# Natural Heritage of the Peloncillo Mountain Region

San Bernardino Valley, Bob Van Deven 2005

## A Synthesis of Science

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Protecting our Mountain Islands and Desert Seas

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# Executive Summary:

## Significance & Conservation Value of the Peloncillo Region

## Introduction: A Rare and Wonderful Place

The Peloncillo region and its ranges, connecting valleys, and drainages encompass a landscape that includes an international border and the boundaries between four states: Arizona and New Mexico in the United States, and Sonora and Chihuahua in Mexico.

But political boundaries are not all that meet here. The Peloncillo region also overlies the unique juncture of six major biological provinces and numerous discrete habitat types. The result is one of the most diverse and productive natural areas in North America, a refugium for dozens of threatened and endangered species, and a vital corridor for wildlife movement and migration. Yet it is an area that is underappreciated, understudied, and in need of protection and stewardship to maintain both its natural and its cultural values.

Realizing the conservation potential of the Peloncillo region, and the threats it might face, in 2003 the World Wildlife Fund (WWF), Sky Island Alliance (SIA), and other partners cosponsored a workshop at which a group of experts evaluated the existing knowledge—and gaps in that knowledge—pertaining to the Peloncillos. The region was categorized as very high in herpetofauna, bird, invertebrate, and plant diversity, as well as significant in endemism and rare species. The greater Chihuahuan Desert Ecoregion has been identified as globally outstanding in its biological distinctiveness, most notably in a conservation assessment published by WWF in 1999. Clearly, further study was called for, and the seeds of this report were sown.

For the purposes of the workshop and future conservation planning, the greater Peloncillo region includes the Peloncillo Mountains, the Animas Valley and Animas Mountains to the east, the San Simon Valley to the west, and the San Bernardino Valley and San Luis mountains to the south. The total land area within this region is roughly 3,000 square miles (7,700 square kilometers)—about the size of Yellowstone National Park. Watersheds include drainages that flow into the San Simon Valley and then north into the Gila River, those that flow from the southern Peloncillo and San Luis Mountain area south into the Río Yaqui system, and those that flow into the closed basin of the Animas Valley.

Six otherwise distinct biological provinces overlap and intergrade in the Peloncillo region. Many plant and animal species characteristic of the Rocky Mountains reach their southern extent here, and even more species from Mexico's Sierra Madre reach their northern limit. Although the Peloncillo region lies within the bounds of the Chihuahuan Desert, elements of the Sonoran Desert infiltrate from the west, and some characteristics of the Great Basin and Great Plains appear as well.

The floral and faunal diversity produced by the mix of these provinces is enhanced by the basin and range topography of the area—long, north/south oriented mountain ranges separated by

valleys. These isolated mountain ranges of southwestern New Mexico and southeastern Arizona are referred to as “Sky Islands,” since in their upper, cooler and wetter elevations they support an assemblage of plants not found in the valleys below. Thus within a very short linear distance one can find desert-adapted species such as cacti, mesquite trees, and creosote bushes, then montane species such as oaks, junipers, and pines. Also notable in the mix of Peloncillo habitats are several remarkably intact riparian corridors largely free of invasive plant and animal species.

A final element affecting diversity in the Peloncillos lies in a twist of continental topography. The long spine of the Continental Divide, stretching from British Columbia to Central America, reaches its lowest point at several passes in the Peloncillo region. These passes allowed “leakage” of plant assemblages otherwise blocked by high elevations. For example, the Animas Valley, between the Peloncillo Mountains and the Animas Mountains to their east, is considered the southwestern most extension of the Great Plains.

## *Floral and Faunal Diversity*

The end result of the warp and weft of divergent biomes is a region extremely high in both plant diversity and outright numbers of species. At least 879 plant species occur in the Peloncillo Mountains proper—25 percent of all the plant species in New Mexico within just 2 percent of the state’s area. Much of the floral diversity in the Peloncillo region occurs in the Sierra San Luis, which has not yet been fully catalogued, so this number can be expected to rise much higher as research is continued.

The great diversity of plants and habitat in the Peloncillo region supports an equally rich fauna. Within each life zone—Chihuahuan desertscrub, desert grassland, oak woodland, pine/oak forest, and riparian corridor—many species of invertebrates, reptiles, birds, and mammals flourish, including an impressive percentage of endemic species.

For example, more species of reptiles and amphibians live in the Peloncillos than any other single mountain range in New Mexico: at least 89, which is 72 percent of the 123 species known in the entire state. Just one small area, Antelope Pass, harbors the highest lizard diversity of any comparably sized area in the United States. Even amphibian numbers are surprisingly high, despite the xeric nature of the area: 14 native species can be found here, more than half the total for the state.

Mammal diversity is equally high. Hidalgo County, which contains much of the U.S. Peloncillos, has 91 recorded species. As an additional indication of the density of mammals, one 49-acre study site in the San Simon Valley, seven miles west of the Peloncillo Mountains, has produced 25 small mammal species—more than all the mammal species in the state of Pennsylvania. And the Gray Ranch, which constitutes the northeastern portion of the Peloncillo region, has recorded 75 mammal species—more than are known from Yellowstone National Park, America’s most famous mammal haven.

Birds are the most visible form of biodiversity, and their success in the Peloncillo region is obvious. At least 318 species are known here, including 15 hummingbirds, the majority of

hummingbird species found in the United States. Many birds are resident year-round; others find in the region suitable habitat for summer nesting or over wintering. Wintering species include sandhill cranes, some of which have flown from northeastern Siberia; summer species include Swainson's hawks from the pampas of Argentina. The grassland communities of the Peloncillo region support permanent and wintering populations of 25 species of sparrow.

A salient feature of biodiversity in the Peloncillo region is the number of relatively intact species assemblages—groups of indigenous, interdependent species existing with little competition from exotic, introduced or invasive species.

## *Rare and Endemic Species*

The diverse terrain and isolation of the Peloncillo region provide refuge for dozens of threatened and endangered species. Although so-called charismatic megafauna species such as the jaguar receive the most publicity, many lesser-known animals also survive here, with less benefit from news reports.

One of the rarest snakes in the United States, the New Mexico ridge-nosed rattlesnake, is found only in the Peloncillo region. The ranges of the Chiricahua leopard frog, federally listed as threatened, and the lowland leopard frog, a New Mexico state endangered species, both overlap the Peloncillo region.

Of 28 bird species listed as threatened or endangered by New Mexico, 23 can be found here, including aplomado falcon, southwest willow flycatcher, elegant trogon, and buff-collared nightjar. Additionally, the Peloncillo Mountains harbor the only fully native population of threatened (New Mexico state listed) Gould's turkey, though the species has been reintroduced into a few other U.S. mountain ranges.

Little recognized is the importance of the Peloncillo region as a refugium for indigenous southwestern fish species. Although only a few sources of perennial water exist in the region, those sources, such as Cajón Bonito, are high in native species and low in invasive exotic species.

## *Biological Corridors*

The location and undeveloped nature of the Peloncillo landscape provide many avenues for the unimpeded movement of wildlife, on both a localized and a continental scale.

Migratory birds traverse the Peloncillos as a link between wintering grounds in Mexico, Central America, and South America, and summer nesting territories in the United States and Canada. Many species follow the natural north/south route along the Continental Divide, which extends through the Peloncillo region. Species that must stop to water and feed along their migration route find riparian corridors in the Peloncillo region extremely high in primary productivity.

Like birds, many species of butterflies—most famously the monarch—use this same continental pathway that bridges the tropical south and the temperate north. Two endangered nectar-feeding bat species that have Central American winter ranges feed on agave plants in the oak woodland and desert grassland habitats of the Peloncillo region during their summer residency.

The region also provides opportunity for the movement of larger species. The most spectacular example of this was the jaguar photographed in the southern Peloncillos in 1996. This large male is believed to have moved north from a population in Sonora, and the incident bridged a decade-long gap in the documentation of jaguars north of the U.S./Mexico border. Given the recent photo documentation of other jaguars in southern Arizona, the value of the Peloncillos as potential habitat for more of these large cats is very high. Efforts to protect habitat in Sonora—where sustained breeding has been documented just 150 miles south of the Peloncillo Mountains—further raise the potential for this region to function both as vital habitat for recovering jaguar populations, and as a conduit for these cats to repopulate portions of their former U.S. range.

Historically the Peloncillos were within the range of the Mexican gray wolf, until its extirpation in the United States. The recent reintroduction of gray wolves into the Blue Range, as well as the Gila Wilderness Area, just a stone's throw from the north end of the Peloncillo range, offers the potential for the natural return of these predators to the Peloncillos, since the two regions are connected by a mosaic of protected habitat.

The Peloncillo region offers potential for the return to the United States of several bird species formerly found there, but now generally restricted to Mexico. These include the thick-billed parrot and the aplomado falcon. Higher elevations of the Peloncillo region also appear to be ideal habitat for the eared quetzal, sighted sporadically in Arizona but not officially recorded for New Mexico.

## *Conservation Concerns and Recommendations*

The Peloncillo region has world-class biological value within the Chihuahuan Desert Ecoregion. Recently, Conservation International (CI) recognized the importance of this region by naming the Madrean Pine-Oak Woodlands of Mexico and the United States—of which the Peloncillo region is the northernmost portion—a Global Biodiversity Hotspot, in need of continued study and protection. According to CI's Hotspot description, "The Madrean Pine-Oak Woodlands are home to about 5,300 species of flowering plants, a quarter of the Mexican flora. Although it is difficult to gauge the level of endemism because of the incompleteness of inventories, high-end estimates suggest that as many as 75 percent of these species may be found nowhere else on Earth . . . Amphibian diversity is remarkable . . . and a quarter of the 200 butterfly species are endemic." These habitats may also offer the last refuge for wild populations of jaguar and the return of the Mexican gray wolf. The immediate threats to the entire Madrean Pine-Oak Woodland—including massive loss of habitat to logging in Mexico (pine-oak woodlands once covered 21% of Mexico and today less than 8% of this habitat covers Mexico)—underscore the need to ensure that the northern portion of the Hotspot is adequately protected. The Peloncillo

region may well become the only refuge for many species facing extirpation due to habitat destruction farther south.

Preliminary workshop discussions on conservation values and threats identified three broad conservation targets: grasslands, aquatic systems, and habitats for wide-ranging species of concern. Experts also discussed several other targets, including rare and/or endemic species, keystone species, and distinctive habitat types (e.g., canyon riparian woodlands, limestone outcrops, and alkaline playas). Each chapter of Section 2 addresses the importance and needs of these targets in more detail. The mammal chapter, for example, notes which mammals depend on grassland habitats and what threats these animals face, as well as how these threats might be mitigated.

The information compiled in this report illustrates that the region warrants immediate further study and additional protection and management. A timely and broad-based conservation plan for the Peloncillo region will offer a chance to preserve a magnificent and valuable landscape before it can be fragmented and destroyed by neglect and unchecked exploitation and development.

# Section One: The Chihuahuan Desert and a Framework for Conservation in the Peloncillo Region

# 1.1 A Global Biodiversity Priority: The Chihuahuan Desert

The Chihuahuan Desert Ecoregion is one of the three most biologically rich and diverse desert ecoregions in the world, rivaled only by the Great Sandy-Tanami Desert of Australia and the Namib-Karoo of southern Africa.[1] The Chihuahuan covers 243,000 $mi^2$ (629,000 $km^2$), stretching from southeastern Arizona across southern New Mexico and west Texas. It runs deep into Mexico, encompassing large parts of Sonora, Chihuahua, Coahuila, Durango, Zacatecas, and San Luis Potosí, and small portions of Nuevo León, Tamaulipas, Querétaro, and Hidalgo.

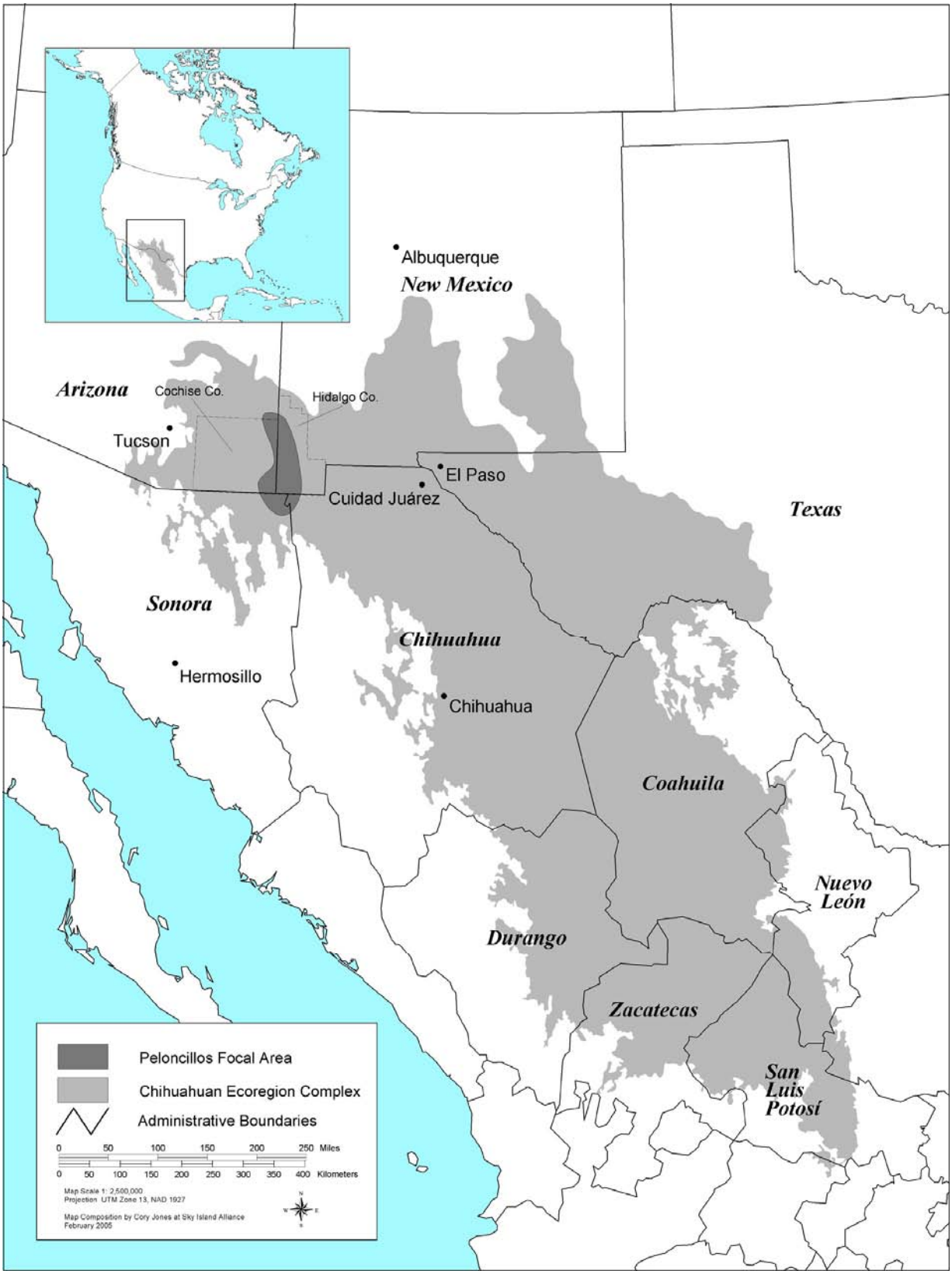
This ecoregion encompasses many habitat types, from hot-desert springs to conifer forests, unified in their close geographic and ecological relationships with the Chihuahuan desert biotic community.

This ecoregion was formally recognized as a top continental-level conservation target for World Wildlife Fund (WWF) in 1999. As part of its commitment to preserve representative components of North America's contributions to global biodiversity, WWF published a conservation assessment and conservation prioritization of terrestrial ecoregions of the United States and Canada.[2]

WWF's hierarchical approach to prioritizing conservation action starts at the Ecoregion Level. In this assessment, the Chihuahuan Desert was identified as globally outstanding in its biological distinctiveness, yet vulnerable to numerous threats.

### *Science as a Foundation of Conservation*

- *World Wildlife Fund and Sky Island Alliance are committed to using the best scientific knowledge to preserve the diversity and abundance of life on Earth.*
- *The Chihuahuan Desert is one of the most diverse ecoregions in the world.*
- *The Peloncillo region has world-class biological value within the Chihuahuan Desert Ecoregion and is a vital corridor between tropical Mexico and temperate North America.*
- *Distinctive characteristics include high diversity of herpetofauna, birds, mammals, and invertebrates; high numbers of endemic and rare species; key representative species assemblages; and largely intact habitats.*



Map 1.1. The Chihuahuan Desert Ecoregion, with the Peloncillo region indicated in dark gray

Even prior to this continent-level report, WWF has been working to define a vision and develop a framework for conservation in the Chihuahuan Desert. Experts at a 1997 workshop that focused on the Chihuahuan Desert Ecoregion[3] identified four major components for successful conservation here:

1. Conservation in perpetuity of the ecoregion's most distinctive biological features:
    - areas of high endemism for cacti and other endemic plants,
    - globally rare assemblages of freshwater fish species, and
    - representation of all major plant communities in the four biogeographic subregions of the ecoregion.

2. Restoration of landscapes and communities, building on the following features:
    - restoration of flora and fauna associated with prairie dog colonies,
    - restoration of desert springs altered by the presence of exotic species,
    - restoration of riparian corridors along desert rivers that suffer from altered water flow,
    - restoration of desert plant communities affected by overgrazing and overbrowsing, and
    - restoration of specialized gypsum-soil habitats (and their associated plants and animals) that have been degraded.

3. Management of large "conservation landscapes" of sufficient size and connectivity to maintain important ecological processes and wide-ranging species. This includes restoring and protecting populations of the following animals:
    - Mexican wolf,
    - mountain lion,
    - jaguar,
    - pronghorn, and
    - aplomado falcon.

4. Conservation of sites important to hemispheric and regional migrants that spend part of their lives in the Chihuahuan Desert and other parts of their life histories in adjacent or distant ecoregions. These migrants include the following:
    - birds,
    - bats, and
    - butterflies.

Within the Chihuahuan Desert Ecoregion, few areas are more representative of these four conservation components than the 3,000-$mi^2$ (7,700-$km^2$) Peloncillo region, which straddles the Arizona-New Mexico and Sonora-Chihuahua borders. In the 1997 ecoregion experts workshop, the Peloncillo area was identified as particularly high in diversity of herpetofauna, birds, invertebrates, and vegetation, as well as high in endemism and rare species. Other important features noted at that workshop were its representative species assemblages and relatively intact habitats.

In order to begin the process of assembling all current knowledge of the Peloncillo region —both published and new, unpublished information—WWF partnered with other conservationists in 2003 to host an additional experts workshop focused specifically on this unusual place. The purpose of this workshop was to document the collective knowledge of those assembled; this document reports and synthesizes data gathered at the workshop and adds data gathered later from other sources. As implied above, this workshop was intended to jumpstart a larger process of gathering and collating scientific and natural history knowledge of the Peloncillo region. By publishing and distributing this information, we hope to make it more accessible to land and wildlife managers as well as conservationists so that they can use this place-based research and knowledge in planning for research, management, and conservation projects.

In addition, this publication highlights where knowledge is sparse or lacking, in the hope of generating more research and information sharing to fill those gaps. (For more on the workshop, its methods, and details, see Chapter 1.3 and Appendix A.)

**Notes, Chapter 1.1**

[1] Olson, D. M., and E. Dinerstein. 1998. The Global 200: a representation approach to conserving the earth's most biologically valuable ecoregions. Conservation Biology 3:502-512.

[2] Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial ecoregions of North America: a conservation assessment. Island Press, Washington, DC.

[3] Dinerstein, E., D. Olson, J. Atchley, C. Loucks, S. Contreras-Balderas, R. Abell, E. Iñigo, E. Enkerlin, C. Williams, and G. Castilleja, editors. 2000. Ecoregion-based conservation in the Chihuahuan Desert: a biological assessment. World Wildlife Fund, Washington, DC.

## 1.2 The Peloncillo Region: A Gem of Biodiversity in the Northwest Chihuahuan Desert

Tucked into the northwestern Chihuahuan Desert, the Peloncillo region is a little-known biological gem where jaguars hunt among the rocky oak woodlands, and black bears share terrain with desert bighorn sheep. Few places in North America can boast a more complete assemblage of animals or more intact historical habitats—including rare high-elevation desert grasslands, intricate pine-oak woodlands, and riparian areas that harbor full assemblages of native fish and amphibians and are virtually free from nonnative invasives.

The Peloncillo region as discussed here is centered on an arc of connected ranges, running south down the Peloncillo Mountains to meet the Sierra San Luis and then east to the adjacent Animas Mountains. The watersheds of these three ranges fall within the bounds of this report as well, since plants and animals move along these valleys as well as throughout the highlands.

The Peloncillo Mountains form the spine of this region, with a hundred miles of rocky, rugged ridges and canyons that bridge the gap between the Mexican Sierra Madre and the U.S. Rocky Mountains. The range also lies at the meeting point of four biomes: the Sonoran and Chihuahuan Deserts, and the Great Plains and Great Basin[1] (see Section 2 for biogeographic details.) These ranges and valleys are part of the dramatic Sky Island province (also known as the Madrean Archipelago or Apache Highlands) comprising some 40 distinct mountain ranges that are crowned by pine forests, wreathed in oak woodlands and chaparral, and surrounded by semi-arid valleys of deserts and grasslands.

### *Meet the Peloncillos: Diverse, Remote, and Intact*

- *3000 $mi^2$ (7,770 $km^{2)}$; Approximate acreage: 1,923,000*
- *Crossroads of four states and two countries*
- *Habitats ranging from playas and desertscrub (from 4,000 ft/1,220 m) to montane forest (up to 8,600 ft/2,600 m)*
- *Three main mountain ranges and three high grassland valleys*
- *Part of the Madrean Sky Island Archipelago province and at the intersection of four major biomes*

In these Sky Islands, many species live far south or north of their usual tropical or temperate homelands. Thick-billed parrots are pursued by northern goshawks, and lesser long-nosed bats migrating from South America fly through the same habitats used by flocks of sandhill cranes that hatched in Siberia.

## *Geography of the Peloncillo Region: Mountains, Valleys, and Connections*

For the purposes of discussing its ecology and conservation in this report, the Peloncillo region is centered around the Peloncillo Mountains and includes adjacent ranges and valleys. The Peloncillo Mountains proper are a north-south-trending range extending along the Arizona-New Mexico border from the Gila River southward approximately 100 miles to the Mexico border.

The high point of the Peloncillo range is Owl Peak, at 6,625 ft (2,019 m). At their north end, the Peloncillo Mountains meet the Gila Mountains and adjacent Blue Range, separated only by a single narrow canyon in the rugged Gila Box Riparian National Conservation Area, at the Gila River. Across this canyon the highlands of the Mogollon Rim and Gila Wilderness rise in an unbroken swath of forest up into the Rocky Mountains. At the southern end of the range is Guadalupe Canyon; the hills south of it are sometimes referred to as the Guadalupe Mountains (for the purposes of this report, this southern extension is considered part of the Peloncillo Mountains).

South of the U.S.-Mexico border, the Peloncillo Mountains join the Sierra San Luis, a broad and convoluted range that extends some 40 miles south and east into Chihuahua and Sonora. Locally and in some literature, the Sierra San Luis is sometimes broken out into separate sierras: the Sierra de los Embudos, Sierra Las Minitas, Sierra Pan Duro, Sierra de la Caballera, Sierra Pitaycachi, Sierra La Cueva, Sierra de las Espuelas, Sierra Los Azules, and Sierra Hachita Hueca. This complex abuts the Sierra El Tigre on the southwest, and foothills of the Sierra Huachinera on the southeast.

Because their highland forests connect directly with the central Sierra Madre, the Sierras Huachinera and El Tigre, and the Sierra San Luis by association, are considered the northernmost extension of the Sierra Madre proper. The Sierra San Luis is separated from the others only by a headwater valley of the Río Bavispe, which flows to the Río Yaqui and the Gulf of California.

The northeastern edge of the Sierra San Luis runs into the Animas Mountains in New Mexico. Due east of the Peloncillo Mountains, this small but steep range runs north-south, reaches 8,519 ft (2,596 m), and forms the eastern border of the Peloncillo region as discussed here.

The Peloncillo region feeds four main hydrological basins. Most western slopes of the Peloncillos Mountains proper drain into the San Simon Valley, which drains north into the Gila

***Meet the Peloncillos (continued):***

*In the United States, the Peloncillo region includes*

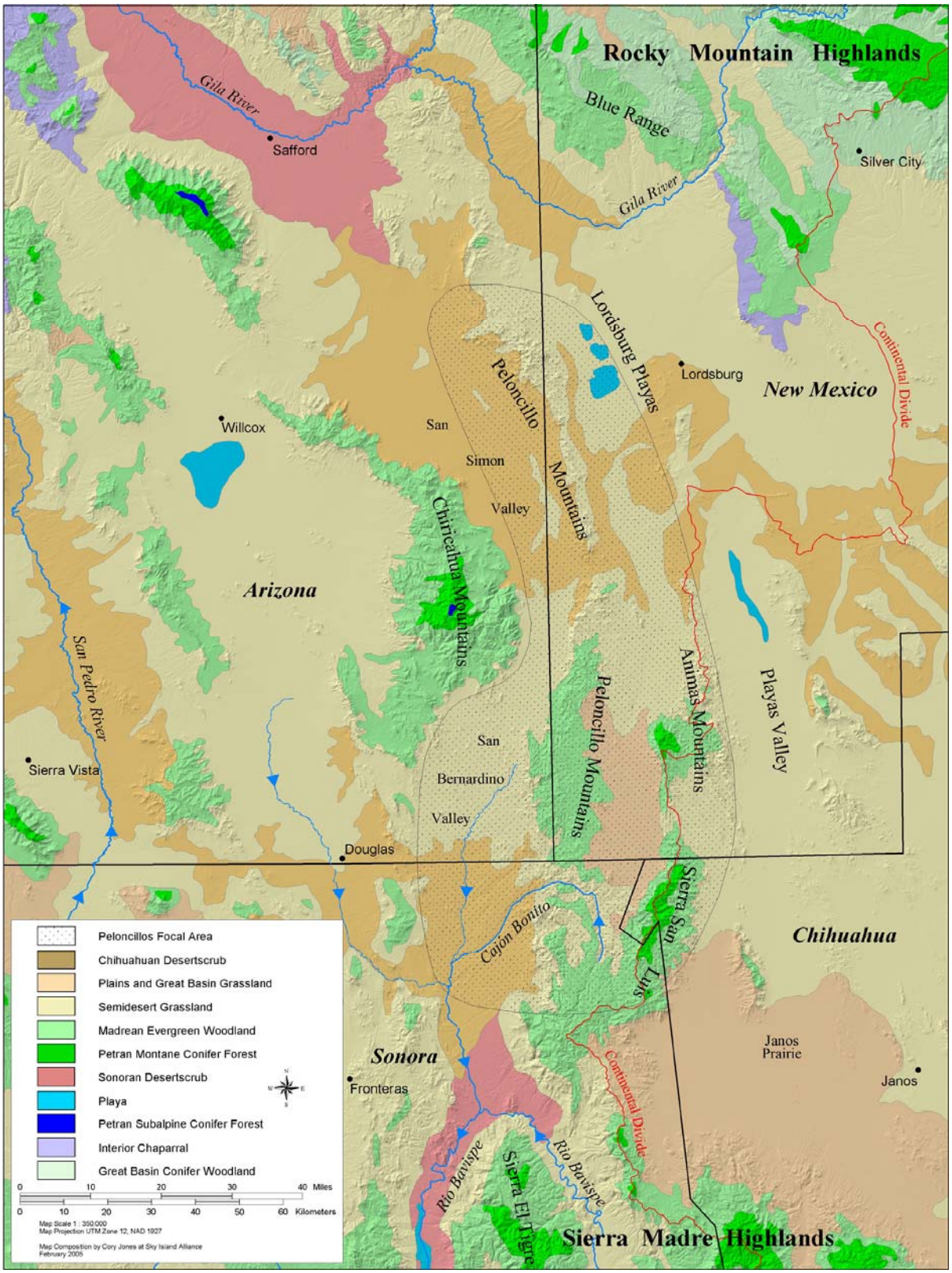
- *At least 318 birds*
- *15 distinct vegetative communities, including 879 plant species in the Peloncillo Mountains alone—significantly more than in comparable areas in the region*
- *89 species of amphibians and reptiles*
- *8 native fishes, with at least 2 endemic and 3 endangered*
- *90 mammals*
- *Several thousand invertebrates, including at least 7 known endemics.*
- *8 federally listed endangered species, 7 federally threatened species*

River system (although surface flow does not reach the Gila except in times of flood). The southern end - including the Guadalupe Mountain section and the western slopes of the Sierra San Luis - drains into the San Bernardino Valley, which is part of the Río Yaqui system. Runoff from the eastern slopes of the Peloncillo Mountains and western slopes of the Animas Mountains drains into a closed basin in the Animas Valley. The eastern slopes of the Animas and Sierra San Luis contribute to the Corralitos/Río Grande watershed, although much of this water ends in internally drained basins like the Playas Basin.

The valleys of these watersheds carry their own biological values that are inseparable from the richness of the mountains that feed them soil and water. The San Simon and San Bernardino Valleys that form the region's western edge are a blend of grassland and shrubby desert that was formerly grassland. These two valleys are separated by a low saddle that is barely perceptible on the ground, yet divides waters falling here into northbound and southbound drainage systems.

The Animas Valley is formed where the southeastern Peloncillo Mountains, the northern Sierra San Luis, and the western Animas Mountains link together in a broad U-shaped basin. The relatively lush southern end of this high valley (5,000 ft/1,533 m) contains a largely intact expanse of grassland and forms the core of the Gray Ranch, a 321,700-acre (150,300-ha) ranch with well-documented conservation values[2] and a long human history.[3] Eighty-five percent of the ranch is deeded private land. This valley section is considered by some the southwesternmost extension of the Great Plains.[4] At the south end, during geologic periods wetter than ours, the closed-basin topography created a lake that left a small saline playa as it dried over time. A set of larger Pleistocene lakebeds, known as the Lordsburg Playas, lies some 60 mi north in a broader semidesert grassland extension of the Animas Valley.

The Continental Divide runs through the Peloncillo region, crossing the Deming Gap—its lowest spot between Alaska and the Isthmus of Tehuantepec—to run down the central ridge of the Animas Mountains. The major passes in this complex—particularly the pass that marks the north edge of the Animas Mountains and Stein's Pass in the Peloncillo Mountains—are therefore among the lowest saddles in the Rocky Mountain-Sierra Madre backbone. These passes allowed "leakages" of plants and animals to and from each side of the continent (see below).




Map 1.2. Ecological context of the Peloncillo region. Biotic community characterizations are based on Brown and Lowe.[5] Blue arrows show direction of water flow.

## *Rocky But Not Sparse: Biological Attributes of the Peloncillo Region*

The Peloncillo region may seem sparse—the word "peloncillo" roughly translates from Spanish as either "sugar loaf" or "little baldy," both implying smooth, bare peaks—but is rich in life. Large tracts of intact habitat provide corridors for wide-ranging mammals such as the jaguar, desert bighorn sheep, and Mexican gray wolves—especially between the Sierra Madre and Rocky Mountains. In 1996 a large male jaguar was photographed in the southern Peloncillo Mountains in Arizona. Once locally extinct, desert bighorn have been reintroduced into the Peloncillo Mountains, and as recently as 50 years ago Mexican gray wolves still moved up and down this range from Mexico to the Mogollon Highlands. This endangered species has been reintroduced in the Mogollon region and may someday return to its southern haunts, if the habitats remain open and protected.

The ranges of the Peloncillo region are all less than 8,600 ft (2,600 m) tall and are dominated by Madrean evergreen woodland. The most common community associations include alligator juniper, gray oak, and Chihuahua pine. These communities support many rare or imperiled species, including the New Mexico ridge-nosed rattlesnake, which is listed as threatened under the U.S. Endangered Species Act. Within the higher patches of montane conifer forest, ponderosa pine and Douglas-fir dominate community associations. The desertscrub and pine-oak woodlands are also home to whiskered screech-owl, violet-crowned hummingbird, Lucifer hummingbird, the endangered Mexican long-nosed bat, and some 18 other recorded species of bat.[6] The mountain canyons with perennial water sources support riparian woodlands of Arizona sycamore and Fremont cottonwood associations[7] and are unusual for their escape from extensive invasion by exotics like saltcedar, an aggressive nonnative shrub that has infested many streams in the southwestern United States. Guadalupe Canyon and Cajón Bonito are particularly intact riparian systems. These woodlands support riparian-dependent species such as the Chiricahua leopard frog, northern beardless tyrannulet, and thick-billed kingbird. The riparian woodlands also help to regulate other processes, such as river temperature, flooding intensity, soil retention, and evaporation rates. In some locales these remarkably healthy riparian systems are home to nearly intact assemblages of native fishes.

The valleys and low slopes are filled by semidesert grasslands (characterized by grasses such as sideoats grama, black grama, tobosa grass, and big alkali sacaton) and Chihuahuan desertscrub (with mesquite, ocotillo, and creosotebush as dominant species). The Animas Valley adds another biotic community to the mix: plains grassland dominated by blue grama and black grama grasses. This valley's hoarding of water, combined with layers of near-surface clays in its volcanic soils, may have buffered it from the shrub encroachment that has taken over so many former grasslands in the region. Other research suggests that Animas Valley grasslands may be kept open by cold air from the surrounding ranges "ponding" in the valley bottom on winter nights; velvet mesquite does not survive extended exposure to temperatures below about $-11^0$ C ($12^0$ F), and temperatures here routinely drop well below this throughout the winter.[8]

Explorers have commented on the lushness of this valley for more than 150 years. In 1851, John R. Bartlett, of the Boundary Commission, traveled across this region and wrote of the Animas

Valley: *"Our course to-day was nearly south, over a broad valley, from eight to ten miles across, hemmed in on both sides by high ranges of mountains. So level was that valley, and so luxuriant the grass, that it resembled a vast meadow . . ."*

Dozens of species of wintering grassland birds are found here, including McCown's longspur, chestnut-collared longspur, western and eastern meadowlarks, and Baird's sparrow. During breeding season, globally declining grassland birds such as Botteri's sparrow use the sacaton grasslands. Fire has been brought back in as a management tool in many parts of this region, but especially in the Animas Valley. The natural springs, or *ciénegas,* in the Animas and the San Bernardino Valleys support endangered aquatic herpetofauna, including the declining Chiricahua leopard frog (listed as threatened under the U.S. Endangered Species Act). The Animas Valley's Cloverdale Cienega boasts an especially important refuge for these frogs, with none of the invasive bullfrogs or chytrid fungus that have drastically reduced populations of native frogs elsewhere in the West.[9] This wetland also is one of the finest examples of intact cienega habitat in the Southwest. Antelope Pass, linking the Animas and San Simon Valleys, has the highest lizard species diversity in the continental United States.[10] This area may also contain the highest diversity of granivorous mammals in the United States. Kangaroo rats play a major role in maintaining grasslands by caching and distributing seeds and by moving soil. Black-tailed prairie dogs, once major "engineering species" throughout the region, have been reintroduced into the southeast flanks of the Animas Mountains, separated from the Animas Valley proper by one low pass. Their effects on flora, fauna, and soils are being studied in depth.

Southeast through San Luis Pass lies the Janos Prairie in the Mexican state of Chihuahua—home to the largest remaining black-tailed prairie dog town in North America. While this prairie is outside the Peloncillo focal area per se, it remains an important biotic influence capable of sustaining and repopulating ecologically similar parts of the Peloncillo region valleys. The prairie provides suitable wintering habitat for large numbers of ferruginous hawk and mountain plover. Year-round residents associated with the prairie dog towns include kit fox, badger, golden eagle, burrowing owl, and endangered black-footed ferrets (reintroduced in 2001). Prairie dog towns are found throughout the prairie and were at one time contiguous with the Animas and Hachita Grassland prairie dog towns that have since been extirpated.[11] These Mexican and U.S. grasslands once supported healthy breeding populations of aplomado falcon, now considered endangered by both nations. They still provide a corridor for the movement for pronghorn and for a herd of bison that some scientists believe may be a remnant of the "great southern herd" isolated from northern bison populations for hundreds, if not thousands, of years.

Published biological information about the very northern Sierra Madre (including the Sierra San Luis, its northernmost extension) is scarce but improving.[12] The region is known, however, to be extremely important for landscape-scale conservation. The thick-billed parrot nests here, as do the eared quetzal and golden eagle. The old growth forests are important wintering areas for Williamson's sapsucker. The eastern slopes of the Sierra contain seasonally inundated wetlands, which are critical stopover sites for migrating birds; shorebirds, raptors, and cranes depend upon shallow playa waters during continental migrations. These Mexican playas function as steppingstones en route to similar playas in the United States, at the north end of the Animas Valley, New Mexico, in Willcox, Arizona, and in places beyond.

The northernmost major breeding population of jaguars lies just 150 miles south of the border, where the Río Bavispe joins the Río Aros. The jaguar photographed in the Peloncillos in 1996 is presumed to have come from this population, as are most others sighted in the United States in recent decades. International efforts to protect this population[13] increase the likelihood that jaguars will continue to roam the Peloncillo region. In the United States, collaborative work to protect habitat on both sides of the border and to foster appreciation for these giant cats as part of our collective natural heritage sets the stage for their return to the U.S. part of their range.[14]

On the western slopes of the Sierra San Luis rises Cajón Bonito ("beautiful box canyon"), which drains to the southwest, joining the headwaters of the Río Yaqui. Cajón Bonito, which runs within six miles of the U.S. border, contains one of the finest assemblages of native aquatic and riparian species in the North American deserts. At least nine species of native fishes occur in the cajón's small river, widely considered the best stream in the region. Two of these fishes are endemic to the area and three are recognized as endangered by the U.S. government.

Cienegas in the region also support the San Bernardino springsnail (endemic to San Bernardino National Wildlife Refuge and adjacent Rancho San Bernardino) and the southernmost population of Chiricahua leopard frog. Neotropical river otters have been documented in the adjoining Río Bavispe. The presence of all these groups is truly rare in both the United States and Mexico.

Without doubt, the Peloncillo region is one of the most biologically diverse and intact regions remaining in North America. With adequate protection, further research, and continued stewardship, this region will remain a vital corridor for many species that move across the international boundary, repopulating the Sierra Madre Occidental, the Mogollon Plateau, and portions of the southern Rocky Mountains with their native fauna, including Mexican gray wolves, jaguars, bison, and prairie dogs.

## *Demographics of the Peloncillo Region*

The Peloncillo region includes several small, unincorporated rural communities, including Rodeo, Animas, and Road Forks, all of which are in New Mexico. The nearest towns of any size are Lordsburg, New Mexico (population 3,379; 15 miles from the Peloncillo Mountains); Douglas, Arizona (population 14,312; 25 miles away); Agua Prieta, Sonora (population in 2000 was officially 61,944 but other estimates of peak transitory population reach as high as 150,000)[15]; and Janos, Chihuahua (population 10,214; 50 miles away).[16] Data on closest cities are summarized in the table below:

| CITY | POPULATION (YEAR 2000) | DISTANCE FROM PELONCILLO REGION |
|---|---|---|
| Tucson, Arizona | 486,699 | 120 miles |
| El Paso, Texas | 563,622 | 140 miles |
| Ciudad Juárez, Chihuahua | 1,218,817 | 150 miles |
| Hermosillo, Sonora | 609,829 | 190 miles |
| Albuquerque, New Mexico | 448,607 | 250 miles |
| Chihuahua City, Chihuahua | 671,790 | 270 miles |

Table 1.1. Population and distance data for cities neighboring the Peloncillo region. Distance is approximate and is measured in a straight line from each city center to the nearest edge of the region as shown on Map 1.1. Population data are taken from the U.S. Census 2000 and Mexico's Censo General de Población y Vivienda, 2000. U.S. data are for areas within city limits. Mexican data are listed by municipio, which can include rural areas surrounding a city.

The U.S. portion of this region falls in Hidalgo County (New Mexico) and Cochise County (Arizona). Hidalgo and Cochise Counties have densities of just 1.7 and 19.1 people per square mile, respectively. Both are rural counties, although larger towns elsewhere in Cochise County inflate its apparent population density relative to what exists in this far southeastern corner. The Hidalgo County population has declined slightly in recent years, down 0.4% from 1990 to 2000 compared with a statewide increase of 20% in this same time period. Cochise County is growing (20% from 1990 to 2000) but not as quickly as the rest of Arizona (statewide increase of 40% from 1990 to 2000).

Ethnic demography reflects the area's borderland heritage, with 52% of Hidalgo and 31% of Cochise County's population identifying as Hispanic; most of the rest identifies as non-Hispanic white. Unemployment rates in 2000 were moderate for both counties (3.4 % in Cochise and 5.4% in Hidalgo). Governments employ about a quarter of the job-holding adults in each county (28% and 22% respectively). Most (63% and 69% respectively) count as private wage and salary workers. About 8% count as self-employed in unincorporated businesses. The region has no large industries. Agriculture and related industries (forestry, fishing and hunting, and mining) make up a small portion of the workforce in Cochise County (3%) but considerably more in Hidalgo County (15%). The industry category of educational, health and social services tops the charts for both counties, with 20% and 17% respectively.[17]

## *Current Land Management of the Peloncillo Region*

The Peloncillo region, as defined above and represented in Map 1.2, comprises some 1,920,000 acres (776,996 ha) of federal, state and private land in the United States and Mexico. The Safford and Las Cruces Field Offices of the Bureau of Land Management manage 502,300 acres (203,273 ha) within the region, while the Coronado National Forest manages 85,000 acres (34,398). The U.S. Fish and Wildlife Service manages another 2,309 acres (934 ha) at the San

Bernardino National Wildlife Refuge. The states of Arizona and New Mexico own 338,500 acres (136,986 ha). Private land in the United States comprises approximately 600,000 acres (242,811ha). The Animas Foundation and Malpai Borderlands Group work to promote wildlife-friendly management and retention of open space on large portions of the U.S. private lands. Fundación Cuenca Los Ojos is responsible for conservation-focused management of some 100,000 acres (40,469 ha) in the Mexican portion of this region. Most of these holdings have recently received formal designation from the Mexican government as Áreas Naturales Protegidas (natural protected areas).

Current conservation status and concerns, as expressed by WWF biological assessment reports[18], are briefly described below and more thoroughly covered in each chapter in Section Two: Systems and Species of the Peloncillo Region.

## Conservation Status

Most of this region is intact, although portions are seriously degraded. Nevertheless, as a whole, the region plays a critical role in migration, movement, and permanent habitat for a wide assemblage of species representing Chihuahuan, Sierra Madre, Rocky Mountain, and Sonoran ecoregions.[19]

The following summary is adapted from World Wildlife Fund's Chihuahuan Desert Ecoregion Assessment,[20] with some corrections and additions.

- **Peloncillo-Animas:** The land status through this area includes federal, state, and private. Large portions of the ranges are protected through special management areas and conservation easements. Within the Peloncillos, the Bureau of Land Management (BLM)-Safford District manages Guadalupe Canyon Area of Critical Environmental Concern (ACEC; 2,160 acres/874 ha), and Baker Canyon Wilderness Study Area (WSA) at 4,811 acres (1,947 ha). The BLM Las Cruces District manages an adjacent Guadalupe Canyon ACEC in New Mexico (4,168 acres/1,687 ha), the Granite Gap ACEC (1,750 acres/708 ha), the Central Peloncillo Mountains ACEC (77,850 acres/31,505 ha), the Antelope Pass Research Natural Area (RNA; 8,700 acres/3,610 ha), the Lordsburg Playa RNA (4,510 acres/1,871 ha) and the Gray Peak WSA (14,675 acres/5,939 ha). The Coronado National Forest manages Bunk Robinson WSA (15,960 acres/6,459 ha) and Whitmire Canyon WSA (12,840 acres/5196 ha). Scattered parcels of private land are managed under a range of strategies. The Malpai Borderlands Group—formed by ranchers in the Chiricahua, Peloncillo, and Animas Mountains and the San Bernardino, San Simon, and Animas Valleys—combats subdivision of open landscapes via conservation easements, while improving range conditions, and facilitating collaboration among land managers. The Malpai Group promotes rangeland practices that are designed to restore degraded lands by improving the fire regime, providing grassbanks during times of poor forage production, alleviating both perceived and real conflicts with imperiled species, etc. Most but not all large landowners in the area participate in the Malpai Group.

