	Santa Rita Rabdotus
Gyraulus circumstriatus	Disc Gyro	*Sonorella walkeri*	Santa Rita Talussnail
Sonorella bicipitis	Dos Cabezas Talussnail	*Promenetus exacuous*	Sharp Sprite (A Planorbid Snail)
Sonorella waltoni	Doubtful Canyon Talussnail	*Lynceus brevifrons*	Short Finger Clam Shrimp
Sonorella ferrissi	Dragoon Talussnail	*Gastrocopta dalliana*	Shortneck Snaggletooth
Eremarionta rowelli	Eastern Desertsnail	*Sonorella anchana*	Sierra Ancha Talussnail
Sonorella imperialis	Empire Mountain Talussnail	*Vallonia cyclophorella*	Silky Vallonia
Sonorella bartschi	Escabrosa Talussnail	*Holospira sherbrookei*	Silver Creek Holospira
Eubranchipus hesperius	Ethologist Fairy Shrimp	*Gastrocopta pellucida*	Slim Snaggletooth
Sonorella vespertina	Evening Talussnail	*Gastrocopta ashmuni*	Sluice Snaggletooth
Pyrgulopsis simplex	Fossil Springsnail	*Lucilla (Helicodiscus) singleyana*	Smooth Coil
Ferrissia fragilis	Fragile Ancylid	*Gastrocopta prototypus*	Sonoran Snaggletooth
Sonorella rooseveltiana fragilis	Fragile Talussnail	*Sonorella magdalenensis*	Sonoran Talussnail
Galba (Fossaria) techella	Freshwater Snail	*Thysanophora hornii*	Southwestern Fringed-snail
Sonorella galiurensis	Galiuro Talussnail	*Leptestheria compleximanus*	Spinynose Clam Shrimp
Sonorella dalli	Garden Canyon Talussnail	*Streptocephalus coloradensis*	Colorado Spinytail Fairy Shrimp
Tryonia gilae	Gila Tryonia	*Microphysula ingersolli*	Spruce Snail
Cochlicopa lubrica	Glossy Pillar (Snail)	*Sonorella allynsmithi*	Phoenix (Squaw Peak) Talussnail
Valvata humeralis	Glossy Valvata	*Sonorella franciscana*	St. Francis Talussnail
Galba (Fossaria) obrussa	Golden Fossaria	*Holospira ferrissi*	Stocky Holospira
Sonorella coloradoensis	Grand Canyon Talussnail	*Holospira danielsi*	Stongrib Holospira
Pyrgulopsis bacchus	Grand Wash Springsnail	*Eocyzicus digueti*	Straightbacked Clam

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
			Shrimp
Streptocephalus texanus	Greater Plains Fairy Shrimp	*Discus shimekii*	Striate Disc
Sonorella bequaerti	Happy Valley Talussnail	*Sonorella dragoonensis*	Stronghold Canyon Talussnail
Lynceus brachyurus	Holarctic Clam Shrimp	*Oreohelix subrudis*	Subalpine Mountainsnail
Chaenaxis tuba	Hollow Tuba (Snail)	*Catinella vermeta*	Suboval Ambersnail
Holospira campestris	(no common name)	*Sonorella superstitionis*	Superstition Mountains Talussnail
Holospira cionella	(no common name)	*Sonorella milleri*	Table Top Talussnail
Holospira millestriata	(no common name)	*Physa gyrina*	Tadpole Physa
Sonorella binneyi	Horseshoe Canyon Talussnail	*Holospira tantalus*	Teasing Holospira
Oreohelix concentrata	Huachuca Mountainsnail	*Pyrgulopsis trivialis*	Three Forks Springsnail
Pyrgulopsis thompsoni	Huachuca Springsnail	*Pisidium insigne*	Tiny Peaclam
Sonorella huachucana	Huachuca Talussnail	*Sonorella delicata*	Tollhouse Canyon Talussnail
Ashmunella levettei	Huachuca Woodlandsnail	*Pupilla syngenes*	Top-heavy Column
Pyrgulopsis hualapaiensis	Hualapai Springsnail	*Sonorella tortillita*	Tortolita Talussnail
Pyrgulopsis sp. A	(undescribed springsnail)	*Sonorella imperatrix*	Total Wreck Talussnail
Pyrgulopsis sp. B	(undescribed springsnail)	*Pisidium variabile*	Triangular Peaclam
Pyrgulopsis sp. C	(undescribed springsnail)	*Pisidium casertanum*	Ubiquitous Peaclam
Branchinecta kaibabensis	Kaibab Fairy Shrimp	*Holospira montivaga*	Vagabond Holospira
Pyrgulopsis conica	Kingman Springsnail	*Pyrgulopsis glandulosa*	Verde Rim Springsnail
Sonorella xanthenes	Kitt Peak Talussnail	*Branchinecta lindahli*	Versatile Fairy Shrimp
Eubranchipus bundyi	Knobbedlip Fairy Shrimp	*Pisidium walkeri*	Walker Peaclam
Sonorella sitiens	Las Guijas Talussnail	*Sonorella coltoniana*	Walnut Canyon Talussnail
Sonorella pedregosensis	Leslie Canyon Talussnail	*Vitrina pellucida alaskana*	Western Glass Snail
Sonorella parva	Little Talussnail	*Sonorella macrophallus*	Wet Canyon Talussnail
Triops longicaudatus	Longtail Tadpole Shrimp	*Holospira whetstonensis*	Whetstone Holospira
Sonorella clappi	Madera Talussnail	*Sonorella insignis*	Whetstone Talussnail

Invertebrates			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Deroceras laeve	Marsh Slug (or Meadow Slug)	*Pupoides albilabris*	White-lip Dagger
Columella columella	Mellow Column (Snail)	*Oreohelix yavapai*	Yavapai Mountain Snail
Thamnocephalus mexicanus	Mexican Beavertail Fairy Shrimp	*Helisoma anceps*	Two-ridge Rams-horn
Cyzicus mexicanus	Mexican Clam Shrimp		

Mammals			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Sciurus aberti chuscensis	Abert's Chuska Squirrel	*Chaetodipus formosus*	Long-tailed Pocket Mouse
Sciurus aberti	Abert's Squirrel	*Microtus longicaudus*	Long-tailed Vole
Idionycteris phyllotis	Allen's Lappet-browed Bat	*Mustela frenata*	Long-tailed Weasel
Antilocapra americana americana	American Pronghorn	*Peromyscus merriami*	Merriam's Deermouse
Taxidea taxus	American Badger	*Dipodomys merriami*	Merriam's Kangaroo Rat
Castor canadensis	American Beaver	*Sorex merriami*	Merriam's Shrew
Ursus americanus	American Black Bear	*Tadarida brasiliensis*	Mexican Free-tailed Bat
Lepus alleni	Antelope Jackrabbit	*Canis lupus baileyi*	Mexican Gray Wolf
Perognathus apache melanotis	Apache Pocket Mouse	*Choeronycteris mexicana*	Mexican Long-tongued Bat
Sigmodon arizonae cienegae	Arizona Cotton Rat	*Didelphis virginiana californica*	Mexican Opossum
Sciurus arizonensis	Arizona Gray Squirrel	*Microtus mexicanus*	Mexican Vole
Microtus montanus	Arizona Montane Vole	*Neotoma mexicana*	Mexican Woodrat
Myotis occultus	Arizona Myotis	*Neotoma mexicana mexicana*	Mexican Woodrat
Perognathus amplus	Arizona Pocket Mouse	*Puma concolor*	Mountain Lion
Sorex arizonae	Arizona Shrew	*Tamiasciurus hudsonicus grahamens*	Mt Graham Red Squirrel
Chaetodipus baileyi	Bailey's Pocket Mouse	*Odocoileus hemionus*	Mule or Black-tailed Deer
Dipodomys spectabilis	Banner-tailed Kangaroo Rat	*Zapus hudsonius luteus*	New Mexican Jumping Mouse
Eptesicus fuscus	Big Brown Bat	*Erethizon dorsatum*	North American

Mammals			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
			Porcupine
Nyctinomops macrotis	Big Free-tailed Bat	*Sylvilagus nuttallii grangeri*	North Kaibab Mountain Cottontail
Mustela nigripes	Black-footed Ferret	*Glaucomys sabrinus*	Northern Flying Squirrel
Lepus californicus	Black-tailed Jackrabbit	*Onychomys leucogaster*	Northern Grasshopper Mouse
Cynomys ludovicianus	Black-tailed Prairie Dog	*Thomomys talpoides*	Northern Pocket Gopher
Lynx rufus	Bobcat	*Baiomys taylori*	Northern Pygmy Mouse
Thomomys bottae	Botta's Pocket Gopher	*Procyon lotor*	Northern Raccoon
Peromyscus boylii	Brush Mouse	*Leopardus pardalis*	Ocelot
Neotoma cinerea	Bushy-tailed Woodrat	*Dipodomys ordii*	Ord's Kangaroo Rat
Peromyscus eremicus	Cactus Mouse	*Corynorhinus townsendii pallescens*	Pale Townsend's Big-eared Bat
Macrotus californicus	California Leaf-nosed Bat	*Peromyscus truei*	Pinon Mouse
Myotis californicus	California Myotis	*Reithrodontomys montanus*	Plains Harvest Mouse
Parastrellus hesperus	Canyon Bat	*Nyctinomops femorosaccus*	Pocketed Free-tailed Bat
Peromyscus crinitus	Canyon Mouse	*Ammospermophilus leucurus tersus*	Prospect Valley White-tailed Antelope Squirrel
Myotis velifer	Cave Myotis	*Vulpes vulpes*	Red Fox
Sciurus nayaritensis chiricahuae	Chiricahua Fox Squirrel	*Tamiasciurus hudsonicus*	Red Squirrel
Dipodomys microps celsus	Chisel-toothed Kangaroo Rat	*Bassariscus astutus*	Ringtail
Neotamias dorsalis	Cliff Chipmunk	*Peromyscus nasutus (difficilis)*	Rock Mouse
Notiosorex cockrumi	Cockrum's Desert Shrew	*Chaetodipus intermedius*	Rock Pocket Mouse
Pecari tajacu	Collared Peccary	*Otospermophilus variegatus*	Rock Squirrel
Tamias quadrivittatus	Colorado Chipmunk	*Ovis canadensis canadensis*	Rocky Mountain Bighorn Sheep
Sigmodon arizonae plenus	Colorado River Cotton Rat	*Cervus elaphus nelsoni*	Rocky Mountain Elk
Urocyon cinereoargenteus	Common Gray Fox	*Xerospermophilus tereticaudus*	Round-tailed Ground Squirrel

Mammals			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Ondatra zibethicus	Common Muskrat	*Perognathus flavus*	Silky Pocket Mouse
Odocoileus virginianus couesi	Coues Whitetail Deer	*Lasionycteris noctivagans*	Silver-haired Bat
Canis latrans	Coyote	*Chaetodipus penicillatus*	Desert Pocket Mouse
Notiosorex crawfordi	Crawford's Desert Shrew	*Antilocapra americana sonoriensis*	Sonoran Pronghorn
Peromyscus maniculatus	Deer Mouse	*Lontra canadensis lataxina*	Southeastern River Otter
Ovis canadensis mexicana	Desert Bighorn Sheep	*Onychomys torridus*	Southern Grasshopper Mouse
Ovis canadensis nelsoni	Desert Bighorn Sheep	*Thomomys umbrinus intermedius*	Southern Pocket Gopher
Sylvilagus audubonii	Desert Cottontail	*Clethrionomys gapperi*	Southern Red-backed Vole
Dipodomys deserti	Desert Kangaroo Rat	*Sylvilagus nuttallii pinetis*	Southwestern Cottontail
Neotoma lepida	Desert Woodrat	*Myotis auriculus*	Southwestern Myotis
Sorex monticolus	Dusky Shrew	*Lontra canadensis sonora*	Southwestern River Otter
Sorex nanus	Dwarf Shrew	*Euderma maculatum*	Spotted Bat
Sylvilagus floridanus	Eastern Cottontail	*Spermophilus spilosoma*	Spotted Ground Squirrel
Lasiurus borealis	Eastern Red Bat	*Perognathus flavus goodpasteri*	Springerville Pocket Mouse
Myotis thysanodes	Fringed Myotis	*Neotoma stephensi*	Stephen's Woodrat
Reithrodontomys fulvescens	Fulvous Harvest Mouse	*Mephitis mephitis*	Striped Skunk
Callospermophilus lateralis	Golden-mantled Ground Squirrel	*Sigmodon fulviventer*	Tawny-bellied Cotton Rat
Tamias cinereicollis	Gray-collared Chipmunk	*Spermophilus tridecemlineatus*	Thirteen-lined Ground Squirrel
Perognathus parvus	Great Basin Pocket Mouse	*Tamias umbrinus*	Uinta Chipmunk
Eumops perotis californicus	Greater Western Mastiff Bat	*Eumops underwoodi*	Underwood's Mastiff Bat
Cynomys gunnisoni	Gunnison's Prairie Dog	*Reithrodontomys megalotis*	Western Harvest Mouse
Thomomys bottae subsimilis	Harquahala Southern Pocket Gopher	*Lasiurus blossevillii*	Western Red Bat
Ammospermophilus harrisii	Harris's Antelope Squirrel	*Myotis ciliolabrum*	Western Small-footed Myotis

Mammals			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Sigmodon hispidus	Hispid Cotton Rat	*Spilogale gracilis*	Western Spotted Skunk
Chaetodipus hispidus	Hispid Pocket Mouse	*Sorex navigator*	Western Water Shrew
Lasiurus cinereus	Hoary Bat	*Neotoma albigula*	Western White-throated Woodrat
Conepatus leuconotus leuconotus	Hog-nosed Skunk	*Lasiurus xanthinus*	Western Yellow Bat
Mephitis macroura	Hooded Skunk	*Microtus longicaudus leucophaeus*	White-bellied Long-tailed Vole
Dipodomys microps leucotis	Houserock Valley Chisel-toothed Kangaroo Rat	*Peromyscus leucopus*	White-footed Mouse
Panthera onca	Jaguar	*Nasua narica*	White-nosed Coati
Sciurus aberti kaibabensis	Kaibab Squirrel	*Ammospermophilus leucurus*	White-tailed Antelope Squirrel
Vulpes macrotis	Kit Fox	*Ammospermophilus leucurus cinnamomeus*	White-tailed Antelope Squirrel
Tamias minimus	Least Chipmunk	*Pognathus amplus cineris*	Wupatki Arizona Pocket Mouse
Leptonycteris yerbabuenae	Lesser Long-nosed Bat	*Sigmodon arizonae jacksoni*	Yavapai Arizona Cotton
Perognathus longimembris	Little Pocket Mouse	*Sigmodon ochrognathus*	Yellow-nosed Cotton Rat
Myotis evotis	Long-eared Myotis	*Sigmodon hispidus eremicus*	Yuma Hispid Cotton Rat
Myotis volans	Long-legged Myotis	*Myotis yumanensis*	Yuma Myotis
Chaetodipus formosus	Long-tailed Pocket Mouse	*Antrozous pallidus*	Pallid Bat

Reptiles			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Crotalus cerberus	Arizona Black Rattlesnake	*Crotalus willardi obscurus*	New Mexico Ridge-nosed Rattlesnake
Kinosternon arizonense	Arizona Mud Turtle	*Rena dissectus*	New Mexico Threadsnake
Xantusia arizonae	Arizona Night Lizard	*Coluber constrictor*	North American Racer
Xantusia bezyi	Bezy's Night Lizard	*Thamnophis eques*	Northern Mexican Gartersnake
Thamnophis cyrtopsis	Black-necked	*Terrapene ornata*	Ornate Box Turtle

Reptiles			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
	Gartersnake		
Crotalus molossus	Black-tailed Rattlesnake	*Urosaurus ornatus*	Ornate Tree Lizard
Oxybelis aeneus	Brown Vinesnake	*Chrysemys picta*	Painted Turtle
Lampropeltis californiae	California Kingsnake	*Tantilla nigriceps*	Plains Black-headed Snake
Aspidoscelis stictogramma	Canyon Spotted Whiptail	*Sceloporus tristichus*	Plateau Fence Lizard
Thamnophis marcianus	Checkered Gartersnake	*Aspidoscelis velox*	Plateau Striped Whiptail
Tantilla wilcoxi	Chihuahuan Black-headed Snake	*Crotalus viridis*	Prairie Rattlesnake
Gyalopion canum	Chihuahuan Hook-nosed Snake	*Aspidoscelis xanthonota*	Red-back Whiptail
Hypsiglena jani	Chihuahuan Nightsnake	*Phrynosoma solare*	Regal Horned Lizard
Aspidoscelis exsanguis	Chihuahuan Spotted Whiptail	*Chionactis annulata*	Resplendent Shovel-nosed Snake
Sceloporus clarkii	Clark's Spiny Lizard	*Crotalus willardi willardi*	Ridge-nosed Rattlesnake
Masticophis flagellum	Coachwhip	*Diadophis punctatus*	Ring-necked Snake
Sauromalus ater	Common Chuckwalla	*Crotalus lepidus*	Rock Rattlesnake
Sceloporus graciosus	Common Sagebrush Lizard	*Lichanura roseofusca*	Rosy Boa
Uta stansburiana	Common Side-blotched Lizard	*Phrynosoma modestum*	Round-tailed Horned Lizard
Aspidoscelis uniparens	Desert Grassland Whiptail	*Phyllorhynchus browni*	Saddled Leaf-nosed Snake
Phrynosoma platyrhinos	Desert Horned Lizard	*Crotalus cerastes*	Sidewinder
Dipsosaurus dorsalis	Desert Iguana	*Sceloporus slevini*	Slevin's Bunchgrass Lizard
Lampropeltis splendida	Desert Kingsnake	*Tantilla hobartsmithi*	Smith's Black-headed Snake
Xantusia vigilis	Desert Night Lizard	*Kinosternon sonoriense sonoriense*	Sonora Mud Turtle
Hypsiglena chlorophaea	Desert Nightsnake	*Crotaphytus nebrius*	Sonoran Collared Lizard
Sceloporus magister	Desert Spiny Lizard	*Micruroides euryxanthus*	Sonoran Coralsnake
Crotaphytus collaris	Eastern Collared Lizard	*Gopherus morafkai*	Sonoran Desert Tortoise
Salvadora grahamiae	Eastern Patch-nosed	*Trimorphodon lambda*	Sonoran Lyresnake

