Ecoregion-Based Conservation in the Chihuahuan Desert

A Biological Assessment


Editors: Eric Dinerstein, David Olson, Jennifer Atchley, Colby Loucks, Salvador Contreras-Balderas, Robin Abell, Eduardo Iñigo, Ernesto Enkerlin, Christopher Williams, and Guillermo Castilleja

Maps and GIS data: Colby Loucks, Wesley Wettengel, Fabian Lazano, and Thomas Allnutt


A collaborative effort by World Wildlife Fund, Comisíon National para el Conocimiento y Uso de la Biodiversidad (CONABIO), The Nature Conservancy, PRONATURA Noreste, and the Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM).

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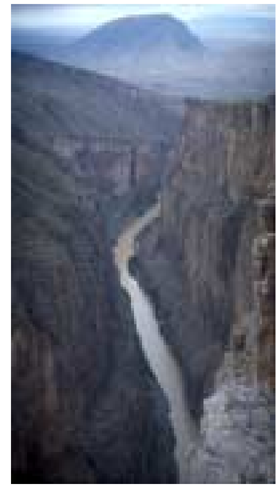
A Vision for the Chihuahuan Desert



The Chihuahuan Desert, shared by two nations, is one of the most biologically rich desert ecoregions in the world, alive with large mammals, birds, reptiles and an unmatched diversity of cactus species. The desert's rivers, streams and springs are considered to be of global significance, home to fish species found nowhere else on earth.

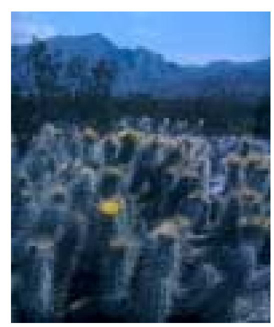
Our vision is a Chihuahuan Desert where governments, local communities, non-governmental organizations, academic institutions, landowners, and other stakeholders are working together to ensure that the richness and diversity of wildlife, habitats, natural communities, and ecological processes of the Chihuahuan Desert are conserved and, where necessary, restored.

For our part, WWF will strive to fulfill this vision by promoting protection of unique and important habitats and improved management of public and private lands. Tying it all together is the life-giving water of the desert's rivers, streams and springs. WWF will operate on the international, national, and local levels, advocating legal and policy changes, researching economic instruments and conservation strategies, and educating the public about the importance of leaving enough water in the desert's rivers, streams and aquifers to conserve its unique species and habitats.

Finally, we envision a Chihuahuan Desert where local people, the source of the region's economic and cultural dynamism, have the knowledge, the resources, and the tools to take the lead in conserving their own natural heritage. Thus, we are committed to building capacity through education, technical assistance and funding.

Una Visión para el Desierto Chihuahuense

El Desierto Chihuahuense, compartido por dos naciones, es una de las ecorregiones desérticas de mayor riqueza biológica en el mundo, semillero vivo de grandes mamíferos, aves, reptiles y una diversidad única de especies de cactáceas. Más aún, en el Desierto Chihuahuense brotan manantiales, arroyos y ríos de agua dulce que tienen importancia global, ya que albergan especies de peces que no se pueden encontrar en ninguna otra parte del mundo.



Tenemos la visión de un Desierto Chihuahuense en el que los gobiernos, las comunidades locales, las organizaciones no gubernamentales, los propietarios de tierras y otros interesados trabajen juntos para asegurar que la riqueza y diversidad de flora y fauna, hábitats, comunidades naturales y procesos ecológicos de esta ecorregión se conserven y, donde sea necesario, se reestablezcan.

Por nuestra parte, en WWF trabajaremos para hacer realidad esta visión promoviendo la protección de hábitats únicos e importantes y el mejor manejo de tierras públicas y privadas, teniendo como eje el agua viva de los ríos, arroyos y manantiales del desierto. En WWF operaremos en el ámbito internacional, nacional y local, promoviendo cambios legales y de políticas, investigando instrumentos económicos y estrategias de conservación, y promoviendo una conciencia entre el público sobre la importancia de dejar suficiente agua en los ríos, arroyosy acuíferos del desierto para conservar sus especies y hábitats únicos.

Visualizamos un Desierto Chihuahuense donde la gente local, fuente del dinamismo cultural y económico de la región, tenga los conocimientos, recursos y herramientas para asumir el liderazgo de la conservación de su patrimonio natural. Así, estamos comprometidos a ayudar a construir estas capacidades mediante la educación, asistencia técnica y apoyo financiero.

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Executive Summary

Deserts, by their very name, are seldom regarded as important reservoirs of biological diversity. But some deserts are extraordinarily rich in species, rare plants and animals, specialized habitats, and unique biological communities. One example is the Chihuahuan Desert, identified by a WWF-sponsored global assessment of biodiversity as one of the most important arid ecoregions on Earth (Olson and Dinerstein 1998). Spanning an area of almost 629,000 km^2 from the southwestern U.S. to the Mexican Central Plateau, the Chihuahuan Desert is world renowned as a center of diversity for cacti (family Cactaceae). Besides cacti, many desert plants, fish, and reptile species show rather localized patterns of endemism and exhibit high turnover of species with distance - the hallmark of a biologically rich ecoregion. The complexity of the freshwater fish assemblages elevates the Chihuahuan as the only desert ecoregion recognized for both its freshwater and terrestrial biodiversity in the Global 200 analysis (Olson and Dinerstein 1998).

The conservation of Chihuahuan biodiversity requires a comprehensive ecoregion-scale strategy rather than ad-hoc activities at isolated sites. This document contains the first layer of information needed to create such a strategy- a biological assessment and a biodiversity vision. We address the following key questions: 1) How can we accurately delineate the biological features that elevate the Chihuahuan Desert as one of the highest priority ecoregions in the world? 2) What constitutes a vision of success for conservation of these outstanding features over the next fifty years?

To preserve Chihuahuan biodiversity over the long term, we applied an ecoregion-based conservation (ERBC) approach. The goal of ERBC is to conserve the full range of species, natural communities, habitats, and ecological processes characteristic of an ecoregion. The ERBC process began with a series of meetings to enhance collaboration among many U.S. and Mexican scientists, conservationists, and representatives from government agencies and non-governmental organizations. We then conducted an extensive literature review and preliminary mapping study of the Chihuahuan Desert. Together with our collaborators - Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), PRONATURA Noreste, The Nature Conservancy, and the Instituto Tecnilogico y de Estudios de Superiores Monterrey (ITESM) - we invited over 100 experts to participate in a priority-setting workshop to test the proposed approach to ERBC. Sixty of the 100 invitees attended, representing a wide array of taxonomic experts with extensive personal knowledge of the ecoregion. A subset of those unable to attend the workshop provided peer review for this assessment.

We devised a method for Chihuahuan experts to provide data on species occurrences and distributions, natural communities, ecological processes, and intact habitat areas (Chapter 2). The first activity at the workshop was to map important sites for conservation of six indicator taxa - birds, mammals, herpetofauna, invertebrates, obligate freshwater species, and plants - and distinct habitats. These 299 locations became known as nominated sites for an ERBC strategy. The second activity was to synthesize the data layers of the overlapping nominated sites to create a smaller subset of 61 terrestrial candidate priority sites.