- **Yaqui Headwaters:** The San Bernardino National Wildlife Refuge manages 2,309 acres (934 ha), with a management emphasis on fishes and birds. In the United States, ranching

families affiliated with the Malpai Borderlands Group manage lands (95,000 acres/38,445 ha total, 38,000 acres/15,378 deeded) surrounding the National Wildlife Refuge. These families are working together to ensure long-term protection of this area with a management emphasis on restoring watersheds and protecting the Chiricahua leopard frog, jaguar, lesser long-nosed bat, New Mexico ridge-nosed rattlesnake, and the Río Yaqui drainage fishes. In Mexico, the Fundación Cuenca Los Ojos works to protect and restore watersheds with a management emphasis on native fishes, migratory birds, and various mammal species on another 87,000 acres (35,208 ha).

- **San Simon Valley:** This area is not protected by any special management designations. However, a long-term ecological study site has produced detailed information about the past and current environmental conditions. Several rangeland revegetation studies have also been conducted here. The watershed is considered highly degraded by groundwater pumping, historical grazing practices, and conversion to farming.[21]

- **Animas Valley-Chihuahuan Grasslands:** The Gray Ranch protects some 321,700 acres (150,300 ha) with a mix of conservation easements, wildlife-friendly range management, and ecological research. The BLM's Cowboy Springs ACEC is 6,738 acres (2,727 ha). Antelope Pass RNA (8,708 acres/3,524 ha) was designated to protect the 19 known lizard species.[22]

- **Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera):** The Fundación Cuenca Los Ojos works to protect and restore watersheds with a management emphasis on native fishes, migratory birds, and various mammal species on approximately 45,000 acres (18,211 ha). The Nature Conservancy recently purchased Rancho El Uno (36,000 acres/14,568 ha) in the adjacent Janos Prairie. Sky Island Alliance has provided support for the scientific research station in Janos, now overseen by the Universidad Nacional Autónoma de México (UNAM).

## Management Concerns and Threats

- **Peloncillo-Animas:** Over collection of reptiles threatens local native populations. Problems with grazing management continues to occur on some private, state, and federal lands. Motorized recreation continues to grow as a significant negative use. Subdivision of private ranches and subsequent development remains a threat, particularly in the San Bernardino Valley.

- **Yaqui Headwaters:** The economy of the area at one time was based almost solely on smelting operations from large copper mines in Bisbee, Arizona, which began to close in the early 1980s. Agua Prieta, Sonora has 62,000 people and Douglas, Arizona, has 14,300. Both communities contribute to depletion of water resources and a decline in air quality. As many as 165,000 people may live in the area (see preceding section). Overgrazing, downcutting of channels, water depletion through agriculture, and municipal and mining uses on the Mexican side of the border are issues. In the United States, motorized recreation continues to grow as a significant threat. Within wetland and aquatic habitats, exotic bullfrogs (*Rana catesbeiana*) threaten native frog, snake, and fish populations.[23] Depletion of spring flows from excessive groundwater pumping, stream

diversion and streambank erosion are primary threats to native fishes in the smaller tributaries. The introduction of nonnative fish species is also a serious threat to native species.[24]

- **San Simon Valley:** Historical degradation from livestock grazing continues to erode some areas. Subdivision of ranch lands into private home sites, motorized recreation, and continued groundwater pumping are primary threats.

- **Animas Valley-Chihuahuan Grasslands:** Water diversions for agriculture disrupt cienega vegetation and in many cases eliminate the wetlands. Continuous livestock grazing in periods of drought damages grasslands and riparian areas. Poisoning of prairie dogs in Mexico occurs. Subdivision and commercial development fragment the landscape in the northern part of the Animas Valley.

- **Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera):** Pesticides associated with agriculture in Casas Grandes and Colonia Juárez are threats to riparian woodlands. Logging regulations are not enforced. Cattle ranching has altered grassland communities and riparian areas. Poaching of deer has reduced the prey base for wolves.

**Notes, Chapter 1.2**

[1] Gehlbach, F. R. 1981. Mountain islands and desert seas. Texas A & M Press, College Station, TX; and Curtin, C. G., N. F. Sayre, and B. D. Lane. 2002. Transformations of the Chihuahua borderlands: grazing, fragmentation, and biodiversity conservation in desert grasslands. Environmental Science and Policy 5:55-68.

[2] Ibid.

[3] Human history of the Gray Ranch and surrounding areas is summarized in works such as the following:

Hilliard, G., 1998. A hundred years of horse tracks: the history of the Gray Ranch. High-Lonesome Books, Las Cruces, NM.

Lyons, P. D., A. J. Goldberg, and G. Bodner, editors. 2005. Cultural crossroads: the Peloncillo Planning Area cultural resources overview. Unpublished report, to be released in 2006.

Hadley, D., T. E. Sheridan, and P. Warshall. 1999. Human occupation and ecological change in the borderland region of Arizona/New Mexico/Sonora/Chihuahua: an analysis of causes and consequences. Pages 51-56 *in* Gottfried, G. J., L. G. Eskew, C. G. Curtin, and C. B. Edminster (compilers). Toward integrated research, land management, and ecosystem protection in the Malpai Borderlands: conference summary, January 6-8, Douglas, Arizona. United States Department of Agriculture Forest Service Rocky Mountain Research Station Proceedings RMRS-P-10. Rocky Mountain Research Station, Fort Collins, CO.

[4] Brown, D. E., and C. H. Lowe. 1980. Biotic communities of the Southwest. United States Department of Agriculture Forest Service General Technical Report RM-78.

[5] Ibid.

[6] New Mexico Department of Game and Fish, Biota Information System of New Mexico (BISON-M) database, available online at <http://nmnhp.unm.edu/bisonm>, last searched February 2005.

[7] Bourgeron, P. S., L. D. Engelking, H. C. Humphries, E. Muldavin, and W.H. Moir. 1995. Assessing the conservation value of the Gray Ranch: rarity, diversity, and representativeness. Desert Plants 11(2&3).

[8] Ben Brown, Western Ecosystems Consulting, Animas, NM, pers. comm. 2005. Based on unpublished studies by Ray Turner and Pete Sundt.

[9] Many water sources in the region, including the San Bernardino National Wildlife Refuge and some Animas Valley stocktanks and marshes, do harbor nonnative fishes and bullfrogs. According to Charles Painter (pers. comm. 2005), however, surveys for bullfrogs and chytrid fungus in the Cloverdale Cienega have turned up negative.

[10] United States Department of the Interior Bureau of Land Management. 1993. Mimbres resource management plan. Las Cruces District Office. Mimbres Resource Area. USDI Bureau of Land Management.

See also Painter, C., Herpetofauna of the Peloncillo region, Chapter 2.3 of this report.

[11] Bailey, V. 1908. Field notes from travels in the borderlands. National Archives, Washington, DC.

[12] E.g., several papers presented at the conference Connecting Mountain Islands and Desert Seas: Biodiversity and Management of the Madrean Archipelago II and 5th Conference on

Research and Resource Management in the Southwestern Deserts, May 11-15, 2004, Tucson, Arizona. Presentations focused on the Sierra San Luis included the following:

Ponce Guevara, E., K. Pelz Serrano, and C. López Gonzales. Coyote abundance in relation to habitat characteristics in the Sierra San Luis, Sonora, Mexico.

Pelz Serrano, K., E. Ponce Guevara, and C. López Gonzales. Beaver abundance and habitat characteristics in the Sierra San Luis.

Luna Soria, H., and C. López Gonzales. Abundance and food habits of cougars and bobcats in the Sierra San Luis, Sonora.

Sierra Corona, R., I. A. Sáyago Vázques, M. del C. Hurtado Silva, and C. López Gonzales. Black bear abundance, habitat use, and food habits in the Sierra San Luis, Sonora.

[13] Efforts are spearheaded by the Northern Jaguar Project, Naturalia, A.C., Octavio Rosas Rosas (New Mexico State University), and others, and involve working with local communities, purchasing land for conservation, and studying jaguar ecology and movements.

[14] The Jaguar Conservation Team, coordinated by the Arizona Game and Fish Department, brings together agency biologists, academic researchers, conservationists, ranchers and other landowners, and any other interested parties. Several times per year this dedicated but diverse group convenes to work out their differences and devise plans for habitat protection and outreach. Meeting minutes and schedules can be found online at <www.gf.state.az.us/w_c/jaguar_management.shtml>.

[15]One of the challenges of the population on the U.S.-Mexico border is its extreme transitory nature. Many commentators estimate Agua Prieta's population at more than twice the official census number. The following article cites Agua Prieta's population as 120,000: <http://www.migrationint.com.au/ruralnews/moscow/oct_1999-11rmn.asp>. Another states, "Agua Prieta's population has mushroomed to about 150,000, eclipsing that of Douglas' approximately 17,500" (from http://www.arizonahandbook.com/douglas.htm>).

[16] Instituto Nacional de Estadística, Geografía, e Informática (INEGI). IV al XII Censos de Población y Vivienda, 1930 a 2000. [Mexican government census data, 1930-2000]

[17] U.S. Census Bureau, Census 2000 data, available at <http://www.census.gov>. Last viewed February 2005.

[18] Dinerstein, E., D. Olson, J. Atchley, C. Loucks, S. Contreras-Balderas, R. Abell, E. Iñigo, E. Enkerlin, C. Williams, and G. Castilleja, editors. 2000. Ecoregion-based conservation in the Chihuahuan Desert: a biological assessment. World Wildlife Fund, Washington, DC.

[19] Turner, D. S., S. Brandes, M. Fishbien, and P. W. Hirt. 1994. Preserve design for maintaining biodiversity in the Sky Island Region. Pages 524-530 *in* United States Department of Agriculture Forest Service. Biodiversity and management of the Madrean Archipelago: the Sky Islands of the southwestern United States and northwestern Mexico. USDA Forest Service General Technical Report RM-GTR-264.

[20] Dinerstein, E., et al. 2000 (see footnote 18 above).

[21] United States Department of the Interior Bureau of Land Management. 1990. Safford District Resource Management Plan Environmental Impact Statement. USDI Bureau of Land Management.

[22] United States Department of the Interior Bureau of Land Management. 1993 (see footnote 10 above).

[23] United States Department of the Interior Fish and Wildlife Service. 1995. San Bernardino and Leslie Canyon Comprehensive Management Plan, Albuquerque, New Mexico.

[24] Williams, J. E., D. B. Bowman, J. E. Brooks, A. A. Echelle, R. J. Edwards, D .A. Hendrickson, and J. J. Landye. 1985. Endangered aquatic ecosytems in North American deserts with a list of vanishing fishes of the region. Journal of the Arizona-Nevada Academy of Sciences 20:1-62.

# 1.3 Gathering Knowledge and Setting a Framework for Conservation

In February 2003, WWF co-hosted a two-day experts workshop focused specifically on the Peloncillo region, with the following goals:

1. Identify and define a geographic area for conservation;
2. Update species lists;
3. Characterize the significance of species diversity in the Peloncillo region;
4. Develop the framework for conservation and management of the Peloncillo region; and
5. Provide the groundwork for publication of a document that makes the workshop's information and conclusions available to land managers and conservationists.

## *Workshop Methods*

Twenty-five experts were invited; the 21 participants represented all disciplines (see page 3). Approximately 35 additional experts were consulted in the process of producing and peer-reviewing this report.

The group began summarizing knowledge for each group by reviewing and fleshing out species lists, and linking species to their typical habitats (based on divisions in GIS-habitat models in the New Mexico Gap Analysis Project[1]). Experts then characterized species' contributions to larger biodiversity patterns according to the following criteria (sample forms are included in Appendix A):

- Endemic to Peloncillos region
- Endemic to Chihuahuan Desert or Apache Highlands Ecoregions
- Edge of range–noting which edge (north, south, east or west)
- Highly unusual interaction or assemblage
- Extraordinary radiation of taxa
- Relict taxa
- Large-scale ecological phenomena (e.g., high local numbers, migration routes)
- Peloncillo population critically important for survival of the species
- Exotic and/or invasive

### *Background on Experts Workshops in Conservation*

- *Experts workshops are widely used as planning tools by groups such as WWF, Conservation International, and the Wildlife Conservation Society.*
- *Workshops provide a way to assemble as many place-based experts as possible and capture their collective knowledge efficiently and quickly.*
- *Experts workshops not only collate information into a single access point but also focus attention on an important region and help to jump-start additional science and conservation planning.*
- *Capturing diverse viewpoints is a hallmark of workshops.*

- Other—explain (e.g., genetic resources for human utility, education value, ecosystem services, biological inventory)

The experts were then asked to comment on species assemblages and their importance, and finally to review the New Mexico Natural Heritage Tracking List and discuss possible additions, including justifications. This commentary could include species that do not occur in the Peloncillos now, but once did. When time allowed, experts identified conservation targets. Additional experts who could not attend the workshop were also consulted, through telephone interviews and email discussions, and in the peer-review process for this report.

Workshop experts were asked to define the most biologically appropriate boundaries for conservation planning. The map presented here therefore represents lengthy discussions about what biologically informed spatial boundaries might look like. The first result of these discussions was that experts were nearly unanimous in recommending that valleys receive as much emphasis as mountain ranges. Experts—especially people who work with wide-ranging taxa or who think about long-term climate dynamics—next emphasized the value of the Peloncillo region as a bridge between the Sierra Madre and the Rocky Mountains-Mogollon Plateau. As such, the area of focus expanded from an initial emphasis on the central Peloncillo Mountains proper, to include the northern part of the range almost to the Gila River, as well as the southern (Sierra San Luis) extension of the complex almost to the Río Bavispe. The focal area boundaries shown on Map 1.2 stop just short of these connection points for two reasons: (1) participants felt that the central parts of this long bridge are now subject to greater threat than the ends, and (2) relatively little is known about the areas on the fringes of the Peloncillo region. Experts on each group further focused their discussions on the subset of this larger Peloncillo region for which they had the most information. Spatial extent of discussions thus varies by group.

A combination of methods from WWF and The Nature Conservancy was used to identify conservation priorities and major threats to biodiversity. As the last part of the workshop, experts were asked to identify "systems" of conservation import (species, species assemblages, or habitats), plus "stresses" and "sources of stress" that have affected, are affecting, or could affect the viability of these conservation targets. This method was adapted from The Nature Conservancy's planning tool known as the Five-S Framework for Site Conservation.[2]

Workshop participants identified three broad conservation targets: grasslands, aquatic systems, and habitats for wide-ranging species of concern. They also chose several other targets, including rare or endemic species, keystone species, and unique and important habitat types like canyon riparian woodlands, limestone outcrops, and alkaline playas.

The workshop's threat discussions yielded a consensus on which habitats are critical to conservation of multiple taxonomic groups, e.g., canyon riparian woodlands that are havens for many species of birds, reptiles, invertebrates, and plants, including numerous species that are rare, endangered, or both. They also produced a preliminary list of stresses and sources of stress for some of these habitats, summarized in Appendix I. Most of these priorities and threats are discussed in more detail in particular chapters, according to taxonomic group. The final two "S"s—strategies and measures of success—were not within the scope of this meeting.

The results of the workshop were analyzed and synthesized by the authors of each subsequent chapter in this report (see page 1 for authors list). Experts and report editors then worked together to refine the above goals and accomplish the following:

- Capture all available knowledge of plant, mammal, bird, reptile, amphibian, and fish species;
- Document as many invertebrates as possible;
- Draw relationships among taxa;
- Provide a thorough bibliography;
- Create a list of threatened, endangered and candidate species by country and state; and
- Demonstrate the biological importance of this area, in terms of
    - Species diversity,
    - Biological phenomena,
    - Large mammal corridor,
    - Migratory stopover, and
    - Rare and endemic species.

## *Report Rationale, Content, and Structure*

This region has a pressing need for place-based compilation of research results. Although aspects of the flora and fauna of the Peloncillo region have been described in a variety of journals and symposia, these remain largely buried in the scientific and agency literature banks. Researchers from many different universities, institutes, and agencies also work in the area. Information about the Peloncillo region's biota has never been compiled into any accessible format; no document contains all the species known to the range, the importance of their occurrence, or recommended conservation and management goals and targets. Such a compilation is especially important because of this region's mosaic of land tenure. In addition to dozens of private landowners in the United States and Mexico, parts of this area are managed by the U.S. Forest Service, the Bureau of Land Management (out of two separate offices), the U.S. Fish and Wildlife Service, the Arizona State Land Department, and the New Mexico State Land Department. With so much of the Chihuahuan Desert Ecoregion's biodiversity at stake in the Peloncillo region, a compendium of biodiversity analysis will give land managers access to such information in one place. This document is the beginning point of this compilation of knowledge.

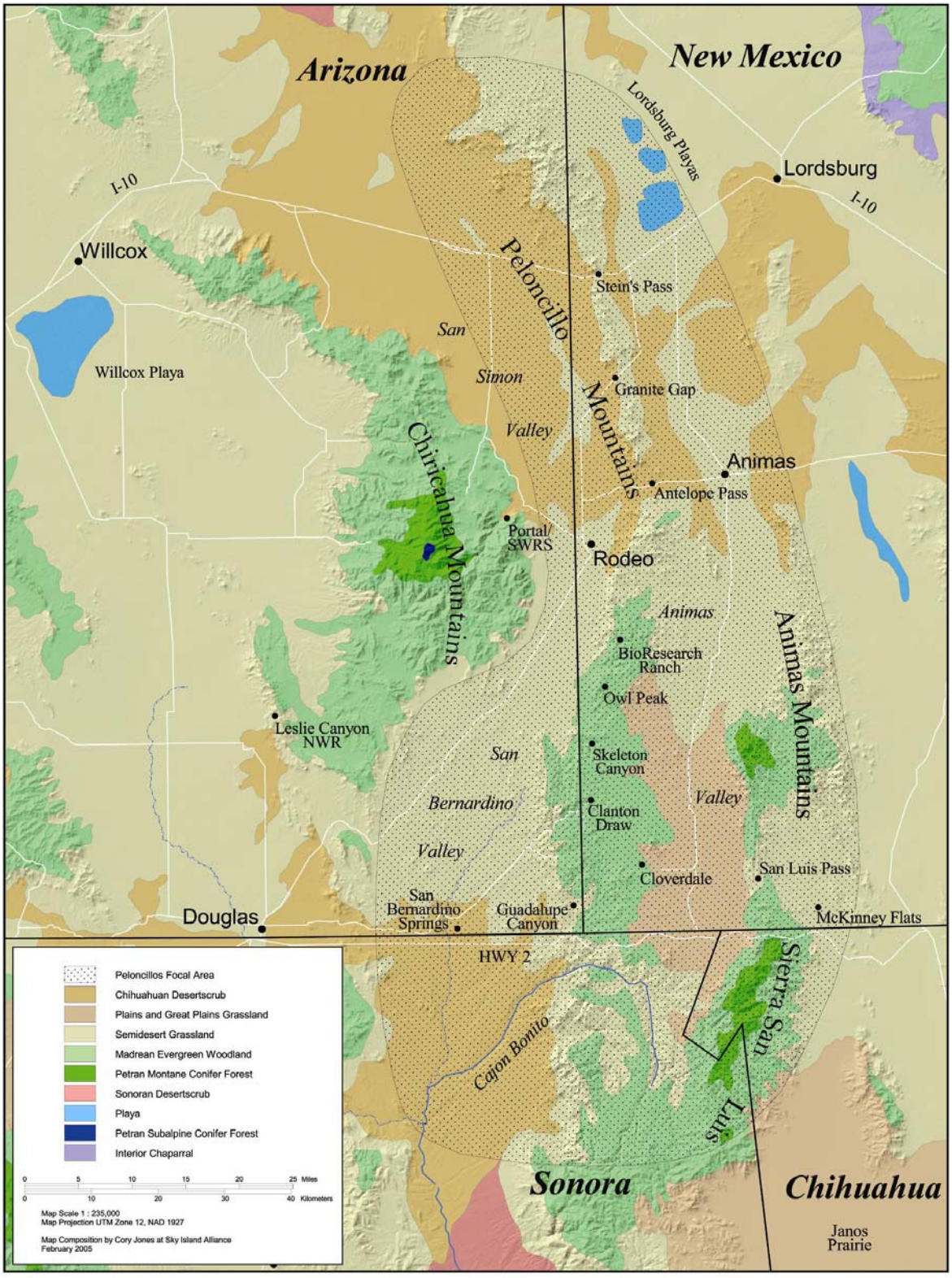
This report includes introductory chapters, a chapter on ecological processes, six chapters focusing on the flora and fauna of the region, and an executive summary. Chapters 2.2-2.7 include the following sections:

- Introduction – Setting the stage for the chapter subject.
- Geographic Scope – Because each subject had its own group of experts at the workshop, the geographic scope of each discussion varied slightly from subject to subject, largely based on available data. A brief description is included at the beginning of each chapter.
- Description – The bulk of each chapter includes the compendium of knowledge collected and synthesized at the workshop.

- Knowledge Gaps – Key gaps in data are pulled out of the chapter description and discussion and listed in bullet format.
- Conservation Targets – As in knowledge gaps above, key or critical conservation targets that are discussed in the chapter are pulled out and listed in bullet format.
- Literature Cited – Notes are numbered as endnotes in text, or a chapter bibliography is provided, organized by section head, at the end of the chapter.

Additionally, the report has nine appendices, including species lists and examples of workshop forms and other tools.

Map 1.3 illustrates the major landscape features discussed throughout this report.




Map 1.3. Major landscape features discussed throughout this report, with biotic communities (see Map 1.2) used as a base layer.

**Notes, Chapter 1.3**

[1] Thompson, B. C., P. J. Crist, E. Muldavin, J. S. Prior-Magee, R. A. Deitner, and D. L. Garber. 1996. Examining natural floral heritage and management for biological diversity in New Mexico using gap analysis. New Mexico Journal of Science 36:327-354.

[2] The Nature Conservancy. 2000. The Five-S Framework for Site Conservation: a practitioner's handbook for site conservation planning and measuring conservation success. Available online at < http://nature.org/summit/files/five_s_eng.pdf>.

# Section Two: Systems and Species of the Peloncillo Region

# 2.1 Earth Forces and Living Systems in the Peloncillo Region

All species live within the context of interactions between the abiotic "stage" and the living "actors." Ecosystems are dynamic and constantly changing; some changes are predictable, others are much less so. This chapter discusses some of the most significant driving forces that affect ecosystem dynamics in the Peloncillo region—factors that people interested in restoration of the landscape and conservation of species must grapple with.

Dynamics discussed here include weather and climate; fire; topography, geology, and soils; hydrology of both surface and groundwater; past and present vegetation change; and foodweb integrity. Other dynamics such as nutrient cycling and carbon sequestration also affect the area but are beyond the scope of this report. The chapter will concentrate on ecosystem changes since approximately 1880, with a timeline summary in the final section.

### *Outstanding Features*

- *Basin-and-Range topography includes relatively high mountains and three high-elevation alluvial valleys.*
- *Origin of substrate is largely volcanic, but with diverse sedimentary elements.*
- *Region sits within the Continental Divide's lowest dip between Alaska and southern Mexico; flora and fauna "leak across" to blend western and eastern elements.*
- *Fire has been a crucial driver of ecosystem change in the Peloncillo region.*
- *Attention to soil types, fire, hydrology, and foodweb dynamics is crucial to successful restoration of species and habitats.*

## *Earth Forces: Abiotic Factors*

### Topography and Landforms

The Peloncillo region sits in the continental saddle between the massive highlands of the Rocky Mountain-Mogollon Plateau and those of the Sierra Madre. Like other "sky island" complexes, the Peloncillo Mountains (and contiguous Sierra San Luis and Animas Mountains) are isolated from other ranges by desert and grassy lowlands.

The Peloncillo region's three contiguous mountain ranges are flanked by relatively high-elevation valleys. The valleys run typically two to six miles wide. The three central mountain/valley complexes considered here are

- The northern San Bernardino/Río Yaqui headwaters on both sides of the U.S./Mexico border (draining south);
- The San Simon River Valley, from its headwaters to just north of U.S. Interstate 10 (draining north); and
- The Animas River channel from its headwaters to the Lordsburg Playas (draining north).

| | |
|---|---|
| Cloverdale (Animas Valley) | 5,262 |
| Animas Peak | 8,519 |
| Animas (town) | 4,405 |
| San Luis Pass | 5,500 |
| Black Point | 6,467 |
| Owl Peak | 6,625 |
| Pierce Peak | 6,149 |
| Rodeo (town) | 4,154 |
| Chiricahua Peak | 9,817 |
| San Bernardino NWR | 3,800 |
| College Peak | 5,425 |
| Bunk Robinson | 6,276 |
| Guadalupe Mountain | 6,488 |

Table 2.1. Elevations of major peaks and valleys (in feet)

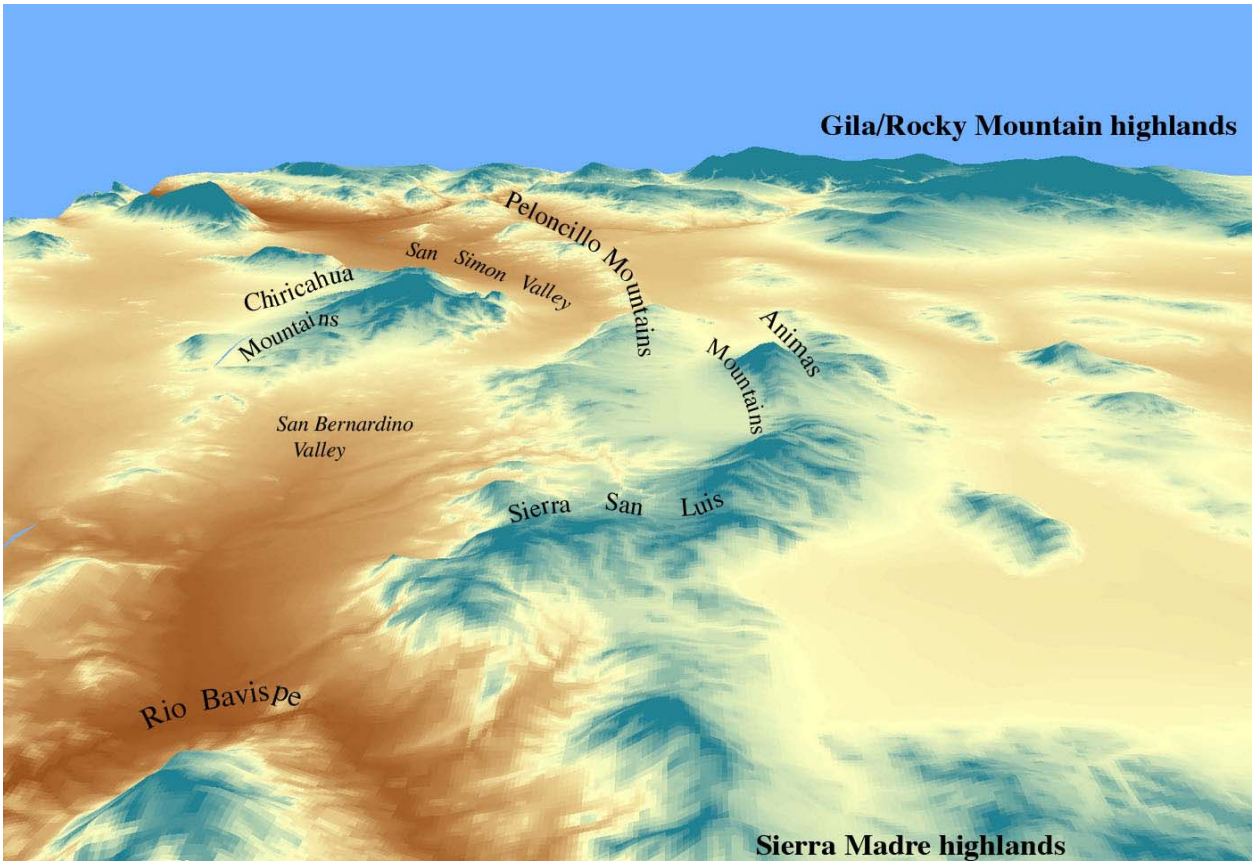
Since the Pleistocene, water, wind, and tectonics have shaped the numerous landforms typical of western North America: bajadas, river terraces, alluvial fans, buttes or cuestas, arroyos, draws, dunes, closed drainage basins, playas, and isolated mountainous terrain. The main landscape forms here are the basaltic volcanic fields with pyroclastic cones and lava flows of the San Bernardino Valley, and the more alluvial valleys of the Animas and San Simon. All sections of the Peloncillo region, however, have alluvial fans and deposits.

Despite their relatively low profile, the approximately 100-mile long Peloncillo Mountains proper are easily traversable through just a few passes. These include Stein's Pass (where U.S. Interstate 10 crosses), Granite Gap (route of Highway 80), and Antelope Pass (route of New Mexico Route 9). The others, including Guadalupe Canyon, Skeleton Canyon, and Clanton Draw, remain rough and unpaved.

The ruggedness of this landscape, with few permanent sources of water, has helped to preserve the Peloncillo region. Human populations have remained low and the wildlife has found shelter in terrain inhospitable to humans. Until the recent expansion of Highway 2 in Mexico, no major roads or railroads crossed the central area of high biodiversity.

The low-elevation passes through the Peloncillos have, through time, provided a leakage point for plains and semidesert grasslands, Chihuahuan Desert, and Sonoran Desert flora and fauna to mix. This topographical element is one reason for the high biodiversity of the region.

No major mines have been established in the region—it has been spared this drastic impact on topography. Nevertheless, a combination of an 1887 earthquake, valley subsidence, and numerous human impacts has led to the downcutting and lateral movement of some reaches of the river channels (e.g., Black Draw, San Simon Cienega, and Silver Creek). The San Simon Cienega and San Bernardino channels have been foci of major erosion-control projects.



Map 2.1.1. Aerial view of the Peloncillo region and beyond. Vertical relief is exaggerated to illustrate topography better.

## Weather

Local weather is the primary determinant of resources and disturbances, including the availability of forage, seed and mast, and shelter for wildlife; the frequencies of floods and severe freezes; and the winter die-offs and drought mortality of wildlife and livestock. Weather patterns in the region are highly variable in terms of the proportion of winter vs. summer rains, duration of multiyear droughts, length of time between storms, ignition and spread of fires, and frequency and intensity of catastrophic freezes and floods—all of great import to conservation.

Matching past ecosystem effects with climatic patterns is made more difficult by the scarcity of consistent long-term weather data. Local climate history therefore rests largely on incomplete oral history of climatic events. The Western Regional Climate Center lists five stations within the region (with dates of operation and elevation): Animas (1923, 1948-present; 4,400 ft), the Eicks Ranch (1933-1961; 5,300 ft), San Simon (spotty data from 1909-1915, 1942-1962, and 1986-present; 3,900 ft), San Simon 9ESE (1962-1986; 3,900 ft), and Rodeo (1914-1978; 4,100 ft). Several other stations are nearby: Douglas (1948 to present; 4,000 ft), smelter at Douglas (1903-1973; 4,000 ft), Portal (1914-1955; 5,000 ft), Portal SW (1965-present; 5,400 ft), Hachita (1913-2003; 4,300 ft), and Chiricahua National Monument (1909-1919, 1948-present; 5,300 ft). Unfortunately, many of these stations produced spotty data, e.g., rainfall only for some years, temperature only for other years. Almost all data before the 1940s are precipitation only. Many ranchers and other landowners operate their own rain gauges—including the BioResearch Ranch

(1978 to present), the Gray Ranch (since the early 1990s), the Stephens Ranch (since the early 1980s), and others. Unfortunately, this information has never been compiled across the landscape.

Tree ring studies and adjacent weather station reports indicate that decadal trends have followed general trends in southern Arizona and New Mexico, but details are scarce. New research efforts with elaborate weather station components are increasing the scope, reliability, extent, and spatial resolution of local weather data. These will be invaluable for examining ecological responses such as the relationship between fire effects and pre- and post-burn weather conditions, or physiological effects of varying rainfall patterns on grass-shrub competition.

Precipitation: The Peloncillo area experiences a biseasonal ("Sonoran") precipitation pattern, with a humid winter (December-March); an arid foresummer (April-June); a humid midsummer (July-September); and arid aftersummer (October-November). Seasonal and annual rainfall is erratic and highly unpredictable. May tends to be the driest month. In various parts of the three valleys, 11 to 15 inches may fall in a year. In addition, valleys may receive 1 to 1.5 inches of snow. Rainfall in the mountains increases about 4 inches per 1,000-foot rise in elevation. Having relatively equal amounts of precipitation in winter vs. summer rainy seasons is considered typical of the Sonoran Desert. Periodically, however, this region falls into a pattern in which it receives more summer rain and less winter rain than other parts of southeastern Arizona. This predominance of summer rain tilts this area's climate toward that typical of the Chihuahuan desert.

In the winter, the Peloncillo region experiences southerly displaced cold fronts, which deliver rainfall to the valleys and snow to higher elevations. Some frontal passages, however, are associated with warmer, subtropical atmospheric flows and yield only rainfall. In the summer, the monsoonal storm tracks arrive from the Gulf of Mexico, the humid regions of Mexico, the Gulf of California, or the Pacific Ocean, and more rarely from eastern North Pacific tropical storms. The Peloncillo region sits in the tension zone between these frontal, monsoonal, and dissipating tropical cyclones—adding to the variability of its rainfall patterns.

Local topography and regional topography both modify the patterns of rainfall intensity. During the summers, the more closely spaced and higher mountains such as the Chiricahuas encourage more rainfall and more frequent rainfall due to orographic effects. This greater rainfall increases runoff and seepage on the west side of the San Simon Valley.

Temperature: Maximum daytime temperatures occur in June and July with mean monthly maximums in the high 80s (ºF) at mid elevations. The coldest months are December and January. Elevations with woodland and forest typically have one or more months with mean monthly temperatures below freezing. At elevations supporting grassland and Chihuahuan desert, mean monthly temperatures usually remain above freezing during the winter months. Registration of below-freezing temperatures for 15 to 20 hours at lower locations is usually considered "catastrophic." These catastrophic freezes can set back shrub and cactus invasions of grasslands and change the composition of the Chihuahuan Desert. They usually occur within 17 days of the winter solstice. Catastrophic freezes occurred in southeast Arizona in 1913, 1937, 1949, 1962, 1971, and 1978. Locals report a heavy freeze in 1948 and 1981.

Climate cycles and long-term change: As variable as climate is here (particularly precipitation), several cyclical patterns emerge. El Niño years bring much heavier winter rains, La Niña years bring more summer monsoons and dry winters. Tree ring data also show profound effects of both the Pacific Decadal Oscillation and the El Niño/Southern Oscillation on the intensity of droughts over the past few thousand years. They seem to show that duration of droughts is correlated with an interaction effect between the two.

As it has across the globe, temperature in this region has been climbing over the past half century—intensifying drought, shortening winter, and jumpstarting spring. Meteorologists' debate over how many of these changes can be attributed to the same decadal cycles that have been acting here for the past few thousand years, and how many must be ascribed to the larger phenomenon of global climate change. Meteorologists discussing decadal cycles predict the current trends will last at least another 20 years. In terms of global climate change, various long-term scenarios for the region agree in predicting further increases in temperature, though the magnitude of their predictions varies. Climate change scenarios diverge much more, however, on what they predict will happen to precipitation patterns. Some predict a shift toward winter rains, others toward summer rains; net precipitation is predicted by some to decline, and by others to increase. Nevertheless, two predictions are consistent among almost all models: rainfall is expected to become even more erratic, and a larger proportion of yearly precipitation is expected to come in extreme events.

Whatever the cycles already set in motion, the new weather patterns of the Peloncillo region are now beyond the powers of human control. Radical cuts in greenhouse gas emissions may decrease the magnitude of climate change a hundred years from now but will not affect coming decades. The increased erratic behavior of storms and increased temperatures must be accepted and worked with in all conservation projects. New tasks may be necessary to maintain biodiversity—for example, trucking water at the Magoffin ranch to conserve a local population of Chiricahua leopard frog in the San Bernardino Valley. Erosion-control efforts increase in importance for maintaining soil productivity in the face of larger storms. The final section of this chapter includes further discussion of this history of weather patterns with other dynamic drivers of ecosystem change.

## Geology

Most Peloncillo-area bedrock is volcanic in origin, formed some 30 million years ago during the same period of explosive volcanism that created the Sierra Madre Occidental. Hundreds of active calderas spread across the southwestern United States and northern Mexico. These caldera-type eruptions spewed ignimbrites (rhyolite, breccia, ash and welded tuff) across the region, sometimes piling new rock miles thick. The Peloncillo region housed many active calderas, including two large cauldrons near Clanton Canyon. Volcanic activity gradually tapered off after this peak period but was sufficient to leach minerals from some rocks and to deposit steamborne minerals in others. This volcanic activity was generated in large part by the subduction of the Pacific Plate under the west coast of the continent.

The topography of the Peloncillo region as we know it began to take shape some 15 million years later, with the Basin and Range Disturbance. Impacts from the subduction of the Pacific

Plate declined, and the continent began to relax and stretch. This stretching broke apart large crustal blocks across the West. Some blocks fell, creating deep valleys, while others were left suspended on high as rough mountain chunks. This block faulting left behind a vast array of isolated ranges across the American West and northern Mexico, most aligned in a north-south direction. Although the bedrock mountain blocks that make up the Peloncillo, Animas, and Sierra San Luis are mostly composed of Cenozoic volcanic material discussed above, block-faulting also raised to the surface occasional outcrops of older Paleozoic and Mesozoic Era limestone. Their location and block-faulting origins cast the Peloncillo Mountain complex as part of the Mexican Highlands section of the Basin and Range Province.

Wind, water, and ice then spent the next several million years paring these high rock blocks into the shapes of our now-familiar ranges. Rhyolite, welded ash, and tuff are famous for eroding into tall spires, hoodoos, and soft red cliffs like those of Skeleton Canyon and the nearby Chiricahua National Monument. Erosion from the Peloncillo Mountains and other surrounding ranges gradually filled the down-dropped valleys with alluvium. Bit by bit, this alluvial flow raised the Animas, San Bernardino, and San Simon Valleys from blocky chasms to gently sloping valleys full of gravel and soil. Most of the valley filling began in the Pliocene Period (eight to three million years ago).

Volcanic eruptions and dramatic bedrock faulting continued into recent times, though at much reduced intensity. Over the past three million years, local vents in what has become known as the Geronimo Volcanic Field have continued to expel lava; these are most apparent in the “malpai” area of the San Bernardino Valley. The perfectly shaped cinder cones of the San Bernardino Valley stand as monuments to this recent basaltic volcanism. As individual vents blew blobs of gas-filled lava into the air, the molten rock broke into small fragments that solidified and fell as cinders around the vent—forming a circular or oval cone. When lava hit underground water, the resulting steam blew out the rock above and left basins called maar craters; Paramore Crater is one of the largest of these exploded basins. Some of these basalt and cinder flows settled over millions of years of alluvial deposits in the San Bernardino and Animas Valleys. Numerous basalt dikes and sills found in the Peloncillo range provide additional evidence for these events. At least one such dike provided the raw material for locally made arrowheads, spear points, and scrapers that helped feed the region’s inhabitants for thousands of years.

Ancient faults continue to create new movement. The most spectacular shift in historic times was an earthquake in 1887 that rocked the region with a magnitude 7.3 jolt, and left a 12-ft scarp along the lower half of the San Bernardino Valley. This 1887 Pitaycachi Fault is named after Pitaycachi Peak, a dramatic landmark along the western side of the Sierra San Luis.

Millions of years of steam intrusions have added other mineral formations, including numerous quartz veins. Some of these veins include pyrite “fool’s gold.” Small concentrations of iron, manganese, aluminum, and zinc have been found at a seep in Upper Cottonwood Creek. Stream sediments near Clanton Canyon have also revealed small amounts of tin. Deposits along the limestone-granite contact zone near Granite Gap produced a variety of semiprecious minerals, which hardscrabble miners tried to exploit in the late 1800s and early 1900s; mining in the region has not been economically viable since. In fact, the only marketable mineral resources to be

produced in any quantity from the Peloncillo Mountains were volcanic rocks used to line the tracks for the local Southern Pacific Railroad bed.

## Soil Formation and Biological Dynamics

Soil types, and the geologic formations that produce them, have major influences on the Peloncillo region's biodiversity. Age and source of soil affect soil stability, moisture retention, and nutrient availability, and therefore an area's ability to support the region's great variety of grasses, shrubs, and trees. Soil type also affects the ability of the soil to withstand hoof trampling, sheet erosion, and other disturbances. Soil type and texture also directly affect ground-dwelling species such as prairie dogs, badgers, burrowing owls, ants, bees, and other burrowing invertebrates.

The large limestone and volcanic chunks exposed by Basin and Range block-faulting are not only responsible for the shape of the Peloncillo, Animas, and other mountains; they are also responsible for the kinds of sediments that fill the valleys and various erosion features. At lower elevations, for example, the landforms include floodplains, stream terraces, and fan remnants (alluvial deposits), hillslopes (weathered, eroded or transported), playas (lake deposits), and dunes (wind-blown deposits).

Borderland soils evolved from valley fill (stream deposits, lake beds and lava beds), as well as directly from Tertiary volcanics, Paleozoic limestones, and Cretaceous sedimentary and metamorphic rocks. The volcanic calderas that laid down ignimbrites, and intrusive oceans that laid down limestone, have been most important to soil formation. Each rock type, depending on age, formed a variety of soil types with different depths, textures, structures, and layers. These soils set the stage for the soil's moisture-holding abilities and, indirectly, floral and faunal biodiversity and resiliency to change.

Generally, the most important soil-type difference is between calcic soils (derived from limestone and caliche) and soils with an argillic horizon (a clay horizon that prevented deep root penetration of shrubs and held the water table up close to grass roots). For example, the limestone-derived soils at the southern end of the San Bernardino Valley apparently supported shrublands even before the advent of cattle. On these soils, the impact of livestock was not great. Similarly, the heavy clay argillic layer in parts of the Animas Valley prevented the invasion of mesquites and other shrubs, despite heavy cattle use.

Soil age also has a large effect on flora and fauna—partly because young soils have had less time to develop argillic horizons. Permeable soils without horizons (e.g., young alluvium) have an increased potential for shrub and tree invasion. In such permeable soils, rainfall can seep below the root zone of grasses, especially if the grasses have been grazed. The pool of water, out of reach of the grasses, becomes available for the deeper rooting shrubs such as mesquite. Soils underlain by lava flows, and those formed from cinder deposits, show the same trend, in which older soils are more apt to retain grasslands and resist shrub encroachment.

In some areas, the soils are conducive to prairie dog towns. Prairie dogs' excavations bring up the lower layers of some soil profiles. These ecologically engineered new soils change plant

species mixes and create their own special mini-ecosystems (see below). In the United States, prairie dogs have recently been reintroduced to “fossil” towns on the Gray Ranch where they thrived a century ago. Studies of their impacts are now under way.