Reptiles			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
	Snake		
Holbrookia elegans	Elegant Earless Lizard	*Lampropeltis pyromelana*	Sonoran Mountain Kingsnake
Phrynosoma mcallii	Flat-tailed Horned Lizard	*Chionactis palarostris*	Sonoran Shovel-nosed Snake
Heloderma suspectum	Gila Monster	*Aspidoscelis sonorae*	Sonoran Spotted Whiptail
Aspidoscelis flagellicauda	Gila Spotted Whiptail	*Masticophis bilineatus*	Sonoran Whipsnake
Plestiodon gilberti	Gilbert's Skink	*Kinosternon sonoriense longifemorale*	Sonoyta Mud Turtle
Phrynosoma goodei	Goode's Horned Lizard	*Sceloporus cowlesi*	Southwestern Spiny Lizard
Pituophis catenifer	Gophersnake	*Crotalus pyrrhus*	Speckled Rattlesnake
Crotaphytus bicinctores	Great Basin Collared Lizard	*Crotalus pyrrhus* (Tinajas Altas)	Speckled Rattlesnake (Tinajas Altas)
Plestiodon obsoletus	Great Plains Skink	*Phyllorhynchus decurtatus*	Spotted Leaf-nosed Snake
Cophosaurus texanus	Greater Earless Lizard	*Sceloporus virgatus*	Striped Plateau Lizard
Phrynosoma hernandesi	Greater Short-horned Lizard	*Masticophis taeniatus*	Striped Whipsnake
Senticolis triaspis	Green Ratsnake	*Thamnophis elegans*	Terrestrial Gartersnake
Hypsiglena species novum	Hooded Nightsnake	*Phrynosoma cornutum*	Texas Horned Lizard
Lampropeltis knoblochi	Knobloch's Mountain Kingsnake	*Gyalopion quadrangulare*	Thornscrub Hook-nosed Snake
Holbrookia maculata	Lesser Earless Lizard	*Lichanura trivirgata*	Three-lined Boa
Aspidoscelis inornata	Little Striped Whiptail	*Crotalus tigris*	Tiger Rattlesnake
Gambelia wislizenii	Long-nosed Leopard Lizard	*Aspidoscelis tigris*	Tiger Whiptail
Rhinocheilus lecontei	Long-nosed Snake	*Crotalus pricei*	Twin-spotted Rattlesnake
Urosaurus graciosus	Long-tailed Brush Lizard	*Sceloporus bimaculosus*	Twin-spotted Spiny Lizard
Elgaria kingii	Madrean Alligator Lizard	*Chilomeniscus stramineus*	Variable Sandsnake
Plestiodon multivirgatus	Many-lined Skink	*Coleonyx variegatus*	Western Banded Gecko
Sistrurus tergeminus	Massasauga	*Crotalus atrox*	Western Diamond-backed Rattlesnake
Heterodon kennerlyi	Mexican Hog-nosed	*Sonora semiannulata*	Western Groundsnake

Reptiles			
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
	Snake		
Lampropeltis triangulum	Milksnake	*Salvadora hexalepis*	Western Patch-nosed Snake
Lampropeltis triangulum (Cochise Co.)	Milksnake (Cochise Co.)	*Crotalus oreganus*	Western Rattlesnake
Uma scoparia	Mohave Fringe-toed Lizard	*Plestiodon skiltonianus*	Western Skink
Crotalus scutulatus	Mohave Rattlesnake	*Rena humilis*	Western Threadsnake
Chionactis occipitalis	Mohave Shovel-nosed Snake	*Tantilla yaquia*	Yaqui Black-headed Snake
Uma thurmanae	Mohawk Dunes Fringe-toed Lizard	*Sceloporus jarrovii*	Yarrow's Spiny Lizard
Gopherus agassizii	Mojave Desert Tortoise	*Kinosternon flavescens*	Yellow Mud Turtle
Plestiodon callicephalus	Mountain Skink	*Sceloporus uniformis*	Yellow-backed Spiny Lizard
Thamnophis rufipunctatus	Narrow-headed Gartersnake	*Uma rufopunctata*	Yuman Desert Fringe-toed Lizard
Crotalus willardi obscurus	New Mexico Ridge-nosed Rattlesnake	*Callisaurus draconoides*	Zebra-tailed Lizard

Appendix D: Species of Greatest Conservation Need with Vulnerability Scores

Species are listed in the table first alphabetically by taxa, then by 2022 SGCN tier (1, 2, or 3).

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Amphibian	*Hyla wrightorum* (Huachuca-Canelo Hills Population)	Arizona Treefrog (Huachuca-Canelo Hills Population)	1	2	2	1	2	1	2	2	1
Amphibian	*Rana chiricahuensis*	Chiricahua Leopard Frog	1	1	2	1	2	2	1	2	2
Amphibian	*Rana yavapaiensis*	Lowland Leopard Frog	1	1	2	1	1	2	1	2	1
Amphibian	*Rana pipiens*	Northern Leopard Frog	1	1	2	1	1	1	1	2	2
Amphibian	*Rana blairi*	Plains Leopard Frog	1	1	2	1	0	1	0	0	2
Amphibian	*Rana onca*	Relict Leopard Frog	1	1	2	1	2	1	2	2	2
Amphibian	*Ambystoma mavortium stebbinsi*	Sonoran Tiger Salamander	1	1	2	1	2	2	2	1	1
Amphibian	*Rana tarahumarae*	Tarahumara Frog	1	1	2	1	1	1	1	1	1
Amphibian	*Anaxyrus microscaphus*	Arizona Toad	2	1	2	2	0	2	2	2	1
Amphibian	*Craugastor augusti*	Barking Frog	2	2	2	2	2	1	2	2	2
Amphibian	*Gastrophryne mazatlanensis*	Sinaloan Narrow-mouthed Toad	2	3	2	2	2	2	2	2	1
Amphibian	*Smilisca fodiens*	Lowland Burrowing Treefrog	2	2	2	2	2	2	2	2	1
Amphibian	*Incilius alvarius*	Sonoran Desert Toad	2	2	2	2	2	2	2	2	1
Amphibian	*Anaxyrus retiformis*	Sonoran Green Toad	2	2	2	2	2	2	2	2	1
Amphibian	*Hyla wrightorum*	Arizona Treefrog	3	3	2	2	0	2	2	2	2
Bird	*Falco femoralis septentrionalis*	Northern Aplomado Falcon	1	1	1	1	1	2	1	2	2
Bird	*Haliaeetus leucocephalus*	Bald Eagle	1	1	2	1	2	1	1	2	2
Bird	*Gymnogyps californianus*	California Condor	1	1	2	1	2	1	1	1	2

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Bird	*Glaucidium brasilianum cactorum*	Cactus Ferruginous Pygmy-owl	1	2	2	1	2	2	1	2	1
Bird	*Colinus virginianus ridgwayi*	Masked Bobwhite	1	1	2	1	1	1	1	2	1
Bird	*Falco peregrinus anatum*	American Peregrine Falcon	1	1	2	1	2	2	1	2	2
Bird	*Rallus obsoletus yumanensis*	Ridgway's Rail	1	1	2	1	0	2	2	2	2
Bird	*Strix occidentalis lucida*	Spotted (Mexican) Owl	1	1	2	1	2	2	1	2	2
Bird	*Rhynchopsitta pachyrhyncha*	Thick-billed Parrot	1	1	1	1	0	0	0	0	0
Bird	*Empidonax traillii extimus*	Willow (Southwestern) Flycatcher	1	1	2	1	1	2	2	1	2
Bird	*Coccyzus americanus occidentalis*	Yellow-billed (Western) Cuckoo	1	1	2	1	0	2	2	2	2
Bird	*Melozone aberti*	Abert's Towhee	2	2	2	2	2	2	2	2	1
Bird	*Botaurus lentiginosus*	American Bittern	2	2	2	2	1	2	2	2	2
Bird	*Peucaea botterii arizonae*	Arizona Botteri's Sparrow	2	2	2	2	2	2	2	2	1
Bird	*Cinclus mexicanus*	American Dipper	2	2	2	2	1	2	2	2	2
Bird	*Falco sparverius*	American Kestrel	2	N/A	2	2	1	2	2	2	2
Bird	*Anthus rubescens*	American Pipit	2	3	2	2	0	1	2	2	2
Bird	*Dryobates arizonae*	Arizona Woodpecker	2	2	2	2	2	2	2	2	1
Bird	*Ammodramus bairdii*	Baird's Sparrow	2	3	2	2	1	2	2	2	2
Bird	*Patagioenas fasciata*	Band-tailed Pigeon	2	3	2	2	1	2	2	2	2
Bird	*Toxostoma bendirei*	Bendire's Thrasher	2	3	2	2	1	2	2	2	2
Bird	*Dendrocygna autumnalis*	Black-bellied Whistling-Duck	2	3	2	2	1	2	2	2	2
Bird	*Pica hudsonia*	Black-billed Magpie	2	2	2	2	1	2	2	2	2
Bird	*Polioptila nigriceps*	Black-capped Gnatcatcher	2	2	2	2	2	2	2	2	1
Bird	*Setophaga nigrescens*	Black-throated Gray Warbler	2	3	2	2	1	2	2	2	2

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Bird	*Spizella atrogularis*	Black-chinned Sparrow	2	N/A	2	2	1	2	2	2	2
Bird	*Lampornis clemenciae*	Blue-throated Mountain-gem	2	2	2	2	1	2	2	2	1
Bird	*Euphagus cyanocephalus*	Brewer's Blackbird	2	N/A	2	2	1	2	2	2	2
Bird	*Spizella breweri*	Brewer's Sparrow	2	3	2	2	1	2	2	2	2
Bird	*Cynanthus latirostris*	Broad-billed Hummingbird	2	2	2	2	2	2	2	2	1
Bird	*Selasphorus platycercus*	Broad-tailed Hummingbird	2	N/A	2	2	1	2	2	2	2
Bird	*Empidonax fulvifrons pygmaeus*	Northern Buff-breasted Flycatcher	2	2	2	2	2	2	2	2	1
Bird	*Antrostomus ridgwayi*	Buff-collared Nightjar	2	2	2	2	0	2	2	2	1
Bird	*Icterus bullockii*	Bullock's Oriole	2	3	2	2	1	2	2	2	2
Bird	*Athene cunicularia hypugaea*	Western Burrowing Owl	2	2	2	2	1	2	1	2	2
Bird	*Campylorhynchus brunneicapillus*	Cactus Wren	2	N/A	2	2	1	2	2	2	2
Bird	*Perisoreus canadensis*	Canada Jay	2	2	2	2	2	1	2	2	2
Bird	*Melozone fusca*	Canyon Towhee	2	N/A	2	2	1	2	2	2	2
Bird	*Haemorhous cassinii*	Cassin's Finch	2	N/A	2	2	1	2	2	2	2
Bird	*Calcarius ornatus*	Chestnut-collared Longspur	2	3	2	2	1	2	2	2	2
Bird	*Corvus cryptoleucus*	Chihuahuan Raven	2	N/A	2	2	1	2	2	2	2
Bird	*Aechmophorus clarkii*	Clark's Grebe	2	3	2	2	1	2	2	1	2
Bird	*Buteogallus anthracinus*	Common Black Hawk	2	3	2	2	2	2	2	2	1
Bird	*Chordeiles minor*	Common Nighthawk	2	2	2	2	1	2	2	2	2
Bird	*Calypte costae*	Costa's Hummingbird	2	3	2	2	1	2	2	2	2
Bird	*Dendragapus obscurus*	Dusky Grouse	2	2	2	2	2	1	2	2	2
Bird	*Myiarchus tuberculifer*	Dusky-capped Flycatcher	2	2	2	2	2	2	2	2	1
Bird	*Sialia sialis fulva*	Azure Bluebird	2	2	2	2	0	2	2	2	1

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Bird	*Trogon elegans*	Elegant Trogon	2	2	2	2	2	2	2	2	1
Bird	*Coccothraustes vespertinus*	Evening Grosbeak	2	2	2	2	1	2	2	2	2
Bird	*Buteo regalis*	Ferruginous Hawk	2	2	2	2	2	2	1	2	2
Bird	*Amphispizopsis quinquestriata*	Five-striped Sparrow	2	2	2	2	2	2	2	2	1
Bird	*Psiloscops flammeolus*	Flammulated Owl	2	3	2	2	0	2	1	2	2
Bird	*Melanerpes uropygialis*	Gila Woodpecker	2	2	2	2	2	2	2	2	1
Bird	*Colaptes chrysoides*	Gilded Flicker	2	2	2	2	1	2	2	2	1
Bird	*Aquila chrysaetos*	Golden Eagle	2	2	2	2	2	2	1	2	2
Bird	*Setophaga graciae*	Grace's Warbler	2	3	2	2	1	2	2	2	2
Bird	*Ammodramus savannarum ammolegus*	Arizona Grasshopper Sparrow	2	2	2	2	1	1	2	2	1
Bird	*Ammodramus savannarum perpallidus*	Western Grasshopper Sparrow	2	2	2	2	1	1	2	2	2
Bird	*Empidonax wrightii*	Gray Flycatcher	2	3	2	2	1	2	2	2	2
Bird	*Vireo vicinior*	Gray Vireo	2	2	2	2	1	2	2	2	2
Bird	*Parabuteo unicinctus*	Harris's Hawk	2	3	2	2	2	2	1	2	2
Bird	*Catharus guttatus*	Hermit Thrush	2	N/A	2	2	1	2	2	2	2
Bird	*Icterus cucullatus*	Hooded Oriole	2	3	2	2	1	2	2	2	2
Bird	*Eremophila alpestris*	Horned Lark	2	N/A	2	2	1	2	2	2	2
Bird	*Columbina inca*	Inca Dove	2	N/A	2	2	1	2	2	2	2
Bird	*Charadrius vociferus*	Killdeer	2	N/A	2	2	1	2	2	2	2
Bird	*Calamospiza melanocorys*	Lark Bunting	2	N/A	2	2	1	2	2	2	2
Bird	*Toxostoma lecontei*	LeConte's Thrasher	2	2	2	2	1	2	2	2	2
Bird	*Melanerpes lewis*	Lewis's Woodpecker	2	3	2	2	1	2	2	2	2
Bird	*Melospiza lincolnii*	Lincoln's Sparrow	2	2	2	2	2	1	2	2	2
Bird	*Lanius ludovicianus*	Loggerhead Shrike	2	N/A	2	2	1	2	2	2	2

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Bird	*Asio otus*	Long-eared Owl	2	3	2	2	1	2	1	2	2
Bird	*Geothlypis tolmiei*	MacGillivray's Warbler	2	2	2	2	1	2	2	2	2
Bird	*Rhynchophanes mccownii*	Thick-billed Longspur	2	3	2	2	1	2	2	2	2
Bird	*Poecile sclateri*	Mexican Chickadee	2	2	2	2	1	2	2	2	1
Bird	*Ictinia mississippiensis*	Mississippi Kite	2	2	2	2	2	1	2	2	2
Bird	*Poecile gambeli*	Mountain Chickadee	2	N/A	2	2	1	2	2	2	2
Bird	*Charadrius montanus*	Mountain Plover	2	2	2	2	1	2	2	2	2
Bird	*Zonotrichia leucophrys oriantha*	Mountain West White-crowned Sparrow	2	N/A	2	2	0	1	2	2	2
Bird	*Glaucidium gnoma gnoma*	Mountains Pygmy-owl	2	2	2	2	2	2	1	2	2
Bird	*Camptostoma imberbe*	Northern Beardless-Tyrannulet	2	2	2	2	0	2	2	2	1
Bird	*Accipiter gentilis*	Northern Goshawk	2	2	2	2	2	2	1	2	2
Bird	*Circus hudsonius*	Northern Harrier	2	N/A	2	2	1	2	2	2	2
Bird	*Glaucidium gnoma californicum*	Northern Pygmy-Owl	2	3	2	2	2	2	1	2	2
Bird	*Contopus cooperi*	Olive-sided Flycatcher	2	3	2	2	1	2	2	2	2
Bird	*Troglodytes pacificus*	Pacific Wren	2	2	2	2	2	1	2	2	2
Bird	*Pinicola enucleator*	Pine Grosbeak	2	2	2	2	1	1	2	2	2
Bird	*Gymnorhinus cyanocephalus*	Pinyon Jay	2	2	2	2	1	2	2	2	2
Bird	*Falco mexicanus*	Prairie Falcon	2	3	2	2	1	2	1	2	2
Bird	*Progne subis hesperia*	Desert Purple Martin	2	2	2	2	0	2	2	2	1
Bird	*Cardinalis sinuatus*	Pyrrhuloxia	2	N/A	2	2	1	2	2	2	2
Bird	*Cardellina rubrifrons*	Red-faced Warbler	2	2	2	2	1	2	2	2	2
Bird	*Agelaius phoeniceus*	Red-winged Blackbird	2	N/A	2	2	1	2	2	2	2
Bird	*Eugenes fulgens*	Rivoli's Hummingbird	2	2	2	2	0	2	2	2	1