Unfortunately, it is impossible to act immediately at all 61 sites. Thus, the terrestrial experts adopted a matrix and ranking system to prioritize terrestrial sites based on the integration of two powerful variables: biological distinctiveness and landscape integrity (Chapter 2, Figure 2.2). The freshwater experts designed a similar matrix, based on biological distinctiveness and habitat intactness (Chapter 2, Figure 2.3). Biological distinctiveness estimates the relative rarity of biological features at global, continental, and ecoregion scales (Chapter 4). Classification of this variable ranged from sites that supported high levels of endemism, rare communities, or important ecological and evolutionary processes - the highest ranked features - to multiple sites that support similar species and communities in the lowest ranked category. Landscape integrity estimates the probability of long-term persistence of ecological processes, species assemblages, and other important elements of biodiversity (Chapter 5). It is divided into categories based on the size of habitat blocks and their condition: intact or relatively intact, degraded, or highly degraded but still restorable. Habitat intactness, the variable used in the freshwater matrix, is similar to landscape integrity but does not take into account the size of habitat blocks, as this measure is not as relevant or easily measured for freshwater systems. The cells of the matrix were consolidated into five ranks, but only the top four ranks were considered as part of the conservation portfolio for terrestrial sites. Only the top two ranks were considered in the freshwater analysis.

Setting priorities

Sixteen of the 61 candidate priority sites (26%) were selected as highest priority (Level 1) and 18 (30%) as high priority, or Level 2 (Figure 6.1) (Chapter 6). These sites form the core of a Chihuahuan ERBC strategy. Eighteen more sites were ranked as Level 3 (30%), and six as Level 4 (10%). Freshwater specialists identified 37 priority sites (Figure 6.2). Twenty-four of these freshwater sites overlap in area by at least 50% with a terrestrial priority site.

The Chihuahuan Desert ecoregion contains few protected areas designed primarily for conservation of biodiversity, *i.e.* those classified as IUCN categories I-IV, or gap categories 1 and 2 (Chapter 7). Only 2.5% (12,000 km^2) of the ecoregion is under formal protection, a remarkably low total for such a large, sparsely populated area. The U.S. portion holds all of the level I protected areas, even though 75% of the ecoregion is in Mexico. Within the 16 highest priority terrestrial sites (Level I), the amount of total protection is 3.7%, but all of this is in the U.S. A biological skew is also evident: of 121 total protected areas at IUCN level I, only 17 have been designed to conserve freshwater priority sites. Thus, a glaring omission is the lack of effort to protect freshwater rivers, streams, pozas (pools), or basins, even though the Chihuahuan may be the most globally distinct arid ecoregion in terms of freshwater biodiversity (Olson and Dinerstein 1998).

In sum, the current configuration of protected areas does little to address two of the fundamental goals of ERBC: conserving patterns of beta-diversity and large landscapes (Chapter 2). The extraordinary beta-diversity of the Chihuahuan-distributed among basins, isolated springs, gypsum habitats, and mountain ranges - requires a network of reserves distributed widely to capture the complex distributional patterns of many narrow range endemic species. The need to conserve large landscapes is equally ignored in that the median size of the ten protected areas that overlap with the highest priority sites is only 204 km^2. The overlay analyses of priority sites and protected areas - as determined by CONABIO and this assessment - paint a picture of an extraordinarily diverse desert ecoregion, with a clear sense of where biological priorities are, but vastly inadequate efforts in place to conserve these resources.

Threats to priority sites (Chapter 8 and Appendix B) were evaluated and scored on the basis of susceptibility to conversion, degradation, and wildlife exploitation over a period of 20 years, and assigned a level of threat of high, medium, low, or unknown. An unacceptably high percentage of Level 1 and 2 priority sites have a high or medium level of threat. Overall, 24% of priority sites have a high threat level, 43% have a medium threat level, and 25% of priority sites have a low threat level. Water mismanagement and a growing human population in the ecoregion were cited as the gravest threats to biodiversity. Overgrazing and overbrowsing by livestock, agricultural expansion, lack of law enforcement, introduced and exotic species, and overcollection of biota were also deemed responsible for loss of species and habitats.

Towards a biodiversity vision

Based on the current status of biodiversity, landscape integrity, and future threats, the experts helped craft a biodiversity vision and long-term strategy for conservation of the Chihuahuan Desert (Chapter 9).

The core of a biodiversity vision for the Chihuahuan Desert's terrestrial landscape, its rivers, and its springs must be visionary, focusing on what this ecoregion should look like 50 years hence rather than accepting what remains on the map today. Defining success for the Chihuahuan Desert begins with the conservation in perpetuity of its 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 desert.

Another element of the vision is restoration of landscapes and communities which builds on core features. This includes restoration of flora and fauna associated with prairie dog colonies, desert springs and removal of exotic species in these waters, desert plant communities affected by overgrazing and overbrowsing, and gypsum soil habitats that have been degraded. Another element of the vision is to manage large 'conservation landscapes' of sufficient size and connectivity to maintain important ecological processes and wide-ranging species. This includes restoration, where appropriate, of populations of Mexican wolves, mountain lion, jaguar, bison, black bear, pronghorn antelope, and aplomado falcons. Through the protection of these large conservation landscapes, managed in collaboration with a variety of stakeholders, important gaps in the protected area network of this ecoregion will be addressed.

Finally, the vision will address the conservation of sites important to hemispherical 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, such as migratory birds, bats, and monarch butterflies.

For conservation at an ecoregion scale to succeed, the overarching threats identified in this assessment - mismanagement and diversion of water resources, overpopulation in sensitive areas, overgrazing and overbrowsing of native plant communities, and lack of enforcement of existing laws - must be addressed and mitigated in a timely manner. Within a decade, educators, officials, local leaders, and NGOs must sensitize and win support from a cross-section of communities who understand and value the biodiversity in their backyard because of the ecological services it provides as well as its intrinsic value.

Where to focus first

A synthesis of recommendations from Chihuahuan experts provides a plan of where to focus conservation efforts now:

1) Sixteen of the 61 terrestrial priority sites, many of which overlap with sites identified as priorities by CONABIO, are of continental and global importance for biodiversity conservation. These represent the immediate targets for conservation action.

2) Few of these 16 sites are effectively protected. Thus, immediate efforts should concentrate on designing large conservation landscapes around these 16 sites that conserve distinctive elements of biodiversity and enhance connectivity. These landscapes should possess large core areas that protect biodiversity and buffer areas and corridors that allow for limited use depending on the sensitivity of the local biotas.

3) Because protected areas are few, another immediate task is to undertake a comprehensive effort to plan an ecoregion-scale network of reserves that conserves patterns of beta-diversity and maintains linkages to adjacent ecoregions.

4) Among the 37 freshwater biodiversity sites, an immediate goal is to better control the mismanagement of water resources in and around the highest priority areas.

6) Another freshwater target would be to remove alien species where possible to prevent further extinctions in isolated pozas and other habitats such as springs where they threaten native biotas. A concerted effort to prevent the introduction of species should be made in those few freshwater sites that remain free of exotics.