In very local areas, such as those surrounding railroad shipping stations in the San Simon Valley or corrals where cattle were crowded, soil compaction and erosion from hoof trampling have irreversibly changed the soil structures and top layers. Cholla cactus as well as other cattle-resistant plants are now common species in these highly disturbed areas, and the original grassland has been hard to reconstruct. In other local areas, right-of-ways that are annually sprayed with herbicide or scraped to reduce fire danger also disturb the soils and encourage exotic invasive grasses. Boer lovegrass, for example, is spreading rapidly along these disturbed soil corridors.

Many variations on these basic soil types exist in the region. Approximately 50 soil types have been defined by various classification systems. Many have evocative names like Lucky Hills, Outlaw, and Epitaph, pulled from the names of rock formations from which they are derived; others, such as the Magoffin and Mallet soils, are named after longtime residents and their ranches. The past decade has seen the development of increasingly detailed soil maps for parts of the Peloncillo region. The area targeted for protection by the Malpai Borderlands Group has received particularly good research attention. Other parts of the region, particularly the northern Peloncillo Mountains and the Sierra San Luis, are in need of much more research to catch up with their better-known neighbors. Nevertheless, lessons learned on the better-studied regions will be valuable to managers of the lesser-known parts.

Attention to soil types is recent in the Peloncillo region. It is also crucial to restoration. If the topsoil has eroded, restoring it to its previous state is nearly impossible, and one must instead focus on figuring out which subsoil plants would do best. For effective management, soils have finally been added to the classic focus on cattle grazing, fire and weather.

## Geohydrology and Surface Hydrology

The most important hydrologic features that nurture wildlife are those associated with perennial surface water: springs, cienegas, and seeps. Important water bodies in the U.S. portion of the Peloncillo region include the San Simon Cienega, the San Bernardino Cienega, seeps along Animas Creek and Black Draw (San Bernardino Arroyo), and the Clanton and Lang Cienegas in the Animas Valley, as well as springs such as the Spring of Contention and Maverick Springs in the Peloncillos. In Mexico, important water bodies include the Cajón Bonito creek and its associated tributaries and springs, and the continuation of the San Bernardino Cienega.

In recent human history, river and creek channels have had no perennial flows in any of the Peloncillo region valleys in the United States. Nevertheless, the subsurface flow in some tributaries feeds riparian communities, especially along the Animas River. By contrast, the relatively undisturbed western slopes of the Sierra San Luis continue to provide perennial flow through the middle Cajón Bonito.

Map 2.1.2 places the river channels within their greater river basins. When enough runoff and surface flow exist, the upper San Simon Valley could theoretically discharge into the Gila. The Animas disappears into the closed basin of the Animas and Lordsburg Playas. The San Bernardino, Guadalupe, and Cajón Bonito drainages intermittently connect, by way of the Ríos Batepito and Bavispe, to the Río Yaqui.

Major watersheds contributing to the valleys became the first locations for cattle tanks. These tanks (later supplemented by tanks fed by wells) changed the patterns of wildlife movement and increased the ability of cattle to use grasses over larger landscapes. In the case of the Chiricahua leopard frog and Mexican duck, cattle tanks changed their pattern of distribution (metapopulation structure). Map 2.1.2 shows the major tributaries and springs.

Since the Pleistocene, drainage patterns in the Peloncillo area have, in some instances, reversed. For example, at times the San Simon/San Bernardino composite valley drained south into the proto-Yaqui basin and, at times, north into the proto-Gila. Today, the San Bernardino and San Simon basins are separated by a low elevation, hard-to-locate watershed divide. In other words, the three valleys are part of a flat topography that, on longer time scales, can direct surface flows north or south. These geological flip-flop river valleys tend to pond, and all have prehistoric and historic lakes (playas) and small internal basins. Such drainage patterns have created situations in which fishes and frogs have been historically stranded. Conservationists attempt to preserve perennial water in these ancient drainage networks and cienegas (e.g., San Bernardino Cienega).

Until about 1910, surface water seeps and cienegas, and shallow wells, were the only sources of water within what is now the U.S. portion of the region. With the discovery of artesian wells in the San Simon Valley (1910), the deeper hydrogeology of the basins became of increasing interest. The impacts of wells have been extensive: depleted artesian aquifers and perched water tables, subsequent loss of riparian forests, and land subsidence where the aquifers collapsed. The San Simon Valley, for instance, contained four cienegas in the 1890s. The San Simon Cienega was the largest (about five miles long and one-half mile wide) with perennial surface water. Originally, the San Simon Cienega was fed by runoff from the Peloncillos and Chiricahua Mountains that recharged a perched water table. As the perched water table was overexploited, the cienega dried out and farmers switched to deeper aquifers. The San Simon is the only extant cienega remaining in the valley, completely altered from its original landform and artificially recharged by deep wells, but still a major location for wildlife.

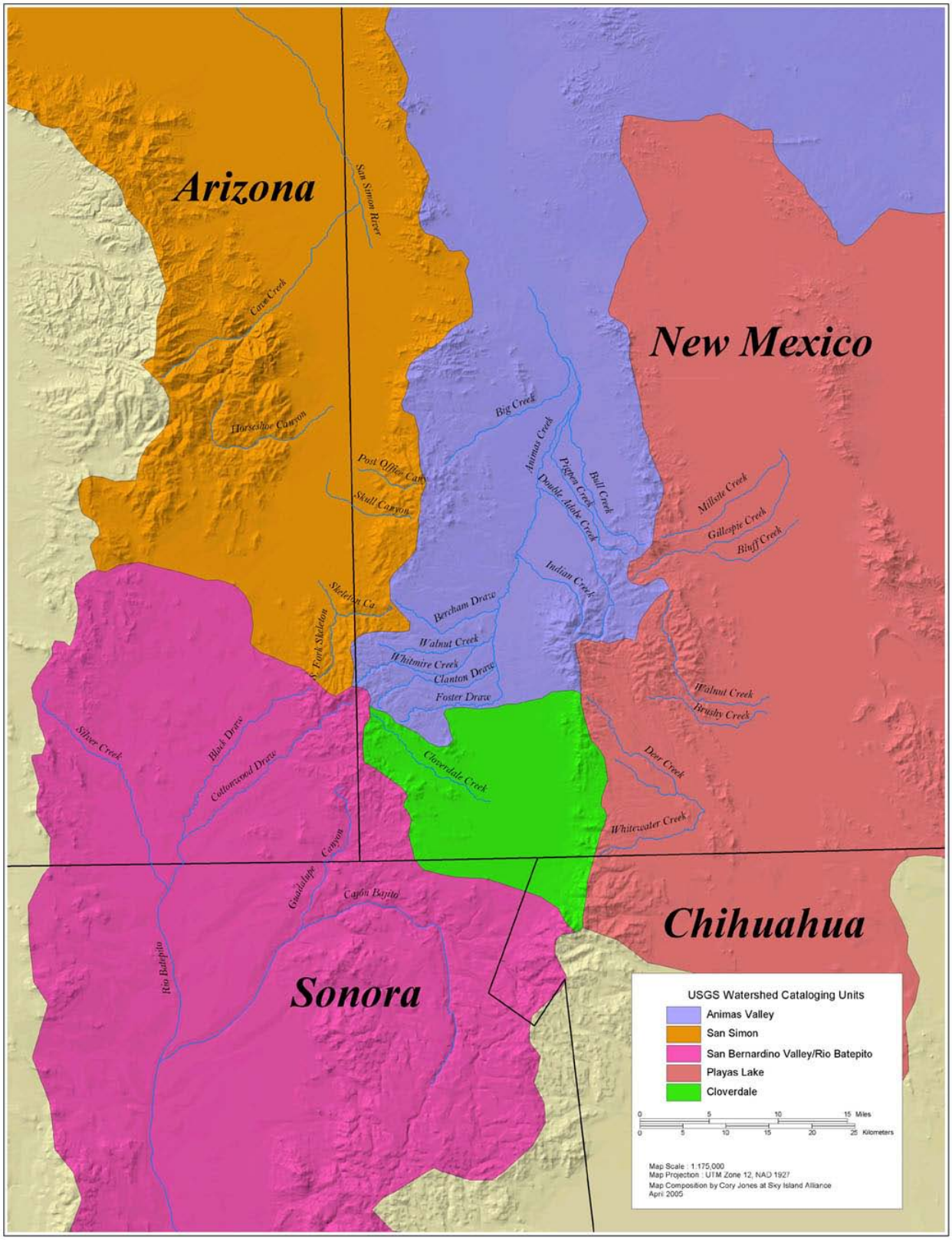
The San Bernardino Refuge and Cienega have multiple springs fed by interlayered alluvium, lake bed deposits and basaltic flows. The subsurface flow starts in the surrounding mountains and drains across the border. Near the mountains, the depth to groundwater is about 600 ft. In the south, groundwater is within 200 ft of the surface. The groundwater that surfaces feeds eight natural springs within the wildlife refuge. The springs have fluctuated with climate, not human use. In other words, no cones of depression caused by pumping wells have been found.

The San Bernardino Cienega is also fed by multiple surface channels, which, like many others in the region, have been downcut. With downcutting of the arroyos, the height of the potentiometric surface (the height to which the confined aquifer water will climb) has dropped 8 ft. A major

rehabilitation effort to reduce channel erosion and return water closer to the surface is under way on the Mexican side of the San Bernardino.

The causes of downcutting are controversial. It can be traced in part to the 1887 earthquake, which has left 8-ft scarps, and in part to local sinking of valleys from tectonics or water withdrawals. Downcutting also has been blamed on overgrazing combined with drought, which increased runoff and stream flood peaks. The increased stream power cut the channels. In other situations, roadwork and culverts instigated and promoted downcutting.

Water resource management has recently focused on these remnant cienegas, the distribution of cattle tanks, and techniques to recharge and reconstruct riparian habitats in order to protect endangered fishes and frogs as well as riparian woodlands and riparian fauna.




Map 2.1.2. Hydrologic basins in the Peloncillo region

## Fire

Fire has been a crucial driver of ecosystem dynamics in the Peloncillo region. As in much of western North America, habitats here have long been shaped by naturally occurring fires. Pre-EuroAmerican fire frequencies varied with habitat, but typical return times were once every 3 to 10 years. Some of the wetter conifer forests had much longer return times. Researchers continue to develop a detailed fire history on a micro and regional scale. The frequency, extent, and intensity of these fires have been studied via numerous tree ring studies, historical documents, and comparisons of behaviors of modern burns with evidence left by past burns. These studies show that natural fire patterns differ by biotic community: grassland, riparian, Madrean woodland, and Petran conifer forest burn at different intervals, with different intensities. Differences in fire behavior in each of these communities are partially responsible for maintaining the distinctions among them—it is a feedback loop. Plant community shapes the fire's "personality" as much as the fire shapes the resulting plant community.

The human role in fire dynamics has changed radically over the past 150 years. Before cattle ranching, Apaches and other Native Americans set fires in all but the upper conifer forests and lowest deserts. During the Indian Wars of the late 1800s, fire was used as a tool in military tactics. With cattle ranching (1880s), the fine herbage fuels disappeared and the grasslands rarely burned. With the advocacy of fire suppression by the Forest Service (beginning in 1904), the more wooded communities had less frequent fires. Fuel buildup from fire suppression has caused fires that do get started to behave very differently from older fires, e.g., becoming crown fires rather than ground fires. This tendency of forest fires to blow up into conflagrations has increased the intensity of fire-suppression efforts.

In the last decade, however, interest has renewed in bringing fire back into the Peloncillo area, especially with the goal of removing shrubs from former grassland. Private landowners, researchers, and public agencies are working together at an unprecedented level to plan and implement burns across the Peloncillo region (see chapter notes). The 2003 Baker Canyon prescribed burn treated some 48,000 acres—the largest-ever intentional burn in the southwestern United States. Nevertheless, the increasing number of roads and subdivisions throughout southeastern Arizona and southwestern New Mexico acts as a barrier to the spread of fire. Future fire may never return to pre-EuroAmerican patterns.

As mentioned above, effects of fire differ among habitats. In Chihuahuan Desert grasslands, fire can kill up to 70% of the succulents, some dying in the postfire period from insect attack. However, plant line-transects in these semidesert grasslands have shown that the impacts of fire can disappear after three to five years. After that time, the fire-generated grassland cannot be distinguished from a nonfire grassland. The longer-term benefits and effectiveness of prescribed fire are being studied. At higher elevations, more frequent fires provide for more open forests. The suppression of fire has probably led to the contraction of chaparral communities and the loss of grasses under denser tree canopies. The effects of these losses on wildlife have not been studied. In general, in wooded areas, graminoids (grasses) and forbs predominate over woody species postfire. Fire suppression has also led to a build-up of fuel loads. The more infrequent fires can cause the replacement of the forest stand.

Despite the recognition that fires are necessary to maintain natural habitat structure, considerable concern has arisen about the short-term effects of prescribed fire in habitats of sensitive species. Prescribed fire during mating, young-rearing, and overwintering seasons can hurt the population size of certain vertebrates. In the Malpai Borderlands Group ranch area, for example, long Endangered Species Act consultations have characterized the prescribed burns and their potential impacts on the endangered New Mexico ridge-nosed rattlesnake, and on the agaves that provide food for endangered nectar-feeding bats.

Nevertheless, no animal or plant species in the Southwest has been known to disappear because of a fire, partly because fires tend to burn in patches. The challenge with returning fire is largely one of getting the best mosaic of unburned, lightly burned, and more intensely burned patches. Some overwintering birds, for example, do better in burned habitat; some thrive in nonburned habitat. Getting the mix of patches right is a restoration challenge. Woody plants, for example, support Brewer's and Cassin's sparrows—both of which are species of special interest in the Peloncillo region's valleys. When woody plants are removed or set back by fire, these species may suffer. On the other hand, fire boosts support for vesper sparrows, another species of concern, by encouraging dicot seeds.

Research in and around the Peloncillo region has found that fire effects also depend on a host of other variables, including timing of the ignition, soil moisture before and after the fire, precipitation in the weeks and even years following the burn, and presence of nonnative species. Off-season early summer fires, for example, can set back or destroy perennial grasses. The effectiveness of grassland fires in killing shrubs varies radically with postfire rainfall. The future impacts of fire on invasive grasses, especially Lehmann's lovegrass, are another major restoration concern. Fire can increase the spread of this invasive, which hurts the quality of grassland habitats for both livestock and wildlife. Lehmann's and other fire-responsive lovegrasses have spread in and around the Peloncillo region.

In short, fire dynamics (the "natural" cycle of fires) have changed drastically in the last century. Ignition styles, fuel loads and kinds, and fire-management practices have and will irreversibly alter fire's impacts on the Peloncillo region.

## *Living Systems*

### Grassland Dynamics

The valleys of the Peloncillo region can be considered mini-high-elevation plains. They do, in fact, harbor grasses from both the Great Plains and semidesert grasslands that extend from Durango to the Mogollon Rim. The region is the home of some of the most imaginative and effective projects in conservation ranching in North America. With a combination of increased scientific study and innovative cattle-raising practices, the Peloncillo region has pioneered locally adapted ways to think about biodiversity and the maintenance of ranching, primarily through the work of the Malpai Borderlands Group (MBG).

| Condition Class | Total Malpai acres | % Malpai grassland | % AH* grassland |
|---|---|---|---|
| Open-native | 286,000 | 46% | 14% |
| Restorable | 202,000 | 32% | 6% |
| Riparian | 9,000 | 1% | 18% |
| Non-native | 42,000 | 6% | 3% |
| Historic | 77,000 | 12% | 2% |
| Unknown | 11,000 | 2% | 1% |
| TOTAL | 628,040 | | 5% |

* Apache Highlands

Table 2.3. Total Malpai Borderlands Group area by grassland condition class according to Apache Highland Grassland Assessment, The Nature Conservancy of Arizona. Comparison data are shown for the surrounding several-million-acre Apache Highlands Ecoregion.

The Malpai Borderlands Group has begun to change both scientific and policy attitudes toward overgrazing, predators, invasive species, weather-related livestock reductions competing herbivores like prairie dogs, water supply and distribution, and fire. The landscape conditions encompassed in the area managed by the MBG indicate tremendous potential for restoration and protection of native landscapes, as shown in Table 2.3.

Many different opinions have been expressed about vegetation change in the arid West. In general, shifts have occurred in C3 grasses, biennials, ephemerals, and exotics, as well as C4 bunch grasses, CAM succulents, and shrubs. Some habitats changed; others did not. Some investigators have thought that cattle and poor cattle management forced the change. Others contend goats and sheep and, locally, horses caused floristic change. Others saw climate and runoff and run-on patterns as the explanation for changes in grass communities. Still others saw fire regimes as crucial, or all three in combination: fire, livestock, and weather. More recently, specific soil types have been shown to play a crucial role in how constant or changeable the plant life is. Finally, the influences of prairie dogs and other rodents, rabbits, and specific insects such as grasshoppers have joined the list of movers of vegetation change.

Combinations of fire and soils, drought-resistant grass species, and grazing management may change vegetation communities. For example, they can encourage the spread of invasive grasses with detrimental impacts on wildlife. The history of these dynamics is summarized at the end of this chapter.

## Foodweb Dynamics

No single study has tracked the interconnections and the new configurations of food webs in the Peloncillos in the modern era. The foodweb dynamics of the Peloncillo region have changed with new species added and subtracted, new and broken links in the web, and new configurations of predation and competition. Figure 2.1 below shows a simplified sketch of the foothills area.

This diagram shows that the addition of cows, pigs, and other exotics, and better armed hunters and increased government control, have changed the foodweb linkages. The extirpation of the jaguar, Mexican wolf, and grizzly bear changed competition and predation patterns. For example, feral pigs in the lower Animas Valley eat acorns in competition with javelinas and Gould's turkey. They have become the prey of mountain lions and black bears. Jaguars have returned to the Peloncillos, at least as visitors, as documented in a 1996 photograph. They are known to displace mountain lions from their kills. Shifts from grassland to shrubland may have increased deer populations; some believe this increase, and possibly the presence of domestic livestock, have boosted mountain lion populations and, by extension, reduced bighorn sheep populations.

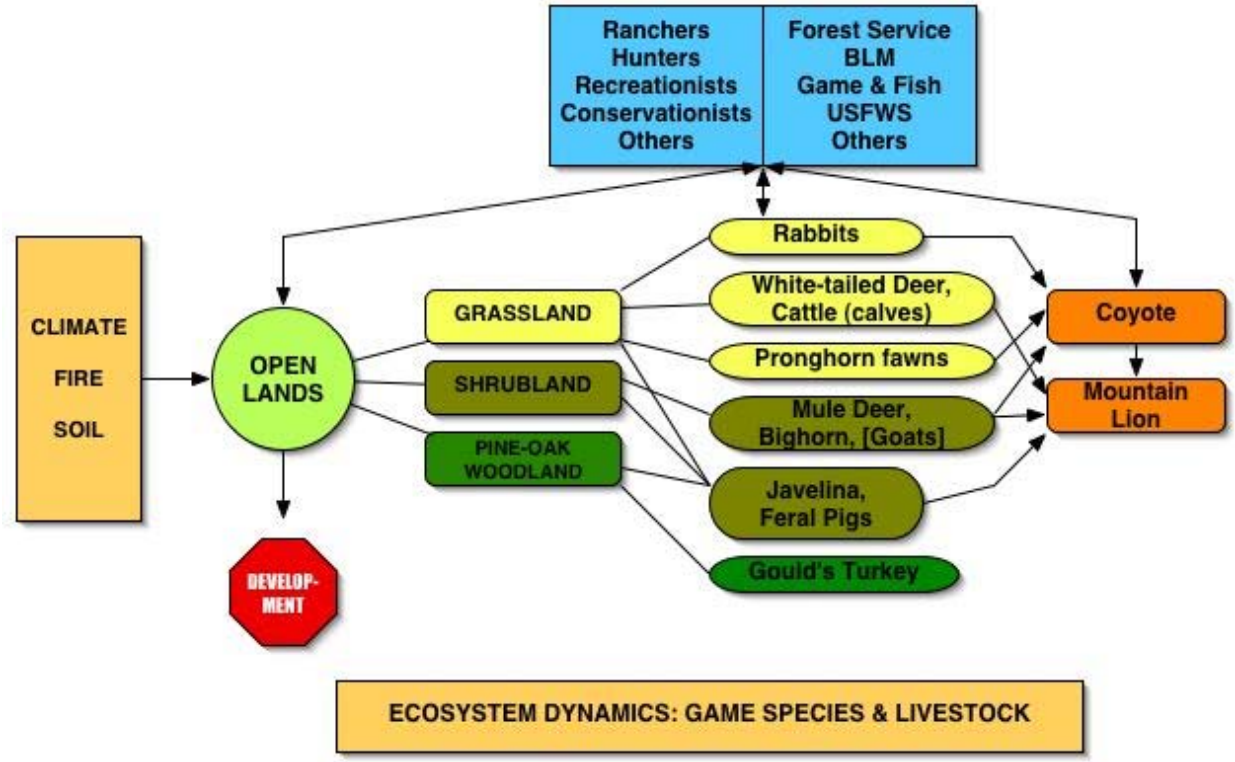



Figure 2.1. Ecosystem dynamics

Coyotes, to give a further example, have expanded their predator role. Coyotes reduce pronghorn recruitment by predation on young, especially during droughts when alternatives shrink and sparse grass cannot provide adequate shelter for the fawns. Without Mexican wolves to displace coyotes, a management question arises: Should coyotes be "controlled" in certain parts of the

Peloncillo region in order to save pronghorn? Or is restoration of grasslands more effective than reduction of predators?

Foodweb dynamics in the region have changed to a large degree because of the extirpation of the black-tailed prairie dog by federal agents at the turn of the century. With their loss, dependent species such as mountain plovers, large migrating shorebirds, black-footed ferrets, and burrowing owls have been depleted. Recently, prairie dogs have been observed girdling young shrubs, apparently so that they can see predators approaching. The removal of shrubs is, ironically, the goal of many cattle raisers.

The influx of pathogens and invasives has changed the region's wildlife. Desert bighorn sheep contracted disease from sheep and goats and were nearly extirpated in the Peloncillos. The population has since been supplemented by captive-raised individuals, but introduced disease remains the species' largest threat across the southwestern United States and northern Mexico. An Asian tapeworm (*Bothriocephalus acheilognathi*) has recently infected sensitive fish species in the area. Bullfrogs have threatened endangered frogs by predation on their tadpoles.

Most important to modern foodweb dynamics has been the enforcement of hunting rules on the region's top predator—the human hunter—by the Arizona and New Mexico Game and Fish Departments. In addition, rules concerning sensitive species set by the U.S. Fish and Wildlife Service have altered foodweb dynamics by placing special emphasis on habitats required for threatened and endangered species.

Diagramming today's food webs would allow biologists to understand better how changing linkages might improve the Peloncillo's ecosystems.

## *A Century-Long Overview*

The present climate, along with its associated flora, became established after 8,000 years B.P., when winter precipitation lessened and summer monsoon precipitation expanded. The mid-Holocene wet periods probably favored development of today's grasslands and provoked the widespread erosion of well-developed, mature soils.

**Pre-1900:** Seasonal temperatures were cooler, increasing both effective soil moisture and plant growth. The spring growth season started later because of lower winter temperatures. The winter weather was consistent and predictable, but spring warming dates changed unpredictably every two to four years. From 1850 to 1900 three clusters of very dry winters occurred, each cluster lasting from five to seven years. Until the droughts of the l890s, ranchers and dry farmers had great hopes for consistent productivity. The C4 bunch grasses still thrived. That illusion led to the overexpansion of livestock and cultivated lands, which subsequently collapsed. This period saw frequent lightning-caused fires at all elevations, as well as aseasonal fires set by Native Americans in their resistance to EuroAmerican conquest. Cattle drives, open range, and marketing by head (vs. weight) had heavy impacts on the region.

**1901 to 1940:** Temperatures rose, reducing effective soil moisture as well as initiating earlier springs and earlier foresummer droughts. Between 1930 and 1940, the warmer temperatures were accompanied by lower rainfall but these droughts did not come in clusters (as in the 1850 to 1900 period). They occurred in fits and starts. The most severe droughts occurred when rainfall was low in both winter and summer. Shrub invasion of grasslands became a concern. Bunchgrasses continued to decrease. Fencing, which ended cattle drives, and calf culling led to better grazing practices. Installation of cattle tanks and increased groundwater pumping were attempts to compensate for lack of water and uneven grazing. Both changed some wildlife movement with mixed benefits. Mediterranean plant invasives took advantage of warmer, wetter winters and spread. The U.S. government introduced African grass species and subsidized prairie dog poisoning and predator reductions. Grizzly bears, wolves, and jaguars were eliminated, as were other species such as thick-billed parrots. During this time massive goat herds were introduced; pigs also escaped farms and became feral to the region. Fire suppression occurred directly—by the U.S. Forest Service—and indirectly, when livestock grazed out the fine fuels.

**1941 to 1960s:** Temperatures cooled, though never back to the pre-1900 levels. Low rainfall persisted. During the 1940s, subnormal rains occurred in the summers, reducing the productivity of perennial grasses. Between 1951 and l956, subnormal rains occurred in both seasons. Plant life was stunted and arid-adapted species (C3 shrubs, CAM succulents) were favored. White-tailed and mule deer populations changed locations. Fire frequency was further reduced by development of roads, which act as firebreaks. Increasing carbon dioxide may have begun to change plant community structure with unknown impacts of plant communities and fire. Prairie dog towns disappeared. Cattle numbers were reduced, and removal of wild horses, goats, and burros improved the range. Irrigated feed supplements and government-subsidized drought offtake helped the cattle industry.

**1960s to 1990s**: Summer rains returned to their pre-1900 levels, encouraging summer grass productivity. Since 1972, temperatures have increased, again harming summer grass production and allowing longer winter growing seasons. Climatic variability increased; El Niño/La Niña events appeared more extreme. Recognition emerged of the negative impacts of total fire suppression. Subdivision development became one of the most major impacts on wildlife habitat and movement. The emergence of Wilderness areas, the Endangered Species Act, and reductions in animal control reduced some pressures on wildlife.

**1990s to present:** Beginning in the 1990s, the most extreme drought of record was recorded, a drought unmatched during the preceding 500 years. The higher long-term temperatures and rainfall shortages have had severe impacts on flora and fauna. Oaks, pinyon and Chihuahuan pines experienced die-offs. Insect infestations attacked trees in nearby mountain ranges, but these have not been investigated in the Peloncillo, Guadalupe or Animas Mountains. The pronghorn, some snake species, and some of the wintering passerine bird populations crashed. Emergency measures had to be taken to maintain habitat for sensitive species such as the Chiricahua leopard frog. Prescribed fire and thinning programs were begun as management tools to lower the number of catastrophic burns and remove shrubs from former grasslands.

Decadal trends in temperature and rainfall, as well as erratic storms, can frustrate the best-laid plans of ranchers and public agencies trying to implement ecosystem management, and of conservationists interested in restoration or long-term preservation of species' habitats.

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# 2.2 Birds of the Peloncillo Region: Globally Significant Biologically & Recreationally

Birds represent one of the most visible aspects of biodiversity in any ecosystem. Though some depend on concealment from predators, birds' extreme mobility frees many to be showy, noisy and colorful. Birds' conspicuousness has sparked a huge, multi-million-dollar recreation industry. By some estimates more than 24 million Americans regularly travel to watch birds.

North American birds found in any given area can be divided into several categories—migrants, vagrants, winter residents, summer breeding residents—each with different needs and varying dependence on the local area. Because of its prime geographic location between wintering and summering grounds of hundreds of bird species, the Peloncillo region boasts a list of over 50 migrant species that routinely pass through here but do not linger. As a major migratory pathway, this region helps sustain the bird diversity of the rest of the U.S. and Mexico—not to mention Canada and the New World tropics.

Many additional long-distance travelers spend some length of time in the Peloncillo region. The region's relatively mild and productive winters support suites of sparrows, hawks, and waterfowl. Wintering species here may also include sandhill cranes hatched the summer before in the marshes of northeastern Siberia. Summer birds here include Swainson's hawks that spend our winter months on the pampas of Argentina, and sulphur-bellied flycatchers from Amazonia.

Another 90 species are periodic visitors or vagrants seen by the watchful and lucky, including many tropical and subtropical species that reach no farther north than this. These, plus some unique Sky Island endemics, are largely responsible for making Southeastern Arizona and Southwestern New Mexico one of the world's most popular birding hotspots. Still other "rare" species are irruptive in nature, occurring only when environmental conditions require them to wander in search of suitable habitat.

*Photo © 2005 Southeast Arizona Bird Observatory; Montezuma quail.*

## *Outstanding Features*

- *362 species recorded.*
- *Of the 28 species in New Mexico listed as threatened or endangered, 23 are found in the Peloncillo region.*
- *15 species of hummingbirds*
- *21 species of sparrows are either winter residents or permanent residents of the grassland communities.*
- *Riparian areas are critical habitat for some of the rarest birds in the U.S.*

Perhaps most important to the birds themselves, however, is the role this area plays as full-time or summer range for approximately 150 species known or thought to breed here. Many species known to breed in surrounding mountain ranges or valleys have yet to be recorded nesting in the Peloncillo region, but such documentation is improving. In quadrat-by-quadrat sampling of breeding bird diversity across Arizona, the Peloncillo region revealed one of the five richest assemblages in the state, with 87 species of breeding bird recorded in just one ten-square-mile block.[1]

In terms of conservation, resident species and migratory species have different needs and are worth considering somewhat separately. In the Peloncillo region, the resident birds remain close to home their entire lives and are completely dependent on local environmental conditions. A fire, prolonged drought, or a change in management practices can drastically affect local resident populations. Migrants, on the other hand, are especially vulnerable to fragmentation of flyways and to the degradation of a relatively small number of key refueling spots (some of which are well known, while others remain known only to the birds themselves). While rare migrating vagrants tend to attract the most attention from birders, the greatest conservation value of the Peloncillo region is as home to this tremendous suite of resident breeders, for whom the habitats here provide a lifetime of sustenance.

As a testament to the region's diversity and conservation value, various parts of the Peloncillo region have received attention under the National Audubon Society "important bird areas" (IBA) program. Sites are chosen by each state chapter, on the basis of presence of state or federally listed endangered and threatened species; Partners in Flight[2] priority species (PIF); rare, unique, or representative habitats; significant concentrations of shorebirds, raptors, or particular other species or assemblages; and value to long-term research and/or monitoring. New Mexico lists the Animas Mountains as a whole, the Animas Valley's *ciénegas*, and the Peloncillo Mountains' Clanton Canyon as IBA's. The Animas are described as follows:

> *This spur of the Sierra Madre is the best example of "Mexican" mountains in New Mexico. This area is the only place in the state where Mexican Chickadee and Yellow-eyed Junco breed. In also contains other "southwestern NM" PIF species including Red-faced Warbler, Greater Pewee, Gould's Wild Turkey, Painted Redstart, and Olive Warbler. The valleys around the mountains will contain Mexican Jay, Verdin, Crissal Thrasher, Bendire's Thrasher, Cactus Wren, Lesser Nighthawk, Cassin's Sparrow, and Botteri's Sparrow.*[3]

The southern Animas Valley ciénegas are highlighted for "…contain[ing] the largest Botteri's Sparrow population in New Mexico… [and] breeding Arizona Grasshopper Sparrows. In migration and winter other priority grassland species include Sprague's Pipit and Baird's Sparrow." Clanton Canyon is highlighted for its "state threatened species, species in rare/unique habitat, [including year-round residents] Montezuma Quail, Whiskered Screech Owl, Western Screech Owl, Northern Pygmy Owl, Arizona Woodpecker, Acorn Woodpecker, Juniper and Bridled Titmouse, Bushtit, Hutton's Vireo, Spotted Towhee, and Canyon Towhee.... Summer residents include Band-tailed Pigeon,

Poorwill, Whip-poor-will, Elf Owl, Dusky-capped Flycatcher, Phainopepla, Grace's Warbler, Black-throated Gray Warbler, Hepatic Tanager, and Scott's Oriole. Yellow-eyed Junco and Mexican Chickadee are present primarily in winter."

Arizona has yet to confirm many of its proposed IBA's, but Peloncillo-area nominees include Guadalupe Canyon and the San Bernardino NWR.

A by-product of the bird watching industry is contributory information on bird populations and movements on a regular basis—in the form of daily, monthly and annual reports. Audubon Christmas Bird Count information, Breeding Bird Surveys, checklists and rare bird sighting information have all provided important information concerning avian distribution and abundance. The challenge is that most of this information may be termed natural history but not science, because it is neither peer-reviewed nor subject to uniform standards. Nearly all of the information comes from voluntary services of bird-watchers. However, it is useful information and comprises a large amount of the knowledge of the birds of the Peloncillo region.

**Geographic Scope.** Species lists from birdwatchers and bird surveys from the greater Peloncillo region, including the Chiricahua Mountains, inform much of this discussion. Excellent bird lists and surveys have been compiled for The Bioresearch Ranch in the central Peloncillo Mountains, the Gray Ranch, Guadalupe Canyon, and Cajon Bonito in Mexico.

## *Discussion of Species by Habitat Communities*

The Peloncillo Mountains, situated between the Chihuahuan and Sonoran Deserts and with the influence of both the Rocky Mountains and the Sierra Madre, are ideally located for biodiversity. The Sky Island mountain ranges of southeastern Arizona, southwestern New Mexico, and northern Sonora have long been recognized as centers of biodiversity. The Peloncillos represent the most contiguous link between the rich habitats of the Sierra Madre in central Mexico and the western U.S.

Within the study area, a variety of habitats from grassland and playa lakes to desert riparian, oak woodland, and pine forest each support distinct avifauna. With the inclusion of the higher elevations found in the Animas Range and the unique wet canyons of Cajon Bonito in Mexico, the bird list reaches 362 species. Of the 28 species of birds occurring in New Mexico listed as threatened or endangered under US or state law, 23 are found in the Peloncillo study area.

### Playa Communities

The low elevation playa habitats are most important as wintering grounds for northern migrants. Large flocks of sandhill cranes and smaller groups of shorebirds such as killdeer and snipe utilize the shallow playa lakes around Lordsburg, New Mexico, as roosting and feeding areas. These shallow lakes also provide roosting and summer

nesting habitat for a variety of shorebirds, including killdeer and smaller numbers of American avocets and black-necked stilts.

## Desert and Grassland Communities

Lower elevation grassland habitats are also important wintering grounds for northern migrants, but are perhaps even more valuable to breeding species such as Swainson's hawks, meadowlarks, and grassland sparrows. Twenty-one species of sparrows are either winter residents or permanent residents of the grassland communities within the Peloncillo region. These include the Arizona race of the grasshopper sparrow (*Ammodramus savannarum ammolegus),* a race found only in extreme southeast Arizona and southwest New Mexico. This subspecies is listed as threatened by the state of New Mexico. Along with grasshopper sparrows, Botteri's sparrows are perhaps the area's most prestigious sparrow residents. The Botteri's sparrow is known to breed in just a handful of New Mexico locales, with the Animas Valley's sacaton grasslands being the most important. Baird's sparrows regularly migrate through here, but can stay for winter when seed crops are good.

Within New Mexico, the Arizona grasshopper sparrow is known to breed only on the Gray Ranch in the southern Animas and the western Playas valleys. This limited range can be attributed in part to the West-wide decline in open native grasslands. Although the species also expands into nearby weed patches and even agricultural areas (e.g. alfalfa fields) during migration and winter, it as entirely dependent on areas of relatively lush native grassland during the breeding season. NMGFD studies initiated in 1987 have shown wide year-to-year fluctuations in breeding numbers, with populations rising and dropping by as much as 64% in a two year period. These fluctuations can be alarming in a bird with such limited range and such strong dependence on a vanishing habitat. However, long-term studies suggest that these cyclical declines and resurgences may be a feature of this bird's natural population dynamics.[4] Efforts to maintain the region's open grasslands will certainly help this species survive such fluctuations.

The southwestern subspecies of eastern meadowlark (*Sturnella magna lilianae*) found here is so distinctive that some authorities have proposed splitting it off into a separate species, the Lilians's or southwestern meadowlark, giving the area another unique form. Grasslands in the Animas Valley harbor especially large numbers of wintering Chestnut-collared Longspurs, along with regular migrant and occasional wintering individuals of the related McCown's longspur.

Desert scrub habitat is home to Gambel's quail, greater roadrunners, black-throated sparrows, and many other species. Lark sparrows and Crissal thrashers nest in these shrub lands, while Bendire's thrashers select areas intermediate between grassland and shrub land for breeding.

The reestablishment of prairie dogs on portions of the Gray Ranch has provided short-grass habitat critical to imperiled mountain plovers[5] and long-billed curlews. Prairie dog towns and grazed pastures also provide winter habitat for ferruginous hawks, golden eagles and burrowing owls.

## Low- and Mid-Elevation Riparian Systems

Southwestern riparian systems are among the most endangered and critical habitats in North America. These oases provide food, water, and shelter for a variety of migrants and residents alike, both mammalian and avian. Very little permanent water is found in the Peloncillo region, so the few springs, perennial streams, and even stock tanks scattered throughout the area are critical to the diversity of species found in the mountains.

Low elevation riparian strands of Fremont cottonwood and Goodding willow and the higher elevation Arizona sycamore riparian forest support some of the rarest birds found in the United States. Guadalupe Canyon on the U.S. Mexico border is a well-known location for Mexican species that only rarely cross the border into the U.S. The first U.S. record for fan-tailed warbler (*Euthlypis lachrymosa*) was a bird collected in here in 1961, and another was seen September 5–8, 1990. Guadalupe Canyon is also habitat for other rare species, including buff-collared nightjar, Lucifer hummingbird, thick-billed kingbird, tropical kingbird and yellow-green vireo.

The lush, watered canyons of Cajon Bonito just south of the U.S.-Mexico border provide the best riparian habitat found within the region and contribute several species to the overall bird list. Cajon Bonito is the site for three records of American dippers—the only Sonoran records for this bird known to frequent only tumbling mountain streams. Many of the same rare species found in Guadalupe Canyon are found here (thick-billed and tropical kingbird, buff-collared nightjar, Lucifer hummingbird) as well as at least one species, white-tipped dove, not recorded for Arizona. Both rufous-capped and fan-tailed warblers have been recorded at Cajon Bonito as has rose-throated becard and green kingfisher. The canyon also provides nesting habitat for both gray hawk and common black-hawk and may provide wintering habitat for elegant trogons, which nest in the nearby Chiricahua Mountains. A noteworthy hummingbird species recorded at Cajon Bonito is the plain-capped starthroat, a Mexican species found only rarely in the U.S. The rarest species seen at Cajon Bonito is an adult white wagtail (*Motocilla alba*) seen April 30, 1974.[6] This is a bird of the high Arctic with only a few enigmatic sightings south of Alaska, including this one.

## Mixed Oak Woodlands and Grasslands

These middle elevations are widely represented in the Peloncillo Mountains and include habitats important to Montezuma quail, violet-crowned and Lucifer hummingbirds, western scrub and pinyon jays, and acorn woodpeckers. This habitat may also be an important migratory pathway along the mountain flanks for woodland species such as the black-throated gray warbler migrating between the tropics and western U.S. The Gould's wild turkey (*Meleagris gallopavo mexicana*) found here is a race of wild turkey historically found in most of the Sky Island mountain ranges. This turkey was extirpated from its entire US range except for the Peloncillo Mountains. It has since been reintroduced into other ranges (with mixed success), and has recolonized at least one additional range on its own.

## Coniferous Forests and Mountain Meadows

The highest elevations in the Peloncillo region occur in the Animas Mountains and Sierra San Luis at more than 8,500 feet. These mountains contain most of the high-elevation coniferous forest in the region and best populations of higher-elevation birds such as yellow-eyed junco, greater pewee, red-faced warbler and eared quetzal. The eared quetzal, formerly called eared trogon, is a mysterious bird not well known even in its stronghold of the Sierra Madre. It has occurred sporadically in the Sky Islands of Arizona with apparent irruption years of 1977 and 1991 when multiple birds appeared in the Chiricahua and Huachuca Mountains of southeastern Arizona. There are unconfirmed reports of eared quetzal from the Animas Mountains, although the bird is not officially recorded for New Mexico. The high elevations of the Animas, an area rarely visited by birders, provides ideal habitat for the species and is closer to the core area of their habitat, the coniferous forests of the Sierra Madre in Chihuahua, than any of the Arizona locations. The eared quetzal is a mountain trogon, adapted to high pine forests and does not migrate south for the winter, like elegant trogons. In fact, there are Arizona records for every month.

The high mountain meadows of the Animas Mountains are also the best habitat for the suite of high-elevation hummingbirds for which this area of the country has become famous among birders. Magnificent, white-eared, blue-throated, berylline, calliope, and rufous are the mountain hummingbirds among the 15 species recorded in the region.

The Animas and higher elevations of the Peloncillo Mountains contain the Apache race of the northern goshawk *Accipiter gentilis apache*. This is the only place with contiguous mountain habitat connecting the Sierra Madre population with those in the U.S. The Peloncillos and Animas are two of the three mountain ranges in the U.S. where Mexican chickadees are found, the other being the nearby Chiricahua Mountains.

## *Extirpated species*

Two species extirpated from the U.S. but still found in Mexico have the potential for recolonization in the Peloncillos region. The aplomado falcon, a beautiful medium-sized falcon once relatively common in the desert grasslands of the Southwest, disappeared around 1910. The habitat at that time was devastated by many years of uncontrolled overgrazing and drought, leading to the desertification of much of the former grassland habitat. Recent research also suggests that the extirpation of prairie dog towns may have had a large hand in the falcon's decline.[7] In recent years the aplomado falcon has been reintroduced into south Texas, and a population in Chihuahua within 100 miles of the U.S. border is well studied. In 2000, an aplomado falcon was observed in southeastern New Mexico, and in 2002 the first nest of these birds seen in New Mexico in many years was observed. The wide-open grassland with scattered yuccas in the periphery of the Peloncillo region would be ideal habitat for aplomado falcons, whether they recolonize naturally or are reintroduced.

The other extirpated species, the thick-billed parrot, was reintroduced to the Chiricahua Mountains in the late 1980s. This short-lived population may have been responsible for the unconfirmed sighting of a thick-billed parrot in the Peloncillo Mountains. This large parrot of the coniferous forests was an irregular visitor to the mountains of southeastern Arizona and southwestern New Mexico in the 1800s. Thick-billed parrots were essentially gone from their former U.S. territory by 1920. Their raucous voices, relatively large size, and tame, inquisitive behavior made them easy targets for subsistence-hunting prospectors and other early settlers. Occasional sightings continued until 1938 in Arizona and until 1964 in New Mexico, but no parrots were recorded thereafter until a few captives were released to the wild in the late 1980s. The reintroduction showed early promise, but it is now believed the birds require a minimum flock size difficult to maintain artificially. Thick-billed parrots are CITES Appendix 1 listed and have become endangered in their remaining Mexican strongholds, principally because of extensive lumbering of old-growth pine forests. As these forests dwindle, it is possible that a flock of these strong fliers might strike out northward from their Chihuahuan home to the Animas Mountain pine forests. The origin of a single thick-billed parrot seen near Truth or Consequences, New Mexico, in the summer of 2003 is still a matter of debate among ornithologists.

## *Knowledge Gaps*

Although a few canyons of the Peloncillo region are well known, other areas are relatively little studied. As stated in the introduction to this chapter, one of the challenges of bird conservation in the region is that much of the knowledge, while valuable, is natural history and anecdotal evidence provided by recreational birdwatchers. What place-based scientific knowledge exists needs to be catalogued. Much of the information presented here on avian diversity was gleaned from two Christmas Count Circles and the Breeding Bird Survey as well as experiences of birders in or near the study area. For example, numerous anecdotal records substantiate the importance of the Peloncillos as a migration corridor. Ongoing monitoring of migrant birds at the Bioresearch Ranch has already yielded four years of detailed data on flyways through the central Peloncillo range, but more systematic monitoring during these critical times needs to be done throughout the region.