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Bird	*Pachyramphus aglaiae*	Rose-throated Becard	2	2	2	2	2	2	2	2	1
Bird	*Peucaea carpalis*	Rufous-winged Sparrow	2	2	2	2	2	2	2	2	1
Bird	*Oreoscoptes montanus*	Sage Thrasher	2	3	2	2	1	2	2	2	2
Bird	*Passerculus sandwichensis*	Savannah Sparrow	2	2	2	2	2	1	2	2	2
Bird	*Callipepla squamata*	Scaled Quail	2	3	2	2	1	2	2	2	2
Bird	*Icterus parisorum*	Scott's Oriole	2	3	2	2	1	2	2	2	2
Bird	*Charadrius nivosus nivosus*	Western Snowy Plover	2	2	2	2	2	1	2	2	2
Bird	*Anthus spragueii*	Sprague's Pipit	2	3	2	2	1	2	2	2	2
Bird	*Cyanocitta stelleri*	Steller's Jay	2	N/A	2	2	1	2	2	2	2
Bird	*Myiodynastes luteiventris*	Sulphur-bellied Flycatcher	2	2	2	2	0	2	2	2	1
Bird	*Buteo swainsoni*	Swainson's Hawk	2	3	2	2	2	2	1	2	2
Bird	*Catharus ustulatus*	Swainson's Thrush	2	2	2	2	1	1	2	2	2
Bird	*Tyrannus crassirostris*	Thick-billed Kingbird	2	2	2	2	2	2	2	2	1
Bird	*Myadestes townsendi*	Townsend's Solitaire	2	N/A	2	2	1	2	2	2	2
Bird	*Auriparus flaviceps*	Verdin	2	N/A	2	2	1	2	2	2	2
Bird	*Pooecetes gramineus*	Vesper Sparrow	2	N/A	2	2	1	2	2	2	2
Bird	*Amazilia violiceps*	Violet-crowned Hummingbird	2	2	2	2	0	2	2	2	1
Bird	*Aechmophorus occidentalis*	Western Grebe	2	3	2	2	1	2	2	1	2
Bird	*Megascops kennicottii*	Western Screech-Owl	2	3	2	2	2	2	1	2	2
Bird	*Contopus sordidulus*	Western Wood-Pewee	2	N/A	2	2	1	2	2	2	2
Bird	*Megascops trichopsis*	Whiskered Screech-Owl	2	2	2	2	2	2	1	2	2
Bird	*Aphelocoma woodhouseii*	Woodhouse's Scrub-Jay	2	3	2	2	1	2	2	2	2
Bird	*Junco phaeonotus*	Yellow-eyed Junco	2	2	2	2	2	2	2	2	1

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Bird	*Picoides dorsalis*	American Three-toed Woodpecker	3	3	2	2	0	2	2	2	2
Bird	*Laterallus jamaicensis coturnic*	California Black Rail	3	2	2	2	0	2	2	2	2
Bird	*Baeolophus wollweberi*	Bridled Titmouse	3	3	2	2	0	2	2	2	2
Bird	*Peucaea cassinii*	Cassin's Sparrow	3	3	2	2	0	2	2	2	2
Bird	*Spizella passerina*	Chipping Sparrow	3	N/A	2	2	0	2	2	2	2
Bird	*Nucifraga columbiana*	Clark's Nutcracker	3	N/A	2	2	0	2	2	2	2
Bird	*Gallinula galeata*	Common Gallinule	3	3	2	2	0	2	2	2	2
Bird	*Columbina passerina*	Common Ground Dove	3	N/A	2	2	0	2	2	2	2
Bird	*Mergus merganser*	Common Merganser	3	N/A	2	2	0	2	2	2	2
Bird	*Podiceps nigricollis*	Eared Grebe	3	N/A	2	2	0	2	2	2	2
Bird	*Sturnella lilianae*	Chihuahan Meadowlark	3	3	2	2	0	2	2	2	2
Bird	*Micrathene whitneyi*	Elf Owl	3	3	2	2	0	2	2	2	2
Bird	*Regulus satrapa*	Golden-crowned Kinglet	3	3	2	2	0	2	2	2	2
Bird	*Dumetella carolinensis*	Gray Catbird	3	2	2	2	0	2	2	2	2
Bird	*Contopus pertinax*	Greater Pewee	3	3	2	2	0	2	2	2	2
Bird	*Baeolophus ridgwayi*	Juniper Titmouse	3	3	2	2	0	2	2	2	2
Bird	*Passerina amoena*	Lazuli Bunting	3	3	2	2	0	2	2	2	2
Bird	*Ixobrychus exilis hesperis*	Western Least Bittern	3	3	2	2	0	2	2	2	2
Bird	*Calothorax lucifer*	Lucifer Hummingbird	3	N/A	2	2	0	2	2	2	2
Bird	*Aphelocoma wollweberi*	Mexican Jay	3	3	2	2	0	2	2	2	2
Bird	*Antrostomus arizonae*	Mexican Whip-poor-will	3	3	2	2	0	2	2	2	2
Bird	*Cyrtonyx montezumae*	Montezuma Quail	3	3	2	2	0	2	2	2	2
Bird	*Sialia currucoides*	Mountain Bluebird	3	3	2	2	0	2	2	2	2
Bird	*Colaptes auratus*	Northern Flicker	3	N/A	2	2	0	2	2	2	2
Bird	*Peucedramus taeniatus*	Olive Warbler	3	3	2	2	0	2	2	2	2

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Bird	*Myioborus pictus*	Painted Redstart	3	3	2	2	0	2	2	2	2
Bird	*Spinus pinus*	Pine Siskin	3	N/A	2	2	0	2	2	2	2
Bird	*Progne subis arboricola*	Western Purple Martin	3	3	2	2	0	2	2	2	2
Bird	*Loxia curvirostra*	Red Crossbill	3	3	2	2	0	2	2	2	2
Bird	*Salpinctes obsoletus*	Rock Wren	3	N/A	2	2	0	2	2	2	2
Bird	*Aimophila ruficeps*	Rufous-crowned Sparrow	3	N/A	2	2	0	2	2	2	2
Bird	*Artemisiospiza nevadensis*	Sagebrush Sparrow	3	3	2	2	0	2	2	2	2
Bird	*Egretta thula*	Snowy Egret	3	3	2	2	0	2	2	2	2
Bird	*Porzana carolina*	Sora	3	3	2	2	0	2	2	2	2
Bird	*Actitis macularius*	Spotted Sandpiper	3	N/A	2	2	0	2	2	2	2
Bird	*Rallus limicola*	Virginia Rail	3	3	2	2	0	2	2	2	2
Bird	*Leiothlypis virginiae*	Virginia's Warbler	3	3	2	2	0	2	2	2	2
Bird	*Sturnella neglecta*	Western Meadowlark	3	N/A	2	2	0	2	2	2	2
Bird	*Aeronautes saxatalis*	White-throated Swift	3	3	2	2	0	2	2	2	2
Fish	*Oncorhynchus apache*	Apache Trout	1	1	2	1	2	1	2	2	1
Fish	*Cyprinella formosa*	Beautiful Shiner	1	1	2	1	1	1	1	2	1
Fish	*Gila elegans*	Bonytail Chub	1	1	1	1	0	2	1	2	2
Fish	*Ptychocheilus lucius*	Colorado Pikeminnow	1	1	1	1	1	2	1	2	2
Fish	*Cyprinodon macularius*	Desert Pupfish	1	1	2	1	2	2	1	2	2
Fish	*Gila intermedia*	Gila Chub	1	1	2	1	2	2	2	2	1
Fish	*Poeciliopsis occidentalis occidentalis*	Gila Topminnow	1	1	2	1	2	2	2	2	1
Fish	*Oncorhynchus gilae*	Gila Trout	1	1	2	1	2	1	2	2	2
Fish	*Gila cypha*	Humpback Chub	1	1	2	1	2	1	1	1	2
Fish	*Lepidomeda vittata*	Little Colorado Spinedace	1	1	2	1	2	1	2	2	1
Fish	*Tiaroga cobitis*	Loach Minnow	1	1	2	1	1	1	1	2	1

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Fish	*Cyprinodon eremus*	Sonoyta Pupfish	1	1	2	1	1	1	1	2	1
Fish	*Xyrauchen texanus*	Razorback Sucker	1	1	2	1	1	2	1	1	2
Fish	*Gila robusta*	Roundtail Chub	1	2	2	1	2	2	2	2	2
Fish	*Gila ditaenia*	Sonora Chub	1	1	2	1	1	1	1	2	1
Fish	*Meda fulgida*	Spikedace	1	1	2	1	2	1	1	2	1
Fish	*Gila seminuda*	Virgin River Chub	1	1	2	1	2	1	1	2	2
Fish	*Plagopterus argentissimus*	Woundfin	1	1	2	1	1	2	1	2	2
Fish	*Ictalurus pricei*	Yaqui Catfish	1	1	1	1	1	1	1	2	1
Fish	*Gila purpurea*	Yaqui Chub	1	1	2	1	1	1	1	2	1
Fish	*Poeciliopsis occidentalis sonoriensis*	Yaqui Topminnow	1	1	2	1	2	1	2	2	1
Fish	*Catostomus discobolus yarrowi*	Zuni Bluehead Sucker	1	1	2	1	1	1	2	2	2
Fish	*Catostomus discobolus*	Bluehead Sucker	2	1	2	2	2	1	2	2	2
Fish	*Catostomus clarkii*	Desert Sucker	2	2	2	2	2	2	1	2	2
Fish	*Catostomus latipinnis*	Flannelmouth Sucker	2	1	2	2	2	2	1	2	2
Fish	*Catostomus* sp. 3	Little Colorado Sucker	2	1	2	2	1	1	1	2	1
Fish	*Agosia chrysogaster*	Longfin Dace	2	2	2	2	0	2	1	2	2
Fish	*Elops affinis*	Machete	2	2	2	2	2	2	1	1	2
Fish	*Campostoma ornatum*	Mexican Stoneroller	2	1	2	2	1	1	1	2	1
Fish	*Catostomus insignis*	Sonora Sucker	2	2	2	2	2	2	1	1	2
Fish	*Lepidomeda mollispinis mollispinis*	Virgin Spinedace	2	1	2	2	2	1	1	2	2
Fish	*Catostomus bernardini*	Yaqui Sucker	2	2	1	2	1	1	1	2	1
Fish	*Mugil cephalus*	Striped Mullet	3	2	2	2	0	2	0	2	2
Invertebrate	*Pyrgulopsis sola*	Brown Springsnail	1	1	2	1	0	2	0	2	1
Invertebrate	*Pyrgulopsis arizonae*	Bylas Springsnail	1	1	2	1	2	2	2	2	1

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Invertebrate	*Anodonta californiensis*	California Floater	1	1	2	1	1	1	1	2	2
Invertebrate	*Sonorella christenseni*	Clark Peak Talussnail	1	2	2	1	0	2	0	2	1
Invertebrate	*Gastrocopta quadridens*	Cross Snaggletooth	1	1	2	1	0	0	0	2	0
Invertebrate	*Pyrgulopsis deserta*	Desert Springsnail	1	1	2	1	0	0	0	2	2
Invertebrate	*Tryonia porrecta*	Desert Tryonia	1	N/A	2	1	2	2	2	2	2
Invertebrate	*Pyrgulopsis simplex*	Fossil Springsnail	1	1	2	1	2	2	2	2	1
Invertebrate	*Tryonia gilae*	Gila Tryonia	1	1	2	1	2	2	2	2	1
Invertebrate	*Pyrgulopsis bacchus*	Grand Wash Springsnail	1	1	2	1	1	1	1	2	1
Invertebrate	*Pyrgulopsis thompsoni*	Huachuca Springsnail	1	1	2	1	2	2	2	2	1
Invertebrate	*Pyrgulopsis hualapaiensis*	Hualapai Springsnail	1	1	2	1	0	0	0	2	1
Invertebrate	*Pyrgulopsis sp. A*	(no common name)	1	N/A	2	1	0	0	0	2	2
Invertebrate	*Pyrgulopsis sp. B*	(no common name)	1	N/A	2	1	2	2	2	2	1
Invertebrate	*Pyrgulopsis sp. C*	(no common name)	1	N/A	2	1	2	0	0	2	1
Invertebrate	*Pyrgulopsis conica*	Kingman Springsnail	1	1	2	1	1	1	1	2	1
Invertebrate	*Sonorella imitator*	Mimic Talussnail	1	2	2	1	0	2	0	2	1
Invertebrate	*Pyrgulopsis montezumensis*	Montezuma Well Springsnail	1	1	2	1	2	2	2	2	1
Invertebrate	*Oxyloma haydeni haydeni*	Niobrara Ambersnail	1	1	2	1	2	1	2	2	1
Invertebrate	*Pyrgulopsis morrisoni*	Page Springsnail	1	1	2	1	2	2	2	2	1
Invertebrate	*Oreohelix grahamensis*	Pinaleño Mountainsnail	1	2	2	1	0	0	0	2	1
Invertebrate	*Sonorella grahamensis*	Pinaleño Talussnail	1	2	2	1	0	2	0	2	1
Invertebrate	*Tryonia quitobaquitae*	Quitobaquito Tryonia	1	1	2	1	2	1	0	2	1
Invertebrate	*Pyrgulopsis bernardina*	San Bernardino Springsnail	1	1	2	1	1	1	1	2	2
Invertebrate	*Sonorella eremita*	San Xavier Talussnail	1	1	2	1	0	2	0	2	1
Invertebrate	*Gastrocopta dalliana*	Shortneck Snaggletooth	1	1	2	1	0	0	0	2	0

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Invertebrate	*Pyrgulopsis trivialis*	Three Forks Springsnail	1	1	2	1	1	1	1	2	1
Invertebrate	*Pyrgulopsis glandulosa*	Verde Rim Springsnail	1	1	2	1	2	1	2	2	1
Invertebrate	*Sonorella macrophallus*	Wet Canyon Talussnail	1	1	2	1	0	2	0	2	1
Invertebrate	*Oreohelix anchana*	Ancha Mountainsnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella baboquivariensis*	Baboquivari Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella danielsi*	Bear Canyon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Naesiotus (Rabdotus) nigromontanus*	Black Mountain Rabdotus	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Sonorella papagorum*	Black Mountain Talussnail	2	2	2	2	0	0	0	2	1
Invertebrate	*Sonorella bradshaveana*	Bradshaw Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Radiocentrum clappi*	Cave Creek Mountainsnail	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Ashmunella chiricahuana*	Cave Creek Woodlandsnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Radiocentrum chiricahuana*	Chiricahua Mountainsnail	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Sonorella virilis*	Chiricahua Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Oreohelix houghi*	Diablo Mountainsnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella bicipitis*	Dos Cabezas Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella rooseveltiana fragilis*	Fragile Talussnail	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Sonorella galiurensis*	Galiuro Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella dalli*	Garden Canyon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Oreohelix concentrata*	Huachuca Mountainsnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella huachucana*	Huachuca Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Ashmunella levettei*	Huachuca Woodlandsnail	2	3	2	2	2	0	0	2	1
Invertebrate	*Sonorella xanthenes*	Kitt Peak Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella pedregosensis*	Leslie Canyon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella clappi*	Madera Talussnail	2	3	2	2	0	0	0	2	1

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Invertebrate	*Sonorella micromphala*	Milk Ranch Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Hyalella montezuma*	Montezuma Well Amphipod	2	2	2	2	0	1	2	2	1
Invertebrate	*Sonorella compar*	Oak Creek Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella ambigua verdensis*	Papago Verde Talussnail	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Sonorella simmonsi*	Picacho Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella rinconensis*	Posta Quemada Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella granulatissima*	Ramsey Canyon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella ashmuni*	Richinbar Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella bagnarai*	Rincon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella (Myotophallus) rooseveltiana*	Roosevelt Talussnail	2	N/A	2	2	0	0	0	2	1
Invertebrate	*Sonorella tryoniana*	Sanford Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella sabinoensis*	Santa Catalina Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Naesiotus (Rabdotus) christenseni*	Santa Rita Rabdotus	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella walkeri*	Santa Rita Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella anchana*	Sierra Ancha Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella allynsmithi*	Phoenix (Squaw Peak) Talussnail	2	2	2	2	0	2	0	2	1
Invertebrate	*Sonorella superstitionis*	Superstition Mountains Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella tortillita*	Tortolita Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella imperatrix*	Total Wreck Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Sonorella coltoniana*	Walnut Canyon Talussnail	2	3	2	2	0	0	0	2	1
Invertebrate	*Oreohelix yavapai*	Yavapai Mountain Snail	2	3	2	2	0	0	0	2	1
Invertebrate	*Vallonia perspectiva*	(no common name)	3	0	0	2	0	0	0	0	0
Invertebrate	*Galba (Fossaria) cockerelli*	(no common name)	3	0	0	2	0	0	0	0	0