7) All of these immediate measures are designed to save source pools for future restoration efforts. Greatest attention should be given the 13 highest priority (Level 1) terrestrial conservation sites that overlap with freshwater priority sites. Conservation efforts made today to save these source pools will pay huge dividends later for ERBC by increasing the probability of successful restoration programs.

A priority for the coming decade

For both terrestrial and freshwater biodiversity, a set of restoration targets with a clear timetable must be formulated within the next few years. For the long-term persistence of biodiversity, degraded lands outside of the core must sustain ecological processes such as dispersal or seasonal movements of larger vertebrates. A long-term vision for conservation of the Chihuahuan Desert will promote the application of “biodiversity friendly” land use and wildlife practices. It will also stress the conservation of keystone habitats, such as riparian habitats and springs, in highly managed areas. This effort will help sustain ecological integrity across human-dominated landscapes and within core areas.

As partners in the conservation of one of the world’s most biologically rich warm deserts, citizens of the U.S. and Mexico have a joint global responsibility before them. Protecting the biological features described in this assessment will set an example for other nations to follow for the long-term conservation of arid ecosystems.

From biodiversity vision to conservation action

The biodiversity vision is the foundation on which people with a stake in the future of the Chihuahuan Desert can build a conservation strategy for the ecoregion. It focuses the conservation planning process on the species, ecological processes, and geographic areas most important for sustaining and restoring Chihuahuan biodiversity, and suggests priorities for action. The biological vision will shape, and in turn will be shaped by, an analogous analysis of the socioeconomic forces at work in the ecoregion that shape human communities and their interactions with nature.

Although the immediate causes of species decline or habitat loss may be intuitively obvious, there are often less obvious cultural, economic, or political forces driving activities that lead to biodiversity loss. A thorough socioeconomic analysis that identifies those “root causes” is necessary in order to clearly discern the true nature of threats to biodiversity and identify the most promising opportunities for conservation action. WWF and PRONATURA Noreste are already at work on a socioeconomic analysis of the Chihuahuan Desert ecoregion.

No matter how firmly grounded in the principles of conservation biology and socioeconomic analysis a conservation strategy may be, it can accomplish little without strong commitment from stakeholders within the ecoregion. Thus, WWF and partners are investing significant resources in activities to raise awareness, build constituencies, enlist the aid of governments, academic institutions, and NGOs, and involve local communities in all aspects of Chihuahuan ecoregion conservation.

Finally, WWF is committed to ensuring that the strategy is implemented by direct action, by building the capacity of other to take action, and encouraging, advocating, and cajoling actors across the ecoregion to take bold steps to make a shared conservation vision for the ecoregion a reality.

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Chapter 1 Introduction

The Chihuahuan desert encompasses one of the most biologically diverse arid regions on Earth. Covering nearly 630,000 km^2, and stretching from eastern Arizona, southern New Mexico, and western Texas, USA, to the edge of Mexico's Meseta Central, the Chihuahuan harbors a diverse assemblage of terrestrial and freshwater plant and animal communities unique to North America (Figure 1.1). Desert grasslands, freshwater springs often described as the freshwater Galapagos of North America for their radiation of desert fishes, gypsum dunes harboring high levels of local endemism, extraordinary diversity of succulents and other desert-adapted species—these biological treasures elevate the Chihuahuan to a rank of global importance.

Recent analyses of global and continental patterns of biodiversity attest to the conservation value of this desert. The Global 200 ecoregions study (Olson and Dinerstein 1998) identified the Chihuahuan as one of the three richest deserts in the world and the only one that supports both globally outstanding terrestrial and freshwater biotas. A study of North American terrestrial biodiversity among the ecoregions north of Mexico ranked the Chihuahuan as one of the most biologically diverse ecoregions, richer than even many forested units (Ricketts *et al*. 1999). Recent studies of cacti (Hernandez and Barcenas 1995) highlight the extraordinary richness and endemism found in this family: among the 1500 species of Cactaceae, approximately 48 genera and more than one-third of all species occur in Mexico. Many of the 345 species found in the Chihuahuan Desert are endemic to it.

Yet, the Chihuahuan Desert remains the overlooked desert in the New World. The low stature of its rich desert scrub is visually overshadowed by the dramatic architecture of the saguaro - the flagship species of the neighboring Sonoran desert - or the charismatic Joshua tree of the Mojave Desert. The spindly-looking creosote bush, the Chihuahuan Desert's dominant plant species, stirs little emotional response. But the postcard-like scenes of the Sonoran, Mojave, and Baja deserts belie the fact that the Chihuahuan dwarfs these other arid ecoregions in species richness and endemism. Appreciation of Chihuahuan biodiversity requires a jeweler's eye because much of its unique features are cryptic. Many species of cacti, for example, are delightful miniatures. The story of cichlid evolution in the lakes and springs of Cuatrociénegas follows a similar pattern to that of the Rift Lakes of Africa, albeit on a smaller scale. Pollination of yucca and some cacti by moths and nectar-feeding bats is a wonderful tale of coadaptation in nature, but rarely witnessed by diurnal naturalists.

The world conservation community must address the serious neglect of this global biological resource. Threats to Chihuahuan biodiversity - particularly water diversion and mismanagement, and overgrazing and browsing - are mounting and opportunities for conservation of intact habitats are dwindling rapidly.

The enormous sweep of the Chihuahuan across two countries and a number of states within the U.S. and Mexico has led to conservation efforts in this region - as in many other large, transboundary ecoregions - that are largely opportunistic and ad-hoc. To conserve biological diversity successfully over the long term, a more comprehensive approach is needed. Guided by the latest concepts in the emerging science of conservation biology, public agencies and conservation organizations are embracing ecoregion-based conservation (ERBC) as the most effective spatial scale to achieve conservation objectives (Box 1.1).

This biological assessment constitutes one of the first examples of trying to integrate the fundamental principles of conservation biology to conservation at an ecoregion scale. The objectives were to:

1. Quantify the biological diversity of the Chihuahuan desert and develop a biodiversity vision for its conservation.

2. Analyze landscape-level features to discern the biological integrity and conservation status of habitats, sites, and ecological processes.

3. Identify the types and severity of threats that diminish conservation potential.

4. Integrate data layers on biological distinctiveness and conservation status to identify core elements of an ERBC approach which can be applied to both terrestrial and freshwater biodiversity.

5. Encourage decision-makers, conservation planners, and the public to adopt an ERBC approach across international and state boundaries.

6. Provide a broad-scale framework to guide government agencies and non-governmental organizations so that they can better position their activities in the ecoregion within a continental and global context, and more effectively allocate resources for biodiversity conservation.