Some of the questions posed by these knowledge gaps include:

- What is the *extent* to which the habitats of the Peloncillo region are important to neotropical migrants? It is generally understood that the Janos Prairie and Animas Valley are particularly important to wintering species, but what about summer importance? Again, research on the Bioresearch Ranch and Gray Ranch have begun to gather data that address this question, but comprehensive answers will require more concerted efforts to gather and compile information.
- How do the grassland bird assemblages compare to grasslands in other regions? Are they declining, and if so, what are the probable causes?

- The intact riparian habitats of Guadalupe Canyon and Cajon Bonito host some of the rarest species of birds, particularly tropical species (including very high numbers of hummingbirds). Are these species rare due to loss of habitat or to geographic placement at the northern fringe of their ranges?
- What is the relationship between fire suppression and loss or decline of such species as thick-billed parrot, Apache goshawk, and other raptors?
- The region is well-known by birdwatchers for its high numbers of cavity-nesting species—including woodpeckers and owls—but what are the reasons for this high diversity compared to other Sky Islands?

The avian populations of the northern portion of the region, north of I-10, is even less well-studied than the southern portion, and is only rarely, if ever, visited by birdwatchers. Even in the southern portions, with the exception of a few well-known birding locations (Guadalupe, Clanton and Skeleton Canyons), the remote location and lack of easy access to some public lands have resulted in the Peloncillos being one of the biologically least-known of the Sky Island mountains.

## *Conservation Targets*

The remote location and rugged nature of the Peloncillo region have spared it from many of the development pressures facing most of the other Sky Island mountain ranges. Even the Chiricahua Mountains, the largest of the Arizona Sky Islands, are feeling the encroachment of subdivisions. The Chiricahua Mountains have also hosted several controversies surrounding intensive recreation pressures related to birdwatching. The Peloncillo Mountains have experienced similar controversy; when rare bird reports drew large numbers of birdwatchers (many of whom flew thousands of miles just to see one bird), local ranchers began closing their lands to recreational birdwatching because of the habitat degradation they felt was being caused by vehicular and foot traffic.

Clearly the region as an intact and unbroken landscape is important to birds migrating to the U.S. and Canada from southern Mexico and Central and South America (neotropical migrants), and to more regional migrants. This is evidenced in the large numbers of wintering species, including waterfowl and hawks, which depend on the Janos Prairie and playas of the Animas and northern San Simon Valley. The decline and disappearance in the U.S. of the aplomado falcon points to the need for more understanding this raptor's conservation needs, as well as the needs of all raptors in the region. Protecting these areas from development or further fragmentation is critical.

More study is also needed to determine the habitat needs of species such as Gould's turkey, especially related to the return of more natural fire regimes. The same is true for thick-billed parrots if we are to see their return to former haunts in the Chiricahua Mountains. The presence of breeding flocks of thick-billed parrots in the Sierra Cebadillas near the Janos Prairie in Mexico is promising for a potential natural recolonization—as are periodic records of flocks in the Sierra San Luis itself.[8]

**Notes, Chapter 2.2**

[1] Corman, T., and C. Wise-Gervais. 2005. Arizona Breeding Bird Atlas. University of New Mexico Press, Albuquerque NM. 636 pp.

[2] Partners In Flight (PIF) is a non-profit partnership of federal and state agencies, industry, non-governmental organizations, and many others, with the goal of conserving North American birds, especially focused on Neotropical migrants. The group has rated bird species in terms multi-year population trends as well as of a wide variety of conservation threats, producing lists of species of concern for many areas of the US and Canada, and the migrants' southern winter homes. See: <http://www.partnersinflight.org.> Site last visited October 11, 2005.

[3] New Mexico Audubon Society Important Bird Areas Program, <http://nm.audubon.org/iba/iba.html>. Site updated January 28, 2005. Last visited October 11, 2005.

[4] Williams, S. O. III. April 5, 1997. 35th Annual Meeting of the NM Ornithological Society, Santa Fe, NM.

[5] Proposed in 1999 for listing as threatened under the Endangered Species Act, the species was removed from consideration for listing in 2003. This change was based partly on a lack of reliable data showing continued severe decline throughout the species range, and partly on the perception that recent recovery efforts on the part of federal, state, and county agencies as well as private citizens and non-profit groups may be enough to stave off extinction (USFWS, September 9, 2003, Withdrawal of the proposed rule to designate the mountain plover as threatened, Federal Register 68(174): 53088-53101).

[6] Monson, G., and A.R. Phillips, 1981. Annotated Checklist of the Birds of Arizona. Second Edition. The University of Arizona Press, Tucson AZ.

[7] Truett, J. 2002. Aplomado falcons and grazing: Invoking history to plan restoration. Southwestern-Naturalist. 47(3): 379-400.

[8] Noel Snyder, pers. comm. 2005.

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# 2.3 Fishes of the Peloncillo Region: Rarity and Endemism in an Arid Region

*Yaqui catfish. Photo courtesy Dale Turner.*

## Outstanding Features

- Three main sites in the Peloncillo region continue to harbor native fish.
- 13 native species known from the upper Río Yaqui basin.
- Four threatened and endangered species (US listings).
- Several species endemic to the Río Yaqui basin.
- Two newly identified and as-yet-undescribed species.
- Extremely high potential for protecting one of rarest natural fish assemblages in the SW US and NW Mexico.

Aquatic habitats harboring native fish populations have become increasingly scarce in the Southwestern US and Northwestern Mexico. As water use and drought have increased, aquatic habitats have diminished drastically. By many estimates Arizona has lost over 90 percent of its riparian habitat.[1] In most of the aquatic ecosystems that remain, introduced species of fishes, amphibians, and crustaceans have had a devastating impact on the native fish fauna. These losses have made preservation of surviving aquatic ecosystems and their native fish populations a major conservation priority. The Peloncillo region is highly significant for preserving some of the last intact assemblages of indigenous fishes left in the Chihuahuan Desert Ecoregion. Much of the following information and recommendations comes from the United States Fish and Wildlife Service (USFWS) 1995 Yaqui fishes recovery plan.

### Geographic Scope

For purposes of discussing fish populations, the Peloncillo region includes a large portion of the northern Rio Yaqui watershed. This basin as a whole comprises 73,000 $km^2$, with 2% of that in the U.S. (portions of southern Cochise County, Arizona, and Hidalgo County, New Mexico; see map, page 12). The Rio Yaqui begins in western Chihuahua and is significantly augmented by the Río de Bavispe as it enters Sonora on its way to its final destination, the Gulf of California. Near its mouth, the Río Yaqui discharges an total annual average of 2,800 $ha^3$, of water, earning it the rank of one of the largest rivers in the region. In addition to collecting runoff from US territory in the southern San Simon Valley and the northern San Bernardino Valley, this river system's watershed includes a significant portion of Mexico's western and northern Sierra Madre.

This report addresses fish communities at the northeastern edge of the Río Yaqui system. The area covered here by current GIS data on native fishes encompasses the area extending from the north end of the Peloncillo range, just north of Interstate 10 in

Arizona, south across the U.S./Mexico border to the Sierra San Luis and the upper reaches of the Río Bavispe in Sonora, and from Leslie Canyon, at the southern tip of the Chiricahua Mountains, east to the Animas Mountains in New Mexico.

## Habitats – Overview

Diversity of aquatic habitats throughout the Río Yaqui basin is high,[2] including both perennial and ephemeral representatives of high, medium, and low gradient streams at elevations ranging from some 2500m to sea level; low salinity warm and cool springs; cienegas; and temporary lagunas. Mountain creeks (high elevation, high gradient streams) support both indigenous and non-indigenous trout, but most fishes in the basin occupy intermediate- to low-elevation, mid- to low-gradient warm water creeks, cienegas, and moderate- to large-sized rivers. Creeks typically have alternating riffles and pools in which heterogeneity is enhanced by undercut banks, boulders and woody debris. Gravel bottoms in swift areas are vegetated with algae. Rivers vary from pool-riffle types with boulder and gravel bottoms to long, strongly flowing reaches over gravel and sand. *Cienegas*, stream-associated marshlands with low, emergent aquatic plants and hydric-adapted trees (e.g., *Salix* spp.), were historically common but have suffered severe degradation in the past two centuries.[3]

The Upper Yaqui area addressed here includes almost all of these features, at elevational ranges from approximately 2500m to 1000m. Most streams in this region are ephemeral, mid- to low- elevation and mid- to low- gradient systems, but a few key reaches are perennial. The Upper Yaqui region has historically had numerous warm and cool springs; some of these still exist. Several cienegas also remain, and some are recovering well from past disturbances. Within the Upper Yaqui, three sites are emphasized here because of their extant fish populations (see below): Cajon Bonito, the San Bernardino National Wildlife Refuge and affiliated habitats on adjacent ranches, and Leslie Creek. More detailed habitat descriptions have been made for both US sites,[4] and for portions of the Mexican sites.[5]

### *Fish Populations in the Region*

According to GIS data compiled by W.L. Minckley and Heidi Blasius,[6] three main areas within the greater Peloncillo region/upper Río Yaqui basin support native fish populations (see Table 2.6.1), with 13 species, including two undescribed. These areas are Cajon Bonito and the upper Bavispe watershed in northern Sonora; and two sites on the northern Bavispe watershed in the United States—the San Bernardino Wildlife Refuge, and Leslie Creek. (See Appendix F, Fish Collection Records in the Peloncillo Region.)

**Table 2.3.1 - Fishes of the Peloncillo Region, with Distributions**[7]

| | Scientific name | Author | Alternate name in recent literature | Taxon notes |
|---|---|---|---|---|
| **Northern Bavispe, including Cajon Bonito, San Bernardino NWR:** | | | | |
| Mexican roundtail chub | *Gila minacae* | Meek, 1902 | *Gila robusta* | *1* |
| Mexican stoneroller | *Campostoma ornatum* | Girard, 1856 | | |
| Ornate shiner | *Codoma ornata* | (Girard, 1856) | *Cyprinella ornata* | |
| Yaqui beautiful shiner | *Notropis formosa* | (Girard, 1856) | *Cyprinella formosa* | |
| Yaqui catfish | *Ictalurus pricei* | (Rutter, 1896) | | |
| Yaqui topminnow | *Poeciliopsis sonoriensis* | (Baird & Girard, 1853) | *Poeciliopsis occidentalis sonoriensis* | |
| Yaqui sucker | *Catostomus bernardini* | Girard, 1856 | | |
| Yaqui longfin dace | *Agosia yaqui* | (Girard, 1856) | *Agosia chrysogaster*, yaqui form | *2* |
| River carpsucker | *Carpiodes carpio* | (Rafinesque, 1820) | *Carpiodes* sp. | *3* |
| **Upper Bavispe only, usually above ~1300 meters:** | | | | |
| Yaqui trout | *Oncorhynchus* sp. | - | | *4* |
| Fleshylip sucker | *Catostomus leopoldi* | Siebert & Minckley 1986 | Bavispe sucker | |
| Yaqui mountain sucker | *Catostomus* sp. | - | | *5* |
| **San Bernardino / Black Draw only, plus Turkey and Leslie Creeks:** | | | | |
| Yaqui chub | *Gila purpurea* | (Girard, 1856) | | |

**1:** Until recently considered as a subspecies of *G. robusta.* now generally viewed as a separate closely related species. **2**: The "yaqui" form is recognized by most systematists as a distinct entity, but is still frequently listed under *A. chrysogaster* in literature. The name *Agosia yaqui* has not yet received formal recognition. **3:** Hendrickson et al. 1981 consider this an introduced population of fishes native to Eastern North America. However, Bart et al. 2004 argue that Mexico has several poorly known or undescribed species of native carpsuckers, implying that these may be native. No data was found on possible negative impacts on other Yaqui drainage fishes. **4:** undescribed species. **5:** The Yaqui mountain sucker is often included under the name *Catostomus plebius* but is probably different and undescribed in reality.

The most significant stream in the region is northern Sonora's Cajon Bonito, which flows from the western slopes of the Sierra San Luis to join the Río Bavispe. About 20 miles south of the U.S./Mexico border, Cajon Bonito supports the most intact suite of native fish species in the Southwestern US and Northwestern Mexico,[8] including Yaqui beautiful shiner, Mexican stoneroller, ornate shiner, Yaqui longfin dace, Mexican roundtail chub, Yaqui sucker, Yaqui topminnow, Yaqui catfish, and Yaqui chub, the last three of which are listed as endangered by the U.S. government. Compared to other Sonoran and Chihuahuan Desert streams, its species richness is very high (see below, Figure 2.6.1).

Most reaches of the Cajon Bonito presently lack invasive non-native species. While it is part of the Río Yaqui system, which has experienced increasing invasion and introduction of non-native fishes such as black bullhead (*Ameirus melas*) and mosquitofish (*Gambusia affinis*), Cajon Bonito is protected from invaders present in lower parts of the Rio Bavispe by a dry downstream reach that prevents easy upstream migration of exotics. It remains vulnerable, however, to invaders present in stocktanks and other impoundments.

Records do exist for the river carpsucker *Carpiodes carpio*, which is native to North America east of the Rocky Mountains. This fish has apparently been in the system for several decades, and is not known to breed with or otherwise negatively impact native species.[910] However, a fish farm stocked with non-native trout and non-native catfish has recently been established (with funding from Mexican federal aquaculture grant program) upstream from one of the most pristine reaches of the Cajon. This fish farm poses an imminent threat of introducing invasive fishes as well as diseases and parasites,[11] and its diversion ponds could have other negative effects on water quality.[12]

The suite of fishes in the Río Bavispe, one of the Río Yaqui's major tributaries, reflect the same assemblage found in Cajon Bonito: Mexican stoneroller, Yaqui beautiful shiner, Yaqui chub, Yaqui catfish, Yaqui topminnow, Yaqui sucker, Yaqui longfin dace, ornate shiner, and Mexican roundtail chub. Higher elevations of the upper Río Bavispe have produced records of two as-yet undescribed species, the Yaqui trout and Yaqui mountain sucker. The Fleshylip sucker (also known as the Bavispe sucker) is also known only from the upper Río Bavispe.[13]

According to Peter Unmack of Arizona State University (2005, pers. comm.), there is one record for desert chub (*Gila eremica*) at a small tributary of the Río Yaqui, 21 miles south of Agua Prieta, Sonora, near the village of Cabullonas. However, that record has been questioned due to an inability to find any specimens since that collection in 1959.

North of Cajon Bonito and the Río Bavispe, about 17 miles east of Douglas in the U.S., is the San Bernardino National Wildlife Refuge, which protects a third source of the Río Yaqui. Historical records indicate that this area once supported around a quarter of the 35 known indigenous fish species in Arizona: Yaqui beautiful shiner, Mexican stoneroller, longfin dace, Yaqui chub, Yaqui topminnow, Yaqui catfish, Yaqui roundtail chub, and Yaqui sucker.[14]

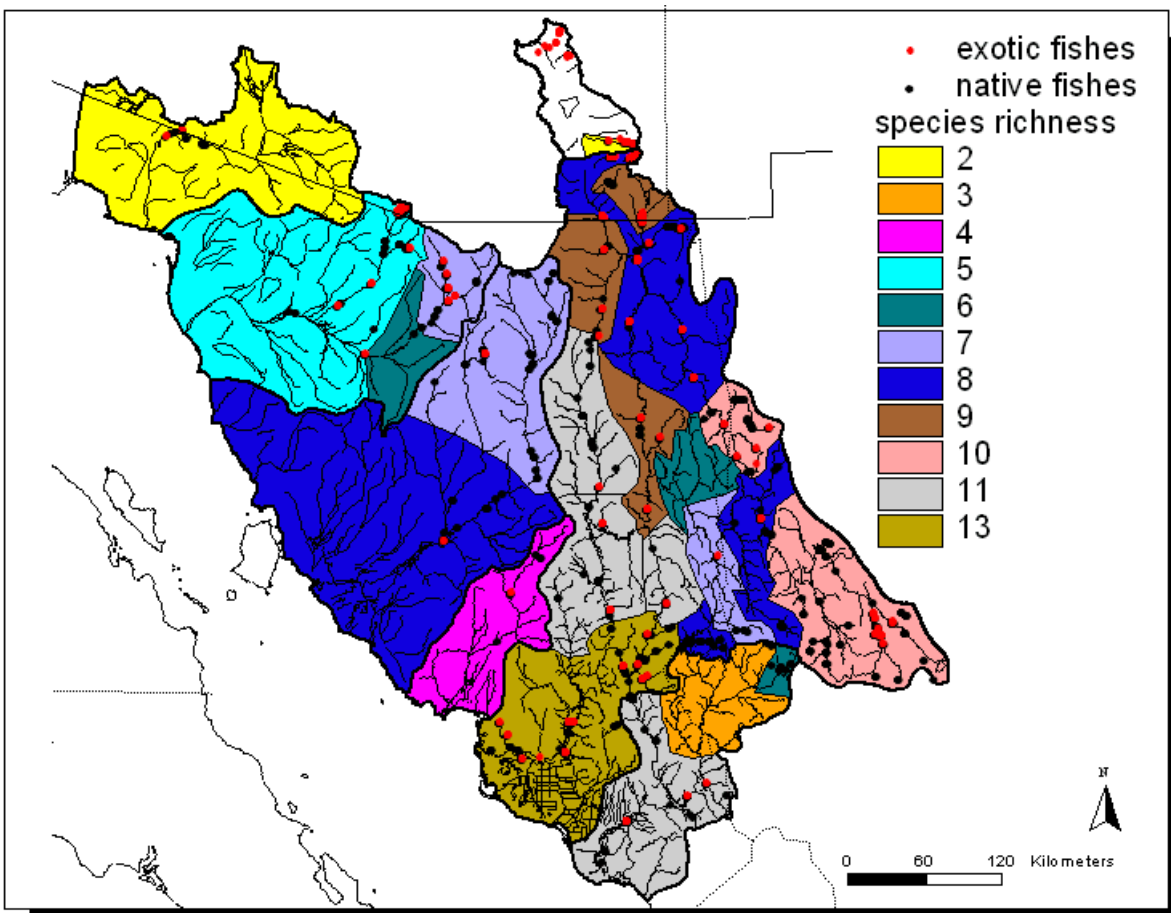


*Figure 2.3.1 – Comparison of Species Richness in Río Yaqui Watershed*[15]

The upper reaches of the Río Yaqui watershed currently harbor four threatened or endangered taxa—the beautiful shiner (*Cyprinella formosa*), Yaqui chub *(Gila purpurea),* Yaqui catfish *(Ictalurus pricei)* and Yaqui topminnow *(Poeciliopsis occidentalis sonoriensis).* Additionally this region has provided historic habitat in the U.S. for four additional indigenous fishes: longfin dace *(Agosia chrysogaster,* Yaqui form*),* Mexican stoneroller *(Campostoma ornatum),*Yaqui roundtail chub *(Gila minacea)* and Yaqui sucker *(Catostomus bernardini*), all currently candidates for listing in both the U.S. and Mexico (see Table 2.6.2). Seven of the eight species are also considered imperiled by the State of Arizona.[16] Livestock overgrazing, erosion, water diversion, aquifer pumping, non-indigenous species, destruction or alteration of most natural fish habitats and drought have caused the extirpation of all eight taxa in the U.S-portion of the Rio Yaqui basin, though four have since recolonized or been reintroduced.[17]

| Taxa | USA | AZ | MEXICO | IUCN | Designated Critical Habitat |
|---|---|---|---|---|---|
| ***Agosia yaqui*** Yaqui longfin dace | Candidate 2[1] | Not listed | Threatened[1] | | Not appl. |
| ***Campostoma ornatum,*** Mexican stoneroller | Candidate 2 | Endangered | Endangered | | Not appl. |
| **** Cyprinella formosa,*** Beautiful shiner** | Threatened | Endangered | Threatened | Vulnerable | Yes |
| ***Gila purpurea,*** Yaqui chub | Endangered | Threatened[2] | Endangered | Vulnerable | Yes |
| **** Gila minacae,*** Yaqui roundtail chub*** | Candidate 2[2] | Endangered | Rare[2] | | Not appl. |
| **** Catostomus bernardini,*** Yaqui sucker | Candidate 2 | Endangered | Rare | Vulnerable | Not appl. |
| ****Ictalurus pricei,*** Yaqui catfish | Threatened | Endangered | Threatened | Vulnerable | Yes |
| ***Poeciliopsis occidentalis sonoriensis,*** Yaqui topminnow | Endangered | -- | -- | Vulnerable | Not appl. |
| ***Catostomus leopoldi,*** Fleshylipped sucker | -- | | | | No |

*Table 2.3.2 - Federal and State Listing Status of Fishes of the Río Yaqui Basin[18]*

**Taxa extirpated from the U.S. portion of the Río Yaqui basin are marked with an asterisk (*).*
***Beautiful shiner has been successfully reintroduced on San Bernardino/Leslie Canyon NWR.*
****Listed by the New Mexico State Legislature (1974) as equivalent to federally endangered.*
1: This species had previously been considered a form of *Agosia chrysogaster*. Endangered status is therefore given for *A. chrysogaster* until this species receives a name and an evaluation of its own.
2: This species was recently split from the Roundtail chub *Gila robusta*. *G. robusta* turned out to be a species complex that included several taxa now officially listed as threatened or endangered. As part of *G. robusta*, this Peloncillo-area fish was a candidate for listing in both the US and Mexico, and was Threatened in Arizona. *G. minacae* is not officially listed under its new name, but may well merit such listing when it is evaluated on its own.

## Current Habitat Conditions

Since the late 1880s stream channels became incised and altered. Diversion and modification of stream channels themselves and excessive exploitation of underground aquifers; all reduced the quantity and quality of natural surface waters. Streams from springs and wells were channeled to fields and tanks. Black Draw, which collects water from the southwestern slopes of the Peloncillo mountains and has fed much of the San Bernardino wetlands, changed from a marshy swale (*cienega*) in the 1850s to a creek lined with cottonwoods *(Populus fremontii)* in the 1890s, to an arroyo by the 1960s that was three to five meters deep, to 25 m wide and usually dry.[19] Similar patterns typified the region. Introduction of non-indigenous species into stock-watering ponds and elsewhere came later, and their spread to remnant natural habitats contributed further to a general decline in aquatic communities.[20] Included were highly predatory taxa such as largemouth bass *(Micropterus salmoides)*, bullfrog, and western mosquitofish, and competitors/predators such as bullhead catfish *(Ameiurus* spp.), bluegill *(Lepomis macrochirus)* and black crappie *(Pomoxis nigromaculatus)*.

Yaqui chub reappeared in Black Draw in 1987, either from the 1980 stocking or through upstream dispersal from Mexico. Considerable effort had by then been expended in erosion control and revegetation, and positive results of this, coupled with consecutive wet years and appearance of Mexican stoneroller (not before recorded from the stream), make the latter more probable.[21] While these activities proceeded, further plans were implemented to acquire extirpated species from Mexico for culture and ultimate reintroduction back into historic habitats.

Personnel from USFWS, AZGFD, AZSU and El Centro de Ecologico, Hermosillo, Sonora, collaborated on two trips for Yaqui catfish and one for beautiful shiner. The Yaqui catfish remain at Dexter National Fish Hatchery and Technology Center (NFHTC), where it has been studied morphologically and genetically for positive identification and to ascertain basic information required for successful culture.[22] The Yaqui beautiful

shiners were held at Dexter NFHTC, then 400 individuals were reintroduced in May 1990 on San Bernardino NWR. It has established and expanded into today's subpopulations.

## Conservation Targets

Two of the existing fish refugia in the Peloncillo region—Cajon Bonito and the San Bernardino National Wildlife Refuge—are extremely important for the viability of the fishes in the Peloncillo region. The San Bernardino NWR, while fully protected by the US government, is not immune to accidental introductions of non-native species. Careful management should remain a priority for the USFWS.

Cajon Bonito in Mexico is a series of privately owned ranches, each with varying degrees of knowledge and sensitivity to issues of fish conservation. While many biologists from the US and Mexico recognize the value of the Cajon's fish assemblages, and The establishment of a non-native fish farm upstream of the most intact stream segment creates tremendous risks to native fish assemblages. This farm operation is currently supported by funding through the Mexican federal agency SAGARPA (Secretario de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación). Coordinated management, protected area status, and acquisition of segments by conservation buyers are all options for reducing threats along particular reaches of Cajon Bonito.

The Río Yaqui system has experienced increasing invasion and introduction of non-native fishes such as black bullhead (*Ameirus melas*) and mosquitofish (*Gambusia affinis*), although not yet to the extent of rivers north of the U.S. border, such as the Gila. This lag is most likely due to the relative inaccessibility of the upper Río Yaqui, and the relatively recent origin of government-funded introduction programs in Mexico.[23]

## Knowledge Gaps

Given the known reduction in riparian habitat within the Chihuahuan Desert Ecoregion, it is probable that the Peloncillo region historically supported more perennial streams and thus more native fish populations than it does today,[24] for example in canyons such as Guadalupe, which even now flows much of the year. Natural cyclic droughts would, however, be sufficient to eradicate species in watercourses that might totally dry up during such periods. More study on potential reintroductions is warranted.

More study is needed to determine the possible historical occurrence of fishes in other areas of the Peloncillos, such as Guadalupe Canyon. Any reintroduction efforts to restore lost populations would require an assured permanent supply of water. Restricting or eliminating cattle access to riparian areas and providing them with other sources of water (e.g., - tanks) is one known way to reduce incision and help retain stream flow, a measure completed or underway in many grazing areas.[25] However, cattle tanks might promote the spread of unwanted exotic species such as bullfrogs (*Rana catesbeiana*), so further study is needed here as well.[26]

Notes, Chapter 2.3

[1] USFWS, 1995. Yaqui fishes recovery plan. United States Fish and Wildlife Service, Region 2, Albuquerque, N.M.

[2] Hendrickson, D.A., W. L. Minckley, R. R. Miller, D. J. Siebert, and P. H. Minckley. 1981. Fishes of the Rio Yaqui, Mexico and United States. Journal of the Arizona-Nevada Academy of Science 15(3): 65-106.

[3] USFWS, 1995.

[4] USFWS, 1995. Yaqui fishes recovery plan. United States Fish and Wildlife Service, Region 2, Albuquerque, N.M.

[5] Hunt, R., and W. Anderson. 2002. A rapid biological and ecological inventory and assessment of the Cajon Bonito watershed, Sonora, Mexico. Part 1: Natural history. Desert Plants 18(2): 3-20.

[6] Blasius, Heidi. 1996. Biogeography of freshwater fishes of northwestern México. Thesis (M.S.), Arizona State University. Data now incorporated into GIS database project, SON fishes database.

[7] Unmack, Peter, unpublished and pers. comm., Jan. 2005. Names are listed so as to conform with the most current taxonomic consensus available.

[8] Dinnerstein et al. 2000 includes the Cajon Bonito and other areas covered in this report within their "upper Yaqui" freshwater priority site, ranked as "highest priority" by their analysis (p. 109) This site's "Contribution to biological conservation strategies" is listed here as "High freshwater fish diversity and diverse riparian habitats, representative habitat types, species assemblages, and intact habitat and biota" (p. D-7). It overlaps considerably with the only Apachean subregion terrestrial priority site that ranked as "highest priority" in this same analysis. In The Nature Conservancy's parallel Apache Highlands ecoregional analysis (which overlaps with the northeastern portion of WWF's Chihuahuan Desert Ecoregion), TNC's Sierra San Luis/Peloncillo Mountains site ranked third highest out of 69 sites in the Apache Highlands analysis in terms of total numbers of aquatic and riparian targets (26) (p. 48). This site ranked second highest overall out of 90 sites for total number of targets (71) (p. 46).

[9] Hendrickson et al. 1981. Hendrickson et al.'s write-up on *Carpiodes carpio* says: "Origin of river carpsucker in the Rio Yaqui system is unknown. They were likely transferred to the area with sport fishes, stocked in one or more mainstream reservoirs, and then spread to most large streams lower than 1,400 m elevation... They are known as 'Conchudo' or 'Bocachiquito', and seasonal spawning migrations of considerable distance from reservoirs are indicated by local testimony and some of our more remote, upstream records (e.g., Cajon Bonito)."

[10] Bart, H. L. Bart, R.D. Suttkus, J. Lyons, and N. Mercado-Silva. Status of Mexican ictiobines: a tribute to Meek and Miller. Presentation to the Desert Fishes Council, November 12 2004.

[11] S. C. Tackley, S. A. Bonar, and A. Choudhury. 2004. Effects of Asian tapeworm (*Bothriocephalus acheilognathi*) on native fishes from the RioYaqui basin, Arizona. Presentation to the Desert Fishes Council, November 12 2004.

[12] Valer Austin, Cuenca Los Ojos, pers. comm. 2003-2005.

[13] Siebert, D. J. and Minckley, W. L. 1986. Two new catostomid fishes (Cypriniformes) from the northern Sierra Madre Occidental of Mexico. Am. Mus. Novit. 1-17

[14] From http://southwest.fws.gov/refuges/arizona/sanb.html

[15] From Peter Unmack, Arizona State University, 2005.

[16] Arizona Game & Fish Department, 1992. Threatened Native Wildlife in Arizona. AZGFD, Phoenix.

[17] USFWS, 1995.

[18] ibid.

[19] DeMarais, B. D. & W.L. Minckley. 1991. Genetics and morphology of Yaqui chub, an endangered cyprinid fish subject to recovery efforts. Final Rep. USFWS, Albuquerque, NM, AZSU, Tempe, in USFWS 1995.

[20] Minckley, W.L, 1985. Native fishes and natural aquatic habitats of U.S. Fish and Wildlife Service Region II, west of the Continental Divide. Final Rept., USFWS-AZSU Interagency Pers. Act Agr., ASU, Tempe.

[21] Hendrickson *et al.* 1981, and DeMarais & Minckley, 1993. Genetics and morphology of Yaqui chub, *Gilu purpurea,* an endangered cyprinid fish subject to recovery efforts. Biol. Conserv. 66: 195-206.

[22] USFWS 1995. Yaqui Fishes Recovery Plan. 2005 presence confirmed by Bill Radke, USFWS, San Bernardino NWR.

[23] Unmack, Peter, and Fagan, William. 2003. Convergence of differentially invaded sytems toward invader dominance: time-lagged invasions as a predictor in desert fish communities. Biological Invasions 6: 233-243, 2004

[24] Minckley, Robert, pers. comm., Jan. 2005.

25 Minckley, Robert, pers. comm., Jan. 2005.

26 Information extrapolated from Chapter 6, note 36: Hammerson, G.A. 1999. Amphibians and Reptiles in Colorado: A Colorado Field Guide. 2nd Edition. Univ. Press of Colorado and Colorado Division of Wildlife. xxvi + 484 pp.

# 2.4 Herpetofauna of the Peloncillo Region: Legendary Diversity & Specific Threats

*Photo ©2005 Paul Condon; New Mexico Ridgenose Rattlesnake, Peloncillo Mts.*

## *Outstanding Features*

- *89 species of reptiles and amphibians live in the Peloncillo region—72% of New Mexico's total species*
- *Antelope Pass has the highest lizard diversity of any comparable-sized place in the U.S.*
- *Although extremely xeric, the region is home to 14 native amphibians — some 58% of the amphibian species known to occur in New Mexico.*
- *One of the most endangered snakes on the continent, the New Mexico Ridgenosed rattlesnake, is found only in the Peloncillo region.*

More species of amphibians and reptiles live in the Peloncillo Mountains than in any other single mountain range in New Mexico—at least 89 species, which is 72% of the 123 species known to occur throughout the entire state of New Mexico.[1] Even more impressive is the fact that these comprise almost a third of the amphibian and reptile species of the Western United States.[2] And just one small pass in the Peloncillos—the 4,265-foot Antelope Pass, between the towns of Animas and Rodeo in Hidalgo County, New Mexico—has the highest lizard diversity of any comparable-sized place in the United States.

These facts underscore the contribution of these mountains to the overall U.S. and global biodiversity. Set in a narrow, north-south row, the arid Peloncillo Mountains run parallel to the New Mexico/Arizona border for approximately 100 miles and continue a short distance into Chihuahua and Sonora, Mexico.

**Geographic Scope.** For the purposes of this chapter, discussions are split into two geographic areas: the Peloncillo Mountains and the Sierra San Luis. The eastern border of the Peloncillo Mountains is the Animas Valley; the western border is the San Bernardino Valley and the San Simon Valley. The higher (1,300-2,520 meters; 4,265 – 8,268' feet) and wetter Sierra San Luis run north-south in Sonora and Chihuahua, Mexico (31º05' - 31º19'N, 108º40'30" - 108º58'W).

### Overview of Geographic Placement & Significance

The herpetological diversity of the Peloncillo region is impressive. At least 89 species of amphibians and reptiles are known from the region, which is 72% of the 123 species known to occur throughout the entire state of New Mexico. The Peloncillo region also includes about a third of the 186 taxa (161 species and 15 additional subspecies[3]) reported from the much more tropical state of Chihuahua, sharing 32% of taxa at the subspecies level and 42% at the species level. The large number of species from the region may be surprising in view of the overall aridity and remoteness from tropical regions. However, the geographical position of

the area, located at the intersection of six major biomes—including the Chihuahuan Desert, Great Plains, Great Basin, Rocky Mountains, Sierra Madre, and Sonoran Desert[4]—results in high species diversity.

Although relatively little is known about the herpetofauna of the Sierra San Luis in Mexico, the diversity of flora and fauna prompted the government of Mexico to declare the Sierra San Luis a Zona de Protección de la Flora y la Fauna Silvestres ye Acuáticas. (http://www.cideson.mx/conserv/sanpes/sanluis.html). This area is characterized by temperate pine-oak, pinyon-juniper, and riparian gallery forests. Douglas-fir and Arizona cypress occurs at the higher elevations. Three major biotic provinces—the Chihuahuan Desert, Sierra Madre Occidental, and Southern Rocky Mountains—influence distribution of the floral and faunal elements of this region. The geographic position, and the great variety of habitats, makes this area an important biological corridor between the Sierra Madre and the Southwestern United States.

Important complex transitional areas, or filter barriers, exist in the region. The most complex and best known of these is the Cochise Filter Barrier of Cochise and Santa Cruz counties, Arizona, Hidalgo County, New Mexico, the northeastern tip of Sonora and extreme northwestern Chihuahua. Physiographically, the Cochise Filter Barrier is a 60 – 120 mile (100 - 200 km) gap between the Sierra Madre Occidental and the Colorado Plateau. It is about 120 miles (200 km) east-west as well. It is a broad, 5,000-foot (1,500 meter) plain disrupted by steep but discontinuous north-south ranges (Chiricahua, Huachuca, and Peloncillo Mountains), up to 9,800 feet (3,000 meters) at their peaks. It is the only physiographic portal along the western wall of the desert. High species diversity in this region is due both to the ecotonal nature of the region and its geographical/physiographical accessibility.[5]

A bibliography of New Mexico herpetology exists at http://www.unm.edu/~msbherp/. This site, maintained by James N. Stuart, provides an updated, annotated bibliography of New Mexico herpetology. A companion to Degenhardt et al.,[6] this bibliography includes all pertinent literature (journal articles, books, unpublished agency and contract reports, and Internet publications) not cited in *Amphibians and Reptiles of New Mexico.* This supplemental bibliography is a work in progress and is continuously updated as new literature is published and older literature is located. It is the most valuable resource that exists when investigating the diversity of the amphibians and reptiles that exist in the borderlands area of New Mexico and Arizona.

A review of many of these borderland species already exists (e.g., Degenhardt et al.[7]). Therefore, only those species, species assemblages, or specific habitat areas identified as special conservation concerns (Peloncillo Region Science Workshop, Herpetofauna Group, Feb. 5 – 6, 2003, Willcox, AZ) are covered in further detail in this report.

## Discussion by Taxon

### Amphibians

Primarily due to the overall xeric nature of the habitat, amphibian diversity in this region is limited. There are 14 native and one introduced species of amphibians—including two salamanders and 13 toads and frogs—known to occur in this region (Appendix D). This is 58% of the 26 amphibian species known to occur in New Mexico, and 32% of the species reported for Chihuahua. Many (e.g., *Bufo*, *Scaphiopus*, *Spea*) are well-adapted to the arid conditions, being "explosive" breeders with short-duration, high-density breeding aggregations that form in ephemeral pools during periods of summer thundershowers. Others (e.g., *Ambystoma, Hyla*, *Rana*) rely upon semi-permanent or permanent streams or stock tanks for breeding.

Two native species of true frogs (Ranidae) occur in this region. Both are experiencing significant population declines in the Arizona and New Mexico and neighboring states, as a result of a combination of factors. Both require permanent to semi-permanent water for breeding and refugia during long-term drought, although both use temporary stock tanks and may disperse considerable distances along aquatic corridors. Fritts et al.[8] reviewed these species in New Mexico.

**Chiricahua leopard frog (*Rana chiricahuensis*)**

This leopard frog occurs in Arizona, New Mexico and Sonora and Chihuahua, Mexico. The distribution is discontinuous. Populations in the northern part of the range are essentially confined to montane habitats of the Mogollon Rim country of central and eastern Arizona, and the montane areas of adjacent western New Mexico. This portion of the range is separated from populations along the southern borders of Arizona and New Mexico by an intervening expanse of scrub desert with elevations below 3,281 feet (1000 meters). Another series of populations are distributed southward in Chihuahua along the eastern base of the Sierra Madre Occidental. The species occurs from 3,281 to 8,530 feet (1,000 to 2,600 meters) in a variety of aquatic habitats, including montane streams, lakes, marshes, and at intermediate elevations, stock tanks and plunge pools of canyon streams. The species was reviewed by Platz and Mecham.[9]

The Chiricahua leopard frog is federally listed as Threatened, primarily due to habitat alteration, destruction and fragmentation, predation by non-native organisms, and disease. Detailed information on the current status and threats to this species is found in USFWS (2002).[10]

The newly described chytrid fungus, *Batrachochytrium dendrobatidis*[11] is often implicated in the die-off of populations of ranid frogs in the Southwestern US.[12] The Declining Amphibian Populations Task Force (DAPTF) has developed guidelines to aid in the efforts to prevent the spread of this little understood fungi. These guidelines can be reviewed at <http://www.fws.gov/ventura/es/protocols/dafta.pdf>. Guidelines are also summarized below in the Conservation Targets section.

**Lowland leopard frog (*Rana yavapaiensis*)**

This leopard frog currently occurs in extreme southwestern New Mexico, southern Arizona, and presumably in adjacent parts of northern Sonora, Mexico although its distribution in Mexico is poorly known. Most populations occupy ponds, streams, and river pools at elevations below

3,281 feet (1,000 meters) in scrub desert localities. Some populations in central Arizona may reach 5,577 feet (1,700 meters) where they are occasionally sympatric with *R. chiricahuensis*. Platz reviewed this species in 1988.[13]

Populations of *R. yavapaiensis* in the Peloncillo Mountains of New Mexico have never been common and breeding has not been documented to occur in the state. Since a single individual was observed in Guadalupe Canyon during 1985, the species was not observed again until an additional specimen was identified there during August 2000.[14] In New Mexico the species is listed as Endangered; in Arizona, it is a Candidate species. Threats include low population levels and innumerable human uses of its aquatic habitat, as well as introduced predaceous crawfish, fishes, and bullfrogs.

**Reptiles**

Overall reptile diversity within the study area is very high, with at least 74 forms known, including three turtles, 34 lizards, and 37 snakes (Appendix D). That is 76% of the 97 reptile species known to occur in New Mexico.

**Hotspot: Antelope Pass**

Antelope Pass is a low pass through the Peloncillo Mountains between Animas and Rodeo, Hidalgo County, New Mexico. The landscape of the area surrounding Antelope Pass is Chihuahuan Desert desertscrub with steep rocky hills and associated bajadas and arroyos; elevation range is 4,265 to 4,921 feet (1,300 to 1,500 meters). The soils vary, being rocky, gravelly, or sand loam depending upon elevation, slope, and aspect. Dominant vegetation includes creosotebush (*Larrea tridentata*) and tarbush (*Flourensia cernua*), with occasional shrubby clumps of mesquite (*Prosopis glandulosa*), allthorn (*Koeberlinia spinosa*), and Mormon tea (*Ephedra* spp.). Small clumps of prickly pear (*Opuntia*) and cholla (*Cylindropuntia*) are common. Sandy areas associated with the barren, rocky arroyos are dominated by Apache plume (*Fallugia paradoxa*), desert willow (*Chilopsis linearis*), littleleaf sumac (*Rhus microphylla*), fourwing saltbush (*Atriplex canescens*), and desert hackberry (*Celtis pallida*). Dwarf desert-holly (*Perezia nana*), snakeweed (*Gutierrezia sarothrae*), and zinna (*Zinnia acerosa*) are common perennial herbs. Grass cover is sparse, with muhly grass (*Muhlenbergia* sp.) and tobosa grass (*Hilaria mutica*) most abundant. Antelope Pass is characterized by summer rainfall, with over half of the annual precipitation received during thundershowers from May-September. Mean annual precipitation is 10.4" (26.4 cm) at Lordsburg and 10.6" (26.9 cm) at Animas.[15]

Sias and Painter reported on data collected by NMDGF during pitfall studies at Antelope Pass conducted between 1987-93.[16] During that time pitfall traps with and without drift fences were operated for 417,366 trap days and caught 8,554 reptiles and amphibians of 45 species. The total catch consisted of 8,288 lizards of 18 species, 177 snakes of 21 species, and 89 amphibians of six species. This catch represented a sampling of the herpetofauna from an area of 3.48 $mi^2$ (9 $km^2$). Thus the herpetofaunal assemblage (lizards and snakes) at Antelope Pass may be the most diverse of any comparable-sized area within the United States. At least 19 species of lizards and 22 species of snakes are known to occur at Antelope Pass (*Sceloporus poinsetti* and *Tantilla yaquia* have been collected at Antelope Pass since completion of the pitfall trapping), while at least 32 species of lizards and 32 species of snakes are known to occur with a 50-mile (80.5 km) radius. Lizard species not collected at Antelope Pass yet known to occur within a 50-mile radius

include *Callisaurus draconoides*, *Sceloporus jarrovii, S. magister, S. slevini*, *S. virgatus*, *Phrynosoma hernandesi, P. solare, Cnemidophorus burti, C. exsanguis, C. inornatus, C. flagellicaudus, C. neomexicanus*, and *Eumeces callicephalus*. Snake species not collected at Antelope Pass yet known to occur within a 80.5 km radius include *Lampropeltis pyromelana, L. triangulum, Masticophis taeniatus, Salvadora grahamiae, Senticolis triaspis, Trimorphodon biscutatus, Crotalus lepidus, C. pricei, C. willardi,* and *Sistrurus catenatus*.

## Lizards

**Whiptail Lizards (*Cnemidophorus* spp.)**

The first modern synopsis of the "most difficult" genus *Cnemidophorus* was by E.D. Cope.[17] After years of study Cope had concluded: "The discrimination of the North American species of this genus is the most difficult problem in our herpetology.[18]" Throughout the distribution of the genus, which includes much of the drier regions in the New World, there are roughly 45 described species. These range from the prairie form *Cnemidophorus sexlineatus* occurring as far north as southeastern Minnesota, to the tropical *C. lemniscatus* group which ranges to Patagonia in southern Argentina, South America.

At least nine species of the widespread teiid genus *Cnemidophorus* occur in the Peloncillo region. [A tenth species, *C. flagellicaudus,* the Gila spotted whiptail, is reported by Stebbins as occurring in the area although the origin of these specimens is unknown.[19] Degenhardt et al. reported the species only as far south as the Gila River in extreme northern Hidalgo County[20], which is not included in this region.] According to Pianka, lizards as a group partition resources in three different ways: by being active at different times, by foraging in different places, and by feeding on different prey.[21] Numerous investigations of resource partitioning in *Cnemidophorus* reveal that all sympatric species are essentially active at the same time of day, eat very similar foods, and possess similar foraging habitats. The major factor preventing competition appears to be the choice of different microhabitats or different areas, although there is extensive overlap in this choice as well.