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Invertebrate	*Lymnaea humilis*	(no common name)	3	0	2	2	0	0	0	2	2
Invertebrate	*Oreohelix* sp. 32	(no common name)	3	0	0	2	0	0	0	0	0
Invertebrate	*Sonorella* sp. 1	(no common name)	3	0	0	2	0	0	0	0	0
Invertebrate	*Vertigo arizonensis*	(no common name)	3	0	0	2	0	0	0	0	0
Invertebrate	*Vertigo coloradensis*	(no common name)	3	0	0	2	0	0	0	0	0
Invertebrate	*Sonorella santaritana*	Agua Caliente Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Nesovitrea electrina*	Amber Glass	3	3	0	2	0	0	0	0	0
Invertebrate	*Hyalella azteca*	(no common name)	3	0	2	2	0	0	0	2	2
Invertebrate	*Gastrocopta cochisensis*	Apache Snaggletooth	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella apache*	Apache Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella meadi*	Aqua Dulce Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Stygobromus arizonensis*	Arizona Cave Amphipod	3	2	0	2	0	0	0	0	0
Invertebrate	*Holospira arizonensis*	Arizona Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Pallifera pilsbryi*	Arizona mantleslug	3	3	0	2	0	0	0	0	0
Invertebrate	*Gyraulus parvus*	Ash Gyro	3	3	0	2	0	0	0	0	0
Invertebrate	*Oreohelix barbata*	Bearded Mountainsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Thamnocephalus platyurus*	Beavertail Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella optata*	Big Emigrant Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella russelli*	Black Mesa Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Vertigo milium*	Blade Vertigo	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Ashmunella pilsbryana*	Blue Mountain Woodlandsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella caeruliflumini*s	Blue Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Cyzicus setosa*	Bristletail Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Glyphyalinia indentata*	Carved Glyph	3	3	0	2	0	0	0	0	0

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Invertebrate	*Holospira chiricahuana*	Cave Creek Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Physella osculans*	Cayuse Physa	3	3	0	2	0	0	0	0	0
Invertebrate	*Streptocephalus mackini*	Chihuahuan Desert Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Ashmunella proxima*	Chiricahua Woodlandsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Discus shimekii cockerelli*	Cockerell's Striate Disc (Snail)	3	3	0	2	0	0	0	0	0
Invertebrate	*Branchinecta coloradensis*	Colorado Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Physella humerosa*	Corkscrew Physa	3	3	0	2	0	0	0	0	0
Invertebrate	*Gastrocopta cristata*	Crested Snaggletooth	3	3	0	2	0	0	0	0	0
Invertebrate	*Pupilla hebes*	Crestless Column	3	3	0	2	0	0	0	0	0
Invertebrate	*Oreohelix yavapai cummingsi*	Cummings Mountainsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Triops newberryi*	Desert Tadpole Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Gyraulus circumstriatus*	Disc Gyro	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella waltoni*	Doubtful Canyon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella ferrissi*	Dragoon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Eremarionta rowelli*	Eastern Desertsnail	3	N/A	0	2	0	2	0	0	0
Invertebrate	*Sonorella imperialis*	Empire Mountain Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella bartschi*	Escabrosa Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Eubranchipus hesperius*	Ethologist Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella vespertina*	Evening Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Ferrissia fragilis*	Fragile Ancylid	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Galba (Fossaria) techella*	Freshwater Snail	3	3	0	2	0	0	0	0	0
Invertebrate	*Cochlicopa lubrica*	Glossy Pillar (Snail)	3	3	0	2	0	0	0	0	0
Invertebrate	*Valvata humeralis*	Glossy Valvata	3	3	0	2	0	0	0	0	0

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Invertebrate	*Galba (Fossaria) obrussa*	Golden Fossaria	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella coloradoensis*	Grand Canyon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Streptocephalus texanus*	Greater Plains Fairy Shrimp	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Sonorella bequaerti*	Happy Valley Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Lynceus brachyurus*	Holarctic Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Chaenaxis tuba*	Hollow Tuba (Snail)	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira campestris*	Holospira (no common name)	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira cionella*	Holospira (no common name)	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira millestriata*	Holospira (no common name)	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella binneyi*	Horseshoe Canyon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Branchinecta kaibabensis*	Kaibab Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Eubranchipus bundyi*	Knobbedlip Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella sitiens*	Las Guijas Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella parva*	Little Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Triops longicaudatus*	Longtail Tadpole Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Deroceras laeve*	Marsh Slug (or Meadow Slug)	3	3	2	2	0	2	2	2	2
Invertebrate	*Columella columella*	Mellow Column (Snail)	3	3	0	2	0	0	0	0	0
Invertebrate	*Thamnocephalus mexicanus*	Mexican Beavertail Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Cyzicus mexicanus*	Mexican Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Lucilla (Helicodiscus) eigenmanni*	Mexican Coil	3	3	0	2	0	0	0	0	0
Invertebrate	*Planorbella tenuis*	Mexican Rams-horn	3	3	0	2	0	0	0	0	0
Invertebrate	*Succinea luteola*	Mexico Ambersnail	3	3	0	2	0	0	0	0	0

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Invertebrate	*Otala lactea*	Milk Snail	3	3	0	2	0	0	0	0	0
Invertebrate	*Hawaiia minuscula*	Minute Gem	3	3	2	2	0	2	2	2	2
Invertebrate	*Ashmunella mogollonensis*	Mogollon Woodlandsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Gastrocopta pilsbryana*	Montane Snaggletooth	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella mustang*	Mustang Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Streptocephalus dorothae*	New Mexico Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Discus whitneyi*	(no common name)	3	3	0	2	0	0	0	0	0
Invertebrate	*Vertigo ovata*	Ovate Vertigo	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Sonorella ambigua*	Papago Talussnail	3	2	0	2	0	0	0	0	0
Invertebrate	*Paralaoma caputspinulae*	Pinhead Spot	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Sonorella neglecta*	Portal Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Physella virgata*	Protean Physa	3	3	2	2	0	0	0	2	0
Invertebrate	*Sonorella odorata*	Pungent Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Galba (Fossaria) parva*	Pygmy Fossaria	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella micra*	Pygmy Sonorella	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella bowiensis*	Quartzite Hill Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Zonitoides arboreus*	Quick Gloss	3	3	2	2	0	0	0	2	2
Invertebrate	*Sonorella reederi*	Rampart Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Ashmunella ferrissi*	Reed's Mountain Woodlandsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Pupoides hordaceus*	Ribbed Dagger	3	3	0	2	0	0	0	0	0
Invertebrate	*Radiodiscus millecostatus*	Ribbed Pinwheel	3	3	0	2	0	0	0	0	0
Invertebrate	*Punctum californicum*	Ribbed Spot	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Galba (Fossaria) modicella*	Rock Fossaria	3	3	0	2	0	0	0	0	0

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Invertebrate	*Branchinecta packardi*	Rock Pool Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Pupilla blandii*	Rocky Mountain Column	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Oreohelix strigosa*	Rocky Mountainsnail	3	3	2	2	0	0	0	2	2
Invertebrate	*Vertigo berryi*	Rotund Vertigo	3	3	0	2	0	0	0	0	0
Invertebrate	*Artemia franciscana*	San Francisco Brine Shrimp	3	3	2	2	0	0	0	0	0
Invertebrate	*Succinea grosvenori*	Santa Rita Ambersnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Promenetus exacuous*	Sharp Sprite (A Planorbid Snail)	3	3	0	2	0	0	0	0	0
Invertebrate	*Lynceus brevifrons*	Short Finger Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Vallonia cyclophorella*	Silky Vallonia	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira sherbrookei*	Silver Creek Holospira	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Gastrocopta pellucida*	Slim Snaggletooth	3	3	0	2	0	0	0	0	0
Invertebrate	*Gastrocopta ashmuni*	Sluice Snaggletooth	3	3	0	2	0	0	0	0	0
Invertebrate	*Lucilla (Helicodiscus) singleyana*	Smooth Coil	3	3	0	2	0	0	0	0	0
Invertebrate	*Gastrocopta prototypus*	Sonoran Snaggletooth	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Sonorella magdalenensis*	Sonoran Talussnail	3	3	2	2	0	0	0	2	0
Invertebrate	*Thysanophora hornii*	Southwestern Fringed-snail	3	3	0	2	0	0	0	0	0
Invertebrate	*Leptestheria compleximanus*	Spinynose Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Streptocephalus coloradensis*	Colorado Spinytail Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Microphysula ingersolli*	Spruce Snail	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella franciscana*	St. Francis Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira ferrissi*	Stocky Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira danielsi*	Stongrib Holospira	3	3	0	2	0	0	0	0	0

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Invertebrate	*Eocyzicus digueti*	Straightbacked Clam Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Discus shimekii*	Striate Disc	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella dragoonensis*	Stronghold Canyon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Oreohelix subrudis*	Subalpine Mountainsnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Catinella vermeta*	Suboval Ambersnail	3	3	2	2	0	2	2	2	2
Invertebrate	*Sonorella milleri*	Table Top Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Physa gyrina*	Tadpole Physa	3	N/A	2	2	0	0	0	2	2
Invertebrate	*Holospira tantalus*	Teasing Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Pisidium insigne*	Tiny Peaclam	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella delicata*	Tollhouse Canyon Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Pupilla syngenes*	Top-heavy Column	3	3	0	2	0	0	0	0	0
Invertebrate	*Pisidium variabile*	Triangular Peaclam	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Helisoma anceps*	Two-ridge Rams-horn	3	3	0	2	0	0	0	0	0
Invertebrate	*Pisidium casertanum*	Ubiquitous Peaclam	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira montivaga*	Vagabond Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Branchinecta lindahli*	Versatile Fairy Shrimp	3	3	0	2	0	0	0	0	0
Invertebrate	*Pisidium walkeri*	Walker Peaclam	3	N/A	0	2	0	0	0	0	0
Invertebrate	*Vitrina pellucida alaskana*	Western Glass Snail	3	3	0	2	0	0	0	0	0
Invertebrate	*Holospira whetstonensis*	Whetstone Holospira	3	3	0	2	0	0	0	0	0
Invertebrate	*Sonorella insignis*	Whetstone Talussnail	3	3	0	2	0	0	0	0	0
Invertebrate	*Pupoides albilabris*	White-lip Dagger	3	N/A	0	2	0	0	0	0	0
Mammal	*Mustela nigripes*	Black-footed Ferret	1	1	2	1	1	1	1	1	2
Mammal	*Cynomys ludovicianus*	Black-tailed Prairie Dog	1	1	2	1	2	1	1	1	2
Mammal	*Cynomys gunnisoni*	Gunnison's Prairie Dog	1	2	2	1	2	2	1	1	2

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Mammal	*Panthera onca*	Jaguar	1	1	2	1	1	1	0	2	2
Mammal	*Leptonycteris yerbabuenae*	Lesser Long-nosed Bat	1	2	2	1	2	2	2	1	1
Mammal	*Canis lupus baileyi*	Mexican Gray Wolf	1	1	2	1	2	2	1	2	1
Mammal	*Tamiasciurus hudsonicus grahamens*	Mt. Graham Red Squirrel	1	1	2	1	1	1	1	2	1
Mammal	*Zapus hudsonius luteus*	New Mexican Jumping Mouse	1	1	2	1	0	1	0	2	2
Mammal	*Leopardus pardalis*	Ocelot	1	1	2	1	0	1	0	2	2
Mammal	*Corynorhinus townsendii pallescens*	Pale Townsend's Big-eared Bat	1	3	2	1	1	2	2	2	2
Mammal	*Antilocapra americana sonoriensis*	Sonoran Pronghorn	1	1	2	1	2	1	1	1	1
Mammal	*Sciurus aberti chuscensis*	Abert's Chuska Squirrel	2	2	2	2	2	1	2	2	1
Mammal	*Idionycteris phyllotis*	Allen's Lappet-browed Bat	2	3	2	2	0	2	0	1	2
Mammal	*Antilocapra americana americana*	American Pronghorn	2	2	2	2	2	2	1	2	2
Mammal	*Lepus alleni*	Antelope Jackrabbit	2	2	2	2	0	2	2	2	1
Mammal	*Sigmodon arizonae cienegae*	Arizona Cotton Rat	2	2	2	2	0	1	0	2	2
Mammal	*Sciurus arizonensis*	Arizona Gray Squirrel	2	2	2	2	0	1	0	2	1
Mammal	*Microtus montanus*	Arizona Montane Vole	2	2	2	2	2	1	0	2	1
Mammal	*Perognathus amplus*	Arizona Pocket Mouse	2	2	2	2	2	2	2	2	1
Mammal	*Sorex arizonae*	Arizona Shrew	2	2	2	2	0	1	0	2	1
Mammal	*Chaetodipus baileyi*	Bailey's Pocket Mouse	2	2	2	2	2	2	2	2	1
Mammal	*Nyctinomops macrotis*	Big Free-tailed Bat	2	3	2	2	0	2	0	1	2
Mammal	*Macrotus californicus*	California Leaf-nosed Bat	2	N/A	2	2	2	2	2	1	1
Mammal	*Myotis velifer*	Cave Myotis	2	N/A	2	2	2	2	2	1	2
Mammal	*Sciurus nayaritensis chiricahuae*	Chiricahua Fox Squirrel	2	2	2	2	0	1	0	2	1

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Mammal	*Notiosorex cockrumi*	Cockrum's Desert Shrew	2	2	2	2	0	1	0	0	1
Mammal	*Sigmodon arizonae plenus*	Colorado River Cotton Rat	2	2	1	2	0	1	0	2	1
Mammal	*Sorex nanus*	Dwarf Shrew	2	2	2	2	0	1	0	2	2
Mammal	*Myotis thysanodes*	Fringed Myotis	2	N/A	2	2	2	2	2	1	2
Mammal	*Callospermophilus lateralis*	Golden-mantled Ground Squirrel	2	3	2	2	2	1	2	2	2
Mammal	*Tamias cinereicollis*	Gray-collared Chipmunk	2	2	2	2	0	2	0	2	1
Mammal	*Eumops perotis californicus*	Greater Western Mastiff Bat	2	2	2	2	1	2	0	1	2
Mammal	*Thomomys bottae subsimilis*	Harquahala Southern Pocket Gopher	2	2	2	2	0	1	0	2	1
Mammal	*Ammospermophilus harrisii*	Harris's Antelope Squirrel	2	2	2	2	2	2	2	2	1
Mammal	*Sigmodon hispidus*	Hispid Cotton Rat	2	2	2	2	0	1	0	2	2
Mammal	*Lasiurus cinereus*	Hoary Bat	2	3	2	2	0	2	2	1	2
Mammal	*Dipodomys microps leucotis*	Houserock Valley Chisel-toothed Kangaroo Rat	2	2	2	2	0	1	0	2	1
Mammal	*Sciurus aberti kaibabensis*	Kaibab Squirrel	2	2	2	2	2	1	2	2	1
Mammal	*Tamias minimus*	Least Chipmunk	2	2	2	2	0	1	0	2	2
Mammal	*Tadarida brasiliensis*	Mexican Free-tailed Bat	2	2	2	2	2	2	2	1	2
Mammal	*Choeronycteris mexicana*	Mexican Long-tongued Bat	2	3	2	2	1	2	2	2	1
Mammal	*Didelphis virginiana californica*	Mexican Opossum	2	2	2	2	0	1	2	2	2
Mammal	*Neotoma mexicana mexicana*	Mexican Woodrat	2	N/A	2	2	0	1	2	2	0
Mammal	*Nyctinomops femorosaccus*	Pocketed Free-tailed Bat	2	3	2	2	2	2	2	1	2
Mammal	*Ammospermophilus leucurus tersus*	Prospect Valley White-tailed Antelope Squirrel	2	2	2	2	0	1	0	2	1

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Mammal	*Peromyscus nasutus (difficilis)*	Rock Mouse	2	3	2	2	0	1	2	2	2
Mammal	*Thomomys umbrinus intermedius*	Southern Pocket Gopher	2	2	2	2	0	1	0	2	1
Mammal	*Myotis auriculus*	Southwestern Myotis	2	3	2	2	0	0	2	2	1
Mammal	*Lontra canadensis sonora*	Southwestern River Otter	2	2	1	0	0	0	0	0	0
Mammal	*Euderma maculatum*	Spotted Bat	2	2	2	2	0	2	0	1	2
Mammal	*Perognathus flavus goodpasteri*	Springerville Pocket Mouse	2	2	2	2	0	1	0	0	1
Mammal	*Neotoma stephensi*	Stephen's Woodrat	2	3	2	2	2	2	2	2	1
Mammal	*Spermophilus tridecemlineatus*	Thirteen-lined Ground Squirrel	2	2	2	2	2	1	2	2	2
Mammal	*Tamias umbrinus*	Uinta Chipmunk	2	2	2	2	0	1	0	2	2
Mammal	*Eumops underwoodi*	Underwood's Mastiff Bat	2	2	2	2	0	2	0	2	1
Mammal	*Lasiurus blossevillii*	Western Red Bat	2	3	2	2	0	2	0	1	2
Mammal	*Sorex navigator*	Western Water Shrew	2	N/A	2	2	0	1	0	2	2
Mammal	*Lasiurus xanthinus*	Western Yellow Bat	2	N/A	2	2	0	2	2	1	2
Mammal	*Microtus longicaudus leucophaeus*	White-bellied Long-tailed Vole	2	2	2	2	0	1	0	2	1
Mammal	*Ammospermophilus leucurus cinnamomeus*	White-tailed Antelope Squirrel	2	3	2	2	0	0	0	2	1
Mammal	*Perognathus amplus cineris*	Wupatki Arizona Pocket Mouse	2	2	2	2	0	1	0	2	1
Mammal	*Sigmodon arizonae jacksoni*	Yavapai Arizona Cotton Rat	2	2	1	2	0	1	0	2	1
Mammal	*Sigmodon hispidus eremicus*	Yuma Hispid Cotton Rat	2	2	2	2	0	1	0	2	1
Mammal	*Myotis yumanensis*	Yuma Myotis	2	N/A	2	2	2	2	2	1	2
Mammal	*Perognathus apache melanotis*	Apache Pocket Mouse	3	3	2	2	0	0	0	2	0
Mammal	*Lepus californicus*	Black-tailed Jackrabbit	3	N/A	2	2	0	2	2	2	2