On September 30-October 2, 1997, under the auspices of World Wildlife Fund (WWF), a group of experts on the biodiversity of the Chihuahuan Desert met at the Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM) in Monterrey, Mexico. The workshop, conducted in collaboration with PRONATURA Noreste, Comisión Nacional para la Conocimiento y Uso de la Biodiversidad (CONABIO), and The Nature Conservancy, was intended to produce an assessment of the status of biodiversity in the Chihuahuan Desert and set priorities for conservation. This document serves, in part, as a description of the workshop, its methodology, and a summary of the results derived from it.
This project originated as a joint effort among WWF, CONABIO, and the Commission for Environmental Cooperation (CEC) to undertake a conservation assessment of high priority ecoregions in North America identified by previous assessments of terrestrial and freshwater biodiversity (Ricketts *et al*. 1999; Abell *et al*. 2000). The Chihuahuan Desert workshop furthered the pursuit of those goals by increasing the level of resolution from the continental scale to the ecoregion scale.

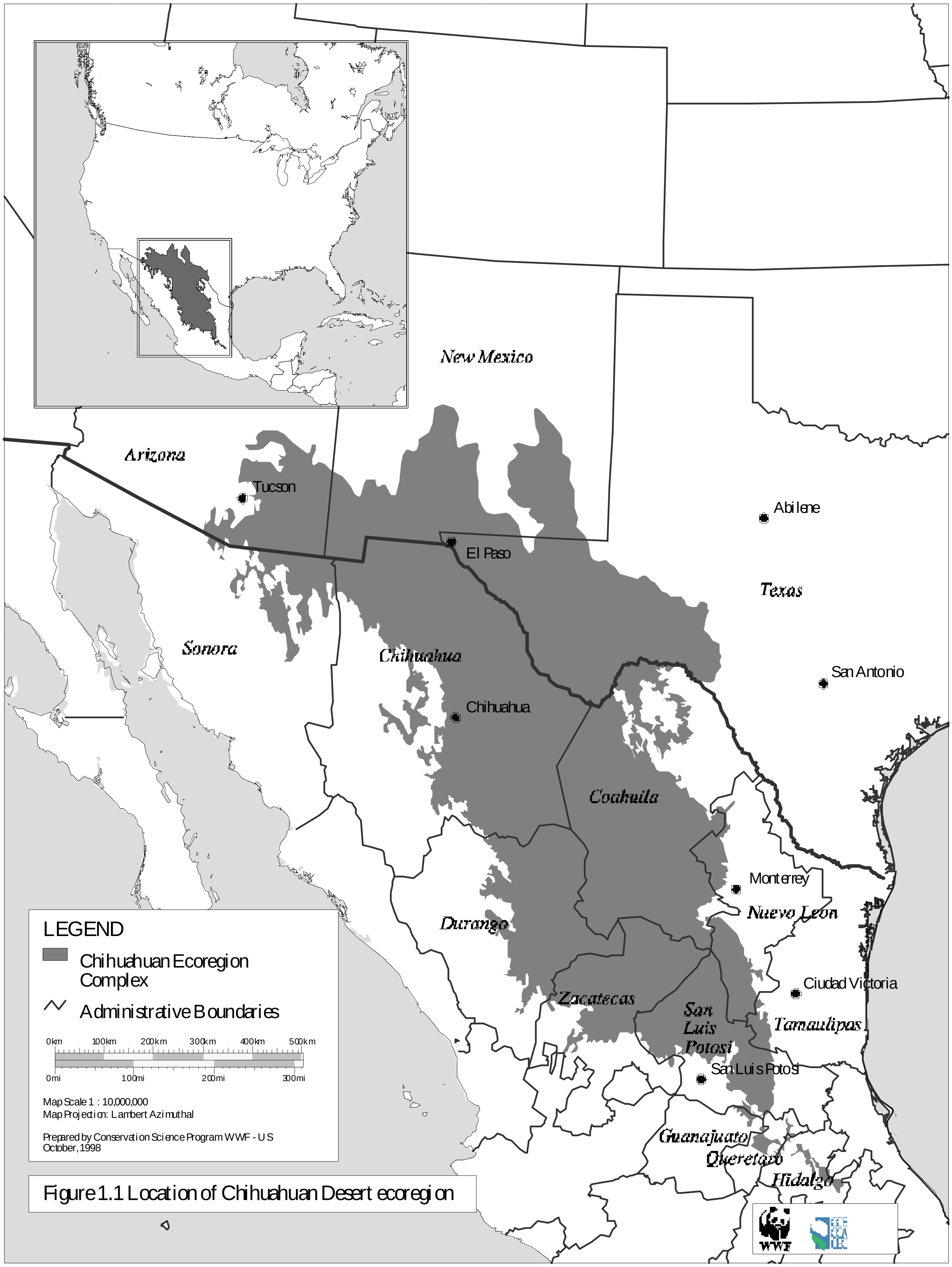


Figure 1-1. Location of Chihuahuan Desert ecoregion

Several weeks prior to the workshop, representatives from WWF, CONABIO, The Nature Conservancy, and ITESM met to devise a set of fundamental biological goals to conserve biodiversity. The group agreed on a working biodiversity vision patterned after Noss (1992):

> "A biodiversity conservation strategy for the Chihuahuan Desert ecoregion must seek to conserve the full range of distinct natural communities and ecological and evolutionary phenomena, maintain viable populations of species, sustain important ecological processes and services that maintain biodiversity, and protect blocks of natural habitat large enough to be responsive to short- and long-term change. The strategy will continue to be developed through a participatory process of identifying priority sites, conservation activities, natural resource uses, and threats."

The working vision was adopted by consensus by the workshop participants as suitably comprehensive and visionary. It set the stage for a number of analyses to follow that are described in detail in this document. Ultimately, this biological assessment will be the foundation for a conservation action plan for the Chihuahuan Desert. It is our hope that this plan will be a product not solely of World Wildlife Fund, but of a coalition of conservation groups, federal, state, and local governments, private landowners, and a spectrum of other stakeholders from the ecoregion.

Structure of the Report

We begin by providing a summary of the approach to conduct the biological assessment (Chapter 2). A more detailed description of assessment methods is presented in Appendix A. A brief biological overview of the Chihuahuan Desert's terrestrial habitats and its rivers and springs (Chapter 3) is then presented. This chapter is intended to be a layperson's introduction. It summarizes a more extensive treatment of Chihuahuan biodiversity presented in the next chapter (Chapter 4). The results of the analyses of biological distinctiveness and conservation status of each of the biogeographic subregions follow (Chapters 5 and 6, respectively). In these chapters we apply a framework for identifying priority sites based on two variables: landscape integrity and biological distinctiveness, and address the representation of major habitat types by priority sites. For freshwater biodiversity we used a similar but modified approach, tailored to the biological and conservation status information available for freshwater systems. Next, we conduct a gap analysis to assess protection of priority sites and compare priorities established by this analysis with other efforts (Chapter 7). The penultimate chapter provides a biologists' perspective of major threats to conservation of the Chihuahuan biota (Chapter 8). We conclude with the delineation of a biodiversity vision and discuss next steps in developing a comprehensive ERBC strategy (Chapter 9).

This report serves two main functions. First, it provides a transparent account of the process used to develop the first steps of ERBC - a biological assessment and a draft biodiversity vision. This function targets the participants of the workshop and other stakeholders in the conservation of the Chihuahuan Desert. The second function is to serve as a prototype for a much wider audience of conservationists undertaking ERBC in various ecoregions. Deserts differ in conspicuous ways from other major habitat types, such as tropical moist forests or tundra, but the conservation targets we identify and issues we address are applicable to most terrestrial and freshwater assessments.