Schall studied interactions between nine *Cnemidophorus* species occurring in the "Trans Pecos" region of west Texas[22] (i.e., that area between the Pecos River and the Río Grande). These whiptails represent a guild of widely foraging, rapidly moving insectivorous lizards. All species studied overlapped greatly in food taxa consumed and the four largest species had no significant difference in prey sizes. There was no evidence of a difference between the all-female and bisexual species in patterns of diet, but the smallest species may use a different size range of prey items. Comparing the bisexual and all-female species revealed the two parthenogenetic species have the broadest microhabitat niche breaths. Activity times and presumed preferred body temperatures were similar for all species. It seems there is little actual competition between the species within this group.

However, the generalized habitat chosen by parthenogenetic species is broader and tends to be in disturbed zones where population sizes of lizards may not have reached their carrying capacities. Wright and Lowe hypothesized that the hybrid, highly heterozygous nature of the all-female whiptails allows them to exploit ecotonal zones.[23] These unisexual species are found over geographic regions that have been most severely altered by changing climatic patterns. Despite

the wider range of macrohabitat occupied by parthenogenetic *Cnemidophorus* species, their geographical ranges are rather restricted compared to other lizards.

**Slevin's Bunchgrass Lizard (*Sceloporus slevini*)**

*Sceloporus slevini* occurs from southeastern Arizona and extreme southwestern New Mexico south to northern Durango, west into eastern Sonora, and east to Nuevo León.[24] In New Mexico, this small lizard is active throughout the year in the intermountain Animas Valley of the border region. Sias and Painter reported year-round activity with captures dates ranging from 4 Jan – 22 Dec.[25] Lizards were most active in the spring and fall. The species was the third most abundant lizard reported (only *Cnemidophorus uniparens* and *C. exsanguis* were more abundant) from the grassland habitat sampled and accounted for ca. 17% of the total lizards captured. *Cnemidophorus uniparens* and *C. exsanguis* accounted for ca. 29% and 23%. Populations in Mexico are poorly known.

Population declines of this species have been reported from high-elevation sites in the Chiricahua Mountains, Cochise County, Arizona, by Ballinger and Congdon, and Tomberlin and Sherbrooke.[26] Overgrazing in high-elevation bunchgrass habitat was implicated in these reported declines. Bock et al. suggested that the apparent restriction of *S. slevini* to montane meadows might be a historic artifact associated with chronic and ubiquitous grazing of lower-elevation perennial grasslands.[27] They further suggest that *S. slevini* may be one of the best indicators of habitat degradation by grazing.

**Turtles**

The turtle fauna of the Peloncillo Mountains and the Sierra San Luis mountains is limited to only three species: the terrestrial desert box turtle (*Terrapene ornata luteola*), and two aquatic mud turtles (*Kinosternon flavescens* and *K. sonoriense*). Although the subspecies occurs throughout much of this region, few life history data are available for the desert box turtle. In many areas it is primarily a prairie grassland species, although the desert subspecies is also found in rocky, xeric habitats and along riparian corridors. The mud turtles occupy perennial or temporary stock tanks or small woodland streams.

Although most species of *Kinosternon* are known for their capacity for terrestrial activity, *K. sonoriense* has long been thought to hibernate underwater. However, Stone studying an intermittent stream in the Peloncillo Mountains reported that during drought periods the entire population likely estivated on land.[28] He also reported movement data for 13 individuals that moved >1km overland, as well as densities that exceeded 3,000 individuals/ha at Blackwater Hole in the Peloncillo Mountains, Hidalgo County, New Mexico. This is among the highest densities ever reported for a freshwater turtle.

**Snakes**

There are 37 species of snakes that are known from this region. That is 80% of the 46 snake species known to occur in New Mexico; 70% of 53 snake species known to occur in Arizona[29]; 58% of the 62 snake species from Chihuahua (and 39% of the state's 79 subspecies); and even includes 51% of 72 snake species known from Texas.[30]

**Northern Mexican Gartersnake (*Thamnophis eques megalops*).**
The subspecies *Thamnophis eques megalops*, occurs in the Chihuahuan Desert region. It is state listed as Endangered in New Mexico where it is very rare or perhaps extirpated, likely as a result of long-term drought and water depletion. In Arizona it is a Candidate species and is restricted to a few wetlands in the southeast corner of the state; and in Mexico where it is listed as Threatened, the status throughout much of its range is unknown.[31] In 2003 Conant reviewed this species in the transvolcanic belt of southern Mexico.[32] In his treatment of the species, he described seven new subspecies, each found in a different lake or remnant of a once-larger lake. Many of these new forms were originally described as *T. e. eques* or *T. e. megalops*.

**Northern Green Ratsnake (*Senticolis triaspis intermedia*).**
The northern green ratsnake reaches the northern edge of the species range in the southern Peloncillo Mountains. The species has a broad geographic distribution, ranging from southeastern Arizona and southwestern New Mexico and southern Tamaulipas southward through Mexico and much of Central America to Costa Rica. The elevational range is from near sea level to over 7,218 feet (2,200 meters). Price reviewed the species in 1991.[33] The green ratsnake is suspected to be common in the Sierra San Luis, although it is reliably represented by only three records from the Peloncillo Mountains of New Mexico (Guadalupe Canyon and Post Office Canyon). Sight records for the Animas Mountains in Hidalgo County have not been verified. The species is highly sought after in the commercial pet trade.[34]

The natural history of the green ratsnake is poorly known. Most individuals have been taken in montane mesophytic forests along the slopes of the Mexican highlands. In western and southern Mexico, it is also found in more xeric thorn forests (Price 1991). In New Mexico, *Senticolis* has been encountered in rocky riparian areas grown to cottonwood, sycamore, oaks, ash, and mesquite. These snakes are secretive but not uncommon along Cave Creek in the Chiricahua Mountains in Cochise County, Arizona.

**New Mexico Ridge-nosed Rattlesnake (*Crotalus willardi obscurus*).**
The ridgenose rattlesnake occurs mostly within the highlands of the Sierra Madre Occidental and associated ranges of northwest Mexico. In the United States it occurs in a few isolated mountain ranges in southeast Arizona and southwest New Mexico. The federally Threatened subspecies, *Crotalus willardi obscurus* is known only from the Animas and Peloncillo Mountains, Hidalgo County, New Mexico and Cochise County, Arizona, and from the Sierra San Luis, Chihuahua and Sonora, Mexico. Elevational range in the U.S. is 5,970 to 8,500 feet (1,820 to 2,591 meters) (Animas Mountains) and 5,600 to 6,200 feet (1,707 – 1,890 meters) (Peloncillo Mountains). Diet of this species was studied by Holycross et al[35]; reproduction was studied by Holycross and Goldberg.[36] Populations in the Sierra San Luis are relatively little-studied, thus the elevational limits in this mountain range is unknown. This montane form is generally restricted to rocky hillsides, canyon bottoms, and talus slopes in Madrean woodlands. Dominant vegetation in the habitat includes various oaks (*Quercus* spp.), Apache pine (*Pinus engelmannii*), Chihuahua pine (*P. leiophylla* var. *chihuahuana*), alligator juniper (*Juniperus deppeana*), Manzanita (*Arctostaphylos* sp.), and various grasses.

## Knowledge Gaps

### Lizards

Little is known of the population status and distribution of *Sceloporus slevini* in Mexico, and further study of this declining species could determine if *S. slevini* is an important indicator of habitat degradation by over-grazing.

### Turtles

Although the desert box turtle (*Terrapene ornata luteola*) occurs throughout much of the Peloncillo region, few life history data are available for the desert box turtle. Additionally it is not known how local collecting events affect this species, and further study is warranted.

### Snakes

Little is known of the status of the northern Mexican gartersnake (*Thamnophis eques megalops)* in Mexico, where it is listed as Threatened.

The northern green ratsnake (*Senticolis triaspis intermedia*) has a broad geographic distribution, but its status and presence in the Peloncillo region is poorly documented. Further study is needed, including its natural history. Additional research programs, including the use of radio telemetry should be initiated.

The population in the Sierra San Luis of the ridgenose rattlesnake (*Crotalus willardi obscurus*) is little known. More study is needed, especially given its restricted distribution and endangered status.

## Conservation Targets

### Leopard Frogs

The newly described chytrid fungus, *Batrachochytrium dendrobatidis*, (Longcore et al. 1999) is often implicated in the die-off of populations of ranid frogs in the arid regions of North America. This and other pathogens and parasites can easily be transferred between habitats on equipment or footgear of fieldworkers, spreading organisms to new locations containing species that have little or no resistance to the agents. Therefore it is vitally important for anyone involved in amphibian research and other types of wetland studies, including those on fish, bats, invertebrates, and plants, to take steps to prevent the introduction of disease agents and parasites. Protocols for helping to stem the spread of this and other diseases are at: <http://www.fws.gov/ventura/es/protocols/dafta.pdf>. These guidelines emphasize sterilizing boots, nets, traps, and other gear between aquatic sites; preventing cross-contamination of animals caught at different sites; and quarantine and disease screening of any animals to be released back into the habitat. All resource and land management agencies, as well as researchers, are encouraged to follow this or a similar protocol to prevent or reduce the spread of amphibian and other aquatic borne diseases. For further DAPTF information see http://www.open.ac.uk/daptf/index.htm.

Proper management of the bullfrog is also an important consideration in the conservation of *R. chiricahuensis.* Bullfrogs are well known as large, voracious, aquatic predators that have been

implicated in the decline of certain native frogs throughout western North America.[37] The expansion of bullfrog populations and the presence of large numbers of these frogs in western North America are a result of intentional introductions and the creation of naturally rare favorable habitats. Prior to settlement by Europeans, permanent ponds and lakes were scarce in the arid parts of this continent. Now however, there are thousands of these aquatic habitats created in response to agricultural, domestic, and recreational needs, and for flood control.[38] Bullfrogs have successfully colonized these habitats and have been an important agent in the disappearance of native leopard frogs through direct competition and consumption.

As important conservation considerations and given that bullfrogs are not native to this area, intentional introductions should be halted. The possession of live bullfrogs (either larvae or adults), by private or commercial interests, intended for bait, pets, or consumption should be strictly controlled or banned. Elimination of bullfrogs, through harvest, dewatering, or other means should be attempted at all occupied sites.

Non-native fishes, especially trout, sunfishes, and catfishes, have also been implicated in the decline of native frogs in the Southwestern US and elsewhere. For example, in the San Rafael Valley, Arizona, *R. chiricahuensis* were found only at sites that lacked non-native fishes,[39] and Sredl and Howland noted that these frogs are nearly always absent from sites supporting bullfrogs and non-native predatory fishes, including mosquitofish, trout, and catfish.[40] Intentional stocking of these species by wildlife management agencies should be halted anywhere near where native leopard frogs are know to occur. The fact that state fish hatcheries and stocking programs are supplemented by federal tax revenues distributed by USFWS—the same agency ultimately responsible for protection of endangered species in the US—emphasized the conservation value of coordinating actions by the many arms of public land and wildlife management agencies.

Maintenance of healthy stock tanks is also important in the conservation of *R. chiricahuensis*. Since many of the remaining populations are located in stock tanks, USFWS proposed a special rule to exempt operation and maintenance of stock tanks on non-federal lands from the Section 9 take prohibitions of the Endangered Species Act.[41] This special rule was designed to encourage private landowners and ranchers to continue to maintain stock tanks.

**Lizards**

Populations of the state-listed *Sceloporus slevini* should be routinely monitored to investigate current status. These studies should be conducted for an entire year, as populations tend to fluctuate widely during the year. Overgrazing in high-elevation bunchgrass habitat was implicated in declines of *Sceloporus slevini.* Bock et al. suggested that the apparent restriction of *S. slevini* to montane meadows might be an artifact of over-grazing of lower-elevation perennial grasslands[42]; further study could determine if *S. slevini* is an important indicator of habitat degradation by grazing.

**Turtles**

One of the main threats to turtle populations in the region comes from human collecting, especially for the pet trade and for "turtle racing" events. In Texas during 1999, for example, 865 *Kinosternon flavescens* and 528 *Terrapene ornata* were reported to be collected by resident or non-resident nongame permit holders.[43] Most of these 1,396 turtles were likely sold into the pet trade. During the "Annual Turtle Race" held each year [since 2000] in Clovis, New Mexico, box turtles are collected and allowed to "race" for a cash prize. These turtles are then liberated "*en masse*" by fair officials at one or two localities, often considerable distances from the original point of capture. During 2000, there were 150 turtles collected for this race; during 2001, 247 turtles; and during 2002, 109 turtles.[44] This suggests these species are commonly encountered and are therefore often collected for the pet trade industry. To further aid in the conservation of these species in the Chihuahuan Desert region, detailed life history studies should be initiated to investigate population status. Collecting permits should be required by wildlife management agencies and monitoring of the take should continue. When the turtles are displaced from their original home ranges, these turtle "races" should be discontinued.

**Snakes**

The subspecies of the Mexican gartersnake (*Thamnophis eques megalops*) is state listed as Endangered in New Mexico where it is very rare or perhaps extirpated, likely as a result of long-term drought and water depletion. In Arizona it is a Candidate species and is restricted to a few wetlands in the southeast corner of the state; and in Mexico where it is listed as Threatened, the status throughout much of its range is unknown.[45] This highly aquatic garter snake should be protected from take throughout its range in the U.S. In Mexico, further distribution studies should be conducted. [Conant conducted most of the fieldwork for his recent review paper[46] during the mid 1960s. Therefore, the current status of the habitat and many of the populations of *T. eques* is unknown, although it is likely that much of the habitat has been dewatered and the populations likely extirpated.]

The northern green ratsnake (*Senticolis triaspis intermedia*) is highly sought after in the commercial pet trade.[47] Its natural history is poorly known, as is its distribution in the region. This species should be protected from take except by qualified researchers investigating various aspects of its life history. Riparian areas should be protected from catastrophic fire, whether management-ignited or naturally occurring.

The ridgenose rattlesnake (*Crotalus willardi obscurus*) is threatened by catastrophic wildfire.[48] In modern times fire frequency within the habitat of *C. willardi obscurus* has decreased greatly as a result of active fire suppression and reduction of fine fuels by livestock grazing. After nearly a century of suppression, fuel loads are greatly elevated above "natural" levels, thus increasing the potential for catastrophic fires. Reintroduction of fire into these habitats is essential in maintaining a mosaic of habitats. However, prior to the reintroduction of large-scale summer fires, consideration should be given to reducing artificially high fuel loads to preserve habitat and reduce mortality of the New Mexico ridgenose rattlesnake.[49]

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# 2.5 Invertebrates of the Peloncillo Region: Richness and Mystery

*Photo © 2005 by Steve Prchal. Mutillid wasp.*

## *Outstanding Features*

- *Largely unexplored insect diversity likely includes at least 5,000 species, and perhaps many times this number.*
- *Almost 400 species of bees are known from the San Bernardino NWR alone and some 1,000 are estimated to live within the Peloncillo region.*
- *Several of the region's narrowly endemic talus snails and springsnails are officially considered species of concern.*
- *As one of the southernmost ranges with direct riparian connections into Mexico, the Peloncillo region hosts a high number of neotropical butterflies.*

Although few formal studies on invertebrate diversity have been conducted within the bounds of the Pelconcillo region, several sources of information suggest that this area represents one of the most diverse arthropod communities in the nation. Several factors contribute to this extraordinary richness, starting with the area's tremendous plant diversity. The area's location at the convergence of so many distinct biotic provinces undoubtedly also boosts diversity. The area also shows many examples of species at or near the edges of their ranges. Here, for example, many predominantly tropical species can be found interacting with a suite of neighbors from all quarters of the continent. There are numerous known endemics (known only from parts of the Peloncillo region), and certainly more that remain undiscovered. Several are part of local radiations, with different forms on each nearby mountain range.

In addition to being species-rich, the invertebrate fauna in and around the Peloncillo Mountains is unusually interesting. The biology of this fauna is arguably better-known than in any comparably rich North American region. Virtually all animal behavior and ecology textbooks in the nation feature case studies discovered or developed in this region (many in the bajadas of the San Simon valley and the neighboring Chiricahua Mountains).[1]

Much remains to be discovered. Many fascinating species are known to occur in nearby lands, but researchers have not yet looked for them in this focal area. When they do collect in the Peloncillo region, researchers often find that their catches extend a species' known range by hundreds of miles, add a new name to lists for the state or for the nation, or reveal a species entirely new to science. Even for species known to occur here, additional research often reveals that local populations have diverged from their outside relatives in genetics, morphology, and/or behavior.

Unlike the field of botany, in which researching the flora of specific sites still has prestige and is readily published, there is very little emphasis on place-based research in invertebrates. Information on what species live where exists, but is widely scattered and embedded in the small print of taxonomic monographs, ecological studies, and the like. Efforts to database entomological collections is making this information much easier to come by, but most collections are still in the early stages of this process.

**Geographic scope**. In desciption of the invertebrates of the Peloncillo region, most questions discussed here are applied to an area from the northern Peloncillo Mountain Wilderness south to Guadalupe Canyon and the border with Mexico, and from just east of the Animas Mountains across the Peloncillo Mountains to the San Bernardino and San Simon Valleys. Contiguous with the southern Peloncillos and Animas Mountains in Mexico lies the Sierra San Luis. The Sierra San Luis range has received very little attention by entomologists, but what has been discovered is quite spectacular; discussions here include this range when possible. Some data discussed in this report come from the Chiricahua Mountains just west of the San Simon Valley and/or from the grasslands of the Jornada Experimental Range some 50 miles east of the Peloncillo Mountains proper. Although these sites are interesting in their own rights, their data are used here only to fill in gaps in knowledge of the fauna in the area outlined in the previous paragraph.

## *Current Knowledge*

Invertebrate species represent over 90% of the terrestrial species on the planet.[2] Because of the sheer number of species involved, details of invertebrate diversity are notoriously difficult to document and to make sense of. The number of species reported from an area, for example, usually has more to do with how much attention the area has received than with how many species actually live in that area. This means, however, that each new effort brings many discoveries. It is not unusual for several of the species collected in a given sample to represent range extensions of hundreds of miles[3], or for a casual observation to reveal behavior or natural history never before known to science.[4]

A report such as this addresses several types of questions and conveys various kinds of knowledge. First is the question of how many invertebrate species reside in the region. Next, what are these species? Where else do they live? What do they do in their own lives? How do they interact with each other, with other flora and fauna, and with abiotic factors such as soils and climate? How do management decisions affect them, and how do they affect outcomes of human activities? To the extent that our knowledge bears upon each of these questions, they are answered below under themes of species richness, species identities, distributions, biology and behavior, ecology, and management.

**Sources of information within the region:** The Peloncillo Mountains have received very little formal invertebrate research of any sort. More has been done in the San Simon Valley, some in and around the San Bernardino National Wildlife Refuge, and some in the Animas Valley. Most site-specific information that does exist for invertebrates in this area remains unpublished and has not been previously compiled in any accessible way. Other data remain to be compiled. Much of our knowledge about invertebrates in this focal area therefore comes from personal communications with experts who have collected there. Taxon lists in Appendix G pull together both unpublished collections data and published information from a variety of sources.

**Sources of information extrapolated from nearby sites:** Much of our knowledge about invertebrates in the Peloncillo region therefore comes from extrapolations, estimates, personal communications with experts who have worked with particular taxa, and studies done nearby.

Studies conducted just outside the region provide quite a bit of information about species that most likely also exist here, and about the ecological roles of invertebrates in similar habitats. Two main sources contribute the lion's share of information: the American Museum of Natural History's Southwestern Research Station (SWRS) and the Jornada Experimental Range (JER). Many of the scientists consulted on site-specific data have also worked out of one or both of these institutions.

The Southwestern Research Station is located on the east flank of Arizona's Chiricahua Mountains, just seven miles across the San Simon Valley from the Peloncillo Mountains. SWRS has been one of the nation's most productive sites for invertebrate research since 1955 when the station was founded at the urging of scientists who felt they had found entomological heaven. SWRS-affiliated scientists work throughout the Chiricahua Mountains, from mid-elevation pine-oak habitats that are well-represented in the Peloncillos, to higher mixed-conifer habitats that do not exist in the Peloncillos proper but do occur at the tops of the Animas and Sierra San Luis. They also work in the bajadas and bottomlands of the San Simon Valley, within the Peloncillo focal area.

Studies based at SWRS have spawned over 400 scientific research papers on insects, including over 200 on ants alone, plus some 60 papers on spiders and scorpions.[5] This number does not include countless taxonomic papers that make use of specimens collected in this area, but are not primarily focused on this site. Unfortunately, taxonomic lists have been compiled for only a handful of the invertebrate groups studied in and around the Chiricahuas; most of the lists that do exist remain unpublished, available only from the list authors or informally circulated online.[6] Nevertheless, the Chiricahua-based research is full of fascinating biological stories, and a determined researcher can glean from this scattered literature a large number of taxa that may well occur in the Peloncillos, as well as an idea of what these creatures may be doing. When a species is found in the Peloncillos, Chiricahua research can add depth to the discovery by bringing to bear previous studies on its behavior, ecology, and/or natural history.

The Jornada Experimental Range lies some 150 miles northeast of the Peloncillos in southern New Mexico. This experimental range was designated in 1912 when a Presidential Executive Order deeded 193,000 acres (78,000 ha.) of grasslands and Chihuahuan desert scrub to the U.S. Department of Agriculture, to be used for research on management and remediation of desert grasslands. The site was included in the National Science Foundation's Long-Term Ecological Research network in 1982, which brought a renewed focus on understanding effects of climate change and other long-term processes on flora, fauna, hydrology, and soils. JER studies on invertebrates have focused largely on the roles of invertebrates in ecological dynamics such as herbivory and plant competition, nutrient cycling, and soil aeration and fertility. JER studies have also included species inventory work for particular invertebrate groups, and behavior and natural history of selected species.

**Other sources of information by extrapolation:** Because of the sheer magnitude of species involved, knowledge about invertebrate richness is generally dealt with differently than that of vertebrate taxa like birds, herps, or mammals. Extrapolations are based on rules-of-thumb relationships and sometimes just hunches. For other species, it is often assumed that lists of observed species are close to complete; i.e., that they represent the whole fauna present. In

contrast, most invertebrate diversity discussions revolve around predictions and estimates; not even the best-studied parks in the nation claim to have a complete inventory of their invertebrate faunas. These predictions are ball-park endeavors. They may be based on correlation between taxa (e.g., between numbers of plant species and numbers of insects, or between, say, butterflies and beetles), or they may be based on equations that use the number of species that have been found only once or twice to predict how many have not yet been found at all. Many predictions do not include taxa such as mites or nematodes that are hyper-diverse but difficult to sample and identify well. The smaller the group, the more accurate estimates tend to be—e.g., predictions of butterfly diversity will be more accurate than predictions of insect diversity, and insect predictions will be more accurate than those of invertebrates as a whole.

## *Overall Patterns of Invertebrate Diversity*

**An overview of current understandings:** Some of the area's broader patterns are evident already, even with the limited amount of work done here. Several sources of information suggest that the Peloncillo region represents one of the most diverse arthropod communities in the nation. The area's exceptional plant diversity (see Chapter 2.2) almost certainly drives much of the diversity of herbivorous insects such as butterflies, grasshoppers, and many beetles. As in other animal and plant groups, this area is a mixing ground for the temperate and tropical groups. Many groups range no farther north than this region, and others range no farther south. The region includes, for many taxa, representatives of species typical of the western reaches of the continent as well as species typical of the eastern reaches. There are some local endemics (especially in certain groups such as talus snails) and more for which this area makes up a large portion of their known range. The high elevations typically host very different invertebrate communities than do the low elevations. The diversity of soil types increases local diversity of many groups, and the high diversity of plant species brings with it a huge increase in insect diversity relative to other parts of the U.S. For a select set of taxa about which a noteworthy amount is known, information is summarized below and fleshed out later in the chapter. At the end of this chapter, we also outline preliminary strategies for improving knowledge of Peloncillo-area invertebrates.

### Overall Species Richness

Intensive inventories could reveal an overall invertebrate diversity in the tens of thousands of species. The Great Smoky Mountains National Park has documented over 4,200 invertebrate species (mostly arthropods), and estimates that the total number may exceed 70,000.[7] By virtue of its size and biogeographic location the Peloncillo region likely harbors at least as many as this park. Researchers making informal, conservative predictions of insect diversity in other southwestern parks estimate at least five insect species per plant species.[8] This ratio predicts the Peloncillo region would harbor over 4,000 insect species alone, and that adding other arthropod groups such as spiders, scorpions, and centipedes would likely bring the total to well over 5,000 (not including hyper-diverse, difficult to survey taxa such as mites).[9] This is probably a severe underestimate; in five years of collecting, one Smithsonian entomologist has found 4,000 insect species in his Maryland backyard.[10] True arthropod diversity of the Peloncillo could be several times this number, given the huge diversity of hard-to-sample taxa such as mites and parasitoid

wasps. Including other hard-to-sample non-arthropod taxa such as nematodes and other soil invertebrates would be the factor that brings the total diversity number into the range of the tens of thousands estimated at the Great Smokies park.

Insect collections done in the region support these richness predictions, as low end order-of-magnitude figures. The University of Arizona entomology collection already contains nearly 2,000 species from the neighboring Chiricahua Mountains; 1,009 of these are beetles.[11] This collection represents mostly haphazard collecting rather than systematic attempts to inventory the range, suggesting that the additional collecting would add many, many more species.[12] Richness of Hymenoptera, Diptera, and Lepidoptera could reasonably be expected to be on the same order of magnitude as that of Coleoptera. While many fewer collections have been done in the Peloncillo region,[13] all but the highest-elevation Chiricahua species could occur here (and even these could occur in the taller Animas and Sierra San Luis Mountains).

## Unusually High Diversity Within Groups

Bees take the grand prize for unusually high diversity, with over 400 species known from the San Bernardino National Wildlife Refuge alone and some 1,000 estimated to live within the Peloncillo region.[14] This is far more than in a similar-sized plot of tropical rainforest. Ants and butterflies are close behind, with some estimated 200-300 species each.[15] If beetles were better known for the area, they would likely rival or top each of these groups.

## Biogeography: Regional Mixing Ground

The Peloncillo region represents an overlap and blending of several major biogeographic zones, spanning the transition from tropical to temperate and the saddle between the eastern and western slopes of North America's mountain spine. Within this blending zone, the Peloncillo region hosts invertebrate species typical of the Chihuahuan Desert, Sonoran Desert, Rocky Mountains, Sierra Madre, and beyond. Butterflies exhibit some of the clearest examples of these patterns within the Peloncillo area. The Desert hoary-edge skipper (*Achalarus casica*), for example, is predominantly a Sonoran Desert species, while the range of the Chiricahua white *(Neophasia terlootii)* largely tracks that of the Sierra Madre. Similarly, the Eastern black swallowtail (*Papilio polyxenes asterius*) reaches its western-most U.S. distribution here, just where the Western orangetip (*Anthocharis sara*) nears its eastern edge. The Peloncillos lie at the south end of the ranges for some temperate and alpine species such as the Western tiger swallowtail (*Papilio rutulus arizonensis*) and the Western marble (*Euchloe hyantis*). Many more species find their northern limits here. The Yellow brimstone (a.k.a. angled sulphur *Anteos maerula*), for example, ranges from here to Peru. The Black-tipped (a.k.a. yellow mimosa sulphur *Eurema nise*) ranges from here south to Argentina.

## Endemism and Evolutionary Radiations

Of all the invertebrates examined here, mollusks have the highest known rates of endemism, with each mountain range in the region typically having at least one endemic species and most having more. Many of these are part of evolutionary radiations that are particular to the Sky Island region: species on various ranges have all diverged from a common ancestor, and each has

become unique to its own small range. Talus snails of the genus *Sonorella* are well-known for this type of radiation in the Sky Islands.[16] Several endemic *Sonorella* species occupy particular sections of the greater Peloncillo region.

One relatively well-known local radiation with a Peloncillo representative concerns the jumping spider *Habronattus pugillus*. This oak woodland spider has isolated populations on at least 18 Sky Island ranges. Each population is adorned with its own distinct set of courtship ornaments, and males on each range perform their population's own unique dance for their females.[17] The Peloncillos form, discovered in 1998, differs from all other population most strikingly in having shiny butterscotch-colored pedipalps, which males wave prominently during their courtship displays.

## Edge-of-Range Representatives

The family Mutillidae (velvet ants) presents one of the clearest patterns of species near the edges of their ranges. The Peloncillo region includes several species such as *Dasymutilla dugesii* that reach their farthest south here, and even more that come from tropical ranges to their northern limits here. *Dasymutilla magnifica* and several more flow in from the western deserts to reach their farthest east here. *Dasymutilla nigripes* and others are mostly eastern species that "leak" across this low point of the Continental Divide.[18]

Scorpions show some similar patterns, with Sonoran Desert species near the eastern edge of their ranges occupying many low elevation Peloncillos rock outcroppings. Chihuahuan Desert species more typical of lands east of here tend to occupy the valleys and bajadas.[19]

## Neotropical Representatives

Dragonflies are one of the best examples of Neotropical representation. Although several of the species known from this area are common throughout North America, and a handful of others are typical Western species, the majority are predominantly tropical. A number of our species range as far south as Brazil and Argentina. The Sky Island region of far southeastern Arizona and southwestern New Mexico forms most or all of the U.S. range for a dozen dragonfly species, and several more damselflies. These include the malachite darner (*Coryphaeschna luteipennis*), the spotwinged meadowhawk (*Sympetrum signiferum*), and the plateau dragonlet (*Erythrodyplax connata*). The desert shadowdamsel (*Palaemnema domina*) is the only representative of this tropical family to be found within the U.S.

While many, many tropical species in other invertebrate groups range as far north into the Peloncillo region, it is the tropical butterflies that attract thousands of humans each year to the Sky Islands to see species found virtually nowhere else in the U.S. Because of this attention, butterflies have become perhaps the best known of the invertebrates in the region. As one of the southernmost ranges with direct riparian connections into Mexico, the Peloncillos harbors more than its share of neotropical butterflies. Guadalupe Canyon in particular is a popular destination for many traveling butterfly fans.

## Habitat Diversity

The Peloncillo region includes a wide range of habitat types. The diversity of tiger beetles is one of the best examples of how the diversity of habitats can boost that of species. Several of the region's tiger beetles are specialists on alkaline salt flat habitats that periodically fill with water (known locally as *playas*). Playa species include *Cicindela willistoni, C. haemoragica,* and *C. nevadica*. Grassland species tend to be restricted to grasslands; these include *C. pulchra, C. horni, C. debilis*, and *C. obsoleta.* The latter is so particular about its haunts that it is considered a possible habitat quality indicator for healthy native bunchgrass habitats. Another species, *Amblycheila baroni* (suspected but not yet confirmed in the region), lives only at the bases of large granite boulders.

## Vulnerable Species and Habitats

Few invertebrates are officially listed as threatened or endangered, simply because we don't have enough information about each to know which are vulnerable. Several of the Peloncillo region's narrowly endemic talus snails and springsnails are officially considered species of concern.[20] Some entomologists in the region also consider the unicorn mantis (*Pseudovates arizonae*) a species of concern due to its rarity and localized distribution[21]; this species has been found in the southern Peloncillos.[22]

General landscape protections established for wide-ranging "umbrella species" such as jaguars or wolves will preserve habitats needed by most invertebrates. However, some species with very small ranges or very specific habitat requirements may need additional targeted management. Endemic talus snails or springsnails, for example, may live on just one hillside or in one isolated cienega. Negative impacts to such small areas can usually be avoided easily—if the need to do so is recognized. Invertebrate diversity can pop up in surprising places: rare soil types may harbor unique native bees; stabilized dunes may be home to tiger beetles found nowhere else in the region; rain may turn a shallow dry puddle into a seasonal pool teeming with fairy shrimps and other crustaceans. Plant assemblages such as willow thickets that form valuable *parts* of other animals' habitats may be the only thing that sustains a species such as the increasingly rare viceroy butterfly.

The valleys and mountains of this region have a wide variety of ephemeral waters, including alkaline playas, stock ponds, seasonal washes, rock holes, and other puddle-forming sites. These pools fill with water for anywhere from a few days to several months, once a year or several times per year, and provide habitats for an untold number of invertebrates. Within weeks of a filling rain, pools such as these have been documented accumulating over 100 invertebrate species, many of which are found only in these habitats.[23] When a pool dries, mobile species, including most of the aquatic insects, leave to find other waters or to complete a dry-land phase of their lifecycle. Others, including the freshwater crustaceans, stay put and enter a state of suspended animation until their own pool refills – perhaps many years in the future.

Riparian areas also contribute disproportionately to the Peloncillo region's total invertebrate diversity, even though they comprise a small percentage of its overall acreage. Native bee diversity tends to be highest in riparian areas, as does that of butterflies, beetles, ants, spiders, and more. Many of these invertebrates depend on the many plant species that grow only in more

mesic parts of the focal area, while others depend on riparian areas' increased abundance of potential prey species, on soft riparian soils, or on the availability of water itself. Springs provide some of the same general resources; they also provide isolated patches of habitat that tend to support a unique set of species, including some endemics.

The diversity of soils present in the region includes micro-habitats important to invertebrates such as ground-nesting bees and tiger beetles but overlooked by most humans. Experts strongly suspect that some patches of unusual soils contribute disproportionately to invertebrate diversity, but the identity and location of such soils are still subjects of speculation.

Additionally, many flying insect species engage in a behavior called "hilltopping," in which males and females congregate at the tops of hills to find mates. These topographical "singles bars" may seem to humans as unremarkable bumps on the landscape, but development of hill tops (e.g., homesites) can interrupt the lifecycles of many dragonflies, butterflies, beetles, and other invertebrates.

## *Discussion by Invertebrate Group*

### MOLLUSKS

Most mollusks known from the region are land snails from several genera. Studies in the 1950s on land snails of central and north-central New Mexico found that lands between 8,100 and 10,000 feet in elevation tended to harbor the most species of land snails, with slightly fewer from 7,100 to 8,100 feet and many fewer below 7,000 feet.[24] Not surprisingly, more mollusks are known from the Animas Mountains than from the Peloncillos. Local mollusk expert Richard Worthington lists 22 species from the Peloncillo and Animas Mountains. Little is known about the mollusk fauna of the Peloncillo region south of the Mexican border (Sierra San Luis). Because mollusks in the area remain poorly studied, any conclusions regarding diversity should be regarded as tentative pending further study. In particular, experts note that permanent water resources have not been adequately checked for mollusks.[25]

**Endemism**: The most notable feature of mollusks in this region is how many are endemic to very small areas, often to just part of one mountain range. Across the Southwestern US, high-elevation land snails in these isolated mountain ranges tend to be restricted to one or two mountain ranges, and some are found only in one part of one range. Nearby ranges often harbor related but distinct species. Several snails now known from one small area have been found as Pleistocene fossils from other sites, suggesting that some of this endemism is relatively recent (e.g., within the last 13,000 years) and that these snails may be good indicators of climate change.

The Peloncillo Mountains have an endemic mollusk, the talus snail *Sonorella hatchitana peloncillensis.* The genus *Sonorella* is known for its high rates of endemism in the region.[26] *S. h. peloncillensis* appears to be restricted to the Skull Canyon area of the range. Other parts of the range with apparently suitable habitat have been studied but no other populations have been found.[27] One *Sonorella* shell that may belong to this species was collected in Doubtful Canyon to the north.[28] However, because the individual was immature and species-specific diagnostic

features of adult genitalia are not present in immature shells, we cannot know for certain whether this shell represents a population of *S. h. peloncillensis* or not.

The Animas Mountains are home to three endemic snails, including the talus snail, *Sonorella animasensis.* This species is known from near Black Bill Spring, from the north slope of Animas Peak, and from Indian Creek Canyon.[29] All were found in rock rubble and talus of steep slopes. The Animas Peak woodland snail (*Ashmunella animasensis*) is known only from volcanic rock talus slope in the high elevations of the Animas Mountains. Little else is known about this endemic snail.[30] The Animas Mountains tube-shell (*Holospira animasensis*) was described in 2003 from the base of a limestone cliff. The species is now considered to be endemic to the Animas Mountains, since live specimens have been found only in this single mountain range. Fossil shells of what appear to be the same species are known from the nearby Little Hatchet range, suggesting that these snails were more widely distributed during the last ice age.[31]

The San Bernardino NWR harbors an endemic water snail, aptly named the San Bernardino springsnail (*Pyrgulopsis bernardina*; also referred to as *Fontilicella* sp.[32]). This species lives solely in the small complex of springs and spring outflow waters of the SBNWR and adjacent lands. While management at the SBNWR is primarily directed at native fishes and frogs, water-related activities are evaluated and adjusted for the protection of this endemic snail.

**Other mollusks from the region:** Two aquatic species have been found in Clanton Canyon of the Peloncillo Mountains, including the ash gyro (*Gyraulus parvus*) and *Physella virgata*. Both are widespread in the U.S. Three other snails are known from the Blue Mountain region of the Peloncillos. The whitewashed rabdotus snail (*Rabdotus durangoanus*) is a cone-shaped land snail known only from New Mexico. The Southwestern fringed-snail (*Thysanophora hornii*) is a desert snail characteristic of the low, arid mountains of the southern part of New Mexico and Arizona. *T. hornii* needs some cover, for which it will use leaf litter, dead sotol (*Dasylirion*) or yucca stalks, or rock rubble and talus.[33] The genus *Thysanophora* is Neotropical, reaching the northern edge of its range just north of here in Sierra County, New Mexico. A specimen closely resembling the Santa Rita ambersnail (*Succinea grosvenori*) is also known from Blue Mountain, but difficult taxonomy makes it unclear whether the specimen truly belongs this species or to a closely related species (Worthington pers. com.).

The shortneck snaggletooth snail (*Gastrocopta dalliana dalliana*) is known from Indian Creek Canyon in the Animas Mountains, as well as numerous localities in Arizona and Mexico. The species has also been reported from fossil deposits from Santa Rosa (Guadalupe County, New Mexico), where it was found in flood-related deposits along the Pecos River. Because it has only been collected once in New Mexico and its population trends overall are unknown, it was considered for endangered species listing in 1994. This consideration has since been dropped, but it remains a federal "species of concern.[34]"

**Special management concerns:** The main threat to mollusks in this region is destruction and degradation of springs. Fortunately, the San Bernardino National Wildlife Refuge is working to protect the springs under their management, and staff are alert to the needs of the endemic snails. Talus slope endemics are probably much less vulnerable. Even though they, too, are known from very small areas, talus slopes don't tend to be consumed and altered by humans in the way that

springs are. Nevertheless, care should be taken not to alter these small patches of habitat. Neither prescribed burns nor fire suppression is likely to affect species on rocky slopes with little vegetation. Woodland snails, however, could be vulnerable to extreme fire events. (See Appendix G for a list of Peloncillo mollusks, compiled by Richard Worthington.)

## INSECTS

### Order Hymenoptera: Bees, Wasps, and Ants

#### Bees

**Extraordinary diversity**: The most notable feature of this region's bee fauna is its extraordinary species richness. More than 300 species of bees have been found in an area of about 12 $km^2$ around the San Bernardino NWR (SBNWR) and adjacent Rancho San Bernardino (RSB).[35] In the spring months, more than 100 species are active at the same time in the same place. When one considers the Peloncillo and Animas Mountains and their flanking Animas, San Simon, and San Bernardino valleys, bee diversity probably exceeds 1,000 species. Because the abundance of many native bee species varies tremendously from year to year, it may take several seasons of collecting to find most of the species that could be called "common," and many more to develop a relatively complete species list.

Certain habitats contribute disproportionately to this diversity. Habitats where standing water is present support larger bee populations, probably because plants growing there bloom longer and are more abundant. Nesting habitats are also a limiting resource for many native bees. Though each bee species tends to have quite specific requirements for nesting, certain habitats are probably important for more than their share of species. Bees that nest above ground adopt beetle burrows in trees, so forested areas with mature trees (e.g., riparian forests and mesquite bosques) are likely to be especially valuable. Most bees nest in the soil, so areas with loose but stable soils, dunes, wash edges, and the like can be very attractive to bees.

The ecological roles of bees as pollinators mean their importance as a group exceeds that of just their numbers of species. Among the bee species in the Peloncillo area, about 40% are specialists that visit only one or several very closely related plant species. The degree of plant specificity presumably is one reason this area has the highest biodiversity of bees in the world.

**The island effect:** At least two species are restricted to mountaintops, with no apparent migration between populations. One (*Lasioglossum boreale*) has a northern distribution that is isolated on mountaintops in the southern edge of its range. The other species (*Mexalictus californica*) extends from the Sierra Madre Occidental north on Sky Island mountaintops to the Santa Catalina Mountains near Tucson.

**Edge of ranges:** A number of species that are common farther south are known as singletons (only one specimen collected in a given place) in southeastern Arizona and northeastern Sonora.[36] One example of this phenomenon is the capture of single specimen of orchid bee in Arizona. Not only is this the northernmost record for this species, the species itself is a northern representative of a solidly tropical tribe that contains some 180 species in the New World tropics.

Minckley and Reyes note nine other predominantly tropical bee genera that reach their northernmost limits in the Madrean Sky Island region.

**Special management concerns:** Because so many bee species are found in riparian areas, protection of these habitats is obviously very important to native bees. Heavy recreational use of riparian forests could be damaging to native bees by removing snags and dead branches that serve as nesting sites. Chemical brush control over large areas would likely be harmful to native bees, as well as to other invertebrates.

## Mutillid Wasps

Parasitic wasps in the family Mutillidae are commonly called velvet ants because of the soft-looking fuzz that covers their bodies. They may also be called cow killers or mule killers because the stings of some species are reportedly among the most painful of any insect. [The likelihood of getting stung, however, is quite low. Female velvet ants are wingless and have no hive to defend; almost all sting victims either grab or squish a velvet ant on the ground. Males have no stingers.] Velvet ants are most often encountered as solitary wingless females wandering on the ground or low vegetation; winged males also show up at lights at night.

Velvet ants reproduce by parasitizing the cocoons of other solitary bees and wasps in ground nests, wood tunnels, and mud or resin cells. Mutillid females spend most of their adult lives seeking out and parasitizing other bees and wasps, including the ground-nesting bees discussed above. Mutillid diversity is therefore tied directly to the region's legendary local diversity of solitary bees. Some mutillids are generalists while others appear to attack only one or a few host species. Many species, however, are known only from wandering adults, so nothing is known about which hosts they might utilize.

**Unusually high diversity:** This region, and far southern Texas, are perhaps the prime areas for mutillid diversity in the United States. There is extreme local diversity in this region. Mutillid expert Don Manley has collected or identified in other collections over 50 species in the range. This is approximately the same number of species as are known from the entire eastern United States. The fact that over half the species known from the Peloncillos are represented by just one sex strongly suggests that many resident species have not yet been collected. As with native bees above, large year-to-year fluctuations in species' abundances mean that it may take several seasons of collecting to find most of the mutillid species that live in the area.

**Edge-of-range representatives:** As with many other groups, this area does represent the edge of the ranges of many mutillids. The Peloncillo region includes several species such as *Dasymutilla stevensii* that reach their farthest south here. *Dasymutilla magnifica* and several more flow in from the western deserts to reach their farthest east here. *Dasymutilla nigripes* and others are mostly eastern species that "leak" across this low point of the continental divide.