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Mammal	*Neotoma cinerea*	Bushy-tailed Woodrat	3	2	2	2	0	2	2	2	2
Mammal	*Peromyscus crinitus*	Canyon Mouse	3	3	2	2	0	2	2	2	2
Mammal	*Dipodomys microps celsus*	Chisel-toothed Kangaroo Rat	3	2	2	2	0	2	0	2	2
Mammal	*Tamias quadrivittatus*	Colorado Chipmunk	3	2	2	2	0	2	0	2	2
Mammal	*Neotoma lepida*	Desert Woodrat	3	3	2	2	0	2	0	2	2
Mammal	*Conepatus leuconotus leuconotus*	Hog-nosed Skunk	3	3	2	2	0	2	2	2	2
Mammal	*Microtus longicaudus*	Long-tailed Vole	3	2	2	2	0	2	2	2	2
Mammal	*Mustela frenata*	Long-tailed Weasel	3	3	2	2	0	2	2	2	2
Mammal	*Peromyscus merriami*	Merriam's Deermouse	3	N/A	2	2	0	2	2	2	2
Mammal	*Sorex merriami*	Merriam's Shrew	3	2	2	2	0	2	2	2	2
Mammal	*Microtus mexicanus*	Mexican Vole	3	2	2	2	0	2	2	2	2
Mammal	*Sylvilagus nuttallii grangeri*	North Kaibab Mountain Cottontail	3	2	2	2	0	2	2	2	2
Mammal	*Glaucomys sabrinus*	Northern Flying Squirrel	3	N/A	2	2	0	0	2	2	2
Mammal	*Thomomys talpoides*	Northern Pocket Gopher	3	3	2	2	0	2	0	2	2
Mammal	*Reithrodontomys montanus*	Plains Harvest Mouse	3	3	2	2	0	2	0	2	2
Mammal	*Chaetodipus penicillatus*	Desert Pocket Mouse	3	N/A	2	2	0	0	2	2	2
Mammal	*Clethrionomys gapperi*	Southern Red-backed Vole	3	3	2	2	0	2	0	2	2
Mammal	*Sylvilagus nuttallii pinetis*	Southwestern Cottontail	3	2	2	2	0	2	2	2	2
Mammal	*Sigmodon fulviventer*	Tawny-bellied Cotton Rat	3	3	2	2	0	2	0	2	2
Mammal	*Spilogale gracilis*	Western Spotted Skunk	3	3	2	2	0	2	2	2	2
Mammal	*Sigmodon ochrognathus*	Yellow-nosed Cotton Rat	3	2	2	2	0	2	0	2	2
Reptile	*Phrynosoma mcallii*	Flat-tailed Horned Lizard	1	1	2	1	1	2	2	2	2
Reptile	*Heloderma suspectum*	Gila Monster	1	2	2	1	2	2	2	2	1
Reptile	*Sistrurus tergeminus*	Massasauga	1	1	2	1	1	2	2	2	2

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Reptile	*Lampropeltis triangulum* (Cochise Co.)	Milksnake (Cochise Co.)	1	1	2	1	0	1	2	2	1
Reptile	*Gopherus agassizii*	Mojave Desert Tortoise	1	1	2	1	1	2	1	2	2
Reptile	*Thamnophis rufipunctatus*	Narrow-headed Gartersnake	1	1	2	1	1	1	1	2	1
Reptile	*Crotalus willardi obscurus*	New Mexico Ridge-nosed Rattlesnake	1	1	2	1	0	1	2	2	2
Reptile	*Thamnophis eques*	Northern Mexican Gartersnake	1	1	2	1	1	1	2	2	1
Reptile	*Terrapene ornata*	Ornate Box Turtle	1	1	2	1	1	2	1	2	2
Reptile	*Crotalus willardi willardi*	Ridge-nosed Rattlesnake	1	1	2	1	2	1	2	2	1
Reptile	*Crotalus lepidus*	Rock Rattlesnake	1	1	2	1	2	1	2	2	2
Reptile	*Gopherus morafkai*	Sonoran Desert Tortoise	1	1	2	1	2	2	1	2	1
Reptile	*Kinosternon sonoriense longifemorale*	Sonoyta Mud Turtle	1	1	2	1	1	1	2	1	1
Reptile	*Crotalus pricei*	Twin-spotted Rattlesnake	1	1	2	1	2	1	2	2	1
Reptile	*Crotalus cerberus*	Arizona Black Rattlesnake	2	2	2	2	2	2	2	2	1
Reptile	*Kinosternon arizonense*	Arizona Mud Turtle	2	2	2	2	2	2	2	2	1
Reptile	*Xantusia arizonae*	Arizona Night Lizard	2	2	2	2	0	1	2	2	1
Reptile	*Xantusia bezyi*	Bezy's Night Lizard	2	2	2	2	0	1	2	2	1
Reptile	*Oxybelis aeneus*	Brown Vinesnake	2	2	2	2	2	2	2	2	1
Reptile	*Aspidoscelis stictogramma*	Canyon Spotted Whiptail	2	2	2	2	2	2	2	2	1
Reptile	*Tantilla wilcoxi*	Chihuahuan Black-headed Snake	2	2	2	2	2	1	2	2	1
Reptile	*Phrynosoma goodei*	Goode's Horned Lizard	2	2	2	2	2	2	2	2	1
Reptile	*Senticolis triaspis*	Green Ratsnake	2	2	2	2	2	2	2	2	1
Reptile	*Hypsiglena species novum*	Hooded Nightsnake	2	2	2	2	2	2	2	2	1
Reptile	*Elgaria kingii*	Madrean Alligator Lizard	2	N/A	2	2	2	2	2	2	1

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Reptile	*Uma scoparia*	Mohave Fringe-toed Lizard	2	2	2	2	2	1	2	2	2
Reptile	*Uma thurmanae*	Mohawk Dunes Fringe-toed Lizard	2	N/A	2	2	2	2	2	2	1
Reptile	*Plestiodon callicephalus*	Mountain Skink	2	N/A	2	2	2	2	2	2	1
Reptile	*Chrysemys picta*	Painted Turtle	2	2	2	2	2	1	2	2	2
Reptile	*Aspidoscelis xanthonota*	Red-back Whiptail	2	2	2	2	2	2	2	2	1
Reptile	*Phrynosoma solare*	Regal Horned Lizard	2	2	2	2	2	2	2	2	1
Reptile	*Phyllorhynchus browni*	Saddled Leaf-nosed Snake	2	2	2	2	2	2	2	2	1
Reptile	*Sceloporus slevini*	Slevin's Bunchgrass Lizard	2	2	2	2	1	1	2	2	1
Reptile	*Kinosternon sonoriense sonoriense*	Sonora Mud Turtle	2	2	2	2	2	2	2	2	1
Reptile	*Crotaphytus nebrius*	Sonoran Collared Lizard	2	2	2	2	2	2	2	2	1
Reptile	*Micruroides euryxanthus*	Sonoran Coralsnake	2	2	2	2	2	2	2	2	1
Reptile	*Chionactis palarostris*	Sonoran Shovel-nosed Snake	2	2	2	2	2	2	2	2	1
Reptile	*Aspidoscelis sonorae*	Sonoran Spotted Whiptail	2	3	2	2	2	2	2	2	1
Reptile	*Masticophis bilineatus*	Sonoran Whipsnake	2	2	2	2	2	2	2	2	1
Reptile	*Crotalus pyrrhus* (Tinajas Altas)	Speckled Rattlesnake (Tinajas Altas)	2	2	2	2	2	2	2	2	1
Reptile	*Sceloporus virgatus*	Striped Plateau Lizard	2	N/A	2	2	2	1	2	2	2
Reptile	*Gyalopion quadrangulare*	Thornscrub Hook-nosed Snake	2	2	2	2	2	2	2	2	1
Reptile	*Lichanura trivirgata*	Three-lined Boa	2	2	2	2	2	2	2	2	1
Reptile	*Crotalus tigris*	Tiger Rattlesnake	2	2	2	2	2	2	2	2	1
Reptile	*Chilomeniscus stramineus*	Variable Sandsnake	2	2	2	2	2	2	2	2	1
Reptile	*Tantilla yaquia*	Yaqui Black-headed Snake	2	2	2	2	2	1	2	2	1
Reptile	*Sceloporus jarrovii*	Yarrow's Spiny Lizard	2	N/A	2	2	2	2	2	2	1
Reptile	*Kinosternon flavescens*	Yellow Mud Turtle	2	2	2	2	2	1	2	2	2

			SGCN Tier		Vulnerability Criteria Score						
Taxonomic Group	Scientific Name	Common Name	2022	2012	Extirpated Status	Federal State Legal Status	Declining Status	Disjunct Status	Demographic Status	Concentration Status	Distribution Status
Reptile	*Uma rufopunctata*	Yuman Desert Fringe-toed Lizard	2	2	2	2	2	1	2	2	1
Reptile	*Thamnophis cyrtopsis*	Black-necked Gartersnake	3	3	2	2	0	2	2	2	2
Reptile	*Chionactis occipitalis*	Mohave Shovel-nosed Snake	3	3	2	2	0	2	2	2	2

Appendix E: Sensitive Plant Species of the AWCS

NAME	COMMON NAME	ESA	NPL	GRANK
Aconitum infectum	Arizona Monkshood			G1Q
Actaea arizonica	Arizona Bugbane	CCA	HS	G2
Agave delamateri	Tonto Basin Agave	SC	HS	G2
Agave murpheyi	Hohokam Agave	SC	HS	G2?
Agave parviflora ssp. parviflora	Santa Cruz Striped Agave	SC	HS	G3T3
Agave phillipsiana	Phillips Agave		HS	G2
Agave schottii var. treleasei	Trelease Agave	SC	HS	G5T1Q
Agave x arizonica	Arizona agave		HS	GNA
Agave yavapaiensis	Page Springs Agave		SR	G1
Allium gooddingii	Goodding Onion	CCA	HS	G2
Amoreuxia gonzalezii	Saiya	SC	HS	G1
Amsonia kearneyana	Kearney Blue-star	LE	HS	G1
Argemone arizonica	Arizona Pricklypoppy	SC		G1
Asclepias welshii	Welsh's Milkweed	LT	HS	G1
Astragalus cobrensis var. maguirei	Coppermine Milk-vetch	SC	SR	G4T1
Astragalus cremnophylax var. cremnophylax	Sentry Milk-vetch	LE	HS	G1G2T1
Astragalus cremnophylax var. hevronii	Marble Canyon Milk-vetch			G1G2T1
Astragalus cremnophylax var. myriorrhaphis	Cliff Milk-vetch	SC	SR	G1G2T1
Astragalus holmgreniorum	Holmgren (Paradox) Milk-vetch	LE	HS	G1
Astragalus hypoxylus	Huachuca Milkvetch	SC	SR	G1
Astragalus lentiginosus var. ambiguus	Freckled Milk-vetch	SC		G5T1Q
Astragalus newberryi var. aquarii	Aquarius Milkvetch			G5T1
Astragalus pinonis var. atwoodii	Duane's Milkvetch			G2G3T1
Astragalus toanus var. scidulus	Diamond Butte Milkvetch			G4G5T1
Carex specuicola	Navajo Sedge	LT	HS	G2
Castilleja kaibabensis	Kaibab Indian Paintbrush			G1
Castilleja mogollonica	White Mountains Paintbrush	SC	SR	G1Q
Chylismia confertiflora	Grand Canyon Suncup			G1
Chylismia specicola ssp. hesperia	Kaibab Suncup	SC		G2T1
Clematis hirsutissima	Clustered Leather Flower		HS	G4
Coryphantha recurvata	Santa Cruz Beehive Cactus		HS	G3
Coryphantha robbinsorum	Cochise Pincushion Cactus	LT	HS	G1
Coryphantha scheeri var. robustispina	Pima Pineapple Cactus	LE	HS	G4T2Q
Cryptantha semiglabra	Pipe Springs Cryptantha			G1
Cuscuta dentatasquamata	Los Pinitos Dodder			G1

NAME	COMMON NAME	ESA	NPL	GRANK
Cycladenia humilis var. jonesii	Jones Cycladenia	LT	HS	G3G4T2Q
Cyperus hypopitys	Pine Flatsedge			G1G2
Cypripedium parviflorum var. pubescens	Yellow Lady's-slipper		HS	G5T5
Dalea tentaculoides	Gentry's Indigo Bush	SC	HS	G1
Echinocactus horizonthalonius var. nicholii	Nichol Turk's Head Cactus	LE	HS	G4T2
Echinocereus arizonicus ssp. arizonicus	Arizona Hedgehog Cactus	LE	HS	G5T2
Echinomastus erectocentrus var. acunensis	Acuna Cactus	LE	HS	G3QT1T2Q
Erigeron heliographis	Pinalenos Fleabane	SC		G1
Erigeron hodgsoniae	Hodgson's Fleabane			G1
Erigeron kuschei	Chiricahua Fleabane	SC	SR	G1
Erigeron lemmonii	Lemmon Fleabane	SC	HS	G1
Erigeron piscaticus	Fish Creek Fleabane	SC	SR	G1
Erigeron sceptrifer	Scepterbearing Fleabane			G1G2
Eriogonum heermannii var. subspinosum	Tabeau Peak Wild Buckwheat			G5T1?
Eriogonum lachnogynum var. sarahiae	Sarah's Wild Buckwheat			G4?T1
Eriogonum terrenatum	San Pedro River Wild Buckwheat			G1G2
Eriogonum thompsoniae var. atwoodii	Atwood Wild-buckwheat	SC	SR	G4T1
Eryngium sparganophyllum	Arizona Eryngo	LE		G1G2
Graptopetalum bartramii	Bartram Stonecrop	LT	SR	G2
Hexalectris warnockii	Texas Purple Spike	SC	HS	G2G3
Hymenoxys ambigens var. ambigens	Pinaleno Mountain Rubberweed			G3?T1?
Hymenoxys ambigens var. wagneri	Dragoon Mountains Rubberweed			G3?T1
Lilaeopsis schaffneriana ssp. recurva	Huachuca Water-umbel	LE	HS	G4T2
Limosella pubiflora	Chiricahua Mudwort	SC		G1Q
Loeseliastrum franciscanum				G1
Lotus mearnsii var. equisolensis	Horseshoe Deer Vetch			G3T1
Lupinus latifolius ssp. leucanthus	Broadleaf Lupine			G5T1T2
Lupinus lemmonii	Lemmon's Lupine			G1Q
Mentzelia holmgreniorum	Holmgren's Stickleaf			G1
Mentzelia memorabalis	September 11 Stickleaf			G1
Monardella eplingii	Black Mountains Monardella			G1Q
Opuntia martiniana	Seashore Cactus		SR	G1Q
Packera franciscana	San Francisco Peaks Ragwort	LT	HS	G1
Pectis imberbis	Beardless Cinchweed	LE		G3
Pediocactus bradyi	Brady Pincushion Cactus	LE	HS	G1
Pediocactus paradinei	Paradine (Kaibab) Plains Cactus	CCA	HS	G1G2
Pediocactus peeblesianus ssp. fickeiseniae	Fickeisen Plains Cactus	LE	HS	G2T2
Pediocactus peeblesianus ssp. peeblesianus	Peebles Navajo Cactus	LE	HS	G2T1
Pediocactus sileri	Siler Pincushion Cactus	LT	HS	G2G3

NAME	COMMON NAME	ESA	NPL	GRANK
Pediomelum pauperitense	Poverty Mountain Breadroot			G1
Pediomelum pentaphyllum	Chihuahua Scurfpea	SC		G1G2
Pediomelum verdiensis	Verde Breadroot			G1
Pellaea lyngholmii	Lyngholm's Brakefern			G1
Pennellia tricornuta	Chiricahua Rock Cress			G1G2
Penstemon discolor	Catalina Beardtongue		HS	G2
Penstemon linarioides var. maguirei	Maguire's Penstemon		SR	G5T1
Perityle ajoensis	Ajo Rock Daisy		SR	G1
Perityle ambrosiifolia	Lace-leaf Rockdaisy			G1
Perityle cochisensis	Chiricahua Rock Daisy		SR	G1
Perityle saxicola	Roosevelt Dam Rockdaisy	SC		G1
Phacelia cronquistiana	Cronquist's Phacelia			G1G2
Phacelia furnissii	Furniss' Phacelia			G1
Phacelia higginsii	Higgins' Phacelia			G1
Phacelia hughesii	Hughes' Phacelia			G1
Phacelia sonoitensis	Sonoita Phacelia			G1G2
Pholisma arenarium	Scaly Sandplant		HS	G3
Pholisma sonorae	Sandfood	SC	HS	G2
Polygala piliophora	Huachuca Mountain Milkwort			G1
Potentilla arizonica	Garland Prairie Cinquefoil			G1
Potentilla demotica	Hualapai Cinquefoil			G1
Potentilla rhyolitica var. chiricahuensis	Chiricahua Cinquefoil			G1G2T1
Potentilla rhyolitica var. rhyolitica	Huachuca Cinquefoil			G1G2T1T2
Potentilla sanguinea	Flagstaff Cinquefoil			G1
Psilotum nudum	Whisk Fern		HS	G5
Puccinellia parishii	Parish Alkali Grass	SC	HS	G2G3
Purshia subintegra	Arizona Cliff Rose	LE	HS	G2
Ranunculus inamoenus var. subaffinis	A Buttercup			G5T1
Rosa woodsii var. ertterae	Ertter's Rose			G5T1
Rumex orthoneurus	Blumer's Dock	SC	HS	G3
Salix arizonica	Arizona Willow	CCA	HS	G2G3
Salvia pachyphylla ssp. eremopictus	Arizona Rose Sage			G4T1
Sclerocactus sileri	Siler Fishhook Cactus		SR	G1
Scutellaria platyphylla var. occidentalis	Mexican Skullcap			G3G5T1
Scutellaria potosina var. grahamiana	Mexican Skullcap			G3G5T1
Scutellaria potosina var. kaibabensis	Mexican Skullcap			G3G5T1
Senecio multidentatus var. huachucanus	Huachuca Groundsel		HS	G2G4T2
Silene rectiramea	Grand Canyon Catchfly	SC		G1
Sphaeralcea gierischii	Gierisch Mallow	LE		G1