Box 1-1. A primer on ecoregin-based conservation (ERBC)

What is an ecoregion?
An ecoregion is a relatively large unit of land or water containing a geographically distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions. An ecoregion functions effectively as a conservation unit because its boundaries roughly coincide with the area over which key ecological processes most strongly interact.

Why conduct ecoregion-based conservation?
Several hypotheses drive the shift towards ERBC. First, conservation planning at ecoregion-scales - typically greater than 20,000 km^2 - more effectively addresses the full range of biodiversity than will isolated efforts scattered among a few sites. Second, many significant threats to biodiversity affect multiple sites simultaneously. Third, coordinated regional efforts can better achieve the goal of representation and avoid redundancy than groups working independently at sites. Fourth, ERBC can more accurately define an arena for restoration than can efforts restricted to political boundaries or agendas. Finally, comprehensive ecoregion strategies will have a greater leveraging effect on political impact and donor interest and support than will initiatives focused on sites.

ERBC also helps us:

- understand how local actions fit into global and regional conservation strategies,
- ensure that there are clear and strong linkages between all conservation activities and biodiversity conservation objectives,
- assess how well conservation strategies represent the full range of distinctive biodiversity, conserve larger blocks of intact habitat, and maintain ecological processes and species populations within their natural range of variation,
- tailor conservation analyses and activities to the particular patterns of biodiversity, ecological dynamics, and responses to disturbance of different major habitat types, such as deserts or tropical dry forests.

The boundaries of ecoregions reflect the distribution of natural communities and landscapes over which ecological processes operate. Ecoregions represent the area within which one would expect to find the vast majority of individuals of characteristic species or a large proportion of their subpopulations. Ecoregions also allow us to better address the large-scale dynamics that are unique to certain ecoregions or critical for maintaining their species and communities. For these reasons, ecoregions provide a biologically coherent unit for conservation groups and natural resource agencies to use when planning a portfolio of site-based activities and policy initiatives. Finally, ERBC can help determine where increased investments are complementary, additive, or possibly redundant, particularly where ecoregions span state, provincial, or international boundaries.

How does ecoregion-based conservation improve on current efforts to conserve Chihuahuan biodiversity? Five features distinguish the WWF approach to ERBC. First, we seek to develop a strategy centered on the protection of biodiversity features - terrestrial and freshwater species assemblages, processes, and phenomena - previously identified as globally outstanding for xeric ecoregions (Olson and Dinerstein 1998). Second, we begin with a biodiversity vision that goes far beyond the current configuration of protected sites and management practices. We ask from a conservation perspective, “What should the Chihuahuan desert look like 10, 20, even 50 years hence?” This point highlights our commitment to the restoration of biologically valuable but degraded landscapes, strong legislation and enforcement programs that protect native biodiversity, and the nurturing of an ecoregion-wide conservation movement. All of these actions take time to develop. Thus, the biodiversity vision requires us to plan conservation activities over larger spatial and temporal scales than in the past. To achieve this goal, we challenge conservation biologists to define what success looks like in the context of conserving Chihuahuan biodiversity. Too often, we confine our efforts to rearguard actions to protect isolated sites rather than promote a more far reaching strategy for successful conservation at an ecoregion scale. Without this critical step, ERBC is merely an incremental improvement over existing ad-hoc approaches.

Third, we focus on conservation of ecological processes, important evolutionary phenomena, higher order diversity (generic and family), and rare habitat types as well as the more traditional taxonomic indicators of priority-setting - species richness and endemism. Fourth, we highlight intact or near intact large vertebrate assemblages as vital conservation targets because of their increasing rarity worldwide. Some of the highest priority areas identified in this assessment focus on sites that support, or with moderate restoration efforts, could support assemblages of Chihuahuan megafauna and keystone species: jaguars, mountain lions, black bears, Mexican wolves, bison, pronghorn, and prairie dogs. At the other end of the spectrum, we highlight the critical importance of invertebrates and diminutive vascular plants - the most speciose taxa in an ecoregion. A few priority sites, for example, are elevated because of their more cryptic biodiversity: distinct ant or tiger beetle faunas, or highly endemic cacti that barely break the soil surface. Finally, we seek to mitigate overarching threats to biodiversity that operate over multiple sites within the ecoregion rather than on a site-by-site basis.

Chapter 2 Summary of Approach

Before describing the biological values and conservation priorities of the Chihuahuan Desert, an explanation of the methodological approach will illustrate how we obtained this information. The challenge of achieving meaningful conservation at an ecoregion scale is formidable. In order to create an effective strategy, it is essential to assemble as complete a picture as possible of the biodiversity of the region and set priorities for action. Those priorities must be based on the goal of full representation of species, habitats, and ecological processes. This chapter summarizes the approach used to identify conservation priorities for terrestrial and freshwater biodiversity in the Chihuahuan Desert. It is divided into two sections: conservation goals and targets, and analytical steps. Readers interested in a more detailed description of the approach should consult Appendix A.

I. Conservation goals and targets

Four fundamental goals of biodiversity conservation help to identify biological priorities (Noss 1992):

- Representation of all distinct natural communities within a network of protected areas or areas primarily managed for biodiversity conservation.
- Maintenance of ecological and evolutionary processes that create and sustain biodiversity.
- Maintenance of viable populations of species.
- Conservation of blocks of natural habitat large enough to be resilient and responsive to large-scale periodic disturbances and long-term changes.

These goals have received increased acceptance as the foundation for biodiversity conservation strategies at virtually all spatial scales from global, to regional, to ecoregions, to watersheds (Noss 1992). Thus, the priority sites and activities included in ERBC should be linked to achieving these four fundamental goals.

Important as they are to frame the ERBC approach, the fundamental goals are rather general. We can improve the rigor of ERBC by focusing our conservation activities to address more specific biodiversity targets:

1. Distinctive communities, habitats, and assemblages

   Representative examples of all distinct habitat types, species assemblages, and ecological or evolutionary phenomena - ideally over their full natural ranges of variation - are important conservation targets. Distinctive units include areas of extraordinary richness, endemism, higher taxonomic uniqueness, or unusual ecological or evolutionary phenomena. These can be evaluated at different biogeographic scales (*i.e.*, globally, regionally, bioregionally, or locally). Some examples found in the Chihuahuan Desert are gypsum dune communities containing many local endemics, assemblages of endemic fish and invertebrates in desert springs, and distinct habitat types such as semi-desert grasslands or montane chaparral.

2. Large expanses of intact habitats and intact biotas

   Intact natural ecosystems and biotas are becoming increasingly rare because of unsustainable human activities. Large units of natural habitat where species populations and ecological processes still fluctuate within their natural range of variation are rapidly disappearing around the world. Larger units are emphasized because principles of landscape ecology and conservation biology suggest that biodiversity will best persist under these conditions. Chihuahuan examples of this target include areas of semi-desert grasslands that still harbor prairie dog communities, pronghorn, and intact floral communities. Other examples are intact pine-oak and chaparral habitats of some desert ranges and spring systems with their full complement of native species still extant.