Numerous Peloncillo region mutillids are primarily Neotropical, including *Dasymutilla eminentia, D. apicalata, D. bonita, D. connectens, D. fasciventris, D. ferruginea, D. foxi, D. furina, D. intermixta, D. sicheliana, Ephuta tegulicia, Timulla coahuila, T. neobule, T. oajaca, T. suspensa sonora,* and *T. suspensa suspensa.*

**Endemism and evolutionary radiations:** There are several species of mutillid that seem to be endemic to this area, although only one of these (*Dasymutilla tomberlini*) has been formally described. The Peloncillo region makes up a large part of the known geographic range of several other named species; 13 species are known only from Arizona and/or New Mexico, and 12 additional species are known just from Arizona, New Mexico, and Mexico. Another possible endemic is *Aphonopelma* n. sp. from Clanton Canyon. The scorpion *Diplocentrus peloncillensis* is not known to occur anywhere but in the Clanton Canyon area.

Other named species in the area appear to have differentiated into locally distinct populations. Manley notes that when specimens of these species are sent to him for identification, he can tell at a glance where a specimen was originally collected, within a 30-50 mile radius.

**Special management concerns**: These concerns are likely to be very similar to those for native bees, since mutillid larvae are parasites on native bees. The mutillid species with narrowly restricted ranges should be considered vulnerable to extinction. Several of these restricted-range species are quite numerous in this area. However, so little is known about the biology of these species that it is not at all clear what types of habitat alteration would constitute a threat to their continued existence.

(See Appendix G for a list of Peloncillo region mutillids.)

### Ants

The state of knowledge about ants in this region is an odd mix of rather little published data on diversity at specific localities, and a tremendous amount of long-term, in-depth knowledge about behavior, ecology, and natural history. While little collecting and no formal inventories have been conducted in the Peloncillo Mountains themselves, the neighboring San Simon Valley and Chiricahua Mountains are some of the best-known and most interesting ant communities in the nation.

**Species diversity and composition:** The *Ants of New Mexico* lists collecting localities in the Peloncillos proper for 54 species of ants. [37] Collections at the University of Arizona and locality maps from Arizona State University[38] added six more species (see Appendix G). Quite a few of these species have been found just once in the Peloncillos, which suggests that many more remain to be discovered in this range. For five of these species, the Peloncillo region is the only place they are known to occur within the state of New Mexico. One, *Temnothorax emmae* (formerly *Leptothorax*) was known from nowhere else in the world until it was recently caught in the Chiricahuas.[39] To get a sense for the level of diversity likely to be present in the evergreen woodland habitats of the region, a four-day study of a single small hill in the Chiricahuas yielded 30 ant species.[40] All of these are likely present in the Peloncillos (although only 10 are yet reported from this neighbor range), as the study was conducted just 10 miles away within a range of elevation and plant communities that is common in the Peloncillos.

Valley faunas have received much more attention. Although no species lists have been compiled from these studies, a quick tally includes dozens of species. Robert Chew found an astonishing 23 species in a single 30-meter grid-study plot, in just eight days of sampling in a single season.[41]

Various sources of evidence suggest that the Peloncillo ant fauna could exceed 200 species when the Sierra San Luis and Animas Mountains and flanking valleys are included. Ant researchers have found over 250 species in the Sky Island region.[42] Based on their respective ecology and known ranges, most of these could easily occur within the greater Peloncillo focal area. A draft checklist of ants of Arizona lists 321 species.[43] Of these, 187 have been found in the neighboring Chiricahua Mountains (many during ant taxonomy courses at the Southwestern Research Station).[44] Virtually all of these Chiricahua ants could occur in the Peloncillo region, although high-elevation species would likely be restricted to the upper reaches of the Sierra San Luis and Animas Mountains. Many additional species could occur in the flanking valleys.

**Ecology:** Ants are a major part of virtually any area's ecological dynamics. Researchers estimate that ant biomass exceeds vertebrate biomass in most ecosystems, and that ant bodies make up some 10% of the Earth's total biomass.[45] In this part of the world, decades of studies have shown them to have a major influence on soil aeration and fertility, soil chemistry, seed dispersal and survival, dynamics of plant recruitment, rodent community dynamics, composition of other arthropod communities, arthropod herbivory, and so on.[46] Several of these studies have been running long enough to show the effects of slow acting processes like climate change and to track long-term multi-species population cycles. These are a rare treasure in a world where only a small percentage of ecological studies last more than a few field seasons.

**Behavior and natural history:** Many of North America's most interesting ant natural history and behavior stories have been discovered, and continue to be researched, in this area.[47] For example, dozens of papers have now been published on the slave making ant (*Polyergus breviceps*), which cannot produce its own workers and instead raids the brood of several other local ants, then raises these as their own indentured servants and prevents them from breeding.[48] The seed harvester ant *Pogonomyrmex anergismus* has ceased to harvest seeds and instead functions as a social parasite living inside the nests of related ant species and breeding in the corners of the host's tunnels.[49] Nature films and children's magazines have made the region's *Myrmecocystus* honeypot ants famous.[50] The Peloncillos have at least four species of *Myrmecocystus*, which store sweet nectar in their own bodies. Honey-filled abdomens of these ants can reach an inch long, and make an irresistible treat to almost any animal that is lucky (or persistent) enough to find them—including humans with an adventurous palate.[51]

Deborah Gordon's 20-plus years of studying seed harvester ants in the San Simon Valley (near Rodeo, New Mexico) forms much of the foundation for our understanding of how ant societies function across the globe. Her book *Ants at Work* summarizes these understandings for the lay reader and is one of the most widely recommended books on invertebrate biology. Her work, in turn, builds upon the studies of one of the fathers of ethology, Bert Holldobler, who continues to study ants in the San Simon Valley and surrounding hills. Together with dozens of colleagues, this research group has published some 200 papers on ant behavior and natural history in this region—with far too many discoveries to summarize here.

This area's neotropical affinities make it an especially fascinating place to encounter ants. Most people imagine finding army ants in the densest tropical rainforest. The Peloncillos, however, have at least four species of *Neivamyrmex* army ants, and probably more than 10. One of these, *N. nigriscens,* can reach colony sizes of over a quarter million individuals. Much of what we know about army ant behavior comes from studies in the bajadas of the San Simon Valley.[52] This area also has leaf-cutter ants (*Acromyrmex versicolor),* close relatives to the ones featured in tropical nature shows. Just as they do in the rainforest, leaf-cutter ants here can defoliate entire trees to feed their huge subterranean fungus gardens (albeit smaller desert trees). One often comes across flotillas of bright petals and leaves skimming across the ground and disappearing into gravel craters, with a spiny ant hidden under each piece. *Acromyrmex* nests in the Peloncillo's Granite Gap can show complexes of nest entrances that span more than 20 feet (6 meters) in diameter.

**Special management concerns:** Ants tend to be fairly robust to human activities, though ones with restricted ranges and narrow habitat preferences can still be vulnerable. Species currently known only from this area, or for whom this area constitutes a large part of their total range, should be evaluated to predict what activities might cause them harm.

Riparian species may be more vulnerable to human disturbance than others, simply because these habitats are so limited in arid western North America and because they are favorite places for humans to recreate, build, divert water, and otherwise alter habitat characteristics.

The other major threat to such communities is invasion by exotic species. Whole communities of native ants in the southeastern United States—and other native invertebrates and vertebrates alike—have been devastated by the invasion of the imported fire ant *Solenopsis invicta* (also known as *Solenopsis wagneri*). In 1985 this ant established a small population at Stein's Pass; luckily it was found early and could be exterminated before it spread. So far, no other reports of *S. invicta* have surfaced here, but they should be considered a serious threat. Some researchers suggest that *S. invicta* would have difficult time establishing in places as arid as is much of the Peloncillo region. Others dispute this, citing the fact that this invader has already spread past what were initially considered to be its ecological boundaries. Regardless, the region's riparian areas would be especially vulnerable to invasion by this or other exotic species. The region has at least one native fire ant that looks quite a bit like *S. invicta*; identification of *Solenopsis* species should be done with care to avoid false positives while still making sure invasions are detected early.

(See Appendix G for a list of ants from Peloncillos and Chiricahua Mountains.)

### Order Odonata: Dragonflies and Damselflies

The jewel-like dragon and damselflies have begun to vie with butterflies for the attentions of popular bug-watchers. Because of this, and because odonates have long been recognized as indicators of water and aquatic habitat quality, local species lists and regional distribution maps have been improved greatly in recent years. Odonate-hunters are often still rewarded for their efforts with rare species, new localities, and range extensions.

All dragonflies and damselflies have aquatic larvae and therefore need water sources to breed. Some require perennial streams, others lakes or ponds; several rapid-developing species can even breed in temporary pools. The Peloncillo region has an abundance of ephemeral pools, quite a few perennial stock ponds, several springs, and, in Mexico, both perennial streams and hot springs. The lack of year-round flowing water in the U.S.-portion of this focal area obviously limits the number of odonates that can breed on this side of the border. Adults of many species, however, are strong fliers and can be found miles from the nearest water. Some species found as adults in the Peloncillo Mountains proper may therefore be emissaries from creeks in nearby ranges, or across the border.

As with many other invertebrate taxa, most of the focal area has not been formally surveyed for dragonflies or damselflies. The San Bernardino NWR, however, has attracted many odonate researchers, who report an impressive total of 28 damselfly and 40 dragonfly species from its relatively small management area (see Appendix G).

The states of Sonora and Chihuahua are far undercollected for odonates, but this situation is beginning to change. Collections done on the behalf of the Cuenca Los Ojos foundation in and around Cajon Bonito (in the Sierra San Luis) and the Rancho San Bernardino property (adjacent to the San Bernardino National Wildlife Refuge) have found 55 odonate species.[53] 18 of these have not yet been reported from the US portion of the Peloncillo region.

In adition to species now reported from the Peloncillo region, a Cochise County odonate checklist adds another eight species to the species pool of possible residents, and a new website of New Mexico odonates adds nine more known from Hidalgo County or nearby, bringing the known local species pool to 106 species (note that New Mexico is poorly collected compared with Arizona, so county lists are much less complete).[54] These are listed here as possible residents (see Appendix G). Range maps of several additional species overlap or come very close to the Peloncillo region.[55]

**Biogeography:** The majority of odonates reported from this area have primarily southern distributions (below). Several others are Western specialists, such as the California spreadwing (*Archilectes californica*) and the California dancer (*Argia agrioides*). A few more Boreal species find their southern limits here, including the Plains forktail (*Ischnura damula*). Eastern specialists are scarce, probably because this arid zone offers few of the wet habitats these insects are adapted to on the rainy side of the continent. Some have very broad distributions, like the dusky dancer (*Argia translata*), which ranges from southern Canada to Argentina, and the American rubyspot (*Hetaerina americana*), which occurs throughout North America.

**Neotropical representatives:** As mentioned above, many of the odonates in this area are predominantly tropical. Neotropical dragonflies include the malachite darner (*Coryphaeschna luteipennis*), the spotwinged meadowhawk (*Sympetrum signiferum*), and the plateau dragonlet (*Erythrodyplax connata*). Several damselfly species are primarily Mexican species that extend north into southern Arizona, e.g., the Sierra Madre dancer (*Argia lacrimans*), the Aztec dancer (*Argia nahuana*), and the claw-tipped bluet (*Enallagma semicirculare*). Others range far into Central America, such as the spine-tipped dancer (*Argia extranea*) and the black and white

damsel (*Apanisagrion lais*). The canyon rubyspot (*Hetaerina vulnerata*) ranges all the way to Brazil.

**Endemism and taxa with limited ranges:** While several Arizona and New Mexico damselfly species are endemic to small areas, none of these is yet known from the Peloncillo region. Several of the species in this general area, however, do have limited known distributions. The desert shadowdamsel (*Palaemnema domina*), for example, has never been found in the U.S. outside of Arizona's Graham and Cochise counties.[56]

**Conservation notes:** The odonate diversity of this area is quite remarkable, especially considering the scarcity of perennial waters. Odonate experts are lauding land and water protection efforts in the US and Mexico for their roles in maintaining this diversity. Said Sandy Upson to Joe and Valer Austin of the Cuenca Los Ojos foundation, "the demonstrated continued health of populations of *Argia lacrimans, A. tarascana, Macromia magnifica* and *Dythemis maya*, among others, establish Cajon Bonito as being among the most important Odonata centers in Sonora and arguably in northern Mexico. Since dragonflies serve as indicators of the good health of ecosystems, your own efforts are clearly having a major effect. Thank you again!"
(See Appendix G for a list of dragonflies from San Bernardino NWR, Cajon Bonito, Cochise County, and vicinity).

### Order Coleoptera – Beetles

The order Coleoptera is one of the three largest insect orders, with global species estimates ranging into the tens of millions. At this point in time, beetle species lists for the Peloncillo region would be exceedingly long, woefully incomplete, and largely uninformative. A few anecdotes and general comments, however, may help set the stage for future examination of the area's beetle fauna. In addition, one relatively tractable and more thoroughly studied group, tiger beetles, is reviewed in detail below.

Two nearby sources of data may give a sense of the magnitude of beetle diversity present across this region. Collections at the University of Arizona catalog some 400 beetle genera from the Willcox Playa. Over 100 of these were collected by one researcher during a single season of sampling.[57] Most of these could also occur in the Lordsburg Playas area. The family Cerambycidae (longhorn beetles) is one of the largest groups in many forested regions. Linsley et al. report 132 species from the Chiricahuas (including San Simon Valley localities), including photographs and natural history information for many of these.[58] The University of Arizona collections list some additional 30 species. The authors consider almost half of these to be more-or-less endemic to the Sky Island region, and most seem to be on more than one range (e.g., species reported most from the Huachuca Mountains have also been found in the Chiricahuas). Most of the Chiricahua species could occur in our focal area, although the high-elevation species would likely be relegated to the Animas and Sierra San Luis peaks.

Several suites of beetle species from various families—including Cerambycidae (longhorn beetles) and Elateridae (click beetles)—are adapted to fire. Many of these species reproduce only in burned forests of various ages, some only in trees that are still warm from the smolder and others in a successional series as the burnt trees age. Many of these species are rare in collections

because of their ephemeral presence. This has raised concern that some may be vulnerable to extinction, although the fact that they must be very good dispersers to track their ephemeral habitats may buffer them from extinction. The return to a semi-natural fire regime is likely be very beneficial to these beetles, as well as to other fire-adapted insects.

The UA collection reports 60 native bark beetle species (Scolytidae, though many scolytids do not attack trees) from the Chiricahuas, many of which must also occur in the Peloncillos. Some, but not all, bark beetle species naturally experience large population fluctuations that are termed "outbreaks." Outbreaks of bark beetles have raised concern throughout the West. Most of the outbreaks are resolved as the beetles' natural predators (primarily parasitoid wasps but also birds and other insectivores) bring the populations back down to a level at which humans fail to notice their continuing effects. These beetles can cause large local die-offs of certain tree species, which can harm other wildlife that depend on forests. Tree die-offs are also visually alarming to people, and may increase fire risk, which is viewed very negatively when there are human habitations nearby. While such population fluctuations are a natural part of the dynamics of both beetles and forests, there is considerable evidence that some of these fluctuations have become more severe and/or more widespread than they have been in the past (i.e., are outside the normal range of variation). Much of this change is attributed to drought, tree overcrowding, fire suppression, and/or global warming. Carefully thinning overcrowded trees in particular areas may reduce beetle kill in future outbreaks by giving remaining trees more resources to defend themselves, but harvesting infested trees has limited effectiveness in stopping or slowing spread or intensity of an outbreak. Returning to natural fire regimes is probably the most effective and economical means to reduce severity of bark beetle outbreaks in regions such as this.[59]

Another noteworthy event is the apparently recent invasion of the area by the introduced dung beetle *Onthophagus gazella*. This beetle was first noticed in southern New Mexico several years ago, and has been gradually reported from a broader and broader area since then. David Richman at New Mexico State University states that he had not seen many in the Peloncillos until this year, although they may have been here somewhat longer.[60] The UA collection lists 15 species of native dung beetle from the Peloncillos and 24 from the Chiricahuas (many of which probably also occur in the Peloncillo region). This introduced species has the potential to out-compete some natives, particularly congeners with similar habits and body sizes. The process of community change with invasion would be fascinating to document, although there seems little hope of altering its course since there are no known methods for controlling dung beetles (which are beneficial to nutrient cycling and therefore not generally considered pests, even as non-natives).

### Tiger Beetles

Some 111 tiger beetle species are found in North America. Most are restricted to environments with access to open ground, including stream edges, saline flats, seashores, and sand dunes. Although mostly small in size, tiger beetles are important predators of the insect world. Their beauty, diversity, and wariness make them a favorite among collectors worldwide. Besides their appeal to collectors, researchers find tiger beetles to be excellent models to study community ecology, biology, morphology, thermoregulation, predator-prey interactions, biogeography, and physiology. Because of these factors, tiger beetles are one of the best studied non-pest insects. Tiger beetles are also easily studied bioindicators of environmental quality. The presence or

absence of certain species can provide information on the quality of the habitat, successional stage of the habitat, and/or alterations to the habitat. Because of their restricted habitat requirements, tiger beetles are sensitive to environmental degradation, and several species and subspecies are state or federally protected.

Adult tiger beetles are active pursuit predators that hunt on open substrates where can they use their excellent eyesight to locate small arthropod prey, then chase down prey on foot or on the wing. They are legendary for their speed and agility; because of these abilities, catching tiger beetles is considered a great challenge for amateur and professional entomologists alike. Many species are brilliantly colored. Others are well-camouflaged; populations of cryptic species may vary in color according to the soil colors in particular areas. About three-fourths of the tiger beetles in North America belong to the genus *Cicindela*. Species can be distinguished by differences in size, coloration, and markings on their wing covers.

Tiger beetle larvae typically occur in the same location as adults. The adult female selects a spot to lay her eggs, excavates a small hole up to a centimeter deep, deposits a single egg, then covers the hole. Females are extremely selective in choosing oviposition sites, with each species following its own set of preferences. Preferences are so narrow that one rarely finds more than one species of larva in the same site, even where adults of several species are present.[61] After hatching, the larva digs a cylindrical burrow at the site of oviposition. Larvae are also predators, but rely on ambushing their prey from the mouths of these burrows. How quickly larvae develop depends on climate and food availability, and most take two to three years to reach adulthood. The prolonged and sedentary life cycle exposes the larvae to environmental stresses including flooding, drought, and ground disturbance.

**Biogeography:** Of the tiger beetle species in the U.S., almost half (48 species) live in Arizona and/or New Mexico (32 of these occur in both states). Several of these are divided into multiple subspecies; including these subspecies, New Mexico has a total of 64 taxa, more than any other state in the nation. At the species level, 15 are known to occur in the Peloncillo area, with six to eight more considered likely to be found with more collecting.[62] This high diversity can be attributed to the intersection of faunal provinces and to the amount and diversity of arid, open habitats in the region.

Tiger beetle diversity across this region is fairly well documented, though locality information can be spotty. Within New Mexico, however, the southwestern corner of this state remains under-represented.[63] Southeastern Arizona has hosted some excellent studies on tiger beetle biology.[64] The Sulphur Spings Valley (one valley west of the focal area), is considered a "hotspot" for tiger beetle diversity, with documented richness of up to 17 species in and around the salt flats of the Willcox Playa.[65] However, claims about diversity and distributions sometimes conflict with one another. One agency document reports there being 40 species of tiger beetles there (with no supporting documentation or taxon lists), more than are otherwise reported from the entire state.[66] This appears to refer, in reality, to total taxa, including more than one subspecies for several species.

**Edges of ranges and neotropical representatives:** As with many other taxa, the Peloncillo region is near the edges of ranges for several tiger beetle species. *Cicindela wickhami*, for

example, is predominantly a Sonoran Desert species, nearing its eastern edge here. The range of *C. debilis* tracks that of the Chihuahuan Desert, which brings it near its northern and western edge here. The Peloncillos lie at the south end of the ranges for *C. willistoni* and *C. oregona,* and the north end of the ranges of *C. viridistica*, *C. wickhami*, and *C. fera.* Several of the region's tiger beetles are predominantly neotropical, reaching their northern limits in this area. These include *C. viridistica, C. fera, and C. debilis.* The genus *Tetracha* (sometimes included under *Megacephala)* is a primarily tropical genus, with 10 species and six additional subspecies in the tropics and subtropics of Central America and the Caribbean, and two species in the United states, including *T. carolina* in the Peloncillo region.

**Endemism and taxa with limited ranges:** There are no tiger beetle species that are known to be strictly endemic to the Peloncillo region (the geographic area as defined in this report), although *Cicindella pimariana* comes close, being known only from the far southeast corner of Arizona and far southwest corner of New Mexico. For several other species this region makes up a large portion of the species' known range. These include *Amblychela baroni, Cicindela fera, C. horni, and C. viridistica.* Saline species, including *C. willistoni* and *C. nevadica* thought to occur here, exhibit a tendency to form restricted-range subspecies. However, southwestern New Mexico has not been well enough studied to reveal the local diversification patterns in these species.[67]

**Special management concerns – tiger beetles:** Fire supression, development, invasion by non-native weeds, livestock grazing, altered hydrologic cycles, and off-road driving are the activities with the greatest potential to affect tiger beetle species in this area. However, because most tiger beetles need open ground, some moderate-intensity ground-disturbance activities may be positive, at least in certain circumstances.

Direct effects of fire on tiger beetle individuals is not well known, although fire suppression has been implicated in the decline of rare species.[68] Numerous studies report tiger beetles becoming more abundant in an area following fires that open up ground vegetation.[69]

For salt-pan and water-edge species, any activity that changes hydrologic patterns is highly likely to affect the species. Impact to dune-dependent tiger beetles caused by stabilization or destabilization of dunes is well documented.[70] No dune species are currently known from the Peloncillo region, but appropriate habitats have not yet been well surveyed.

Off-road driving has been implicated in the decline or local extirpation of some tiger beetle species.[71] However, because such driving destroys vegetation and leaves bare soils, it has boosted populations of some tiger beetles in heavily vegetated areas. In cases where fire supression or invasive weeds have allowed vegetation to exceed natural levels, off-road driving and other ground-disturbing activities appear to have helped certain tiger beetle species by opening up more bare ground.[72] Such positive effects are not expected in this arid environment.

Grazing does not tend to harm adult tiger beetles, but can trample larvae in their burrows if use is heavy in prime beetle habitat. However, moderate grazing can also maintain open ground that may benefit particular species.[73] Effects on species with restricted ranges and/or narrow habitat preferences should be examined on a case-by-case basis.

Appendix G lists species known to or strongly suspected to occur within the Peloncillo region, along with typical habitat characteristics. Two of these (*Amblycheila baroni* and *Cicindela horni*) are tracked by the Arizona Game & Fish Heritage Management Database as species of interest, presumably because of their restricted ranges (although the choice of these two and omission of species such as *C. pimeriana*, which has an even more restricted range, seems rather arbitrary). None are officially species of concern by any entity catalogued in the New Mexico or Arizona heritage databases.

**Special management concerns - Coleoptera:** With the magnitude of diversity in question, few specific concerns can be addressed, apart from recognizing the special value of riparian areas, and the value of fire to both certain beetle groups and to forest dynamics influenced by bark beetles.

A few species of beetle in the region are considered sensitive or species of concern by various entities. The only one documented from this region is the Animas minute moss beetle (*Limnebius aridus*), listed as a species of concern by the state of New Mexico, New Mexico BLM, and U.S. Fish and Wildlife Service. The Center for Biological Diversity lists it as having gone extinct.[74] Little is known about this species apart from its original taxonomic description.

Beetles of this genus often hide in moss or algae at the edges of springs, marshes, or streams. Because of their small size and secretive nature, they are easy to miss in collecting.

### Order Lepidoptera – Butterflies and Moths

#### Butterflies

Their bright colors, large fan base, and importance as pollinators make butterflies a flagship group for invertebrate conservation. More is known about butterfly ranges and habitat needs than about the needs of any other large invertebrate group. Still, the fauna is so rich that much remains to be discovered.

**Unusually high diversity:** The Sky Island region's remarkable butterfly diversity attracts enthusiasts from around the world to southeastern Arizona and southwestern New Mexico. Although few published lists exist for specific localities in this focal area, regional butterfly diversity patterns can help fill in the gaps, even where we lack data for particular localities. With just one small formal study published, more than 133 species of butterflies have already been reported from the U.S.-portion of the Peloncillo region[75], plus an additional 87 species reported from the Rancho San Bernardino immediately adjacent to San Bernardino NWR on the Mexican border.[76] Since the species list for Cochise County exceeds 240 species[77], and the Gray Ranch list already includes eight species not on the Cochise County list, local butterfly experts predict that more study could easily bring the official U.S. portion's total past 200. If the Sierra San Luis and its riparian drainages were included, the area's butterfly list could exceed 300 species.

**Neotropical representatives:** Southern affinities of the range are strong, especially at the south end of the Peloncillo Mountains, with species like the tropical checkered skipper (*Pyrgus oileus*) and Erichson's white-skipper (*Heliopyrgus domicella*). Guadalupe Canyon has been a favorite

butterfly-watching site for decades. Because this wet canyon opens to the south into Mexico's large Río Yaqui drainage, it is an excellent place to find wandering tropical butterflies. In formal terms, "this canyon is one of the very best influx traps in the region and has a variety of strays rivaled only by Sycamore Canyon[78]" (in Santa Cruz County, Arizona; the most famous butterfly site in Arizona, and one of the best in the nation). *Butterflies of Arizona* notes of Sycamore Canyon: "It is here that one can feel the breath of the Neotropics from mid-June to September, when the land turns green and the sun angels in their countless thousands dance and glide though the air, bringing us dreams of those magical lands to the south.[79]"

**Migratory species:** Many butterfly species make at least short-distance movements at particular times of the year. Individuals will travel to find mates, to find adult foods (puddles, flowers, etc.), to find fresh host plants for their larvae, and, in some species, to overwinter in warmer or more sheltered habitats. Only these last are considered fully migratory.[80]

The Peloncillos are tropical enough to host year-round populations of several species that are migratory in other parts of the U.S. The painted lady (*Vanessa cardui*), for example, summers throughout the Americas. In winter, these lovely butterflies retreat to the south where they will not freeze. The Peloncillos lie in the very northern edge of the painted lady's wintering grounds; it is from these wintering grounds that they spread each spring to repopulate the rest of North America.

Other species require even milder winters, so are found here only in the warmer months. The large orange sulphur (*Phoebus agarithe*), for example, winters in coastal and central Mexico (and south Florida), and graces this area with its bright tangerine wings only during summer monsoons. Another special migratory member of this fauna is the southern snout butterfly (*Libytheana carinenta larvata*[81]). This species winters in Mexico, and each spring its northbound flights fill the San Bernardino Valley with thousands upon thousands of fluttering bodies.

The monarch (*Danaus plexippus*), most famous of all migratory butterflies, meet each winter in two main areas: the mountains of Michoacan, Mexico, and the central Pacific coast of California. It was long thought that all monarchs raised east of the Rockies wintered in Michoacan, and those west of the Rockies wintered in California. It is now clear that this "great divide" is a myth, and that at least some individuals cross back and forth between eastern and western populations.[82] The details of these exchanges, however, are not well understood. The Peloncillo region—sitting at the low spot of the Continental Divide—seems a likely place to find monarchs crossing between populations, and would be a valuable place to include in the ongoing efforts to track movements of individual butterflies.[83] Guadalupe Canyon is thought by many to be an important migration route,[84] and anecdotal evidence already suggests that at least some monarchs in this region may be headed towards Michoacan rather than California.[85] If the area is a significant crossover-zone, it may be important to the genetic exchange and metapopulation structure of these eastern and western monarch populations.

**Special management concerns:** Because a fair amount of information remains to be learned about butterfly populations and ecology, management will continue to be a challenge. Caterpillar ecology and host plant use are poorly understood for many species. As mentioned above, migration patterns are also poorly understood. No inventories have been conducted in the higher

elevations of this area. The boreal fauna is therefore unknown. This should be a priority, since high-elevation butterflies are thought to be particularly vulnerable to forces such as climate change because of their lower tolerance for warming[86] and the disproportionate loss of high-elevation habitats in isolated mountains such as these. None of the butterflies known to occur in this region is federally or state listed as endangered or threatened. However, several species are considered vulnerable by one entity or another, and a number of general recommendations can be drawn for the fauna as a whole. The Prittwitz's skipper (*Adopaeodes prittwitzi*) is a cienega specialist known from springs in southeastern Arizona and southwestern New Mexico, including the Gray Ranch. *A. prittwitzi* caterpillars are only known to feed on knotgrass (*Paspalum distichum*). The species has no formal concern status, but is nevertheless of conservation interest to the Arizona Game & Fish Department, which recognizes how vulnerable the species is to continued degradation of spring systems.[87]

The U.S. Forest Service recognizes a number of sensitive butterfly species in Region 3. These include several *Agathymus* skippers, the larvae of which bore into the leaves and stems of agaves. *Agathymus aryxna* is known from the focal area, with *A. polingi* reported but unconfirmed. These species have narrow distributions, but appear to maintain healthy populations wherever their agave hosts occur.[88] The blue silverspot butterfly (*Speyeria nokomis coerulescens*) is a high-elevation butterfly that appears to be extirpated from the U.S. It or other subspecies could occur in the Sierra San Luis, but the range has not been adequately surveyed. The viceroy butterfly (*Limenitis archippus obsoleta*) depends on willow thickets for its larval growth, and has been reported from the San Bernardino springs and the Gray Ranch. Although widespread, this butterfly is considered to be at risk of extinction because so much of its riparian habitat has been lost or degraded. Across its range, some of this habitat loss has come at the hands of the invasive tamarisk tree, which has replaced many cottonwood and willow stands across the West; some has come at the hands of water diversion, overgrazing of riparian areas, and development. Keeping tamarisk out of this area and otherwise maintaining willow thickets will be a boon to the species.

Just one species known from the area has a Heritage Ranking of G2 (Rare/Imperiled) on the global and state (Arizona) scale: the Arizona metalmark butterfly (*Calephelis rawsoni arizonensis*), a resident of low mountains including parts of the Gray Ranch. Global G3 (Uncommon or Restricted) species reported from this area are Chiricahua pine white butterfly (*Neophasia terlootii*), a mid-elevation species well-known in the Chiricahua Mountains with unconfirmed reports from the Animas Mountains;[89] and the Pima orangetip butterfly (*Anthocharis pima*), a desert and foothill species known throughout the Sky Islands, including Cochise and Hidalgo Counties. The cyna blue butterfly (*Zizula cyna*) and the definite patch butterfly (*Chlosyne definita)* are known from nearby counties and may also occur here.

In more general terms, all herbivorous insects depend on finding adequate populations of their host plants. Maintaining ecological processes that sustain plant diversity therefore helps protect insect diversity across the spectrum. Conversion of botanically diverse communities such as open savannas, prairies, grasslands, and woodlands to less-diverse stands dominated by shrubs, trees, or invasive weeds tends to reduce butterfly diversity, sometimes dramatically so. Unless species have been extirpated from a large area, butterfly diversity often rebounds when natural stand structure is restored via fire or other methods.[90]

While restoration of natural plant community structure is generally beneficial to butterfly assemblages as a whole, one must keep in mind that restoration methods (e.g., fire and mechanical thinning) can affect individual species differently in the short term. Species whose habitats are highly fragmented (naturally or as a result of habitat loss) can be vulnerable to direct mortality and short-term loss of food plants from fire.[91] Butterflies are sensitive to changes in microclimate, so thinning of trees or shrubs can affect them directly (positively or negatively).

Declining numbers of particular plants can doom butterfly populations that depend on them, as in the case of the Viceroy above. Any effort to maintain a rare plant species or plant assemblage has the potential to rescue its associated butterflies (and other insects) from decline as well.

Nectar-producing flowers are a resource used by many, many species. Any areas with especially abundant and diverse flowering plants, e.g., riparian areas, are therefore of particular value for butterflies. Migratory species are especially dependent on such "nectar corridors" to fuel their long-distance flights.[92] Any factor that degrades or interrupts these flower swaths, or makes them hazardous to insects, will harm butterfly populations. Activities such as dewatering of streams and widespread application of pesticides in riparian areas or along flowering roadsides should obviously be avoided.

Extensive use of pesticides—and transgenic crops that produce their own pesticides—has caused problems for butterflies in some areas. Peloncillo-region agriculture is now fairly limited, so the area's isolated pesticide use in small patches of cropland is probably not a major threat to butterfly species in general. Nevertheless, some species whose host plants occur in or at the edges of fields may be affected. Some studies have found that monarch caterpillars are poisoned by toxic pollen from transgenic corn when the wind-borne pollen falls on their milkweed host plants (though other studies debate how significant these effects are in natural settings).[93] It is not known whether corn crops here are transgenic, though these varieties have become very widely used. This area harbors several milkweed species, including both field species and others that grow in natural areas away from croplands; caterpillars feeding on the latter should not be affected by agricultural activities.

Global climate change has already begun to affect butterfly distributions and life histories.[94] Maintaining north-south movement corridors and connections between natural habitats at all elevations will help taxa like butterflies to adjust their ranges as conditions shift. Because of this region's elevational gradients and its location at the edge of many species' current ranges, it would likely be a very informative place to study such range shifts. In time, this region may well lose some of its northern and upper-elevation species, but it may also provide refuge for tropical species that do not yet occur here. Climate change may also alter migration patterns of some species.

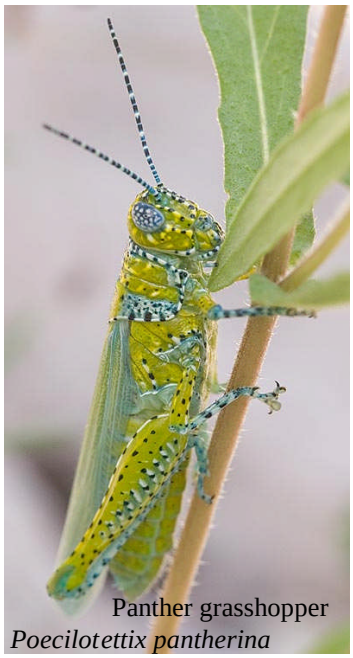
### Moths

No data have yet been compiled on moths, but entomologists expect, as a rule of thumb, that the number of moths in an area will be ten times that of the butterflies.[95] This brings a staggering prediction of 2,000-3,000 moth species in the Peloncillo region. Management concerns would be similar to those for butterflies. In addition, large continuously run lights (such as are used in

some border surveillance operations, typically in densely populated areas) could be a significant population sink for rare species that are strong fliers.

### Order Orthoptera – Grasshoppers, Katydids, Crickets, and Mantids

Grasshoppers are very diverse in this region, and are ecologically interesting because of their roles as herbivores of grasses, shrubs, and forbs. No formal inventories have been done for the region, although the grasshopper fauna is fairly well known. The New Mexico Natural Heritage species list for Hidalgo County includes 86 species, almost all of which could occur in the Peloncillo region. Most are not thought to be significant pests, and several that eat common plants unpalatable to livestock are considered beneficial to rangelands, including the snakeweed grasshopper (*Hesperotettix viridis*) and the creosotebush grasshopper (*Bootettix argentatus*).[96] Appendix G lists these Hidalgo County species, along with commentary about their habits.


Panther grasshopper
*Poecilotettix pantherina*

Crickets and katydids are less well studied; no regional species lists are available. Other orthopterans of interest include several species of praying mantis. Most but not all mantids are widespread species with broad habitat requirements. Some entomologists in the region consider the unicorn mantis (*Pseudovates arizonae*) a species of concern due to its rarity and localized distribution[97]; this species has been found in the southern Peloncillos.[98] This rare, local endemic is known only from local and geographically separated populations. Restricted to dense riparian vegetation habitats, *P. arizonae* is potentially threatened by domestic livestock grazing and water developments, as well as competition from exotic mantids intentionally released for garden pest control. These include the Chinese and European mantids, which are becoming naturalized throughout the United States.

Another rare, regionally endemic mantid may occur in the higher elevation grasslands. *Stagmomantis gracilipes* is known from south-central Arizona (including the Baboquivari, Patagonia, and Santa Rita Mountains, and near Benson and Tucson), and probably also occurs in northeastern Sonora. *S. gracilis* appears to be restricted to high-quality native upland grasslands, which have declined drastically in the Southwestern US. Its main threats appear to be habitat degradation and loss, and potentially competition from exotic mantids.

Nearby ranges (Santa Rita and Santa Catalina Mountains) harbor an endemic high-elevation walking stick, *Timema ritensis*. Collectors working in the high forests of the Animas and Sierra San Luis should be on the lookout for this and related species.

**Biogeography**: As with other invertebrate groups, several grasshoppers near their northern limits here. One of the most handsome examples is the panther grasshopper (*Poecilotettix pantherina*), which ranges through Sonora and southern Arizona grasslands eating shrubs and forbs in the sunflower family.[99] The aptly named toothpick grasshopper (*Achurum sumichrasti*) and the huge

horse lubber (*Taeniopoda eques*) range all the way to Costa Rica. The slender range grasshopper (*Acantherus piperatus*) is predominantly a species of western Mexico.

**Endemics and restricted range species:** No strict endemics are known from this region. However, the lichen grasshopper (*Leuronotina ritensis*) is known from just a few localities in the U.S., including the Animas and Peloncillo Mountains.[100] This rarely seen species has also been found in the Santa Rita Mountains, and two sites in Mexico (Sierra de los Ajos, Sonora, and Basaseachi National Park, Chihuahua). *L. ritensis* eats *Xanthoparmeli* lichens on rocky outcrops in mountains above some 6,000 feet elevation.

The Apache bush katydid **(***Insara apache*) is another possible restricted-range resident, known now only from perennial bunchgrasses in the mid-elevation slopes of the Santa Catalina, Santa Rita, and Huachuca mountains. The pinyon pine monkey grasshopper **(***Eumorsea balli*), known only from the Huachuca, Pinaleño, and Santa Rita mountains, may also occur here. Several endemic grasshoppers are known from nearby ranges, suggesting that additional survey work may turn up endemic species within this focal area as well. These include *Melanoplus chiricahuae* known only from the nearby Chiricahua Mountains, *M. pinaleño* and *Eumorsea pinaleño* from the Pinaleño range, and *Aztecacris gloriosus* from the Atascosa Mountains.

Cave-dwelling camel crickets also tend to have high rates of endemism. The genus *Ceuthophilus* has several species *(C. chiricahuae, C. tinkhami, C. baboquivariae, C. papago,* and *C. wheeleri*) known from just one or two Sky Island ranges; these first two live in the Chiricahua Mountains. Suitable habitats within Peloncillo region have not been surveyed.

**Special management concerns:** Because some grasshoppers can consume significant amounts of crops and range forage, they may become targets of control efforts using pesticides and/or biological control agents such as fungi and protozoan parasites. Most pesticides used for grasshoppers also kill a wide spectrum of other arthropods, including beneficial insects such as the parasitic and predaceous flies that attack grasshoppers and help keep outbreaks from occurring in the first place. Biological control agents are more targeted, but still kill innocuous and beneficial orthoptera along with the pest grasshoppers. This area is host to a large number of species that are rarely, if ever, significant pests to range or crops, and that may help maintain plant diversity across the landscape. Populations of all these species fluctuate naturally, though some more widely than others. In assessing possible "grasshopper outbreaks," care should be taken to avoid confusing population surges of beneficial or innocuous species with "infestations" of pests.


*Diplocentrus peloncillensis* Photo by: Charles Hedgcock

## ARACHNIDS

### Order Scorpiones: Scorpions

**High diversity:** For scorpions, the general area presents an "interdigitation effect" of the Chihuahuan and Sonoran Deserts. In the flats, there is a tendency for Chihuahuan species to

predominate; in the outcrops, the Sonoran species predominate. These divisions, however, are not absolute. One exception is the tiny chocolate-colored Sonoran desert scorpion *Superstitionia donensis*, which has been taken in the San Bernidino Valley.[101] Extensive survey work in the "bootheel" area of New Mexico, conducted by Sissom and colleagues, has turned up 13 scorpion species. At a single sampling site with diverse habitat, one can find up to nine of these. This is very high diversity for North American scorpions. Big Bend National Park lists about 15 and the Anza Borrego Desert reportedly has around 20 or so. Average sites across western North America list between four and six species.[102]

**Endemism and evolutionary radiations:** Two endemic scorpions are known from the Peloncillo Mountains proper. One, an undescribed *Vaejovis* species (descriptions by W. D. Sissom are in manuscript form) is known only from Granite Gap. The unusually handsome *Diplocentrus peloncillensis* is also endemic to the range.

Perhaps most striking examples of regional diversification are the members of the *Vaejovis vorhiesi* "complex." These small scorpions are found at higher elevations in the Sky Islands throughout central and southern Arizona and western New Mexico. They are all very similar, but there is at least some differentiation in the different mountain systems.

### Order Araneae: Spiders

Very little spider research has been done in the mountains of the Peloncillo region. One major exception to this is David Richman's ongoing spider inventory on the Gray Ranch, including the east slopes of the Peloncillos, the Animas Valley, and the west slopes of the Animas Mountains. So far, this work has revealed over 100 species, with no indication that the list is nearing completion; indeed, new species still turn up in every collecting trip.[103]

The spider fauna of the Chiricahua Mountains, however, is better studied than almost anywhere else in the West. As of 1977, this fauna was known to contain a minimum of 363 species in 36 families—including most of the families present in North America. [104] Among these were at least 45 species that were clearly new to science and another 36 that could not be placed to species. About 30 of these species have since been described or assigned to known species, mostly based on Vince Roth's collections and those of a few people who have followed him in Chiricahua spider studies. By 1996, Roth had found another 40 species in the range, but unfortunately did not live to publish an update to the Chiricahua list. [105] He did, however, leave a legacy of spider research that continues to this day, with dozens of researchers having studied spider ecology and behavior in the Chiricahuas and the San Simon Valley.

**Endemism and evolutionary radiations:** An *Aphoenopelma* tarantula species that appears to be new to science has recently been discovered in the Peloncillos proper.[106] While new species are common in other spider groups, tarantulas have received enough attention in the past that a new species in the U.S. is quite a remarkable find.

Specimens of the Sky Island jumping spider *Habronattus pugillus* have also been found in the Peloncillos proper, in a side canyon off of Clanton Draw. This oak woodland spider has isolated populations on at least 18 Sky Island ranges. Each population is adorned with its own distinct set

of courtship ornaments, and males on each range perform their population's own unique dance for their females[107]. The Peloncillos form, discovered in 1998, differs from all other population most strikingly in having shiny butterscotch-colored pedipalps, which males wave prominently during their courtship displays.

### Other Arachnid orders

This area is home to some of the strangest-looking arachnids in the nation. The vinegar-shooting whip scorpion (Arachnida: Uropygi, *Mastigoproctus giganteus,* aptly called the vinegaroon)[108] is fairly common in the valleys and foothills, where it can exceed five inches in length, plus tail. Windscorpions (Arachnida: Solifugae) are also common, with several species across various habitats and elevations. Tailless whipscorpions (Arachnida: Amblypygi) likely occur here as well. Mites and ticks (Arachnida: Acari) occur virtually everywhere on the planet. This area's most conspicuous members are velvet mites—plush, dimpled red animals that can reach over a centimeter in length. Velvet mites become active after the first summer rains, when they can be seen wandering across the ground in search of termite prey.[109]

## MYRIAPODS

This area is home to some of the continent's most conspicuous centipedes and millipedes. Centipedes can be recognized by having just one pair of legs per segment, and despite their name ("100 legs"), most have only about 30. Four superfamilies of these predaceous animals live in the Peloncillo region: Scolopendromorphs are the largest and best-known. Species recorded from this area include *Scolopendra heros, S. polymorpha,* and *S. viridis. S. heros,* sometimes called the giant redheaded or giant desert centipede, can reach almost 20 cm in length, and can inflict a painful but not dangerous bite. *S. heros* comes in several color forms across its range; the Peloncillo *Scolopendra heros* is orange with black head and hind end.