NAME	COMMON NAME	ESA	NPL	GRANK
Spiranthes delitescens	Canelo Hills Ladies'-tresses	LE	HS	G1
Stellaria porsildii	Porsild's Starwort			G1
Tetraneuris verdiensis	Verde Four-nerve Daisy			G1
Townsendia smithii	Blackrock Ground Daisy			G1

ESA = Endangered Species Act (1973 as amended); **LE** = Listed endangered; **LT** = Listed threatened; **CCA** = Candidate conservation agreement; **SC** = Species of concern; **PT** = Proposed threatened
NPL = Arizona Native Plant Law; **HS** = Highly Safeguarded: no collection allowed; **SR** = Salvage restricted
GRANK = Global Rank, **G1** = Critically imperiled , **G2** = Imperiled globally , **G3** = Vulnerable, G4 = Apprently secure, **G5** = Secure

Appendix F: Participating Agencies and Organizations in Public Forums and Stakeholder Engagement, 2020-2021

Altar Valley Conservation Alliance
Arizona State University
ASARCO
Audubon Arizona
Be Outdoors Arizona
Big Sandy NRCD
Borderlands Restoration Network
Bureau of Land Management
City of Flagstaff
City of Peoria
Federal Highway Administration
Fort Huachuca
Friends of Northern Arizona Forests
Grand Canyon University
Hopi Tribe
Maricopa County
Matrix Design Group
McDowell Sonoran Preserve
National Park Service
Navajo Nation Department of Fish and Wildlife
Northern Arizona University
Phoenix Zoo
Pima County
Pinal County
Quail Forever/Pheasants Forever
Salt River-Pima-Maricopa Indian Community
Sierra Club Arizona
Association of Environmental Professionals
The Nature Conservancy
Tucson Audubon Society
University of Arizona
U.S. Army Yuma Proving Ground
U.S. Bureau of Reclamation
U.S. Fish and Wildlife Service
U.S. Fish and Wildlife Service - Ecological Services Field Office
U.S. Forest Service
U.S. Marine Corps Yuma Air Station - Barry Goldwater
USAF Luke Air Force Base - Barry M Goldwater Range East
USDA Wildlife Services
Westland Resources, Inc.
White Mountain Apache Tribe
Willow Creek Environmental
Yuma Crossing National Heritage Area

Appendix G: Aquatic Conservation Opportunity Areas (COAs)

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Agua Fria River	A D Wash (Agua Fria River-Lake Pleasant)	Gila topminnow, lowland leopard frog	None	High
Agua Fria River	Buckhorn Spring (Agua Fria River-Lake Pleasant)	Gila topminnow, lowland leopard frog	None	High
Agua Fria River	Copper Creek (Sycamore Creek-Agua Fria River)	canyon tree frog; possibly Gila topminnow	None	High
Agua Fria River	Cottonwood Tank (Luke Wash-Gila River)	desert pupfish	None	High
Agua Fria River	Grapevine Creek (Sycamore Creek-Agua Fria River)	Gila trout	None	High
Agua Fria River	Horseshoe Ranch Pond	Gila topminnow, desert pupfish, roundtail chub, longfin dace, lowland leopard frog, northern Mexican gartersnake	None	High
Agua Fria River	Indian Creek (Sycamore Creek-Agua Fria River)	roundtail chub, desert sucker, longfin dace, Gila topminnow, northern Mexican gartersnake, lowland leopard frog	None	High
Agua Fria River	Larry Creek (Sycamore Creek-Agua Fria River)	Gila topminnow, roundtail chub, longfin dace, lowland leopard frog	None	High
Agua Fria River	Lousy Canyon (Sycamore Creek-Agua Fria River)	Gila topminnow, roundtail chub, longfin dace, lowland leopard frog	None	High
Agua Fria River	Morgan City Wash (Agua Fria River below Lake Pleasant)	Gila topminnow, longfin dace; possibly roundtail chub	None	High
Agua Fria River	Silver Creek (Sycamore Creek-Agua Fria River)	longfin dace, roundtail chub, Gila topminnow	None	High
Agua Fria River	Stop Sign Tank (Luke Wash-Gila River)	Gila topminnow	None	High
Agua Fria River	Swimming Pool Tank (Luke Wash-Gila River)	Gila topminnow	None	High
Agua Fria River	Sycamore Creek Below Double T Ranch Falls (Sycamore Creek-Agua Fria River)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	High
Agua Fria River	Tule Creek (Agua Fria River-Lake Pleasant)	Gila topminnow, lowland leopard frog, Sonora mud turtle	None	High
Agua Fria River	Twin Tanks (Luke Wash-Gila River)	desert pupfish	None	High
Bill Williams River	Big Sandy River	longfin dace, lowland leopard frog	None	Medium

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Bill Williams River	Bill Williams River - Alamo Lake to Lake Havasu	longfin dace, lowland leopard frog, northern Mexican gartersnake	None	High
Bill Williams River	Bill Williams River - Confluence of Big Sandy and Santa Maria rivers to Alamo Lake	longfin dace, northern Mexican gartersnake	None	High
Bill Williams River	Boner Canyon Complex	longfin dace	None	Medium
Bill Williams River	Boulder Creek Complex	roundtail chub, speckled dace, desert sucker, Sonora sucker, longfin dace	roundtail chub	Medium
Bill Williams River	Burro Creek Complex	roundtail chub, speckled dace, desert sucker, Sonora sucker, longfin dace	roundtail chub	Medium
Bill Williams River	Knight Creek Complex	speckled dace, longfin dace, desert sucker, Sonora sucker	None	Medium
Bill Williams River	Santa Maria River Complex	longfin dace, desert sucker, Sonora sucker	None	Medium
Bill Williams River	Sycamore Creek Complex	roundtail chub, speckled dace, desert sucker, Sonora sucker, longfin dace	None	Medium
Bill Williams River	Trout Creek Complex	roundtail chub, speckled dace, desert sucker, Sonora sucker, longfin dace	roundtail chub	High
Little Colorado River	Alder Canyon	bluehead sucker, Little Colorado spinedace, speckled dace	None	Medium
Little Colorado River	Barbershop Canyon - East Clear Creek to Headwaters	Little Colorado spinedace, speckled dace, Little Colorado sucker, bluehead sucker	None	High
Little Colorado River	Bear Canyon Complex (East Clear Creek Drainage)	Little Colorado spinedace, speckled dace, Little Colorado sucker, bluehead sucker	None	High
Little Colorado River	Benny Creek - Hall Creek To headwaters	speckled dace, bluehead sucker	brown trout	Low
Little Colorado River	Chevelon Canyon - Chevelon Canyon Lake to the confluence of Woods Canyon and Willow Springs Canyon	rainbow trout, brown trout	roundtail chub, speckled dace, bluehead sucker, desert sucker	High
Little Colorado River	Chevelon Canyon - Chevelon Crossing upstream to Chevelon Canyon Lake	roundtail chub, speckled dace, bluehead sucker, Little Colorado sucker, Little Colorado spinedace	rainbow trout, brown trout	Medium
Little Colorado River	Chevelon Canyon - Horse Canyon upstream to Chevelon Crossing	Little Colorado spinedace, roundtail chub, speckled dace, bluehead sucker, Little Colorado sucker	None	Medium
Little Colorado River	Chevelon Canyon - Little Colorado River upstream to Horse Canyon	Little Colorado spinedace, speckled dace, bluehead	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
		sucker, Little Colorado sucker, roundtail chub		
Little Colorado River	Chevelon Canyon Lake	brown trout, rainbow trout	Little Colorado sucker	Medium
Little Colorado River	Clear Creek upstream of Clear Creek Reservoir to Willow Creek Confluence	roundtail chub, speckled dace, bluehead sucker, Little Colorado sucker	None	Medium
Little Colorado River	Colter Creek	speckled dace, bluehead sucker, Apache trout	rainbow trout	Low
Little Colorado River	Coyote Creek - fish barrier to headwaters	Apache trout	None	Medium
Little Colorado River	Dane Canyon Complex	Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	None	High
Little Colorado River	East Clear Creek - C.C. Cragin Reservoir to headwaters	Little Colorado spinedace, speckled dace	None	Low
Little Colorado River	East Clear Creek - Leonard Canyon to C.C. Cragin Reservoir	roundtail chub, Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	rainbow trout	High
Little Colorado River	East Fork Little Colorado River - Fish barrier to headwaters	Apache trout	speckled dace, bluehead sucker	High
Little Colorado River	East Fork Little Colorado River - Little Colorado River to fish barrier	brown trout, rainbow trout, Apache trout	speckled dace, bluehead sucker	Medium
Little Colorado River	Fish Creek	speckled dace, bluehead sucker	None	Low
Little Colorado River	General Springs Canyon Complex	Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	None	High
Little Colorado River	Grasslands Wildlife Area pond	Little Colorado spinedace	None	Medium
Little Colorado River	Hall Creek - Little Colorado River Confluence to White Mountain Reservoir	brown trout, rainbow trout	speckled dace, bluehead sucker	High
Little Colorado River	Houston Draw	Little Colorado spinedace	None	Low
Little Colorado River	Kehl Canyon - East Clear Creek to Kehl Spring	Little Colorado spinedace, bluehead sucker	None	High
Little Colorado River	Kinlichee Creek	bluehead sucker	None	High
Little Colorado River	Lee Valley Creek - Lee Valley Reservoir To Headwaters	Apache trout, bluehead sucker	None	Medium
Little Colorado River	Leonard Canyon Complex	Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	None	High
Little Colorado River	Little Colorado River - Diversion Dam near Hwy 61	roundtail chub, Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Little Colorado River	Little Colorado River - Hwy 261 to River Reservoir	rainbow trout, brown trout	Little Colorado sucker, bluehead sucker, speckled dace	High
Little Colorado River	Little Colorado River - Lower LCR-Colorado River to Blue Spring	humpback chub, speckled dace, flannelmouth sucker, bluehead sucker	None	High
Little Colorado River	Little Colorado River - Lyman Lake to Hwy 261	Little Colorado sucker, bluehead sucker, Little Colorado spinedace, speckled dace, roundtail chub	None	High
Little Colorado River	Miller Canyon Complex	Little Colorado spinedace, speckled dace, bluehead sucker, Little Colorado sucker	None	High
Little Colorado River	Mineral Creek - Fish Barrier to Headwaters	Apache trout	Little Colorado spinedace	Medium
Little Colorado River	Nutrioso Creek middle - USFS Boundary upstream to confluence with Hulsey Creek	Little Colorado spinedace, speckled dace, bluehead sucker	None	High
Little Colorado River	Nutrioso Creek upper - Hulsey Creek confluence to headwaters and tributaries	speckled dace	Apache trout	Low
Little Colorado River	Rudd Creek	speckled dace, bluehead sucker, Little Colorado spinedace	Apache trout	High
Little Colorado River	Silver Creek - Bourdon Ranch Road to Silver Creek Hatchery Boundary	rainbow trout, Apache trout	speckled dace, bluehead sucker, roundtail chub, Little Colorado sucker, Little Colorado spinedace	High
Little Colorado River	Silver Creek - Woodruff Dam to White Mountain Lake	Little Colorado spinedace, bluehead sucker, Little Colorado sucker, speckled dace, roundtail chub	None	Medium
Little Colorado River	South Fork Little Colorado River - upstream of fish barrier	Apache trout	Little Colorado sucker, speckled dace, bluehead sucker	High
Little Colorado River	West Chevelon Canyon	Little Colorado spinedace, speckled dace, bluehead sucker	None	High
Little Colorado River	West Fork Little Colorado River - fish barrier to headwaters	Apache trout	bluehead sucker, speckled dace	High
Little Colorado River	Willow Creek - Clear Creek to Headwaters	Little Colorado spinedace, bluehead sucker, speckled dace, Little Colorado sucker	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Little Colorado River	Willow Springs Canyon - Chevelon Canyon to Willow Springs Lake	brook trout, brown trout	speckled dace, bluehead sucker, Little Colorado sucker	High
Little Colorado River	Yeager Canyon - East Clear Creek to Headwaters	Little Colorado spinedace	None	High
Little Colorado River	Pinetop Ponds	speckled dace, bluehead sucker, Northern leopard frog, narrow-headed gartersnake	grass carp	High
Lower & Middle Gila River	Arnett Creek (Upper Queen Creek)	longfin dace, Gila topminnow	None	High
Lower & Middle Gila River	Boyce Thompson Arboretum (Upper Queen Creek)	desert pupfish, Gila topminnow, possibly roundtail chub	None	High
Lower & Middle Gila River	Mescal Creek (Dripping Springs Wash-Gila River)	desert sucker, roundtail chub, speckled dace, spikedace, loach minnow, Gila topminnow	None	Medium
Lower & Middle Gila River	Mescal Warm Spring (Dripping Springs Wash-Gila River)	Gila topminnow; possibly desert pupfish	None	Medium
Lower & Middle Gila River	Mineral Creek (Mineral Creek-Gila River)	longfin dace, roundtail chub, desert sucker, evaluate for loach minnow, spikedace, and Gila topminnow	None	High
Lower Colorado River	Beal Lake	razorback sucker, bonytail	None	High
Lower Colorado River	Cibola High Levee Pond	razorback sucker, bonytail	None	Medium
Lower Colorado River	Emerald Canyon Golf Course Ponds	razorback sucker	None	Low
Lower Colorado River	Imperial NWR - Ponds 1 - 6	razorback sucker, bonytail	None	High
Lower Colorado River	Lake Havasu	largemouth bass	razorback sucker, bonytail	High
Lower Colorado River	Lake Mohave	largemouth bass, smallmouth bass	razorback sucker, bonytail	High
Lower Colorado River	Palo Verde Oxbow Lake	None	razorback sucker, bonytail	Medium
Lower Colorado River	Parker Dam Pond	bonytail	None	High
Lower Colorado River	Topock Marsh	channel catfish	razorback sucker	High
Lower Colorado River	Colorado River and Associated Backwaters - Davis Dam to Lake Havasu	rainbow trout	razorback sucker	High
Lower Colorado River	Colorado River and Associated Backwaters - Parker Strip	largemouth bass	razorback sucker, bonytail	High
Lower Colorado River	Colorado River and Associated Backwaters - Palo Verde and Cibola Divisions	largemouth bass	razorback sucker, bonytail	Medium
Lower Colorado River	Colorado River and Associated Backwaters - Imperial Division	largemouth bass	razorback sucker, bonytail	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Lower Colorado River-Lake Mead	Beaver Dam Wash (Sand Hollow Wash-Virgin River)	Virgin spinedace, speckled dace, Virgin chub, flannelmouth sucker, desert sucker	None	High
Lower Colorado River-Lake Mead	Bright Angel Creek (Shinumo Creek-Colorado River)	speckled dace, bluehead sucker, flannelmouth sucker, humpback chub	None	High
Lower Colorado River-Lake Mead	Clear Creek (Bright Angel Creek-Colorado River)	speckled dace, bluehead sucker, flannelmouth sucker	None	Low
Lower Colorado River-Lake Mead	Colorado River	speckled dace, bluehead sucker, flannelmouth sucker, humpback chub, razorback sucker	None	High
Lower Colorado River-Lake Mead	Colorado River Lees Ferry Reach	rainbow trout	flannelmouth sucker	High
Lower Colorado River-Lake Mead	Colorado River Tributary Washes	speckled dace, bluehead sucker, flannelmouth sucker, humpback chub, razorback sucker	None	High
Lower Colorado River-Lake Mead	Havasu Creek (Lower Havasu Creek)	humpback chub, speckled dace, bluehead sucker, flannelmouth sucker	None	High
Lower Colorado River-Lake Mead	Lake Mead	striped bass	razorback sucker	High
Lower Colorado River-Lake Mead	North Canyon Creek (Colorado River)	Apache trout	None	High
Lower Colorado River-Lake Mead	Shinumo Creek (Shinumo Creek-Colorado River)	speckled dace, humpback chub, bluehead sucker	None	High
Lower Colorado River-Lake Mead	Tapeats Creek (Tapeats Creek-Colorado River)	speckled dace, bluehead sucker	None	Medium
Lower Colorado River-Lake Mead	Virgin River (North Creek-Virgin River)	Virgin chub, woundfin, speckled dace, desert sucker, flannelmouth sucker	None	High
Salt River	Ash Creek (Salt River Draw-Salt River)	roundtail chub	longfin dace, speckled dace, Sonora sucker, desert sucker	High
Salt River	Bear Wallow Creek (Middle Black River)	Apache trout	speckled dace, loach minnow, desert sucker	High
Salt River	Beaver Creek (Upper Black River)	desert sucker, speckled dace, Sonora sucker	brown trout	Medium
Salt River	Black River (Upper Black River)	roundtail chub, desert sucker, Sonora sucker, speckled dace	brown trout	High
Salt River	Boggy Creek (Upper Black River)	Apache trout	speckled dace, desert sucker	Medium
Salt River	Boneyard Creek (Upper Black River)	speckled dace, desert sucker, Sonora sucker, roundtail chub, loach minnow	brown trout, brook trout	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Salt River	Burro Creek (Upper Black River)	speckled dace, desert sucker, Sonora sucker	Apache trout	Medium
Salt River	Campaign Creek (Pinto Creek)	longfin dace	None	Low
Salt River	Cave Creek (Cave Creek - Arizona Canal Diversion Channel)	longfin dace, desert sucker, speckled dace, Gila topminnow, roundtail chub	None	Medium
Salt River	Centerfire Creek (Upper Black River)	Apache trout	speckled dace, desert sucker, Sonora sucker	Medium
Salt River	Charlebois Spring (Salt River-Apache, Canyon, and Saguaro Lake)	Gila topminnow	None	High
Salt River	Cherry Creek (Salt River-Theodore Roosevelt Lake)	roundtail chub	desert sucker, Sonora sucker, longfin dace, speckled dace	Medium
Salt River	Conklin Creek (Middle Black River)	Apache trout	loach minnow	High
Salt River	Coon Creek (Salt River-Theodore Roosevelt Lake)	longfin dace, desert sucker	None	Medium
Salt River	Cottonwood Creek (Salt River-Theodore Roosevelt Lake)	longfin dace, Gila topminnow, lowland leopard frog	None	Medium
Salt River	Cottonwood Spring (Salt River-Apache, Canyon, and Saguaro Lake)	Gila topminnow	None	High
Salt River	Coyote Creek (Upper Black River)	speckled dace, desert sucker, Sonora sucker, loach minnow	None	Medium
Salt River	Deer Creek (Rye Creek-Tonto Creek)	longfin dace, desert sucker	None	Medium
Salt River	Deer Creek (Upper Black River)	speckled dace, Chiricahua leopard frog	None	Medium
Salt River	Dick Williams Creek (Haigler Creek-Tonto Creek)	speckled dace	None	Medium
Salt River	East Fork Black River (Upper Black River)	loach minnow, roundtail chub, speckled dace, desert sucker, Sonora sucker	Apache trout, rainbow trout, brown trout	High
Salt River	Fish Creek (Salt River-Apache, Canyon, and Saguaro Lake)	roundtail chub, longfin dace, Gila topminnow	None	High
Salt River	Fish Creek (Upper Black River)	Apache trout	speckled dace, desert sucker, Sonora sucker, loach minnow	Medium
Salt River	Gordon Canyon Creek (Haigler Creek-Tonto Creek)	roundtail chub	longfin dace, desert sucker	Medium
Salt River	Greenback Creek (Gun Creek-Tonto Creek)	longfin dace	None	Medium
Salt River	Gun Creek (Gun Creek-Tonto Creek)	roundtail chub	speckled dace	Medium
Salt River	Haigler Creek (Haigler Creek - Tonto Creek)	rainbow trout	Gila trout	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Salt River	Hannagan Creek (Upper Black River)	Apache trout	speckled dace, desert sucker	Medium
Salt River	Hay Creek (Upper Black River)	Apache trout	speckled dace, desert sucker	Medium
Salt River	Head Tank (Upper Black River)	Chiricahua leopard frog	None	Medium
Salt River	Hess Canyon (Salt River Draw-Salt River)	Gila topminnow, longfin dace	None	Medium
Salt River	Hidden Water Spring (Salt River-Apache, Canyon, and Saguaro Lake)	Gila topminnow, longfin dace, lowland leopard frog	None	High
Salt River	Home Creek (Upper Black River)	Apache trout	speckled dace	Medium
Salt River	Houston Creek (Rye Creek-Tonto Creek)	longfin dace, roundtail chub	None	Medium
Salt River	Hunter Creek (Haigler Creek-Tonto Creek)	longfin dace	None	Medium
Salt River	Indian Spring (Salt River-Apache, Canyon, and Saguaro Lake)	longfin dace, Gila topminnow, lowland leopard frog	None	Medium
Salt River	Kayler Spring (Gun Creek-Tonto Creek)	Gila topminnow, longfin dace	None	Medium
Salt River	La Barge Creek (Salt River-Apache, Canyon, and Saguaro Lake)	Gila topminnow	None	Medium
Salt River	Lake Sierra Blanca (Upper Black River)	Unknown	None	Low
Salt River	Marsh Creek (Haigler Creek-Tonto Creek)	roundtail chub	None	High
Salt River	Mashakattee Spring (Cave Creek-Arizona Canal Diversion Channel)	longfin dace, possibly Gila topminnow	None	Medium
Salt River	North Fork East Fork Black River (Upper Black River)	roundtail chub, speckled dace, desert sucker, Sonora sucker, loach minnow	brown trout, rainbow trout	High
Salt River	Open Draw Creek (Upper Black River)	speckled dace	None	Medium
Salt River	Phoenix Zoo (Salt River below Saguaro Lake)	Gila topminnow, desert pupfish, Chiricahua leopard frog, California floater	None	High
Salt River	Pinal Creek (Pinal Creek)	longfin dace	None	Medium
Salt River	Pinto Creek (Pinto Creek)	longfin dace, desert sucker, Gila topminnow, roundtail chub	None	Medium
Salt River	Reavis Creek	Gila topminnow	None	Medium
Salt River	Reservation Creek (Middle Black River)	speckled dace, Sonora sucker, desert sucker	brown trout	Medium
Salt River	Rye Creek (Rye Creek-Tonto Creek)	longfin dace, Sonora sucker, desert sucker	None	Medium