3. Keystone ecosystems, habitats, species, or phenomena

   At regional and local scales, certain habitats may exert a powerful influence on biodiversity in surrounding habitats and ecosystems. Their persistence and intact ecological processes may be critical for many species and ecological processes in neighboring areas. For example, riparian habitats or springs in the Chihuahuan Desert are vitally important for maintaining vertebrate populations in surrounding habitats. Riparian forests are also essential as feeding, shelter, and resting habitat for migratory songbirds, bats, and butterflies. Other linkage habitats, migration corridors, or drought or fire refugia may also be critical habitats for maintaining ecological processes. Keystone species, such as larger mammalian predators and black-tailed prairie dogs, also have a strong influence on the structure and integrity of natural communities.

4. Distinctive large-scale ecological phenomena

   The conservation of distinctive large-scale ecological phenomena—long-distance migration of songbirds or the seasonal, trans-ecoregion migrations of bats—require a combination of site-specific, regional, and policy-level efforts applied over vast continental areas or widely disjunct regions. For example, conservation of flowering cacti across whole landscapes may be important for migratory bats. Habitats or sites that may not be particularly distinctive (*e.g.*, high richness or endemism) or intact may still act as critical habitat for migratory species.

5. Species of Concern

   Depletion of top predators is a serious concern in the Chihuahuan Desert. Mammalian predators along with aplomado falcons would be obvious targets for restoration efforts as part of ERBC. Hunters have depleted mammalian predators and a declining prey-base has impacted raptors. Highly specialized fish fauna that are threatened by invasions of alien species are another target for restoration. Removal of cacti for the plant trade is a conservation concern that the ERBC team must address in designing the conservation plan.

6. Native Communities

   Alien species can cause extinction, extirpation, or major changes in community structure and function. Grasslands and freshwater systems in the Chihuahuan ecosystem are particularly at threat from invasive species.

II. Steps to conducting the biological assessment and biodiversity vision

To identify conservation priorities, we map the distribution of species and communities and highlight the ecological dynamics and biophysical processes that sustain them. The analysis can be broken down and visualized as a set of sequential steps (Figure 2.1). Conducting a biological assessment is an intensive, data-hungry process, but it can be guided by an overriding principle: *Give most attention to conservation of beta-diversity and large landscapes* (J. Quinn, pers. comm.). Beta-diversity is defined as the turnover of species with distance or along environmental gradients such as elevation (see Appendix A for a more detailed explanation).

Step 1: Understanding and mapping ecoregion-wide patterns of biodiversity

a. Conducting representation analyses

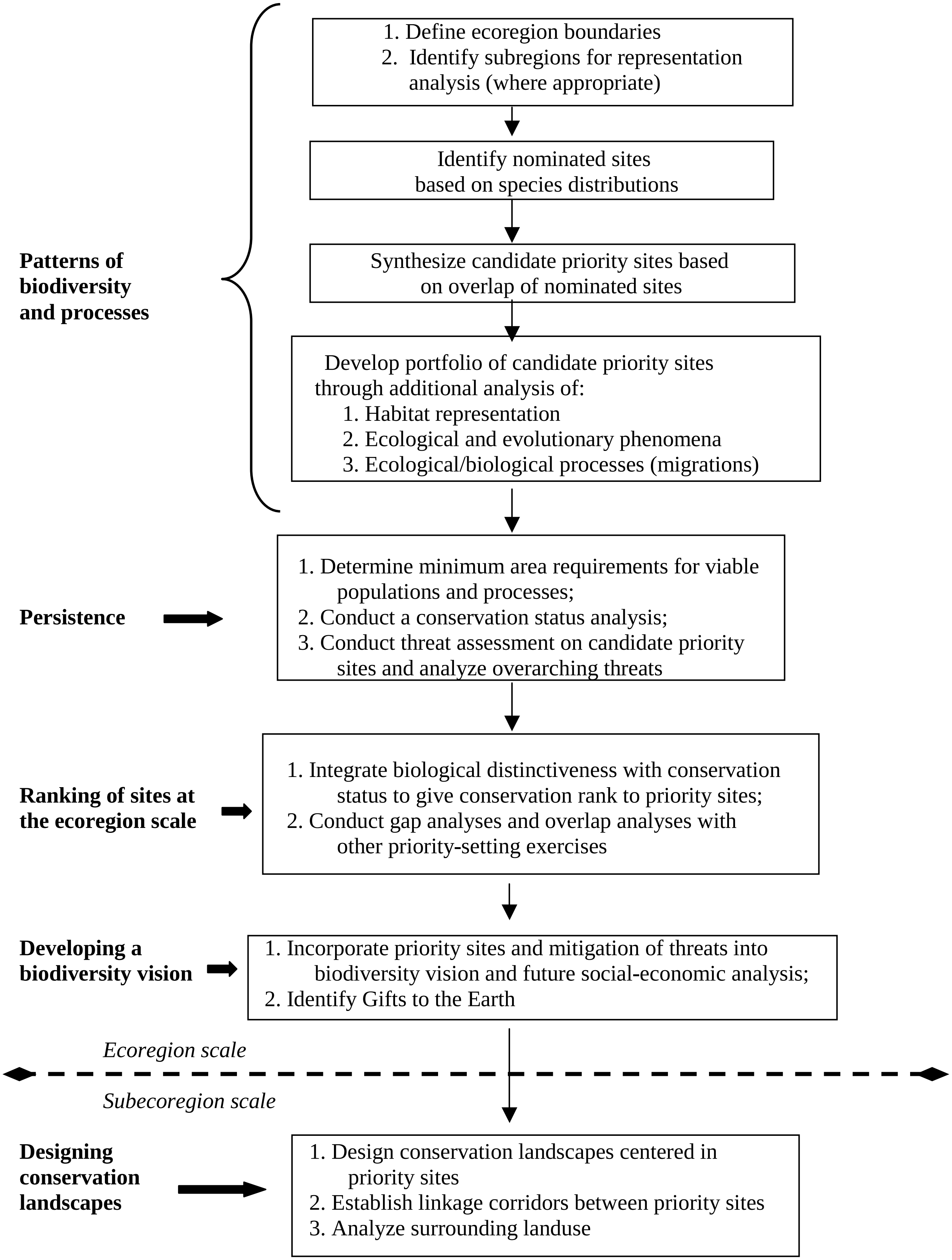
One of the most fundamental steps of an ecoregion assessment is a representation analysis. Here we ask two key questions: 1) How many conservation units are required to represent the broadest range of distinct assemblages and habitats? 2) How should they be distributed over the ecoregion or linked to sites in adjacent ecoregions? This step requires a detailed understanding of the level of complexity of the distributions of species and communities. In ecoregions marked by high turnover in species and community assemblages from one area to another, or along environmental gradients, one will need to invest in conserving multiple areas to capture the full range of biodiversity. Determining the minimum level of representation - the degree of biotic dissimilarity among units - is a critical step because it will influence all subsequent planning and implementation. Decision rules for representation need to be objective, transparent, and fully documented.