Scutigeramorphs such as *Scutigera coleoptera*, the American house centipede, have much longer, more delicate legs, with a maximum of 15 pairs. The eyeless Geophilomorphs tend to live in leaf litter and humus and have more legs than other centipedes—as many as 177 pairs. Lastly, the Lithobiomorphs tend to be found among rocks at high elevations. These orange-brown centipedes resemble small versions of Scolopendromorphs.

Millipedes, with two pairs of legs per segment, are detritivores. The giant desert millipede (*Orthoporus ornatus*) can grow to more than 10 cm. *O. ornatus* and similar species are sometimes kept as pets (as is *S. heros*) and are offered for sale by several collectors. *Orthoporus* millipedes can be quite abundant in this area and may cover the ground by the thousands after good summer rains. The area undoubtedly harbors many other kinds of millipede, but little information exists about this globally under-studied group.

# CRUSTACEA

## Branchiopod Crustaceans

When one thinks of crustaceans, dry mountains and grasslands are hardly what comes to mind. But within days of a filling rain, this area's alkaline playas, stock ponds, seasonal washes, rock holes, and other puddle-forming sites begin to fill with small crustaceans. When a pool dries, these animals return to a state of suspended animation until their pool refills—perhaps many years in the future.

Branchiopod crustaceans, including fairy shrimp (Anostraca), tadpole shrimp (Notostraca), clam shrimp (Diplostraca), and cladocerans (Diplostraca) make up a large fraction of the animal life that depends on such temporary waters. When conditions deteriorate (e.g., when a pool dries, predators appear, or competition increases), most have the ability to dry up into tiny, dust-like cysts that remain in the soil. Cysts can remain viable under extreme cold and heat (including fire[110]) for up to several decades, forming a "cyst bank" very similar to the long-lasting seed banks of desert annual plants. When pools fill again and conditions are right, these cysts hatch, instantly filling the new pools with a complex suite of swimming animal species.

Individual pools usually have just a few dominant species at any given moment, presumably because coexistence is limited by competition and predation among species, and by the fact that each species emerges only under a limited range of conditions. However, sampling a single pond across time or a set of nearby ponds at one time can yield a dozen or more species representing several different crustacean orders.[111] This is much more diverse than a comparable permanent pool or stream, perhaps because the ephemeral crustaceans, like desert annual plants, become segregated in time as well as space.

Branchiopod biogeography is rather complex. Arid western North America is considered a global hotspot for fairy shrimp diversity. Of some 300 species in the world, 30 are found in western North America; half of these are endemic to this part of the continent. Within the West, many species are endemic to very small areas, and even widespread species can show a high degree of genetic structure (e.g., residents of one pool may be genetically distinct from those in a pool just a hundred meters away).[112] This differentiation is presumably due to the patchy nature of the habitat, abiotic habitat differences such as soil mineral content, and restricted gene flow because of low mobility.

No site-specific crustacean inventories have been published on this region. However, locality data embedded in the scientific literature, recent agency reports, and communications with experts who have collected here reveal records of at least 17 species of branchiopod crustacean within our study area. An additional 31 species are known from other parts of New Mexico, Arizona, and/or Mexico (see table in Appendix G for names and sources). Note that Cladocerans in ephemeral pools have received much less attention than fairy shrimp, tadpole shrimp, or clam shrimp,[113] and are therefore discussed here only in passing.

Patterns of branchiopod distribution in the Peloncillo region can be complex and seem to be affected by temperatures, pool form, and salinity and other soil characteristics. Winter rains often bring out a different fauna from summer rains. In the Lordsburg Playas, for example, the winter fauna is dominated by *Brachinecta mackini*, *Lepidus lemmoni*, and *Cysticus mexicanus.* Summer composition switches to predominantly *Thamnocephalus platyuris*, *Streptocephalus* n. sp. 1, and *Leptestheria setosa*. Different habitats tend to harbor different species. Many species show up in stock tanks and other man-made impoundments; the stock tank fauna overlaps quite a bit with species found in natural tinajas. Species in the large playas, however, tend not to show up in tinajas or stock tanks—unless these stock tanks are built into playa soils. One undescribed species (*Streptocephalus* n. sp. 1) has been found only in the large playas. A second (*Streptocephalus* n. sp. 2) has been found in small pools at playa edges and away from playas. Across the West, branchiopods tend to be segregated by elevation, yet so far the Sky Island faunas look to be very similar from valleys to peaks. Because branchiopods are so opportunistic, however, further studies are likely to find exceptions to many of these trends.[114]

Numerous studies on genetics, natural history, and evolution of branchiopods use pools in the San Simon Valley near Portal, Arizona, as the source of several branchiopod species. These species include *Triops longicaudatus* and *Triops newberryi*, *Eulimnadia texana*, and *Eulimnadia diversa*. These studies have brought insights into themes as broad as how animals can survive in such extreme environments[115], how habitat differences affect life history traits[116], how populations can maintain harmful genes at a high frequency[117], and how males and hermaphrodites can coexist in the same population through time.[118] Further studies of *Triops* species in the U.S. and Mexico have revealed complex genetic differentiation and cast doubt on current species limits. For example, *T. newberryi* may not be a valid species, and *T. longicaudata* probably includes more than 15 cryptic species across its range. *T. longicaudata* also comes in several forms that are reproductively isolated from one another by sexual system; a single pool can harbor a sexual form with "normal" males and females, a parthenogenic form, an androdioecious form in which males cannot contribute to the next generation (being functionally sterile products of genetic accidents), and other strange forms.[119]

**Special management concerns:** Chemical alteration of playa systems has occurred in other parts of the region (e.g., dumping of oil wastes in southeastern New Mexico and polluted irrigation wastewater in Texas and Kansas[120]). This type of use would likely be very harmful to playa invertebrates here as well, although more inventory and monitoring would be required to assess precisely what species would be affected how. Effects of chemical poisons such as Rotenone (used for eradicating non-native aquatic vertebrates) or chemical brush-control agents should also be investigated before being applied on a large scale or in pools that may harbor rare species. Because ephemeral pools fill with runoff, chemicals applied on surrounding lands do make their way into pools and can concentrate there.

Many ephemeral pools are kept open and habitable to branchiopods by disturbance of one sort or another. Disturbance should therefore not be viewed as necessarily detrimental, although effects of specific disturbances on rare species should be evaluated on a case-by-case basis. There is no evidence, for example, that grazing harms most branchiopod species in this region. Man-made stock ponds provide excellent habitat for some branchiopod species. It is not clear where these species would have occurred naturally, although many stock ponds simply impound extra water

in sites that accumulated ephemeral pools before impoundment. When stock tanks need to be dug out or recontoured, some branchiopod researchers recommend that the top few centimeters of soil (which contain most of the branchiopod cysts) be removed first, set aside, and replaced after recontouring is complete.[121] Drying of stock ponds to eradicate non-native fishes and frogs will not harm branchiopods.

Branchiopod researchers have suggested that " . . . conservation efforts for playa invertebrates should be implemented on the landscape-level and focus on playas with intact watersheds, because these playas have relatively undisturbed hydroperiods.[122]" The playas in this focal area fit this bill exceptionally well.

Some habitat managers have experimented with "moist soil management," keeping temporary wetlands wet for longer periods of the year in order to benefit waterfowl and other wildlife. Moist soil management can increase the densities of wetland arthropods.[123] However, the effects of altering hydrologic cycles in this way on branchiopod abundance, diversity, and genetic population structuring are not clear. Any proposed hydrologic alterations should be viewed as potentially disruptive, and scrutinized in detail.

**Other Crustaceans**

Amphipods: There are no published records of amphipods in this area, but they are almost certain to exist in at least some springs and cienegas. *Hyalella azteca* is common throughout North American wetlands. Other sites in the Southwestern US and Northwestern Mexico have endemic isopods in the genus *Gammara*, including several species in the *Gammarrus pecos* species complex throughout the northern Chihuahuan Desert.[124] Wetlands should be examined for presence of amphipods. It may take genetic analysis to determine correct species and population placement of some specimens encountered. One non-native, *Gammarus lacustris*, is reportedly introduced into Arizona, but may only occur at higher elevations. [125] Thus far nothing published has been found on the effects this species might have on natives.


Native amphipod *Hyalella azteca*

Isopods: Two species of terrestrial isopods (*Armadillidium vulgare* and *Venezillo arizonicus*), commonly known as pill bugs or rolly-pollies, are known from the Chiricahua Mountains.[126] Both are likely also present in the Peloncillo region.

Crayfish: There are no native crayfish in this part of Western North America, but a species from eastern North America (*Oronectes virilis*) has invaded some streams in the region and causes problems for native fish, amphibians, and aquatic plants where it occurs.[127] Care should be taken to avoid introducing this invasive species into permanent wetlands in the focal area. Luckily, this species does not persist in ephemeral waters.

## *Knowledge Gaps*

There are two main ways to increase our knowledge of the area's invertebrate fauna. The first is to conduct and/or facilitate new inventory projects. The second is to compile existing information into a useable format.

New inventory efforts can be done in intensive or diffuse ways depending on available resources and project goals. An intensive inventory would involve bringing in experts on numerous taxonomic groups along with their sampling teams, setting up high-throughput specimen processing systems, and running all information immediately into a centralized database. This would collect a large amount of baseline data in a short amount of time. Similar rapid assessment inventories have been successful in many places across the globe, and experience from these ventures has led to development of many efficient techniques for specimen and data management.[128] Longer-term, more thorough versions of such inventories are also being undertaken, with the goal of fully documenting the extraordinary richness of invertebrate faunas (or at least getting far enough to produce reliable estimates of total richness).[129]

Diffuse inventories take advantage of work already going on in the region, can be done on a smaller scale, and can more practically be continued or repeated over time. The main expenses of this strategy would be defraying field costs for interested parties and providing an assistant to compile information into a database as it comes in. Small grants ($500 - $3,000) are often enough to cover fieldwork expenses for individual groups (e.g., a team of 3 - 4 experts spending one to two weeks inventorying dragonflies and damselflies in all the springs and streams throughout the planning area). Fieldwork here could be piggy-backed on other research projects, (e.g., invertebrate taxonomy courses run at the SWRS). For example, at the end of the annual week-long bee taxonomy course, students and researchers could be brought into this planning area for an additional three workshop days, likely for the cost of providing them with room and board. The existing butterfly-watching tours of Guadalupe Canyon could be turned into meaningful inventory sessions by providing these experts with a data-recording assistant. Cooperation by agencies and private landowners will be key to encouraging these diffuse inventory efforts. The detailed area descriptions present in this plan and its appendices will greatly improve the efficiency and effectiveness of future inventory work of all sorts by helping researchers sample the breadth of the habitats present and target the sites likely to harbor the richest assemblages of their particular group. Another possibility would be to start a long-term volunteer count associated with the North American Butterfly Association (NMBA) 4$^{th}$ of July Butterfly Counts; New Mexico's Organ Mountain Count now has about 13 years of data which is helpful in tracking butterfly populations as well as species found in a given area.

Much more collecting has been done in the area than has been documented in any formal way. For over 100 years, the Sky Island region had drawn entomologists with the lure of exotic finds. The American Museum of Natural History's Southwestern Research Station, just nine miles from the greater Peloncillo region, was originally founded for its tremendous insect diversity and has attracted hundreds of invertebrate researchers over the last 50 years. Many of these

researchers will have collected in the nearby valleys and ranges, but information from these collections has never been compiled.

Compiling results of these informal collections would represent a huge advance in the knowledge of the area's invert fauna. The centipede *Theatops posticus*, for example, was thought for many decades to be rare in the Southwestern US, known from just one locality in Utah and one in Arizona. But when an expert examined collections in several museums, he found specimens of *T. posticus* (previously unidentified) from nearly 100 sites across the southwestern U.S. and northern Mexico, including the Peloncillo Mountains.[130]

Specimens in existing collections also represent a long time scale, some exceeding 150 years in this borderland area. These collections may include species that no longer exist in their original localities, or ones that occur there only periodically. This information can help identify habitat changes and potentials. If, for example, old collections include a caddisfly that lives only in permanent running streams, this may indicate that a now-ephemeral stream once ran year-round and might do so again with restoration work.

Compiling knowledge from existing collections would require contacting a large number of entomologist and amateur collectors, recording and standardizing collection data from each, and making sense of these data. Because many invertebrate groups are very difficult to identify accurately, data quality will vary from collector to collector and from taxon to taxon. Having one expert in each group review and verify identification of specimens would improve the reliability of these data immensely, though it could be time consuming and expensive. To be practical, compiling existing knowledge would require hiring someone to coordinate the outreach process and to manage the resulting database. Because most invertebrate museum collections are not yet digitized, the coordinator would likely also have to travel to major collections to extract data from collection labels directly. Most professional entomologists are already busy with their existing projects, so providing someone to facilitate their compiling of their information would likely make the difference between having project participants limited to a few retirees and having a large set of collaborators that includes many active researchers.

Public recognition of the value of an area, this report being an excellent example, facilitates increase in knowledge of poorly studied groups in several ways. First, it calls researchers' attention to an area they might otherwise overlook. Second, it focuses funders' attention on the same area, and greatly improves the chances that a researcher who wants to work in the area can get funds to do so. Third, for people have already done work in the area, public recognition adds a level of prestige to this work that causes completion and publication of this work to rise on people's priority lists.

## *Conservation Targets*

Quite a few species are endemic, or nearly endemic, to the Peloncillo region. These should all be considered conservation targets, if only to prevent accidental, avoidable damage to their survival.

Riparian areas are critically important to many invertebrates and disproportionately valuable to many more. This includes riparian bosques as well as the watercourses themselves.

Playas host huge numbers of species when they fill with water. Many of these species are not found outside of these playa areas, or would not survive without access to them.

Isolated springs host at least one and possibly more endemic species. They are a valuable resource to non-endemics as well. Other watersources, including man-made pools, also provide valuable resources for any invertebrates.

Patches of unusual soil types can also be considered conservation targets because of the high diversity of ground-nesting invertebrates known from the region. Not all of them have been identified, although the patch of stabilized dune in the Animas Valley has been suggested as one such type.

Overall, maintaining natural disturbance regimes, including fire, is likely to benefit some invertebrates directly. By supporting continued high plant diversity and natural hydrologic flows, these processes benefit even more invertebrates indirectly.

General landscape protections established for wide-ranging "umbrella species" such as jaguars or wolves will preserve habitats needed by most invertebrates. However, some species with very small ranges or very specific habitat requirements may need additional targeted management. Endemic talus snails or springsnails, for example, may live on just one hillside or in one isolated cienega. Negative impacts to such small areas can usually be avoided easily—if the need to do so is recognized. On the flip side of the coin, protection or restoration of an area too small to sustain larger animals may be very valuable to invertebrates.

Notes, Chapter 2.5

[1] E.g., Alcock, J. 2003. A textbook history of animal behaviour. Animal Behaviour 65: 3-10.
Alcock, J. 2001. Animal Behavior: An Evolutionary Approach. Seventh edition. Sinauer Associates. Sunderland, Mass. 640 pp. (and six previous editions dating back to 1975)

[2] Brusca, R.C., and G.J. Brusca. 1990. Invertebrates. Sinauer Associates, Sunderland, MA. 922 pp.

[3] e.g., Shelley, Roland M. 1990. The centipede *Theatops posticus* (Say) (Scolopendromorpha: Cryptopidae) in the southwestern United States and Mexico. Canadian Journal of Zoology. Vol. 68: 2637-2644.

[4] e.g.,: Alcock, J.1987. Male reproductive tactics in the libellulid dragonfly *Paltothemis lineatipes*: temporal partitioning of territories. Behaviour 103:157-173.

Arnaud, P.H.1972. Sound production in *Agrilus pulchellus* Bland (Coleoptera: Buprestidae). Pan-Pac.Entomol. 48:69.

Chew, R.M.1979. Mammalian predation on honey ants, Myrmecocystus (Formicidae). Southwest. Nat.24:677-682.

Eickwort, G.C., K.R. Eickwort, and E.G. Linsley.1977. Observations on nest aggregations of the bees *Diadasia olivacea* and *D. diminuta* (Hymenoptera: anthophoridae). J. Kans. Entomol. Soc. 50:1-17.

Eisner, T.E.1966. Beetle's spray discourages predators. Nat. Hist. 75:42-47.

Gordon, D.M.1988. Nest-plugging: interference competition in desert harvester ants (Novomessor cockerelli and Pogonomyrmex barbatus). Oecologia 75:114-118.

Greene, E., L.J. Orsak, and D.W. Whitman.1987. A tephritid fly mimics the territorial displays of its jumping spider predators. Science 236:310-312.

Hespenheide, H.A., and M.A. Rubke.1977. Prey, predatory behavior and the daily cycle of *Holopogon wilcoxi* Martin (Diptera:Asilidae). Pan-Pac. Entomol. 61:95-104.

LaMon, B., and H. Topoff.1981. Avoiding predation by army ants: defensive behaviors of three ant species of the genus *Camponotus.* Anim. Behav. 29:1070-1081.

Linsley, E.G., T. Eisner, and A.B. Klots.1961. Mimetic assemblages of sibling species of lycid beetles. Evolution 15:15-29.

Mirenda, J.T., and H. Topoff.1980. Nomadic behavior of army ants in a desert-grassland habitat. Behav. Ecol. Sociobiol.7:129-135.

Reiskind, J.1965. The taxonomic problem of sexual dimorphism in spiders and a synonymy in Myrmecotypus (Araneae, Clubionidae). Psyche 72:279-281.

[5] Numbers based on citations listed in the SWRS bibliography, available at http://research.amnh.org/swrs/bibliography.htm, covering papers published through June 2004.

[6] e.g., Chiricahua species listed in the draft checklist of Arizona ants (see citation below), available only from the researchers or in draft form online.

[7] For a description of this project and its rationales, see: Sharkey, M. J. 2001. The All Taxa Biological Inventory of the Great Smoky Mountains National Park. *Florida Entomologist* 84(4): 556-564; see also the official ATBI Science Plan online at <http://www.dlia.org/atbi/pdfs/Science_Plan.pdf>.

The Smokies' ~4,200 known macroinvertebrate species tally includes some 400 that are new to science. Researchers estimate they have caught the majority of species present in the already groups studied in depth, but that other groups have not yet been tackled. One ATBI brochure estimates that invertebrate diversity will top 70,000 species (including mites, nematodes, etc.; see http://www.discoverlife.org/ATBI_brochure.html). For examples of advanced work on one particular taxon, see:

Coddington, J. A., L. H. Young, and F. A. Coyle. 1996. Estimating Spider Species Richness in a Southern Appalachian Cove Hardwood Forest. 1996. The Journal of Arachnology 24:111–12 8.

[8]Richard Worthington, pers. comm. , 2004. "Some collective thinking from the 'invertebrate group' on how to inventory the invertebrates in the six national parks comprising the Chihuahuan Network." Unpublished, informal position paper on invertebrate inventory approaches, assembled by an informal group of invertebrate biologists working in Chihuahuan Desert national parks .

[9] These predictions represent minimum plausible numbers. Several workshop participants believe true invertebrate numbers could easily exceed 10,000 species, and would be much higher if the Sierra San Luis were included.

[10] Dawson, V. 2004. Bugs Beware. Smithsonian Magazine, October 2004, pp. 48.

[11] University of Arizona Entomology collection, database searched November 2004.

[12] As the site of the American Museum of Natural History's Southwestern Research Station, the Chiricahua range has been visited by thousands of insect and spider collectors from around the world, but has never been the target of comprehensive attempts to inventory the fauna. Impressive as they are, the University of Arizona collections represent just a fraction of the records that exist from the range. Invertebrate records for the range have never been compiled across the many collections in existence. These numbers reflect all species in the UA collection database as of November 2004.

[13] The University of Arizona collection, for example, contains just 350 species from the Peloncillo Mountains.

[14] Dr. Robert Mickley, University of Utah, pers. comm. 2005.

[15] Dr. Stephan Cover, Harvard University, pers. comm. 2004.

[16] McCord, R. D. 1995. Phylogeny and biogeography of the land snail, *Sonorella*, in the Madrean Archipelago. In: DeBano, L.F., P.F. Ffolliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B. Edminster, technical coordinators. 1995. Biodiversity and Management of the Madrean archipelago: The sky islands of Southwestern United States and Northwestern Mexico. USDA Forest Service, General Technical Report RM-GTR-264, pp. 317-324.

[17] Maddison, W., and M. McMahon. 2000. Divergence and reticulation among montane populations of a jumping spider (Habronattus pugillus Griswold). Systematic Biology 49:400-421.

Masta, S. E. 2000. Phylogeography of the jumping spider Habronattus pugillus (Araneae: Salticidae): Recent vicariance of sky island populations? Evolution 54:1699-1711.

[18] Dr. Donald Manley, Clemsen University, pers. comm. 2004.

[19] Dr. W. D. Sissom, West Texas A&M University, pers. comm. 2004.

[20] See listings in the New Mexico Natural Heritage BISON-M database. See also: Arizona Game and Fish Department, 1996. Wildlife of Special Concern in Arizona. Public Review Draft. 2221 West Greenway Road. Phoenix, Arizona.

Federal Register. US Department of the Interior/US Fish and Wildlife Service. February 28, 1996. Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa That Are Candidates for Listing as Endangered or Threatened Species. Notice of Review. Vol. 61(40).

[21] Report on conservation status of Orthoptera of the Apache Highlands (Sky Islands) Ecoregion, by Dr. David C. Lightfoot, Department of Biology, University of New Mexico, March 2004, for use by The Nature Conservancy and others for conservation planning.

[22] Barry Tomlinson, Hatari Invertebrates, pers. comm. 2004.

[23] Hall, D. L., M. R. Willig, D. L. Moorhead, R. W. Sites, E. B. Fish, and T. R. Mollhagen. 2004. Aquatic macroinvertebrate diversity of playa wetlands: The role of landscape and island biogeographic characteristics. Wetlands 24:77-91.

Moorhead, D. L., D. L. Hall, and M. R. Willig. 1998. Succession of macroinvertebrates in playas of the Southern High Plains, USA. Journal of the North American Benthological Society 17:430-442.

Anderson, J. T., and L. M. Smith. 2004. Persistence and colonization strategies of playa wetland invertebrates. Hydrobiologia 513:77-86.

Sublette, J. E., and M. S. Sublette. 1967. The limnology of playa lakes on the Llano Estacado, New Mexico and Texas. The Southwest Naturalist 12(4): 369-406.

[24] Hoff, C. Clayton. 1962. Some Terrestrial Gastropoda From New Mexico. Southwestern Naturalist. 7(1): 51-63.

[25] Dr. Richard Worthington, University of Texas at El Paso, pers. comm. 2004.

[26] McCord 1995 (citation #15).

[27] Worthington, pers. comm. 2004.

[28] Metcalf, A. L. and R. A. Smartt. 1997. Land Snails of New Mexico. New Mexico Museum of Natural History and Science. Bulletin University of Texas at El Paso and The New Mexico Museum of Natural History and Science, Albuquerque, New Mexico.

[29] Metcalf and Smartt 1997 (citation #27)

[30] Metcalf and Smartt 1997 (citation #27)

[31] Gilbertson, L. H., and R. D. Worthington. 2003. A new species of *Holospira* (Pulmonata: Urocoptidae) from New Mexico. The Veliger 46(3): 220-224.

[32] Described by D.W. Taylor, 1987. Fresh-water molluscs form New Mexico and vicinity. New Mexico Bureau of Mines and Mineral Resources. Bulletin 116: 34-36.

[33] (Metcalf and Smartt, 1997).

[34] New Mexico Natural Heritage BISON-M database, September 2004.

[35] Minckley, pers. comm. 2005. Many of these species are referred to in:

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Michener, C.D. 2000. Bees of the World John Hopkins Press.

Minckley, R. L., J. H. Cane, and L. Kervin. 2000. Origins and ecological consequences of pollen specialization among desert bees. Proceedings of the Royal Society of London Series B-Biological Sciences 267:265-271.

[36] Burquez, A. 1997. Distributional limits of Euglossine and Meliponine bees (Hymenoptera: Apidae) in northwestern Mexico. Pan-Pacific Entomologist 73:137-140.

Minckley, R. L., and S. G. Reyes. 1996. Capture of the orchid bee, Eulaema polychroma (Friese) (Apidae: Euglossini) in Arizona, with notes on northern distributions of other mesoamerican bees. Journal of the Kansas Entomological Society 69:102-104.

[37] MacKay, W., and E. MacKay. 2002. The Ants of New Mexico: Hymenoptera: Formicidae. Edwin Mellen Press, Lewiston, N.Y. 398 p.

[38] see *Pogonomyrmex* study maps of Dr. Robert Johnson and the Arizona State University's Social Insect Research Group at http://isweb.la.asu.edu/sirg

[39] S. P. Cover, Museum of Comparative Zoology, Harvard University, pers. comm. 2005.

[40] Chew, A.E., and R.M. Chew.1980. Body size as a determinant of small-scale distribution of ants in evergreen woodland, southeastern Arizona. Insectes Soc. (Paris) 27:189-202.

[41] Chew, R.M.1977. Some ecological characteristics of the ants of a desert-shrub community in southeastern Arizona. Am. Midl. Nat. 98:33-49.

[42] Cover, S. P. 1994. The ant fauna of the Madrean Archipelago: A modern picture. In: DeBano, L. F., and A. N. Garibay, and A. Ortega-Rubio, compliers. Conference on Biodiversity and Management of the Madrean Archipelago. Abstracts: 61.

[43] Cover, S. P., and R. A. Johnson. 2005. Checklist of Arizona Ants, draft version 4.2. Unpublished manuscript updated July 5, 2005. A previous version, updated in 2004, is available online at: http://lsweb.la.asu.edu/sirg/ant%20species_resources.pdf. Current versions are available from the authors: Stefan P. Cover, Harvard Museum of Comparative Zoology, or Robert A. Johnson, Arizona State University.

[44] Cover, S. P., and R. A. Johnson. 2005. Working Checklist of Ants collected from the Chiricahua Mountains [Arizona: Cochise County], revised July 5, 2005. Unpublished manuscript.

[45] Gordon, D. 1999. Ants at Work: How An Insect Society Is Organized. Free Press, New York. 182 p.

[46] Chew, R.M.1977. Some ecological characteristics of the ants of a desert-shrub community in southeastern Arizona. Am. Midl. Nat. 98:33-49.

Chew, R.M.1987. Population dynamics of colonies of three species of ants in desertified grassland, southeastern Arizona, 1958-1981. Am. Midl. Nat. 118:177-188.

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Topoff, H., T. Weickert, and E. Zimmerli.1990. A comparative study of colony takeover between queens of facultative and obligatory slave-making ants (Hymenoptera: Formicidae). J. Insect Behav. 3:813-817.

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[50] Conway, J.R. 1983. Digging up the secrets of honey ants. Ranger Rick Magazine Dec 1983:41-45.

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Conway, J.R.2003. Architecture, population size, myrmecophiles, and mites in an excavated nest of the honeypot ant, *Myrmecocystus mendax* Wheeler, in Arizona. The Southwest. Nat. 48:449-450.

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[53] This list includes observations by Sandy Upson on July 7 2002; Doug Danforth and Sandy Upson on July 6 2003; and Tim Manolis, Annette Manolis, Alan Craig and Narca Moore-Craig on October 20 2004.

[54] Bailowitz, R., D. Danforth, and S. Upson. Arizona Odonates. Online field guide and checklists. Available at <http://www.azodes.com>. Revised 2003, last viewed February 2005.

Larsen, R. 2003. The damselflies (Zygoptera) of New Mexico. Online field guide and checklists available at www.rt66.com/~kjherman/odonata/NMdrgnfly.html,>. Last viewed Feb. 2005.

[55] Dunkle, S.W. 2000. Dragonflies Through Binoculars: A field guide to dragonflies of North America. Oxford University Press, New York. 266 p.

[56] Hoekstra, J.D., and R.W. Garrison. 1999. Range extensions of *Palaemnema domina* Calvert (Odonata: Platystictidae) to southeastern Arizona, U.S.A., a new odonate family for the United States, Proc. Entomol. Soc. Wash., 101(4):756-759.

One USGS website (<http://www.npwrc.usgs.gov/resource/distr/insects/dfly/ar/446.htm>) also lists the species as reported from one county in Arkansas, but the source of this report is not presented.

[57] Smith, D. 2000. Beetle Taphonomy in a Recent Ephemeral Lake, Southeastern Arizona. Palaios 15: 152-160.

[58] Linsley, E.G., J.N. Knull, and M. Statham.1961. A list of Cerambycidae from the Chiricahua Mountain area, Cochise County, Arizona (Coleoptera). Am. Mus. Novit. 2050:1-34.

[59] Some bark beetle species have been in this area for at least the last 13,000 years: see

Elias, S.A. 1992. Late Quaternary Zoogeography of the Chihuahuan Desert Insect Fauna, Based on Fossil Records from Packrat Middens. *Journal of Biogeography* 19(3): 285-297

For a summary of bark beetle ecology, management, and history, see Samman, S., and J. Logan. 2000. Assessment and Response to Bark Beetle Outbreaks in the Rocky Mountain Area. Gen. Tech. Rep. RMRS-GTR-62. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 46 p. Available online at < http://www.fs.fed.us/rm/pubs/rmrs_gtr62.pdf>.

The US Forest Service Region 3 posts bark beetle fact sheets, management resources, and updated maps of outbreaks in Arizona and New Mexico at http://www.fs.fed.us/r3/resources/health/beetle/index.shtml.

See also the Carson National Forest's Bark Beetle Comprehensive Plan, September 2002, available online at <http://www.fs.fed.us/r3/carson/natural_resources/bark_beetle_comm_plan.pdf>.

[60] One specimen was collected at a Lordsberg truckstop as early as 1999 (Specimen # 3480AM at the NMSU Arthropod Museum).

[61] Hoback, W.W., Golick, S.A., Svatos, T.M., Spomer, S.M., and Higley, L.G. 2000. Salinity and shade preferences result in ovipositional differences between sympatric tiger beetle species. Ecological Entomology 25 (2): 180-187.

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Knisley, C. B., R. Acciavatti, and J. Hill, 2001. Tiger Beetles of New Mexico: Distribution, Abundance, Biology, and Conservation Status. Report to the U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, 2105 Osuna NE, Albuquerque NM 87113; and

Pearson, D. L., T. G. Barraclough, and A. P. Vogler. 1997. Distributional Range Maps For North American Species of Tiger Beetles (Coleoptera: Cicindelidae). Cicindela 29 (3-4): 33-84). Updated version available online at http://www.bio.ic.ac.uk/research/tigerb/rangepaper.htm.

[63] Dr. C. Barry Knisley, Randolph-Macon College, pers. comm. 2004.

[64] E.g., Knisley, C. B. (1987). "Habitats, Food Resources, and Natural Enemies of a Community of Larval Cicindela in Southeastern Arizona (Coleoptera, Cicindelidae)." Canadian Journal of Zoology-Revue Canadienne De Zoologie 65(5): 1191-1200.

Knisley, C. B., and D. L. Pearson. 1981. The Function of Turret Building Behavior in the Larval Tiger Beetle, Cicindela-Willistoni (Coleoptera, Cicindelidae). Ecological Entomology 6:401-410.

[65] Pearson, D.R., and E. J. Mury. 1979. Character divergence and convergence among tiger beetles (Coleoptera: Cicindelidae). Ecology 60(3): 557-566.

[66] Arizona Game and Fish Department. 2002. *Cicindela horni*. Unpublished abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 4 pp.

[67] Knisley et al. 2001, p. 83.

[68] Knisley, C. B. and J. M. Hill. 1996. The Florida Highlands tiger beetle, Cicindela highlandensis: habitat requirements, remaining range, life history, and management. Final report, Florida nongame wildlife program grant (NG91-012). Submitted to Florida Game and Fresh Water Fish Commission, Bureau of Nongame Wildlife.

[69] Bess, E.C., Robert R. Parmenter, Stacey Mccoy, and Manuel C. Molles, Jr. 2002. Responses of a Riparian Forest-Floor Arthropod Community to Wildfire in the Middle Rio Grande Valley, New Mexico. Environmental Entomology: Vol. 31, No. 5, pp. 774–784.

Beaudry, S., Duchesne, L.C., and Cote, B. 1997. Short-term effects of three forestry practices on carabid assemblages in a jack pine forest. Canadian Journal of Forest Research 27 (12): 2065-2071.

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[71] Hill, J.M., and C.B. Knisley. 1994. Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis* Say) Recovery Plan. U.S. Fish and Wildlife Service, Hadley, MA.

Yarbrough, W. W. and C. B. Knisley (1994). Distribution and Abundance of the Coastal Tiger Beetle, Cicindela-Dorsalis-Media (Coleoptera, Cicindelidae), in South-Carolina. Entomological News 105(4): 189-194.

[72] E.g., *Cicindela ohlone* and *C. highlandensis.*

[73] Knisley, B.C., and J.M. Hill. 1992. Effects of habitat change from ecological succession and human impact on tiger beetles. Virginia Journal of Science 43: 335-340.

[74] Center for Biological Diversity. 2001. 631 Extinct North American Species Identified As of 6-29 –01. Online.<http://www.sw-center.org/swcbd/activist/ESA/631extinctspecies.pdf>. Viewed January 2005.

[75] This includes 131 species in the BISON database for the Gray Ranch, plus two others noted in Bailowitz and Brock, 1991.

Cary, S.J. 1994. Gray Ranch: Fire and butterflies in southwestern New Mexico. Holarctic Lepidoptera 1: 65-68. (Note: this species list is reproduced, without the life history notes of the original paper, in the New Mexico BISON-M online database.)

[76] Instituto del Medio Ambiente y el Desarollo Sostenible (IMADES) and The Nature Conservancy. 2003. Propuesta para decretar area protegida los ranchos San Bernardino, Puerta Blanca, El Pinito, Y Potrero San Luis; Municipio de Agua Prieta, Sonora. [Joint report on biological value of a set of Sonoran ranches, with feasibility evaluation for formal protection].

[77] U.S. Geologic Survey, Northern Prairie Wildlife Research Center. Butterflies of Cochise County, Arizona, Butterflies of North America checklist project. Online. Internet. Accessed December 2004.
<http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/chklist/states/counties/az_3.htm>

[78] Bailowitz, Richard A., and James P. Brock. 1991. *Butterflies of Southeastern Arizona*. Sonoran Arthropod Studies, Inc. Tucson AZ. Page 9.

[79] Stewart, Bob, Priscilla Brodkin, and Hank Brodkin. 2001. *Butterflies of Arizona*. West Coast Lady Press. Arcata, CA. Page 1.

[80] Scott, J. A. 1986. The Butterflies of North America: A Natural History and Field Guide. Stanford University Press, Stanford CA. 583 pp.

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# 2.6 Mammals of the Peloncillo Region: Bridging the Tropical and Temperate

***Photo: ©1996 Warner Glenn; jaguar in the southern Peloncillo Mts.***

## *Outstanding Features*

- *Over 90 species of mammals.*
- *Five US federally endangered mammals.*
- *Near the largest prairie dog town on North American continent, critical to maintaining native grasslands.*
- *Jaguar photographed in the southern Peloncillo Mts. in 1996.*
- *Jaguar photographed in the northern Sierra San Luis (New Mexico) in 2006.*

The Peloncillo Mountains in southwestern New Mexico and southeastern Arizona are unique in that while they are comparatively low and dry in contrast to other Sky Island mountain ranges, they are part of a region that is biogeographically important for mammals because it provides a linkage between temperate and tropical faunal zones, most notably between the Sierra Madre to the south and the Rocky Mountains to the north.[1] A classic example of this is the 1996 sighting of a jaguar in the Peloncillo Mountains, presumably coming from a breeding population some 150 miles south. Small rodent distributions are arguably more affected by the region's low elevation "underpass" between eastern and western faunas than they are by it's higher elevation "bridge" between Northern and Southern mountain chains. *Perognathus* pocket mice demonstrate this blending of eastern and western faunas; *P. baileyi* is a western species from Baja California and Sonora that spills east over the continental backbone here. *P. flavus* is a species of the eastern plains, spilling westward through this same continental low spot. The region also harbors several species that are rare in the US and/or in Mexico, as well as a handful of mammals with very limited geographic ranges (i.e., narrow endemics).

As highlighted in previous chapters, the Peloncillos and adjoining landscapes are located at the intersection of six major biomes, including the Chihuahuan Desert, Great Plains, Great Basin, Sonoran Desert, Rocky Mountains, and Sierra Madre.[2] This meeting of biomes and associated topographic variation results in phenomenally high mammal diversity for a semi-arid zone, with 91 species documented for New Mexico's Hidalgo County, which contains much of the Peloncillo Mountains and all of the Animas Mountains and Animas Valley (Appendix E). The Animas Mountains, better surveyed for mammals than other parts of the Peloncillo region, report 76 mammal species.[3] This is a full third more than the much larger Yellowstone National Park, North America's park best-known for its mammals.[4] Even local, relatively small-scale sites can possess high levels of diversity. On a 49-acre (20 ha) study site in the San Simon Valley near Portal, Arizona, 25 species of small mammals have been documented since 1977—more mammal diversity than is contained in the entire State of Pennsylvania.[5]

Bats comprise nearly one quarter of the region's mammal diversity, with 18 species known from the Animas Mountains alone.[6] Five additional species have been reported from Hidalgo County, and eight (including two of the Hidalgo County species) from other parts of the Peloncillo region, for a grand regional total of 26-29 species (see Appendix E). Few other U.S. or Borderland locations can boast bat species numbers anywhere near this, with the closest we found being the Big Bend region of Texas with 19 species,[7] and Saguaro National Park in Arizona with 20 species.[8] As with many of the mammals of the Peloncillo region, the high diversity appears to be the result of overlap among species that are typically associated with divergent faunal provinces. For example, several tropical species such as the *Leptonycteris* bats discussed below are at the northern extent of their range here, where they overlap with boreal species.

This region's unique mammal elements make it more than just a high-diversity crossroads. The southern pocket gopher *Thomomys umbrinus emotus* is considered to be endemic to the Animas Mountains.[9] The white-sided jackrabbit *Leppus callotis* is known in the US only from the Animas Valley and adjacent Playas Valley; its distribution in Mexico is often depicted as extending into central Mexico (the Animas' subspecies *gaillardi* reaching northern Durango),[10] but is poorly documented and may have shrunk dramatically with habitat degradation as has happened in the US.[11] Several other species are reported in the US either exclusively or primarily from the Peloncillo region, including the Arizona cotton rat *Sigmodon arizonae cienegae* (a species mainly known from Sonora and southern Arizona, near its eastern range edge here), Yellow-nosed cotton rat *Sigmodon ochrognathus* (a Sky Island and Sierra Madre specialty, known also from the nearby Big Burro Mountains), and Arizona shrew *Sorex arizonae* (known from a handful of other Sky Island mountain ranges). Mearns' pocket gopher *Thomomys bottae mearnsii* is also a Sky Island specialist. The fulvous harvest mouse *Reithrodontomys fulvescens canus* is known in New Mexico only from the Peloncillo and Animas Mountains.

**Geographic scope**. The core data for this chapter center around mammal lists from Hidalgo County, New Mexico, and from studies of the Animas Mountains specifically, but extrapolations and interpretations for the entire Peloncillo region (see map, page 13) including Mexico, are also discussed.

## *Historical Data*

Mammalogists and other biologists have been drawn to the Borderlands of southwestern New Mexico, southeastern Arizona, and adjacent Sonora and Chihuahua for over 100 years. E. A. Mearns noted in his mammal survey of the Mexican boundary that he and F. G. Irwin traveled to the region in 1892, though no specimens were collected.[12] The earliest mammal specimens from southwestern New Mexico were obtained by E. A. Goldman, C. Birdseye, and V. Bailey of the United States Biological Survey in 1908. Subsequent reports on mammals,[13] plants,[14] and birds[15] relied principally on the data collected in that earlier fieldwork. In the late 1950s and early 1960s, J. S. Findley and

students from the University of New Mexico made periodic trips to the area. Specimens from these mammalogists are reported in Findley.[16]

More recent surveys (from ~1950's through 1980's) conducted in the Animas Mountains,[17] as well as the nearby Chiricahua,[18] Huachuca,[19] and Pinaleno (Graham) Mountains,[20] provide regional information on mammal composition to the west. The Big Hatchet and Alamo Hueco mountains east of the Peloncillos were also surveyed for mammals in the 1970s.[21] The above papers are reviewed in Cook.[22]

Because detailed reviews of borderland mammals already exist,[23] the rest of this discussion will not list the mammals of the Peloncillo region separately by species. Instead, discussion will focus on engineering and keystone species that are of fundamental importance in structuring vegetation of the Borderlands,[24] and discuss federally listed species of conservation importance.

## *Landscape Context: Dramatic Vegetation Changes*

The Peloncillo region and surrounding areas have undergone considerable vegetation change since European settlement. While few exotic species exist in the landscape compared with other regions of the county, contrasts of surveyor notes from the 1870s and satellite imagery from the 1990s indicate considerable increases in native woody vegetation.[25] Landscape change in the Southwestern US and Northwestern Mexico is often associated with over-grazing and drought in the late 1800s and early 1900s.[26] There is increasing evidence, however, that continued or accelerating increases in woody vegetation in the 20$^{th}$ century may be associated with fire suppression and high levels of winter rainfall.[27]

Since the late 1990s less seasonal and drier climatic patterns associated with Pacific Decadal Oscillation have displaced recent strong El Nino patterns[28] associated with woody plant growth.[29] It is not clear if current climatic patterns will result in a decline in woody species as happened in the 1950s drought[30], or if recent patterns of shrub and woody vegetation establishment will be sustained.

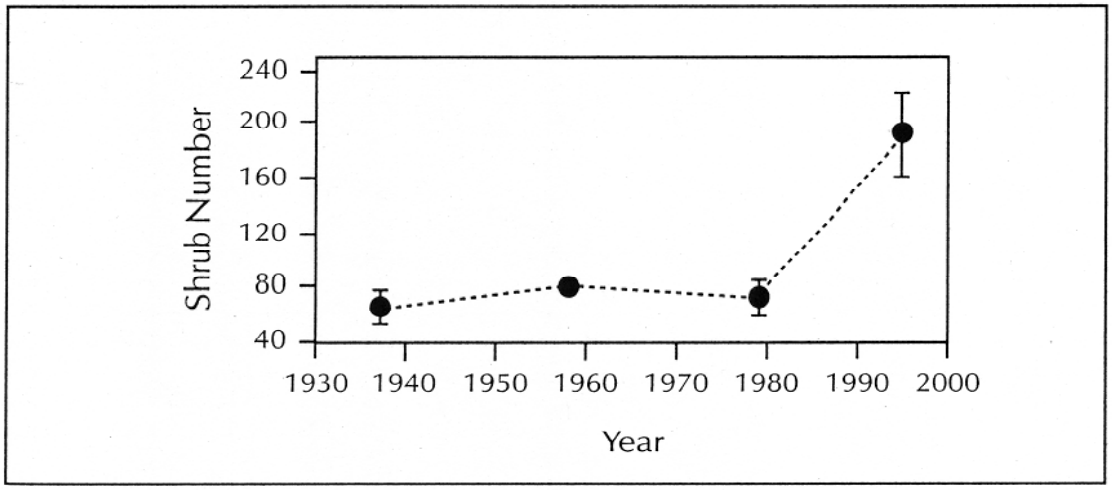


*Figure 2.6.1. Cover of woody shrubs in the San Simon Valley adjoining the Peloncillo Mountains increased three-fold from the 1970s through the 1990s. This increase occurred across the Peloncillo Mountains at all elevations and in grazed and ungrazed habitats (after Curtin and Brown 2001).*

Since 2000 the region of the Peloncillos has experienced considerable drought,[31] yet the response by small mammal populations has been mixed. Long-term studies near Portal, Arizona have recently attained record high numbers of mammals.[32] Mammal populations on the McKinney Flats study site 12 miles (20 km) east of the Peloncillos, however, show considerable declines since initial censuses in 1998, though these populations had been stable through the early 2000s. Recent work by J. H. Brown and associates analyzing over 25 years of mammal data indicates that no simple causation exists between mammal populations and climate with interactions independent of climate and considerably more complex than the simple associations with drought and rainfall.[33]

## *Engineering Species*

### American Bison (***Bison bison***)

Prior to European settlement, bison were the major engineering species throughout the North American continent with a key role in recycling nutrients and creating patch mosaics through disturbance.[34] Bison are recognized as a big game animal in Arizona, but not in New Mexico. A bison herd of roughly 200 animals exists in the Playas Valley east of the Sierra San Luis (12 miles/20 km east of the Peloncillos), and there are no physical barriers to prevent the animals from ranging to the Peloncillo region.