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Salt River	Scottsdale Community College (Indian Bend Wash)	Gila topminnow, Sonoyta pupfish	None	High
Salt River	Seven Springs Wash (Cave Creek-Arizona Canal Diversion Channel)	longfin dace, Sonora sucker, roundtail chub, desert sucker	None	Medium
Salt River	Snake Creek (Middle Black River)	Apache trout	speckled dace, desert sucker, loach minnow	Medium
Salt River	Solar Oasis Pond (Cave Creek-Arizona Canal Diversion Channel)	Gila topminnow, longfin dace, Sonora mud turtle	None	High
Salt River	Soldier Creek (Middle Black River)	Apache trout	None	High
Salt River	Spring Creek (Haigler Creek-Tonto Creek)	roundtail chub, desert sucker, speckled dace	brown trout	High
Salt River	Stinky Creek (Upper Black River)	Apache trout	speckled dace	High
Salt River	Thompson Creek (Upper Black River)	Apache trout	speckled dace, desert sucker	High
Salt River	Tortilla Creek Drainage (Salt River-Apache, Canyon, and Saguaro Lake)	Gila topminnow	None	High
Salt River	Tucker Box (Salt River-Theodore Roosevelt Lake)	Gila topminnow, longfin dace	None	Medium
Salt River	Unnamed tributary to East Fork Black at Three Forks	speckled dace, Sonora sucker, desert sucker, loach minnow	brown trout	High
Salt River	Walnut Spring #392 (Gun Creek-Tonto Creek)	Gila topminnow	None	Medium
Salt River	West Fork Black River (Upper Black River)	Apache trout	speckled dace, Sonora sucker, desert sucker, roundtail chub, loach minnow	High
Salt River	West Fork Pinto Creek (Pinto Creek)	Gila topminnow, longfin dace, desert sucker, roundtail chub	None	Medium
Salt River	Wildcat Creek (Upper Black River)	Apache trout	speckled dace, desert sucker	Medium
San Pedro River-Wilcox Playa	Mud Spring (Headwaters Las Nutrias)	Gila topminnow, narrow-headed gartersnake	None	High
San Pedro River-Wilcox Playa	Sycamore Spring (Headwaters Las Nutrias)	longfin dace	None	Medium
San Pedro River-Wilcox Playa	Aravaipa Creek (Lower Aravaipa Creek)	longfin dace, Sonora sucker, roundtail chub, spikedace, desert sucker, speckled dace, loach minnow	None	High
San Pedro River-Wilcox Playa	Bass Canyon Creek (Muleshoe Coop Mgmt Area, Hot Springs Canyon)	longfin dace, Sonora sucker, desert sucker, roundtail chub, Gila topminnow, speckled dace	None	High
San Pedro River-Wilcox Playa	Bear Creek (Headwaters Las Nutrias)	longfin dace, Gila topminnow	None	Medium

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
San Pedro River-Wilcox Playa	Buehman Canyon (Redfield Canyon - San Pedro River)	longfin dace, Gila topminnow, roundtail chub	None	High
San Pedro River-Wilcox Playa	Bullock Canyon (Redfield Canyon - San Pedro River)	longfin dace, Gila topminnow, roundtail chub	None	High
San Pedro River-Wilcox Playa	Cave Canyon (Headwaters Las Nutrias)	longfin dace	None	Medium
San Pedro River-Wilcox Playa	Deer Creek - Aravaipa (Lower Aravaipa Creek)	None	None	High
San Pedro River-Wilcox Playa	Double R Canyon Creek(Muleshoe Coop Mgmt Area)(Hot Springs Canyon)	longfin dace, roundtail chub, Gila topminnow, speckled dace	None	High
San Pedro River-Wilcox Playa	Edgar Canyon Creek (Alder Wash - San Pedro R)	Gila topminnow	None	High
San Pedro River-Wilcox Playa	Freeman Spring (Babocomari R)	roundtail chub, Gila topminnow	None	Medium
San Pedro River-Wilcox Playa	Hot Springs Canyon (Muleshoe Coop Mgmt Area)(Hot Springs Canyon)	longfin dace, desert sucker, Sonora sucker, roundtail chub, spikedace, Gila topminnow, speckled dace, loach minnow	None	High
San Pedro River-Wilcox Playa	Joaquin Creek (Headwaters Las Nutrias)	longfin dace	None	Medium
San Pedro River-Wilcox Playa	Little Joe Wetland Pond (SPRNCA)	desert pupfish	None	High
San Pedro River-Wilcox Playa	Lone Mountain Canyon (Headwaters Las Nutrias)	longfin dace	None	Medium
San Pedro River-Wilcox Playa	Murray Spring (SPRNCA)	longfin dace, Gila topminnow	None	High
San Pedro River-Wilcox Playa	O'Donnell Canyon (Babocomari R)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	Post Canyon (Babocomari R)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	Medium
San Pedro River-Wilcox Playa	Redfield Canyon (Muleshoe Coop Mgmt Area)(Redfield Canyon-San Pedro R)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	San Pedro River-Lower Reach (Near San Manuel-Gila R Conf.) (Tucson Wash, Dodson Wash-San Pedro R)	longfin dace	None	Low
San Pedro River-Wilcox Playa	San Pedro River-Middle Reach (Near St David-Near San Manuel, Ash Creek, Paige Creek, Redfield Canyon, Alder Wash-San Pedro R)	longfin dace	None	Medium
San Pedro River-Wilcox Playa	San Pedro River-Upper Reach (International Border-Near St. David, Montezuma Canyon,	longfin dace, desert sucker, Sonora sucker, roundtail chub, speckled dace	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
	Banning Creek, Walnut Gulch, Clifford Wash-San Pedro R)			
San Pedro River-Wilcox Playa	Swamp Springs Canyon Creek(Muleshoe Coop Mgmt Area, Redfield Canyon-San Pedro R)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	Turkey Creek (Babocomari R)	longfin dace, Sonora sucker, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	West Turkey Creek (Turkey Creek)	Mexican stoneroller, Yaqui chub, longfin dace	None	High
San Pedro River-Wilcox Playa	Wildcat Canyon (Muleshoe Coop Mgmt Area, Hot Springs Canyon)	Gila topminnow	None	High
San Pedro River-Wilcox Playa	Antelope Tank (Babocomari R)	desert pupfish, Chiricahua leopard frog	None	High
San Pedro River-Wilcox Playa	Bald Hill Tank (Babocomari R)	desert pupfish, Chiricahua leopard frog	None	High
San Pedro River-Wilcox Playa	Big Tank	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Bull Tank (Upper Ash Creek)	Chiricahua leopard frog	None	High
San Pedro River-Wilcox Playa	Dale's Tank	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Home Ranch Tank (Upper Aravaipa Creek)	Chiricahua leopard frog	None	High
San Pedro River-Wilcox Playa	Horse Tank	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Kingfisher Pond (SPRNCA)	None	None	Medium
San Pedro River-Wilcox Playa	Larry-Charlie Tank (Muleshoe Coop Mgmt Area)(Hot Springs Canyon)	desert pupfish	None	High
San Pedro River-Wilcox Playa	Lodge Pond	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Lower Guesthouse Pond	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Lower San Pedro Preserve-East Pond (Dodson Wash - San Pedro R)	desert pupfish, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	Lower San Pedro Preserve-West Pond (Dodson Wash - San Pedro R)	desert pupfish, roundtail chub, Gila topminnow	None	High
San Pedro River-Wilcox Playa	Upper Guesthouse Pond	Yaqui Spp	None	High
San Pedro River-Wilcox Playa	Headquarter Spring (Muleshoe Coop Mgmt Area)	Gila topminnow	None	High
San Pedro River-Wilcox Playa	Mint Spring (Muleshoe Coop Mgmt Area)	desert pupfish	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
San Pedro River-Wilcox Playa	Secret Spring (Muleshoe Coop Mgmt Area)	desert pupfish, Gila topminnow	None	High
Upper Gila River	Howard Well (Buckeye Wash-San Simon River)	Gila topminnow, desert pupfish	None	High
Upper Gila River	Lazy YJ Ranch Tank (Upper Blue River)	roundtail chub, desert sucker, Sonora sucker, longfin dace	None	Medium
Upper Gila River	Sands Draw Wildlife Water (Whitlock Wash-Hospital Flat)	Gila topminnow, desert pupfish, possibly roundtail chub	None	Medium
Upper Gila River	Cold Springs (Black Rock Wash-Gila River)	Gila topminnow, desert pupfish	None	High
Upper Gila River	Blue River - Lower Reach and tributaries (Lower Blue River)	loach minnow, spikedace, roundtail chub, speckled dace, longfin dace, desert sucker, Sonora sucker, Chiricahua leopard frog, lowland leopard frog	roundtail chub	High
Upper Gila River	Blue River - Upper Reach (Upper Blue River)	loach minnow, spikedace, roundtail chub, speckled dace, longfin dace, desert sucker, Sonora sucker	roundtail chub, Gila trout	High
Upper Gila River	Campbell Blue Creek Drainage Below Waterfalls (Upper Blue River)	loach minnow, spikedace, roundtail chub, speckled dace, longfin dace, desert sucker, Sonora sucker, narrow-headed gartersnake, Chiricahua leopard frog	Gila trout	High
Upper Gila River	Cave Creek Drainage Streams (Cave Creek-San Simon River)	speckled dace, desert sucker; possibly roundtail chub and loach minnow	Gila trout	Medium
Upper Gila River	Chitty Creek	Gila trout	speckled dace, longfin dace, desert sucker	Low
Upper Gila River	Coleman Creek-Upper (Upper Blue River)	Gila trout	speckled dace, longfin dace, desert sucker	High
Upper Gila River	Eagle Creek - Middle Reach (Lower Eagle Creek)	speckled dace, longfin dace, Sonora sucker, desert sucker, roundtail chub	None	Low
Upper Gila River	Eagle Creek - Middle Reach Tributaries (Lower Eagle Creek)	speckled dace, longfin dace, Sonora sucker, desert sucker, roundtail chub	None	Low
Upper Gila River	Eagle Creek - Upper Reach and Tributaries (Upper Eagle Creek)	spikedace, loach minnow, roundtail chub, speckled dace, longfin dace, desert sucker, Sonora sucker	Gila trout	High
Upper Gila River	San Francisco River-Middle Reach Tributaries (Mule Creek-San Francisco River)	roundtail chub, longfin dace, speckled dace, Sonora sucker, desert sucker, Gila topminnow	None	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Upper Gila River	San Francisco River and Tributaries Luna Lake to NM Border (Centerfire Creek-San Francisco River)	speckled dace, desert sucker	Gila trout	Medium
Upper Gila River	San Francisco River AZ-NM Border to Gila Confluence (Mule Creek and Chase Creek-San Francisco River)	loach minnow, spikedace, roundtail chub, longfin dace, desert sucker, Sonora sucker, speckled dace, Rio Grande sucker	None	Low
Santa Cruz River	Ash Creek-George Wise Spring-Headwaters to AZGFD Property	Gila topminnow	None	Medium
Santa Cruz River	Boghole Ciénega	Gila topminnow, roundtail chub	Chiricahua leopard frog	Low
Santa Cruz River	Ciénega Creek - Headwaters to I-10	roundtail chub, Gila topminnow, longfin dace,	None	High
Santa Cruz River	Coal Mine Canyon Complex	Gila topminnow	None	High
Santa Cruz River	Cott Tank Drainage	Gila topminnow	None	High
Santa Cruz River	Cottonwood Spring	Gila topminnow	None	High
Santa Cruz River	Fresno Canyon-AZ State Parks property boundary to confluence with Sonoita Creek	Gila topminnow	None	Medium
Santa Cruz River	Lampshire Canyon-Oak Grove Flat	Gila topminnow	None	Low
Santa Cruz River	Peterson Ranch Pond	northern Mexican gartersnake, Chiricahua leopard frog	None	Medium
Santa Cruz River	Redrock Canyon	Gila topminnow	None	Medium
Santa Cruz River	Romero Canyon	roundtail chub	None	Medium
Santa Cruz River	Sabino Creek Complex	roundtail chub	None	Medium
Santa Cruz River	Sharp Spring Complex	Gila topminnow, roundtail chub	None	High
Santa Cruz River	Sonoita Creek Headwaters to Patagonia Lake	None	None	Medium
Santa Cruz River	Santa Cruz River-Potrero Creek Confluence to Elephant Head Road	None	None	Medium
Santa Cruz River	Cave Canyon	longfin dace	None	Low
Santa Cruz River	Fresno Spring	Gila topminnow, longfin dace	None	Low
Santa Cruz River	Santa Cruz River Headwaters to International Border	Gila topminnow, roundtail chub, suite of non-listed species	northern Mexican gartersnake and Chiricahua leopard frog	Medium
Santa Cruz River	Temporal Gulch-Wilderness boundary to confluence with Sonoita Creek	None	None	Low