Representation occurs at several biogeographic scales: within the entire ecoregion and surrounding ecoregions, within subregions of an ecoregion (*e.g.*, mountain ranges and watersheds), or within habitats of a subregion (*e.g*, gypsum dunes within the Central Chihuahuan subregion). Habitats, plant communities, or certain indicator taxa can serve as valuable proxies or surrogates for distinctive assemblages where comprehensive species inventories are lacking. Many ERBC efforts in data-poor ecoregions will rely on surrogates in representation analyses.

Defining the ecoregion and subregions

The boundaries of the Chihuahuan Desert are derived from a terrestrial ecoregion classification of Mexico recently developed by CONABIO and WWF (Appendix A, Figure A-1). We merged the adjacent Meseta Central with the Chihuahuan Desert because the two units share biotas. The two ecoregions form the Chihuahuan Desert ecoregion complex. We also included biological communities adjacent to the complex containing obvious Chihuahuan elements.

Figure 2-1. Flowchart identifying the steps for defining a portfolio of priority sites for conservation and developing a biodiversity vision.



We relied on a recent analysis of freshwater biodiversity of North America to delineate the boundaries of freshwater ecoregions (Abell *et al.* 2000). Twelve freshwater ecoregions overlap with the Chihuahuan Desert ecoregion complex, and an aggregation of these ecoregions includes areas outside the complex (Appendix A Figure A-2). We assessed the biological distinctiveness and conservation status of the freshwater biota of the twelve ecoregions (Appendix A), focusing on those areas within the desert complex and those draining into it, but not on those areas that are both outside and downstream of the complex.

Experts identified four major terrestrial biogeographic subdivisions within the Chihuahuan Desert: the Apachean, the Northern Chihuahuan, the Central Chihuahuan, and the Meseta Central (Figure 4.2). This further delineation ensures adequate representation of habitat types across the ecoregion. The assumption here is that similar habitats in different biogeographic subdivisions will have a suite of distinctive species or higher taxa. This analysis is of particular relevance for Chihuahuan Desert biodiversity because of the turnover of species in certain taxa (*e.g.*, Cactaceae, Asteraceae, Euphorbiaceae) across different basins and mountain ranges.

Determining the resolution of representative habitats

Twenty different terrestrial habitat types were used to conduct a habitat representation analysis within each subregion (Appendix A). Although consensus was elusive, the Chihuahuan experts deemed that the classes employed were of sufficient resolution for this analysis. These habitats fall into three broad categories: desert scrubs and woodlands, grasslands, and montane chaparral and montane woodlands. The representation of each type of habitat within each biogeographic subregion became a key element of the ERBC strategy.

A list of major freshwater habitat types was generated at the start of the workshop, and these were used subsequently for the representation analysis. Eight major habitat categories were identified, five of which were divided into subcategories, for a total of 15 habitat types (Appendix A).

b. Defining areas of biological distinctiveness and importance

Identifying distinctive or important areas for indicator taxa (nominated sites)

After reaching agreement on biogeographic subregions and habitat types, biologists divided themselves up on the basis of their taxonomic specialties. The purpose of this step is to identify particular areas of importance for different taxa, here referred to as *nominated sites* (Box 2.1). Ideally, biologists familiar with the ecoregion-wide distribution of as many taxa as possible should be consulted at this stage. We were limited to fish, birds, mammals, reptiles, invertebrates, and plants. Important areas were selected on the basis of the distributions of these groups are correlated with overall distributional patterns for outstanding or unique biodiversity features, including: pronounced richness or endemism, higher taxonomic uniqueness, unusual ecological or evolutionary phenomena (*e.g.*, unique species assemblages, adaptations, or interactions, extraordinary adaptive radiations, highly intact faunas or floras), or critical sites for large-scale phenomena such as migrations. Experts were asked to delineate and justify the inclusion of each area. Areas where taxonomic information was incomplete or of poor quality were also identified on maps.

Box 2-1. A glossary of terms related to priority-setting used in this assessment

Nominated sites- Sites deemed important for conservation of a single taxon by taxonomic experts and published accounts. Nominated sites serve as the precursors to identify candidate priority sites. Not all nominated sites end up as candidate priority sites or as priority sites. All nominated sites are located on maps and named (Appendix B).

Candidate priority sites- Sites deemed important for conservation based on a synthesis of the taxon overlays of nominated sites for each subregion (terrestrial taxa) or for the entire ecoregion (freshwater). A candidate priority site could be designated as outstanding on the basis of only one taxon, such as invertebrates, but typically, candidate priority sites were selected for their importance for two or more taxa. Candidate priority sites could also be identified if they address gaps in representation of habitats within a subregion or if they contribute to the conservation of areas that maintain ecological processes or phenomena, without qualifying as richness or endemism hotspots. The adjective “candidate” signifies that the site has not been ranked for priority using the integration matrix (Figure 2.2).

Priority sites- Sites whose contribution to ERBC have been ranked at various levels of priority using an integration matrix based on biological distinctiveness and landscape integrity for terrestrial sites (ranks 1-4), or on biological distinctiveness and habitat intactness for freshwater sites, (ranks 1-2) (see Figure 2.2).

Synthesizing taxonomic priorities

The nominated sites for each set of taxa were compiled as mylar overlays, digitized, and returned to the experts. The experts then divided into five groups based on their geographic expertise (four terrestrial subregions) or remained in the freshwater group. Each group: 1) analyzed the important areas for each of the taxa within their subregion and 2) drew lines to demarcate *candidate priority sites* by synthesizing data from the taxon-specific data layers. Most candidate priority sites were selected because they were identified as important for several taxa, but some were maintained as priority because of their outstanding importance for a single taxon. Experts characterized and justified each candidate priority area at this stage.

Revisiting the representation analysis using candidate priority sites

The candidate priority sites were then evaluated in terms of their contribution to representation of each habitat type within each subregion (Box 2.2). If a habitat type was poorly represented within a subregion, the portfolio was reevaluated and revised to meet representation goals. Representation among freshwater candidate areas was carried out for the entire ecoregion complex (Appendix A).

Box 2-2. Decision rules for elevating nominated sites to candidate priority sites

To address the conservation goals and targets discussed earlier, the selection of candidate priority sites was guided by the following decision rules:

1. Each habitat type must be represented in the portfolio of candidate priority sites.
2. Examples of each habitat type in each subregion should be represented. (As mentioned earlier, the freshwater experts did not use the terrestrial subregions, nor did they divide sites up among the twelve Chihuahuan freshwater ecoregions. Instead, the freshwater team examined the distribution of sites among habitat types across the Chihuahuan complex).
3. Wherever possible, the larger blocks of intact habitat for each habitat type should be selected as candidate priority sites.
4. Wherever possible, several candidate priority sites (*e.g.*, three sites) for each habitat type within each subregion should be selected to ensure replication and enhance long-term persistence.
5. Sites that harbor distinct ecological or evolutionary phenomena should be identified and included in the portfolio.
6. Sites that maintain critical ecological processes should be identified and included in the portfolio.

Other considerations include:

1. Identification of sites for their importance in harboring genetic resources, their importance for maintaining ecosystem services, such as watersheds for the benefit of urban areas, or for educational value (natural habitats near cities).