Bison appear to have been a key part of the prehistoric fauna of the Borderlands with reports of bison remains in southern Arizona dated from the 1200s. Prehistoric bison remains are regularly located on the Glenn Ranch in the San Bernardino valley just west of the Peloncillo Mountains. A remnant of America's wild bison herds also existed in the

Palo Duro River Valley of the Texas Panhandle during the 1880s. In the 1950s, 20 head of bison were moved from the Raymond Ranch near Flagstaff, Arizona to the Mexican state of Sonora. It was widely believed until recently that the Playas Valley herd was a part of these Arizona animals (previously from the National Bison Range and therefore of non-local genetic stock).[35] New evidence from Mexico, however, suggests that bison have been a considerably larger part of the recent history of the Borderlands.

From 950 to the time of Spanish settlement, bison appear to have been a major source of protein for the Casas Grandes culture that inhabited the region southeast of the Peloncillos. Since Spanish settlement, bison have been regularly reported starting in 1565 and continuing to the present.[36] Though recently penned on the Hurt Ranch in the Playas Valley, the animals now appear to again be ranging on both sides of the Mexico/U.S. border. Initial genetic work being conducted at Texas A & M University is encouraging in supporting the idea that this may well be a native herd, though conclusive analysis is still pending. This information is of crucial importance not only to conservation in the Peloncillo region, but how we perceive the entire Borderlands region. In the past it has been argued that because bison and other large grazers did not inhabit the Borderlands that ranching and other agrarian land-uses involving cattle could never be an appropriate conservation strategy because the land and the vegetation were fundamentally maladapted to grazing. In contrast, this historic information suggests that large grazers may still have an important role in maintaining the structure and function of these semi-arid ecosystems.

## Family Heteromyidae, kangaroo rats, pocket mice, and allies

Heteromyid rodents are small-bodied rodents with long tails, often modified for jumping, with elongated hind limbs and shortened front limbs. The group is characterized by bi-pedal movement (e.g., hopping) compared with most other rodents that move primarily on all four legs. Other characteristic features are fur-lined cheek pouches that allow them to carry food and auditory bullae (an enlarged audio portion of the skull) that give them remarkable hearing. As a highly desert-adapted organism, they are reported to never drink water and obtain water primarily through eating seeds. They have highly evolved predator defenses. Some species have been reported to have sensitive-enough hearing that they can detect owls in flight. They also appear to be moderately immune to snake venom. Members of this family mainly occupy grasslands and savannas, or lowland desert habitats.[37]

Of particular note for their importance as engineering species are the three species of kangaroo rat that inhabit the Peloncillo region. Ord's kangaroo rat is a plains inhabitant at the southwest edge of its range, which extends north and east across the Great Plains to Canada. Merriam's kangaroo rat is a desert organism found in shrublands and is primarily distributed across the Chihuahuan desert, eastern Sonoran Desert, and the southeastern Great Basin. Finally, of greatest ecological importance, is the larger mound-building banner-tailed kangaroo rat, which is nearly twice the size of the other species at 3 – 3.5 ounces (90 to 100 grams). The banner-tail is at the eastern edge of its range, which

extends across the northwestern Chihuahuan desert and across much of the Sonoran Desert.

Kangaroo rats are perhaps the single most important engineering or keystone species in the Peloncillo region (Figure 2.4.2). Many of the biodiversity hotspots for both vertebrate and invertebrate species appear to be associated with kangaroo rat burrows.[38] When banner-tailed kangaroo rats declined in the San Simon Valley adjoining the Peloncillo Mountains in the late 1980s and early 1990s, populations of other organisms such as burrowing owls and some species of rattlesnake also declined, apparently due to habitat loss.[39] Brown and Heske[40] documented this guild's crucial importance in structuring vegetation, while Chew and Whitford[41] illustrated how ecotonal boundaries between grasslands and shrublands are influenced by kangaroo rats with the abandoned mounds serving as important focal points for shrub establishment. While these studies were sometimes interpreted as evidence that kangaroo rats had a negative role in facilitating desertification, later research illustrates that kangaroo rats and other Heteromyids are crucial to preserving existing vegetation composition in face of recently climatically driven vegetation change.[42]

Curtin et al.[43] illustrate that in the absence of kangaroo rats, shifts in vegetation structure and patch composition would have been 16-fold between 1979 and 1995 on research plots in the Peloncillos, whereas in the same time period, vegetation in plots with kangaroo rats changed 3-fold. Work by Curtin and Kelt[44] presented in Curtin and Brown[45] indicates that rather than directly facilitating shrub increases as suggested by Brown and Heske[46], kangaroo rats dampen environmentally driven vegetation changes by disproportionately impacting the most common species. The tremendous loss of grassland habitats in western North America speaks to the value of any species that can slow the impacts of shrub invasion in remaining grasslands.

## Black-tailed Prairie Dog (*Cynomys ludovicianus*)

Prairie dogs are ground squirrel-like rodents with a short tail (15 - 30% of body length), hind foot as long as the tail, which is dark-tipped.[47] Prairie dogs are frequently cited as the classic keystone or engineering species in North American grasslands[48] and crucial to preserving the biodiversity of grasslands.[49]

As with kangaroo rat mounds, prairie dog burrows provide essential habitat for numerous species ranging from lizards to burrowing owls, while recycling nutrients and increasing overall biodiversity.[50] Prairie dogs have been demonstrated to reduce shrubs and sustain grasslands, and increases in shrubs in the Southwestern US and Northwestern Mexico has been partially attributed to loss of prairie dog colonies.[51]

Although a grassland species and not found in the mountains proper, prairie dogs were documented by surveyor records from the 1870s as being on bajadas west of the Peloncillos in the San Simon Valley, while field notes from Vernon Bailey written in 1908 document widespread prairie dog colonies in the Animas Valley. While these sites were extirpated in the early 20th Century, the largest remaining prairie dog colony in the

world remains near Janos, Chihuahua, Mexico. An active colony occurs north of the border in the Playas Valley, and colonies of recently translocated individuals were established on the Gray Ranch 12 miles (20 km) east of the Peloncillo Mountains.

Most of the information on prairie dogs comes from the central and northern plains. Two fundamental assumptions of the literature are:

1) Prairie dogs are essential to sustaining the structure and function of grasslands, and
2) That cattle grazing and prairie dogs are fundamentally in conflict.

Yet these assumptions have rarely been carefully examined, especially in desert grasslands. Work from the vicinity of Janos, Mexico documents the landscape-level contributions of large colony complexes to overall diversity and system function.[52] Results from experimental studies on the Gray Ranch illustrate that at the local scale of meters, prairie dog contributions to biodiversity are mixed with some factors increasing (lizards and vegetation biomass) and others declining (vegetation diversity and small mammals). Yet the effect of prairie dogs on organisms at a landscape-level are profound, even from small experimental colonies with cattle traveling miles across hot, dry pastures to forage in the vicinity of the prairie dog towns. Burrowing owls (*Athene cunicularia*), once rare in the area, are now common in the pasture. On a 26-mile breeding bird survey the only place the regionally declining Ferruginous hawks (*Buteo regalis*) are found is adjoining the prairie dog towns.[53]

While cattle and prairie dogs have long been considered competitors,[54] the reliance of prairie dogs on large herbivores was recognized as early as the 1850s.[55] Recent studies on the Gray Ranch indicate a positive interaction between cattle and prairie dogs, with cattle important for maintaining low grass and reducing predation pressure on prairie dogs, while prairie dogs reduce shrubs, increase vegetation biomass, and increase vegetation nutrient content.[56] These studies indicate that much of the biodiversity benefits ascribed to prairie dogs are really the result of interactions between prairie dogs and large grazers such as bison or cattle. In grasslands of the Southwestern US, the benefits of prairie dog restoration are as least as tangible for ranchers as they are for conservationists. The reintroduction of prairie dogs represents a potentially important tool for restoring degraded grassland structure while boosting and sustaining landscape-level biodiversity.

## *Rare or Endangered Species*

### *Leptonycteris* Bats

The principal bats of concern are the two federally listed species of *Leptonycteris* bats that have been located in the vicinity of the Peloncillos including the Mexican long-nosed bat (*Leptonycteris nivalis*) and the lesser long-nosed bat (*Leptonycteris yerbabuenae*; formerly known as *L. sanborni* and *L. curasoae yerbabuena* and also referred to as the North American long-nosed bat). The core habitat of these species is in Mexico. For

each the Mexican border region of the United States represents the extreme northern edge of their range.

The New Mexico State-listed western yellow bat (*Lasiurus xanthinus*) is another Mexico species that appears to be extending its range northward.[57] This organism is not included in this discussion of endangered and rare species because, while historically caught in Guadalupe Canyon in the Peloncillos,[58] this is another species at the northern edge of its range, and there is no evidence that it is under specific threat across its range.

During the short time that *Leptonycteris* bats are in the U.S. in the summer, one of their principal natural foods is agave nectar. A key question for bat conservation has been whether agaves are a limiting resource and therefore must be protected to preserve the bat. To answer this question in 1997, Dr. Liz Slauson of the Desert Botanical Garden chose an agave site near a known *Leptonycteris* bat roost in the Peloncillos. At a site less than one-half mile from the known roost, while the roost was occupied, Slauson bagged one portion of the flowering agave, while leaving adjacent flowers unbagged. Her results in the Peloncillos, and in 1998 studies in the Huachuca Mountains, showed no measurable difference in nectar present between those agaves accessible to the bats, and those inaccessible.[59] Dr. Slauson's conclusion was that there was so much nectar being produced within the bat's feeding range that the amount consumed by foraging bats had no effect on nectar availability, indicating that agaves are not a limiting resource.

In a companion study Dr. Peter Scott of Indiana State University in 1997 monitored agaves weekly from mid-July to August 6, and at two-week intervals after that until September 10 in the Peloncillos and Chiricahua Mountains. No bat visits were recorded in Peloncillos until late August and early September when agaves were nearly finished flowering. Similarly, in the Chiricahuas almost no bat observations were recorded from mid-July to mid-August, while between August 20 and September 10, both observation sessions yielded frequent visits.[60] This study, as with the ones by Dr. Slauson, indicates that agave nectar is not likely to be a limiting resource to *Leptonycteris* bats in the Arizona-New Mexico borderlands, and what usage does occur happens during a brief period at the end of the bolting season.

**Mexican long-nosed bat (*Leptonycteris nivalis*)**

The Mexican long-nosed bat has no documented occurrences in the Peloncillo Mountains. It has been found in the Animas Mountains in very small numbers (a few individuals), with reports of roosting bats in Pine Canyon. Its population size and dynamics in Arizona and New Mexico are unknown. Its global population size is unknown. The only substantial roosting site known in the U.S. is in Big Bend National Park, Texas, some 400 miles southeast of the Peloncillos.

**Lesser long-nosed bat (*Leptonycteris yerbabuenae*)**

The lesser long-nosed bat's total population in the Southwestern US is roughly 100,000 individuals. This estimate is based on the known numbers from a maternity roost in the Pinacate region of Sonora with over 65,000-75,000 bats (which disperse into the U.S.), and another 10,000 - 26,000 females at maternity roosts in the Organ Pipe National

Monument area.[61] Some authors postulate severe declines in these bats' population in historic times,[62] while others argue that populations of lesser long-nosed bats in Arizona are large, appear to be stable, and may even have increased in the 20th Century as a result of increases in habitat due to mining.[63]

The largest known U.S. summer roost for lesser long-nosed bat is in a Patagonia, Arizona cave, which up to 41,500 individuals may use on an occasional basis.[64] Other large summer roosts of several thousand bats are found in the Huachuca and Chiricahua Mountains. The Peloncillo Mountains contain a summer roost, which was discovered in the mid-1990s. This natural rock shelter site contained fewer than 100 individuals and therefore represents a fraction of one percent the known U.S. population. It is unknown what proportion of the southern Arizona maternity population stays in Arizona for the summer, and what proportion returns to Mexico. During this summer dispersal period, the primary food source in the U.S. is the nectar of various species of agave. Additionally, a much larger and more diverse food supply exists for these animals in their core habitat in Mexico. It is recognized in the literature that if there is a shortage of food in any one area, these highly mobile animals can move to where adequate food supplies exist.[65]

**Mexican Gray Wolf (*Canis lupus baileyi*)**

The Mexican gray wolf is a large canid with ears that are not markedly pointed, and a weight of up to 125 pounds (60 kg). Color is variable, and males are considerably larger than females.[66] Bogan and Mehlop reviewed the wolves of Arizona, New Mexico, and west Texas and northern Mexico and concluded that two distinct subspecies were present in the region: *Canis lupus youngi* and *C. l. baileyi*.[67] The Borderlands were inhabited by *Canis lupus baileyi*, which was considered the smallest wolf sub-species in North America, with 16 males from Chihuahua averaging 78 pounds (35 kg) and 16 females averaging 63 pounds (28 kg).

The Peloncillo region was perhaps the last stronghold for wolves in the Southwestern United States. From the 1910s through the 1960s government trappers worked out of the OK Bar Ranch 6 miles (10 km) west of the Peloncillo Mountains, with Red Hill in the Animas Valley a favorite wolf denning area. The last wolf was taken in 1965 in Pine Canyon in the Animas Mountains.[68] Although I could find no records of wolves specifically from the Peloncillo Mountains, a number of authors referred to a major wolf runway that appears to have crossed a significant portion of the southern Peloncillos.[69] Wolves reintroduced to the Blue Range Wilderness in east-central Arizona could easily dispersed into the Borderlands, as they could from rearing sites in Mexico's Sierra del Nido. Turner Endangered Species Fund biologist and wolf expert Mike Philips regards the greater Peloncillo region as perhaps the best wolf repopulation site left in North America,[70] whether by direct reintroduction or by natural dispersal.

**Jaguar (*Panthera onca*)**

The jaguar is a large felid with cinnamon-buff color spotted with black. Many of the black spots form broken circles or rosettes with one or more black spots in the center. Tail is about 40 to 45% of the head-body length. Overall length is six to eight feet (1,700

to 2,400 mm).[71] The jaguar is another species that is at the northern extent of its range in the Borderlands.

Even in the time of settlement from the 1880s through 1905, only 30 specimen records exist,[72] with none in New Mexico prior to 1996. With core habitats 150 miles south, the sightings appear to be primarily dispersing young males.[73] E. A. Goldman's 1908 field notes refer to a jaguar having been killed in the "Cloverdale Mountains east of the Animas Valley" five years earlier, but even then they were considered occasional visitors from the Río Yaqui Valley.[74] Sightings in Arizona and New Mexico occur several times a decade with one of the better-documented sightings in 1996 when rancher Warner Glenn photographed a young male in the central Peloncillos.

Jaguars have historically been associated with moist riparian areas, yet recent work by Carlos Lopez Gonzales and David Brown in Mexico indicates that in many areas mid-elevation scrub sites are more typical habitat. This information makes the Peloncillo region appear to be better jaguar habitat than formerly thought, though debate continues over whether the Peloncillo Mountains proper have the prey base to support jaguars. The individual photographed in 1996, however, made its living in the region for nearly a year after this first sighting.[75] The major current threat to jaguar is hunting in Mexico[76]; for example, Carlos Lopez Gonzales reports that the skin of the animal photographed by Warner Glenn was later seen in Mexico.

## Other Species of Concern

The federal "Species of Concern" category includes species that were formerly considered Category 2 and 3 Candidates for federal endangered or threatened listing. Several such mammal species are known from the Peloncillo region, with varying amounts of information available for each.

**Townsend's big-eared bat *Corynorhinus townsendii*** earned its Species of Concern listing by virtue of its low reproductive rate, extreme sensitivity to human disturbance, historic and continuing vandalism of roost caves by recreationists, and disturbance of abandoned mine shafts.[77] Both the pallid subspecies *Plecotus townsendii pallescens* found here and the more northerly subspecies *P.t.townsendii* qualify under this listing. The primary threats to this bat are disruptions of roost sites. Luckily, efforts by federal land managers and private landowners to control access into caves, and to secure mine shafts without blocking bat movement, has begun to ameliorate these threats. These predominantly moth-eating insectivores are also vulnerable to generalized insecticides, but toxic dumping in water sources (e.g., from mining, oil and gas exploration, and agricultural activities) is probably a greater threat in this sparsely populated region.[78]

**The Western red bat *Lasiurus blossevillii*** roosts in trees and shrubs, especially in well-developed riparian cottonwood, sycamore, and willow gallery forests.[79] These insectivorous animals are solitary roosters that often give birth to twins but may raise up to four pups at a time. Historic loss of riparian habitat is thought to be responsible for

declines in Western red bat populations throughout the Western US, but population trends are poorly documented.[80]

**The White-sided Jackrabbit *Lepus callotis*** is of particular interest here since most of its US range falls within the Peloncillo region. This large jackrabbit can be recognized by virtue of sides that are whitish rather than grayish, with the white areas extending far up the sides; ears without black tips; and black or grayish coloration behind the ears and nape.[81] The type-specimen was collected by Mearns in 1896 near Boundary Monument 63 on McKinney Flats within what is now the Gray Ranch.[82]

Recent unpublished studies by Traphagen and Schmitt indicate that the presence of these jackrabbits is typically associated with buffalo grass (*Buchloe dactyloides*) and negatively associated with shrub cover. This animal seems to have gone through a considerable constriction in its abundance and range.[83] In his 1908 field notes, mammalogist Vernon Bailey reports from the Watkins Ranch northeast of Hachita "two shot and saved and half a dozen more seen; half as many as of the gray." This is at least 40 miles (64 km) northeast of the apparent current range. Even in the best of habitats, white-sided jackrabbits only occur with a fraction of the abundance of the common *Lepus californicus.* While extending south into Mexico, *L. callotis* now only occupies two valleys in the United States, the Playas Valley 12 miles (20 km) west of the Peloncillos and the Animas Valley adjoining the Peloncillos (Bailey also reported *L. callotis* to be common here in 1908).

*L. callotis* currently occupies an area of less than 26,116 acres (10,568 ha) within the lower Animas Valley (though several unconfirmed sightings have recently occurred in the Playas Valley). This estimate, based on 1977 studies by Jim Bednarz, is probably optimistic because this area has experienced considerable shrub encroachment since the 1970s. Regular surveys since 1976 have documented a steady decline.[84] This trend appears to not just be occurring north of the border, but also in Mexico. Of the rare and threatened mammals in the Borderlands, the white-sided jackrabbit may be the most threatened with extinction.

**The Arizona shrew *Sorex arizonae*** was proposed for endangered species listing on the basis of being apparently very rare, with extremely localized occurrences in disjunct montane sites. This species is known from four places in the United States—the Chiricahua, Santa Rita, and Huachuca Mountains in Arizona, and Animas Mountains in New Mexico—plus one specimen caught in the Sierra Madre Occidental.[85] Within these mountain ranges, the shrew is known from montane conifer forest, encinal, and Mexican pine-oak woodland, tending to be found in relatively moist canyons with downed logs and well developed tree canopies.[86] Future surveys in appropriate habitats might also reveal Arizona shrews in the Peloncillo and San Luis ranges, though the latter seems more likely given its larger area of high-elevation forest.

## *Knowledge Gaps*

Because of the importance of the Peloncillo region as a corridor for wildlife, more focus must be placed on understanding the sections of the Peloncillos north of Interstate 10 in Arizona and New Mexico. These northern sections of the range are largely unknown by biologists and conservationists. A major knowledge gap remains in understanding the resources of, and threats to, these areas. In addition, very little is known about local populations of several species of concern such as the endangered Mexican long-nosed bat (*Leptonycteris mexicana*). Better local information will be vital to understanding the conservation needs of these species.

## *Conservation Targets*

Though the region's narrow endemics tend to be found in upper elevations, the majority of engineering and species listed as threatened or endangered occur in foothill and valley grasslands. This, and the biogeographic importance of the Peloncillos as a corridor between the Rocky Mountain to the north and Sierra Madre to the south, highlights the importance of focusing conservation efforts not just in upland areas, but in a mosaic of habitat types.

Long-term conservation strategies must therefore focus on not just isolated low-human-use core habitats held by public agencies, but also on preservation of the semi-natural matrix of habitats with a range of human uses.[87] Critical issues needing active conservation planning are:

- Maintaining and expanding the prairie dog complex near Janos adjoining the Sierra San Luis, the Playas Valley, and the San Simon Valley.
- Ensuring that areas adjoining the Peloncillo Mountains, Animas Valley and Gray Ranch are not eventually isolated by development. Without a conservation strategy that includes the preservation of these lower-elevation habitats contained within the larger landscape matrix, critical linkages between Sky Islands in the Borderlands will cease to exist.
- Ensuring that other developments such as border fences and high-speed roads do not further divide the Peloncillo region or isolate it from other parts of its faunal provinces that both feed it and are connected by it.

Additionally, specific species in urgent need of conservation are:

- White-sided jackrabbit, which of the rare and threatened mammals in the Borderlands may be the most threatened with extinction.

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# 2.7 Vegetation of the Peloncillo Region: High-Diversity Crossroads

On first sight the Peloncillo region—particularly the Peloncillo Mountains and adjacent Lordsburg Playa—seem spare and devoid of note to botanical study. But the vegetation of the Peloncillo region is particularly noteworthy for a number of reasons: a high number of species catalogued to date (879 in the central Peloncillo Mountains alone); its placement at the convergence of four major floristic regions[1] (Madrean, Chihuahuan, Sonoran, and Southern Rocky Mountain-Mogollon); and its relatively intact and large tracts of native habitats, which offer opportunities for further study and future conservation banking. A major portion of the region's species richness occurs in the Sierra San Luis, which has not been catalogued; thus the total numbers of species is much higher than now recorded.

**Geographic scope**. In describing the vegetation of the Peloncillo region, the boundaries used here are from Steins, New Mexico, and I-10 south to Guadalupe Canyon, including a portion of the Guadalupe Mountains, and the border with Mexico; and from the Animas Mountains in the east to the Peloncillo Mountains in the west, including the Lordsburg Playas. Adjacent to the Peloncillo Mountains in the south, in Mexico, are the Sierra San Luis. This range has not been completely botanically surveyed, and so numbers cited do not include this range, although they are included in discussions in this chapter.

## *Compiling the First Peloncillo Mountains Flora*

Prior to 2003, the flora of the Peloncillo Mountains was unknown except for local lists for Guadalupe Canyon[2] and the Bioresearch Ranch.[3] The flora of the Peloncillo Mountains (also Lordsburg Playas and the Sierra San Luis) was compiled from an electronic search of databased collections in the herbaria at the University of Texas at El Paso (UTEP), New Mexico State University (NMC, NMCR), the University of New Mexico (UNM), and some online searchable databases for some Arizona herbaria (ARIZ, ASU, et al.).

More than a quarter of a million collections were searched to produce lists of holdings for Hidalgo County, New Mexico (more than 10,000 files). These were then evaluated for occurrence within the Peloncillo Mountains or elsewhere within the area of study (more than 3,000 files). Literature records were also included. Inventories of the Peloncillo

*Photo ©2004 Greg McGee; Gray Peak, Peloncillo Mts.*

### *Outstanding Features*

- *At least 879 plant species in the Peloncillo Mts. proper, comprising over 24% of all plant species in New Mexico in only 2% of its area.*
- *Floral components of four distinct biotic regions.*
- *Isolation and difficult access have preserved remarkable number of intact, now-rare habitat types such as Plains grassland.*
- *Opportunities to study relationships between desert grasslands, prairie dog towns (the largest left in North America occur here), and grazing.*

Mountains, Sierra San Luis and Lordsburg Playas are found at the end of this report (Appendix B).

## *Composition of the Flora*

Floral diversity is affected by many factors including, area, elevational range, substrate types, amount and nature of surface water, activities of man, and proximity to other floristic regions. The Peloncillo region is large and includes two mountain ranges (Animas and Peloncillo Mountains) and a basin playa (Lordsburg Playa). The elevation range is moderate, from 3,800 – 8,500 feet (1,280 – 2,529 m).

Available surface water is limited and mostly seasonal. Substrate types include limestone and igneous rock outcrops and derived soils as well as the alkaline playa soils containing a high clay fraction. Disturbances by man, such as grazing and non-native species introductions, are factors. The area is also peripheral to three major floristic regions: Madrean, Chihuahuan, and Sonoran. It also has elements of a fourth: Southern Rocky Mountain-Mogollon. Accordingly, the flora is large and diverse.

The flora of the Peloncillo Mountains is the best focal point for discussion. Unfortunately the Sierra San Luis is largely botanically unexplored (Appendix B). The flora of Lordsburg Playas is not diverse because it is to a large extent physically controlled by a high clay composition in the soil and is an alkaline environment as well. Nevertheless, it contains important elements worthy of conservation (see below and Appendix B). The Peloncillo Mountains are botanically well-known having been visited on numerous occasions by a number of botanists since the 1930s.

Substrates in the Peloncillo Mountains are both igneous and sedimentary. Reasonably good riparian habitats are found in Guadalupe and Cloverdale Canyons, as well as a few other springs. The highest peak in the Peloncillos is 6,625 feet (2,019 m). An enumeration of the species found in the range is presented in Appendix B.

In Table 2.7.1 (below) the number of species documented from the Peloncillo Mountains is compared with the number of species known from New Mexico.[4] The 879 species making up the flora of the Peloncillo Mountains represent almost 24% of all the species known to occur in New Mexico.

**Table 2.7.1 Flora of the Peloncillo Mountains with Comparisons**

| Taxonomic Group | Peloncillo Mts. | State of New Mexico |
|---|---|---|
| Pteridophytes (ferns and allies) | 22 | 80 |
| Gymnosperms | 6 | 27 |
| Angiosperms (flowering plants) | | |
| Dicots | 678 | 2780 |
| Monocots | 173 | 735 |
| Total number of Vascular Plants | 879 | 3622 |

The significance of the large diversity of plant species (879 species) found in the Peloncillo Mountains can only be appreciated after a comparison with the diversity in other ranges. Few mountain ranges in the region have been adequately studied, but one is the Organ Mountains. The Organ Mountains, in Doña Ana County, are located far enough from the Peloncillos to provide a good comparison. The Organ Mountains rise about 5,000 feet (1,524 meters) above the surrounding basins to an elevation of 9,012 feet (2,746 meters), have limestone and igneous substrates, have permanent water, and have a well-developed Douglas-fir and ponderosa pine zone at the highest elevations.[5] The Peloncillo Mountains rise only 2,200 feet (670 meters) from the surrounding basins to 6,625 feet (2,019 meters), have igneous and limestone substrates, lack the high-elevation Douglas-fir and ponderosa pine community, but have some wetland habitats. The Organ Mountains flora contains about 850 species while that of the Peloncillos is 879 species. The Peloncillos have perhaps 150 more species than would be expected for a range of its size. The reason for the increased diversity is the location of the range in an area where a number of biotic provinces converge.

## Plant Communities

The plant communities in the region are pine-oak woodlands, oak savanna, chaparral, short-grass prairie (including desert grasslands), and Chihuahuan desert-scrub. The Lordsburg Playas is largely a saltbush and dropseed community. Riparian systems in some canyons such as Guadalupe Canyon and Cloverdale Canyon are limited but floristically diverse where they occur.

In the area surrounding Cloverdale at an elevation of 5,262 feet (1,603 meters) is the highest valley bottom in the Apachean or "sky island" region. This intact grassland is probably the most important community in need of conservation. Grasslands of this type are quickly vanishing in Mexico and elsewhere through abuse.[6]

## Biogeographic Considerations

The Peloncillo Mountains, along with their southern extension, the Sierra San Luis, are part of the Sierra Madre Occidental Phytogeographic Province, where Apachean and Madrean biotic provinces blend.[7] The area contains species from the Madrean province, which ends about 90 miles (150 km) south of the U.S. border but is mostly Apachean. The area's species mix is complex because the mountains or "sky islands" are surrounded by basins that contain floristic elements characteristic of other vegetative assemblages. For example, the Deming Plain, largely an arid grassland basin, passes east-to-west through the area and constitutes a "filter barrier" for species characteristic of the Chihuahuan and Sonoran Deserts. The Continental Divide is at its lowest elevation in the area of the Deming Plains, allowing further species interchange. A discussion of each biotic province's and floristic region's characteristics follows.

**Apachean.** The Peloncillo and San Luis Mountains are within what is recognized as the Apachean Biotic Province.[8] It consists of high-elevation grassland and emerging mountain masses ("sky islands") in southeastern Arizona, southwestern New Mexico, and adjacent area of northeastern Sonora and northwestern Chihuahua. The following plants have distributions that are Apachean:

*Berberis wilcoxii*
*Brickellia simplex*
*Bouteloua eleudens*
*Carex chihuahuensis*
*Desmodium batocaulon*
*Eysenhardtia polystachya*
*Fraxinus papillosa*
*Hackelia ursina*
*Hedyotis greenei*
*Mammillaria wrightii* v. *wilcoxii*
*Muhlenbergia arizonica*
*Penstemon supurbus*
*Platanus superbus*
*Verbesina longifolia*

**Madrean.** The Sierra Madre Occidental is within the Madrean Biotic Province. It extends to within 90 miles (150 km) of the U.S.-Mexico border. Some argue that the "sky islands" within the Apachean province are actually isolated assemblages of the Madrean province. Many plant species have distributions primarily within Mexico but reach the United States in the Peloncillo and nearby mountains. These plants reach the northern limits of their distribution in and around the Peloncillo Mountains. Representative plants showing this pattern of distribution (Madrean and/or more widely distributed to the south in Mexico) are the following:

*Abutilon malacum*
*Acacia milifolia*
*Amoreuxia palmatifida*
*Anoda pentaschista*
*Aspicilia hirtella*
*Bouchea prismatica*
*Castilleja ornate*
*Castilleja wrightii*
*Cuphea wrightii*
*Dalea filifolia*
*Dalea grayi*
*Dalea greggii*
*Jatropha macrorhiza*
*Krameria grayi*
*Machaeranthera riparius*
*Mecardonia vandelloides*
*Mimosa dysocarpa*
*Mimosa grahamii*
*Porophylum ruderale*
*Rivina humilis*
*Senecio salignus*
*Sideroxylon lanuginosum*
*Silene thurberi*
*Tephrosia tenella*
*Tripsacum lanceolatum*
*Yucca madrensis*

**Chihuahuan.** Some elements of the Chihuahuan Desert flora extend northeast or east to reach their western limit of distribution in the area of the Peloncillo Mountains. Some representative examples are the following:

*Escobaria orcuttii*
*Philadelphus mearnsii*
*Vaquilenia californica* ssp. *pauciflora*

**Sonoran.** Some plants of the Sonoran Desert extend east into the Peloncillo Mountains region and even beyond. Representative examples are the following:

*Cylindropuntia spinosior*
*Echinocereus rigidissimus*
*Ferocactus wislizeni*

**Western species reaching the eastern limit of distribution in the region.** A number of plant species range from California and Baja California east to the area of the Peloncillo Mountains. Representative examples are the following:

*Castilleja exserta*
*Cirsium arizonicum*
*Eriophyllum lanosum*
*Mirabilis pumila*
*Phoradendron californicum*
*Prosopis velutina*
*Sophora arizonica*
*Yaba microcarpa*

**Northern—including Rocky Mountain—species that reach the southern limit of distribution in the region.** Some species have distributions centered to the north of the region but extend south into the area of the Peloncillo Mountains. Representative examples are the following:

*Aquilegia desertorum*
*Heuchera novomexicana*
*Oenothera elata* ssp. *hirsutissima*
*Purshia stansburiana*
*Solidago missouriensis* var *tenuissima*

**Endemics.** Endemism in plants is uncommon in the region. Two species qualify as endemics.

*Hymenoxys ambigens* var. *neomexicana* [Animas and Peloncillo Mountains]
*Limosella pubiflora* [Chiricahua and Peloncillo Mountains]

## *Flora of the Sierra San Luis*

The Sierra San Luis (San Luis Mountains) are a small north-south trending range of about 25 miles (15 km) in length, extending from just across the U.S. border at San Luis Pass where it is contiguous with the Animas Mountains, south into Mexico along the borders of Chihuahua and Sonora to the vicinity of Mexico Highway 2 at Puerto San Luis. The elevation range is 4,300 - 8,300 feet (1,310 – 2,530 meters). Substrates include volcanic ash, basalt, andesite, felsite, quartz latite tuff, rhyolite tuff and conglomerate.[9] Wetland habitats are limited. In some places a Douglas-fir community is present.[10]

Botanically the San Luis Mountains are largely unexplored. The range is in a sparsely settled region of Mexico where the plant communities should be intact. Accessibility is difficult, hence its biota is poorly known except for incidental collecting in the San Luis Pass area at the north and Puerto San Luis area to the south (Appendix B). Plant communities would be expected to be similar to those known from the Peloncillo and Animas Mountains. Because of their higher elevation (than the Peloncillo Mountains), a stronger Madrean component of the flora is expected. It is known that the Peloncillo Mountains rise to 6,625 ft. (2,019 meters) and support a flora of 879 species (Appendix B) and the nearby Chiricahua Mountains reach 9,726 feet (2,964

meters) and support a flora of 1,200 species.[11] It can be safely concluded that the San Luis Mountains flora would consist of at least 900 species, although this remains to be documented.

The first explorations into the Sierra San Luis were those of Mearns[12] conducted in 1892 and 1893. Mearns explored several canyon systems in the Sierra San Luis and climbed to the tops of the tallest peaks. He collected plant and animal specimens and recorded observations on the elevational distribution of trees and shrubs. He provides a short plant list for the range but the taxonomy has changed so much that some of the observations cannot be accurately recorded in the following list of species without reviewing his vouchers (if vouchered) that are at the U. S. National Herbarium.[13] Mearns published some photographs of the area.

A more recent survey conducted in the Sierra San Luis is that of Marshall[14] for birds inhabiting pine-oak woodlands in the mountains of southern Arizona and adjacent Mexico. Marshall worked in the Turkey Canyon area, a site also explored by Mearns. Marshall writes: "In Turkey Canyon there was a patch of a few acres consisting of this improbable mixture of trees: Douglas-fir, piñon, Chihuahua pine, Apache pine, Arizona cypress, alligator juniper, net-leaf oak, silver-leaf oak, and Arizona madrone." He reports that Turkey Spring is still (in 1953) like the photograph in Mearns. He reports for that time in 1953 no logging and no grazing in the Sierra San Luis was occurring.

The plant list has come from the literature such as it exists and a survey of holdings at four herbaria for collections made at San Luis Pass, where the San Luis Mountains are contiguous with the Animas Mountains. The only significant collections from the south end of the range are from Puerto San Luis along Mexico Highway 2 and a microwave tower road that were made by Van Devender and are at ARIZ. The observations Van Devender made on the flora about his campsite have been provided.[15]

**Table 2.7.2 Plant Collectors, Sierra San Luis**

| **PLANT COLLECTORS VISITING THE SIERRA SAN LUIS [SAN LUIS MOUNTAINS]: PARTIAL RECORD** | | | |
|---|---|---|---|
| **DATE:** | **Collector** | **Place** | **Herbaria** |
| 1892 – 1893 | Mearns | Eside San Luis Mts | US |
| 09 May 1937 | Hershey | San Luis Pass | UNM |
| 31 JUL 1940 | Hershey | San Luis Mts. | NMC |
| 11 NOV 1942 | Hershey | E side San Luis Mts | NMC |
| 09 JUN 1949 | Castetter | San Luis Pass | UNM, NMCR |
| 1951, 1954 | Marshall | Turkey Canyon Area | ARIZ |
| 14 MAY 1955 | Castetter | San Luis Pass | UNM |
| 21 AUG 1955 | Castetter | San Luis Pass | UNM |
| 11 MAY 1956 | Castetter | San Luis Pass | UNM |
| 11 MAY 1957 | R. Jackson | San Luis Pass | UNM |
| 09 May 1962 | Castetter | San Luis Pass | UNM |
| 25 MAY 1962 | J. Blea | San Luis Pass | UNM |
| 21 JUN 1962 | W. Martn | San Luis Pass | UNM |
| 23 SEP 1967 | Hess | San Luis Pass | NMC |

| | | | |
|---|---|---|---|
| 18 SEP 1972 | Lindley | San Luis Pass | NMCR |
| 22 APR 1973 | Soreng & Spellenberg | 1.5 mi. S of San Luis Pass | NMC |
| 20 APR 1975 | W. Wagner | San Luis Pass | UNM |
| 21 MAY 1975 | W. Wagner | San Luis Pass | UNM |
| 18 JUN 1975 | W. Wagner | San Luis Pass | UNM |
| 20 JUN 1977 | W. Wagner | San Luis Pass | UNM |
| 21 OCT 1984 | T. Van Devender | Puerto San Luis | ARIZ |
| 20 APR 1986 | R. Worthington | San Luis Pass | UTEP |
| 26 OCT 1990 | K. Allred | San Luis Pass | NMCR |
| 19 AUG 1993 | K. Allred | San Luis Pass | NMCR |
| 20 AUG 1993 | L. McIntosh | San Luis Pass | NMCR |
| 21 AUG 1993 | D. Ivey | San Luis Pass | UNM |
| 19 SEP 1993 | S. L. Christy | San Luis Pass | UNM |
| 29 MAY 1997 | G. Ferguson | Puerto San Luis | ARIZ |

## *Flora of Lordsburg Playa*

A conspicuous feature of the landscape when driving between Lordsburg and Road Forks on Interstate 10 are the alkali flats of Lordsburg Playas. These landscapes are barren, generally dry, flat, and undrained. The playas soils are strongly alkaline and contain considerable amounts of clay, reducing permeability.[16] This area would seem unworthy of any conservation effort except that an important aquatic arthropod assemblage survives there and flourishes when the playa holds water (see Chapter 7).

Surrounding the alkali flats is a zone of vegetation on Horndale soils of medium grasses, mesquite, saltbush, and althorn.[17] The surface of the soil is silty loam with abundant clay below that. This soil is also strongly alkaline and has slow permeability. The plant community is not diverse but contains some rare plant species worthy of conservation efforts. The greatest threat to this community is grazing, since the vegetation that grows there can tap water resources throughout the year.

## *Rare and Endangered Plants*

A number of resources document rare and endangered plant species.[18] Within New Mexico plants are assigned a "R-E-D Code." More information on the meaning of agency codes can be found on the New Mexico Rare Plants Technical Council (1999) website [http://nmrareplants.unm.edu] and in the Arizona Rare Plant Field Guide. See Appendix B for rare and endangered plant lists.

## *Knowledge Gaps*

A full botanical survey of the Sierra San Luis would be an important addition to the knowledge of the Peloncillo region, elevating its stature as an important botanical area even further.

## *Conservation Targets*

While the Peloncillo region as a whole is fairly intact in its ecosystem health, a few areas of note should be targeted for specific, targeted conservation:

- Grasslands at Cloverdale are in the highest valley bottom in the Apachean or "sky island" region. Native grasslands of all types are quickly vanishing on both sides of the international border, but these plains-type grassland associations dominated by blue- and black-grama are especially rare.[19]

- Lordsburg Playas contains rare plant species (see Appendix B), which are threatened by grazing in this unusual environment.

Notes, Chapter 2.7

[1] For a discussion of the differences between floristic regions, biotic provinces, biotic communities, and vegetation associations (as applied specifically to this region), see:
Bourgeron. P.S.,L. D. Engelking, H. C. Humphries,, E. Muldavin, and W. H. Moir.1995. Assessing the Conservation Value of the Gray Ranch: Rarity, Diversity, and Representativeness. Desert Plants 11 (2-3): 1-66.

[2] Mearns, E. A. 1907. Mammals of the Mexican boundary of the United States. Bull. U. S. Natl. Mus. 56:1-524; Hess, W. 1976. Checklist of plants in Guadalupe Canyon. Typed manuscript; and Spellenberg, R. 1979. A report on the survey for threatened and endangered plant species in Guadalupe Canyon and vicinity, Hidalgo Co., N.M. Report to NM Heritage Program. 48 pp.

[3] Moir, W. H. 2002. Flora of the central Peloncillo Mountains, with emphasis on the Bioresearch Ranch [current ranch checklist]; and Todsen, T. K. 1980. A report on the survey for rare plant species at the Bioresearch Ranch, central Peloncillo Mountains, Hidalgo County, New Mexico. Report to the NM Heritage Program. 32 pp.

[4] Allred, K. W. 1999. A working index of New Mexico vascular plant names (2nd Ed.). Range Science Herbarium, New Mexico State University [and online current edition: http://web.nmsu.edu/~Kallred/herbweb/].

[5] Worthington, R. D., K. Allred, D. Anderson, R. Spellenberg and R. Corral. 1997. An Annotated checklist and inventory of the flora of the Organ Mountains, Doña Ana County, New Mexico. Third Draft. 104 pp.

[6] Gori, D.F., and C.A.F. Enquist. 2003. An assessment of the spatial extent and condition of grasslands in central and southern Arizona, southern New Mexico, and northern Mexico. The Nature Conservancy, Tucson AZ.

[7] Felger, R. S., G. P. Nabhan and R. Bye. [n.d.] Apachean/Madrean region of Southwestern North America. [http://www.nmnh.si.edu/botany/projects/centers/apachmad.htm]

[8] Dice, L. R. 1943. The biotic provinces of North America. Ann Arbor: University of Michigan Press; and Felger, Nabhan & Bye, n.d.

[9] Zeller, R. A., Jr. 1962. Reconnaissance map of the southern Animas Mountains. Geologic Map 17. State Bureau of Mines and Mineral Resources. New Mexico Institute of Mining and Technology, Socorro, New Mexico; and Van Devender, pers. comm.

[10] Marshall, J. T. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Cooper Ornithological Society, Pacific Coast Avifauna No. 32; and Mearns, 1907.

[11] Felger, Nabhan & Bye, n.d.

[12] Mearns, 1907.

[13] ibid.

[14] Marshall, 1957.

[15] Van Devender, T. R. 1984. [Field notes for 20 Oct 1984; campsite plant list for locality above Puerto San Luis (Mexico hwy. 2) on microwave tower road] 4 pp.

[16] Cox, D. N. 1973. Soil survey of Hidalgo County, New Mexico. U. S. Dept. Agriculture, Soil Conservation Service and Forest Service.

[17] ibid.

[18] Arizona Rare Plant Committee [Mima Falk, Coord.]. 2003. Arizona Rare Plant Field Guide. Publ. by the committee; New Mexico Rare Plants Technical Council. 1999. New Mexico Rare Plants. Albuquerque, NM:New Mexico Rare Plants Home Page [http://nmrareplants.unm.edu]; and Sivinski, R. and K, Lightfoot. 1995. Inventory of the rare and endangered plants of New Mexico. Third Edition. New Mexico Forestry and Resources Conservation Division, Energy, Minerals and Natural Resources Department, Miscl. Publ. 4, 47 pp.

[19] Muldavin, E., V. Archer, and P. Neville. 1998. A vegetation map of the Borderlands Ecosystem Management Area. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque, New Mexico, USA.

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