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Santa Cruz River	Bear Canyon-Sycamore Reservoir to Confluence with Sabino Canyon	roundtail chub	None	Medium
Santa Cruz River	Ciénega Creek-I-10 to Del Lago Diversion Dam	roundtail chub, Gila topminnow, longfin dace,	None	Medium
Santa Cruz River	Gardner Canyon	longfin dace	None	Medium
Santa Cruz River	Monkey Spring	Gila topminnow	None	High
Santa Cruz River	Peck Canyon	Gila topminnow, longfin dace	None	Medium
Verde River	Alder Creek	longfin dace, lowland leopard frog, Gila topminnow	None	Medium
Verde River	Beaver Creek	roundtail chub, desert sucker, Sonora sucker, speckled dace	rainbow trout	High
Verde River	Bonita Creek (Bonita Creek)	brook trout	Chiricahua leopard frog	Medium
Verde River	Camp Creek	longfin dace, speckled dace, Gila topminnow	None	Medium
Verde River	Chase Creek	roundtail chub, speckled dace	rainbow trout	Medium
Verde River	Deadman Creek	roundtail chub, speckled dace, desert sucker, Sonora sucker	None	High
Verde River	Dry Beaver Creek	roundtail chub, desert sucker, longfin dace	None	Medium
Verde River	Dude Creek	Gila trout	roundtail chub, speckled dace, desert sucker	High
Verde River	East Verde River-Ash Creek to Verde River	roundtail chub, desert sucker, Sonora sucker, longfin dace	none	Low
Verde River	East Verde River - Mail Creek to Ash Creek	rainbow trout	desert sucker, roundtail chub, speckled dace, longfin dace	High
Verde River	Ellison Creek	speckled dace, longfin dace, Chiricahua leopard frog	rainbow trout	High
Verde River	Fossil Creek	longfin dace, desert sucker, Sonora sucker, roundtail chub, roundtail chub, Sonora mud turtle, spikedace, loach minnow, Gila topminnow, speckled dace	roundtail chub	High
Verde River	Gap Creek	roundtail chub, longfin dace	None	High
Verde River	Gorge Canyon	roundtail chub, desert sucker	None	High
Verde River	Houston Creek	longfin dace, lowland leopard frog, roundtail chub	None	Medium
Verde River	Lime Creek	Gila topminnow, longfin dace, lowland leopard frog	None	High
Verde River	Meath Wash Pond	roundtail chub	roundtail chub	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Verde River	Oak Creek-Grasshopper Point to confluence with Verde River	rainbow trout	northern Mexican gartersnake, roundtail chub, Page springsnail	High
Verde River	Oak Creek-headwaters to Grasshopper Point	rainbow trout, Gila trout	narrow-headed gartersnake, desert sucker, Sonora sucker, speckled dace	High
Verde River	Pecks Lake	northern Mexican gartersnake, roundtail chub	None	Medium
Verde River	Pine Creek-Above Hwy 87	roundtail chub, speckled dace, desert sucker, narrow-headed gartersnake	rainbow trout	Medium
Verde River	Pine Creek-Below Hwy 87	roundtail chub, desert sucker, longfin dace, speckled dace,	None	Medium
Verde River	Pine Creek-Williamson Valley Wash tributary	longfin dace	None	Medium
Verde River	Red Creek	longfin dace, desert sucker, lowland leopard frog	None	Medium
Verde River	Red Tank Draw	roundtail chub, longfin dace, desert sucker	None	High
Verde River	Rock Creek	longfin dace, desert sucker	None	Medium
Verde River	Round Valley Wash	speckled dace, lowland leopard frog	None	Medium
Verde River	Roundtree Canyon	roundtail chub, longfin dace, lowland leopard frog	None	High
Verde River	Sheep Creek	longfin dace, desert sucker	None	Medium
Verde River	Sheepshead Canyon	Gila topminnow	None	Medium
Verde River	Spring Creek	roundtail chub, longfin dace, speckled dace, desert sucker, desert sucker, lowland leopard frog, Gila topminnow, spikedace	None	High
Verde River	Sycamore Creek-Verde River Tributary	longfin dace, desert sucker, lowland leopard frog	None	Medium
Verde River	Tangle Creek	longfin dace, lowland leopard frog, desert sucker	None	Medium
Verde River	Verde River - Beasley Flat to full pool Horseshoe Reservoir	largemouth bass, smallmouth bass, flathead catfish, channel catfish, roundtail chub	roundtail chub, desert sucker, Sonora sucker	High
Verde River	Verde River - Hell Canyon to TAPCO Diversion	roundtail chub	spikedace, loach minnow, northern Mexican gartersnake, terrestrial gartersnake, Sonora sucker, desert sucker,	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Verde River	Verde River - Sullivan Dam to Hell Canyon	roundtail chub	spikedace, loach minnow, northern Mexican gartersnake, terrestrial gartersnake, Sonora sucker, desert sucker	High
Verde River	Verde River - TAPCO Diversion to Beasley Flat	rainbow trout	longfin dace, desert sucker, Sonora sucker, roundtail chub, lowland leopard frog, speckled dace	High
Verde River	Walker Creek	roundtail chub, longfin dace, desert sucker, speckled dace	None	High
Verde River	Walnut Creek Complex	speckled dace, lowland leopard frog, Sonora mud turtle, black-necked gartersnake	None	High
Verde River	Webber Creek	roundtail chub, speckled dace, desert sucker, Sonora sucker	rainbow trout	High
Verde River	West Clear Creek-Headwaters to waterfall	roundtail chub, desert sucker, speckled dace, Sonora sucker	rainbow trout, brown trout, roundtail chub	Medium
Verde River	West Fork Oak Creek	narrow-headed gartersnake, desert sucker, speckled dace, Gila trout	None	High
Verde River	Wet Bottom Creek	roundtail chub, longfin dace, desert sucker, lowland leopard frog	None	High
Verde River	Willow Valley Creek	roundtail chub, desert sucker, speckled dace	rainbow trout, brown trout, roundtail chub	Medium
Upper Gila River	Buckalou Creek (Upper Blue River)	Gila trout	None	High
Upper Gila River	Fishhook Creek (Upper Blue River)	speckled dace, longfin dace	None	Medium
Upper Gila River	Foote Creek (Upper Blue River)	speckled dace, longfin dace, desert sucker, Sonora sucker	Gila trout	Medium
Upper Gila River	Grant Creek (Upper Blue River)	Gila trout, loach minnow, spikedace, speckled dace, longfin dace, desert sucker, Sonora sucker, consider roundtail chub (below waterfall)	Gila trout	High
Upper Gila River	KP Creek (Upper Blue River)	Gila trout, loach minnow, spikedace, speckled dace, longfin dace, desert sucker, Sonora sucker	Gila trout	High

Watershed	COA Name	Primary Strategy Species	Secondary Strategy Species	Mgmt Priority
Upper Gila River	Lanphier Canyon (Upper Blue River)	Gila trout	speckled dace, longfin dace, Sonora sucker, desert sucker	Medium
Upper Gila River	McKittrick Creek (Upper Blue River)	Gila trout, speckled dace, longfin dace, desert sucker, Sonora sucker	Gila trout	High
Upper Gila River	Pinaleño Mountains Streams (Cottonwood Wash, and Stockton Wash-Gila River)	Gila trout	roundtail chub, desert sucker, speckled dace, longfin dace	High
Upper Gila River	Raspberry Creek (Upper Blue River)	Gila trout	Gila trout, loach minnow, spikedace, speckled dace, longfin dace, desert sucker, Sonora sucker	High
Upper Gila River	Sardine Creek and Silver Creek Drainages (Chase Creek-San Francisco River)	speckled dace, longfin dace, Sonora sucker, lowland leopard frog	None	Low

Appendix H: Terrestrial Conservation Opportunity Areas (COAs)

COA Name	County	Primary Site Owner/Manager	AZGFD Region
4 FRI Rim Country	Coconino	USFS, private	R6
Agua Fria National Monument	Yavapai	NPS	R6
Anderson Mesa	Coconino	USFS	R2
Appleton-Whittell and Las Cienagas	Pima, Santa Cruz	BLM, ASLD, USFWS, Private	R5
Aravaipa Canyon Ecosystem	Graham, Pinal	BLM	R5
Atascosa Highlands	Pima, Santa Cruz	USFS	R5
Aubrey Valley	Coconino, Yavapai	AZGFD, ASLD, Private	R3
Bear Springs	Navajo	USFS, AZGFD	R1
Bill Williams Complex	Mohave, Yavapai, La Paz	BLM, ASLD, AZGFD, USFWS, AZSP, USACE	R3, R4
Black Mountains	Mohave	BLM, NPS, AZGFD, ASLD	R3
Black River	Apache, Graham, Greenlee	AZGFD, USFS	R1
Bouse Dunes	La Paz	BLM	R4
Buenos Aires NWR and Alter Valley	Pima	USFWS	R5
Bush Fire and Three Bar Research Area	Maricopa	USFS, private	R6
Canyon Creek	Gila	USFS, Private	R6
Central Arizona Springsnails	Coconino, Gila, Yavapai	USFS, private, AZGFD	R6
Central Yavapai County	Yavapai	ASLD, private, USFS	R3
Chiricahua Mountains	Cochise	USFS, NPS	R5
Coal Mine Spring	Santa Cruz	AZGFD	R5
Colorado River Nature Center Wildlife Area	Mohave	AZGFD, BLM	R3
Cottonwood Seep	Navajo	USFS	R1
Coyote-Baboquivari	Pima	BLM	R5
Coyote-Maimie	Apache	USFS, ASLD, private	R1
Desert Mountains Complex	Yuma	ASLD, BLM, DOD	R4
Dos Cabezas	Cochise	BLM	R5
Dragoon Mountains	Cochise	USFS, private, ASLD	R5
Eagle Creek	Graham, Greenlee	USFS	R1
East Verde River	Coconino, Gila, Yavapai	USFS, private	R6
Escudilla	Apache	USFS	R1
Estrella Maricopa Corridor	Pinal	BLM, ASLD	R4
Galiuro-Winchester	Cochise, Graham, Pinal	USFS	R5
Garland Prairie	Coconino	USFS, ASLD, private	R2
Gila Box	Graham, Greenlee	USFS	R5

COA Name	County	Primary Site Owner/Manager	AZGFD Region
Gila River	Maricopa, Pinal	BLM, Gila River Indian Community, private	R6
Grasslands Habitat Initiative	Coconino, Mohave, Yavapai	BLM, ASLD, private	R3
Goodwin and Contreras Mesas	Mohave, Yavapai	BLM, ASLD, private	R3
Grand Wash Cliffs North	Mohave	BLM	R2, R3
Grasslands Wildlife Area	Apache	AZGFD	R1
Harquahala Plains	Maricopa, La Paz	BLM, ASLD, private	R4
Hassayampa	Maricopa	BLM, private	R4, R6
House Rock Valley	Coconino	AZGFD, BLM, USFS, private	R2
Huachuca Mountains	Cochise, Santa Cruz	DOD, USFS	R5
Hualapai Valley Connectivity	Mohave	BLM, ASLD, private	R3
Imperial-Cibola	La Paz, Yuma	USFWS, BLM, AZGFD, USBR	R4
Ironwood National Monument	Pima, Pinal	NPS	R5
Joshua Tree	Mohave	BLM, ASLD, private	R3
Kaibab Plateau	Coconino	USFS, NPS, PVT	R2
King Valley	Yuma	USFWS, DOD	R4
Kofa Mountains	La Paz, Yuma	USFWS	R4
Lake Havasu	Mohave, La Paz	USFWS, USBR, BLM	R3, R4
Leslie Canyon	Cochise	USFWS	R5
Little Dragoons	Cochise	ASLD, private, BLM	R5
Lower Gila River	Yuma	USBR, BLM, Yuma Crossing Heritage Area	R4
Lower Little Colorado River	Apache, Navajo	ALSD, BLM, private	R1
Lower Oak Creek	Yavapai	USFS, AZGFD, private	R2
Lower Salt and Gila Rivers	Maricopa	BLM, USBR, ASLD, USACE, AZGFD	R6
Lower San Pedro River	Pinal, Pima, Cochise	AZGFD, TNC, BLM, ASLD, private	R5
McDowell-Superstition-Mazatzal Mountains Linkage	Maricopa	USFS, Maricopa County	R6
Marble Canyon and Vermillion Cliffs	Coconino	ASLD, BLM, Private, NPS	R2
Middle Lower Colorado River	Apache	USFS, private, ASLD	R1
Mittry Lake Wildlife Area	Yuma	AZGFD	R4
Mogollon Rim Snow Melt Draws IBA	Coconino	USFS	R1, R2
Mohawks	Yuma	DOD, BLM	R4
Muggins-Laguna-Gila Mt. Complex	Yuma	BLM, ASLD, DOD	R4
Mule Mountains	Cochise	BLM, Private	R5
North Sulphur Springs Valley	Cochise	ASLD, private	R5

COA Name	County	Primary Site Owner/Manager	AZGFD Region
Nutrioso Rudd	Apache	USFS, AZGFD	R1
Old Hatchery	Navajo	AZGFD	R1
Palomas Plain	Maricopa	BLM, DOD, USFWS, ASLD	R4
Patagonia Mountains	Santa Cruz	USFS	R5
Peloncillo Mountains North	Cochise, Graham, Greenlee	BLM	R5
Peloncillo Mountains South	Cochise	BLM	R5
Petrified Forest - Puerco River	Apache, Navajo	NPS	R1
Phoenix Area Snails	Maricopa	Various	R6
Pinaleño Mountains	Graham	USFS	R5
Porter Springs Wash and Cold Springs	Graham	BLM	R5
Queen Creek-Gila River Indian Community	Maricopa	AZGFD	R6
Quigley-Achee Wildlife Area	Yuma	AZGFD	R4
Quitobaquito	Pima	NPS	R4
Ranegras Plain	La Paz	BLM, USFWS, ASLD	R4
Raymond Wildlife Area	Coconino	AZGFD, ASLD	R2
Rim 2 River	Coconino, Gila, Navajo	USFS, ASLD, private	R1
Roosevelt Lake Wildlife Area	Gila	USFS	R6
Salt-Verde Ecosystem	Coconino, Gila, Maricopa, Yavapai	USFS	R6
San Bernardino NWR	Cochise	USFWS	R5
San Francisco Blue	Apache, Greenlee	USFS, AZSP, private	R1
San Francisco Peaks	Coconino	USFS	R2
San Pedro Riparian NCA	Cochise	BLM	R5
San Rafael Grasslands	Santa Cruz	USFS, AZGFD, private	R5
Santa Rita Mountains	Pima, Santa Cruz	USFS	R5
Santa Rita Wildlife Area	Pima	USFS	R5
Santa Teresa Wilderness	Graham	USFS, BLM	R5
Silver Creek to Little Colorado River	Navajo	BLM, ASLD, AZGFD, private	R1
Sonoita Creek SNA/Patagonia Lake	Santa Cruz	TNC	R5
Sonoita Creek TNC Preserve	Santa Cruz	AZSP	R5
Sonoran Desert Borderlands	Pima, Yuma	USFWS, NPS, BLM	R4
Table Top Mountains	Maricopa, Pinal	BLM	R4
Telegraph and Mescal Fire	Gila, Pinal	USFS, ASLD	R6
Tonto Creek	Tonto	USFS	R6
Tortolita Mountains	Pima, Pinal	ASLD, private	R5
Tucson Mountains	Pima	NPS, Pima County	R5
Tucson Sky Islands	Pima, Pinal, Cochise	USFS, NPS, Pima County	R5
Tuzigoot	Yavapai	NPS	R2

COA Name	County	Primary Site Owner/Manager	AZGFD Region
Upper Little Colorado River Watershed	Apache	AZGFD, USFS, Private	R1
Upper Oak Creek	Coconino	USFS, private	R2
Upper Santa Cruz River	Santa Cruz	private	R5
Upper Verde River Wildlife Area	Yavapai	AZGFD, ASLD, USFS	R2, R3
Vekol Valley	Maricopa, Pinal	BLM, private	R4
Virgin River Springsnail	Mohave	private, BLM, ADOT	R2
Weaver Mountains	Yavapai	BLM, ASLD, private	R4
Whetstone Mountains	Cochise	USFS	R5
White Mountains	Greenlee	AZGFD, USFS, private	R1
Whitewater Draw State Wildlife Area	Cochise	AZGFD	R5
Willcox Playa/Cochise Lakes IBA	Cochise	DOD, ASLD, BLM, AZGFD	R5
Woolhouse	Apache, Navajo	USFS	R1
Yuma Desert	Yuma	DOD, USBR	R4