2. Identification of sites or areas that are in need of biological inventories because of a lack of sufficient biodiversity information for effective conservation planning.

Step 2: Determining minimum area requirements for viable populations and processes

Representation must be accompanied by conservation of habitats or sites of sufficient size to promote persistence of native biota over the long term (as determined through persistence analyses in the next step). Thus, in Step 2 we look at where native habitats remain and determine what kind of features promote the long-term persistence of different elements of biodiversity.

For all ecoregion analyses, it is important to identify as accurately as possible the species populations, assemblages, or processes with miminum size requirements. In other words, how large does a block of grassland have to be to conserve a viable population of top predators, species with large home ranges, or wide-ranging species that follow patchy resources? What constitutes an effective size of a habitat type for conserving distinct plant and invertebrate assemblages in areas where larger vertebrates have been largely extirpated? The identification of habitat block sizes was not attempted for freshwater habitats, as sizes are in many cases less important than other attributes, such as linear continuity.

Ecoregion planners need to formally associate different landscape features with their effectiveness for conserving different elements of biodiversity including specific guilds, habitats, or phenomena. One way to approach this is to focus on area-dependent species, such as top predators, wide-ranging herbivores, or species dependent on metapopulations specialized on patchy habitats. One can estimate the total area needed to maintain a viable population of the species at several levels (*e.g.*, long-term persistence = 500 pairs; short-term persistence = 50 pairs; short-term source pool < 10 individuals). The assumption behind this approach is that if plans can meet the requirements of species requiring large areas, they will also conserve adequate habitat and resources for a wide range of other species and phenomena with smaller area requirements.

Another consideration is habitat types or phenomena that require certain minimum areas to be maintained over time, such as natural fire regimes, or habitats characterized by mosaics of many different successional phases. Plans also must consider the area needed to be maintained as core areas (strict protection) versus areas of restricted resource use. Some species will require strictly protected areas as source pools because of their sensitivity to disturbance.

Experts discussed minimum size and configuration thresholds for natural habitats to support different elements of biodiversity such as large ungulates, top predators, or natural fire regimes. These guidelines are useful to clarify the definition of intact blocks of habitat within a Chihuahuan context.

Experts then evaluated the candidate priority sites to ensure that they effectively captured unusual ecological or evolutionary phenomena, or critical sites for large-scale ecological movements such as bird or bat migrations. Areas harboring unusual or outstanding phenomena or critical sites not previously identified could be elevated to candidate priority areas at this stage.

Some areas are important for intra-ecoregional processes, such as linkage zones or dispersal corridors for larger vertebrates between core conservation areas. These features are addressed in the long-term ERBC strategy and biodiversity vision (see Chapter 9).

Step 3: Maintaining landscape integrity: persistence analyses

Large areas of relatively intact habitat and areas with intact biotas (*e.g.*, the full complement of larger native vertebrates) are important conservation targets. Thus, workshop participants evaluated the intactness, in terms of habitat and biotas, of nominated sites and candidate priority areas. Experts relied on their own experience and knowledge to evaluate habitat integrity while reviewing coarse-scale maps of intact, degraded, and altered habitat derived from analyses of satellite imagery (see Appendix A). Areas supporting relatively intact habitats and ecosystems were mapped. Larger areas of intact habitat or biotas which were not selected in the taxonomic or habitat representation analyses thus have the potential to be elevated to priority status at this stage. Experts also documented the variety and severity of threats for each site.
Freshwater experts were also asked to assess the intactness of candidate areas, but did so using definitions of intactness modified for freshwater habitats and without a discussion of minimum size and configuration thresholds. Areas were ranked as “intact,” “altered,” or “heavily altered.” As with the terrestrial, a threat assessment was also conducted for freshwater sites.

Step 4: Identifying priority sites

The ultimate goal of ERBC is to conserve the full expression of biological diversity of the Chihuahuan Desert. However, limited financial and technical resources prohibit embarking on the conservation of all sites simultaneously. Even in small ecoregions, conservationists are faced with the difficult task of setting priorities to determine the timing, sequence, and level of effort required to be successful at an ecoregion scale. We also assume that all candidate sites are not equal in their contribution to biodiversity nor are equally threatened or resilient.

Designing the priority-setting matrix

We asked experts to design, by consensus, a priority setting matrix to rank the importance of sites. A matrix integrating biological distinctiveness and conservation status (landscape integrity) was developed by the terrestrial experts, with each parameter spanning a continuum of higher to lower "quality" in terms of biodiversity or status features (Appendix A) and (Figure 2.2). The biological distinctiveness parameter reflects the relative rarity of the biodiversity of a given site within a subregion, the ecoregion, or the continent. Landscape integrity combines data on the relative size of habitat blocks - scaled to conservation of features and processes characteristic of deserts - and degree of intactness.

Different combinations of these parameters were associated with different levels of priority. For example, an area containing a large block of intact habitat and harboring outstanding levels of endemism and richness for a range of taxa might be deemed highest priority, while a degraded site with medium levels of richness for a single taxon would rank lower. Small, highly degraded sites that contain examples of biodiversity commonly occurring throughout the ecoregion might rank lowest of all. Other ecoregion workshops may choose a different combination of features to determine rankings. However, the purpose of this matrix is to highlight: 1) those areas which harbor the most irreplaceable biodiversity and 2) where biodiversity will have the best chance of long-term persistence in more intact, larger blocks.

On the biological distinctiveness axis of the matrix, we decided to weight high levels of endemism much higher than high species richness (Appendix A). We recognize that matrices developed for ecoregions representing major habitat types characterized by low levels of endemism (*e.g.* taiga, tundra, mangroves, flooded grasslands) might want to put greater emphasis on other criteria. For example, a matrix developed for tundra might want to give higher value to sites that conserve large migratory mammals, maintain the full complement of top carnivores, or conserve extraordinary concentrations of breeding birds.

Chihuahuan experts broke again into the four subregion groups and were asked to assign rankings to the 60 cells in the integration matrix (Figure 2.2) before fitting the data (sites) to the matrix. This *a priori* approach reduced bias towards sites where individuals were already active. Experts were instructed that only about 10% of the 60 cells could be assigned as highest priority. Priority ranks presented for each cell in Figure 2.2 is an average of the rank assigned to each cell by the four subregion groups. There was near concordance in the assignment of levels of priority to each cell among the four groups. We agreed on five levels of priority:

1= sites of global (highest) priority that form the core of a Chihuahuan ERBC strategy.
2= sites of high priority that also contribute to a Chihuahuan ERBC strategy.
3= sites of regional priority that should be considered in a Chihuahuan ERBC strategy.
4= sites that are important in state conservation strategies (*e.g.,* Arizona, Coahuila).
5=sites of lower priority that support occurrences of ubiquitous communities or species assemblages.

Figure 2-2. Integration matrix used to rank the terrestrial candidate priority in the Chihuahuan Desert

Biological Distinctiveness/ Landscape Integrity	High overlap of endemic taxa; or rare communities; or unique ecological evolutionary phenomena	Moderate overlap of endemic taxa; high richness for several taxa	Low endemism; high richness	Low endemism; low richness, but only representative site in subregion	Low endemism;l ow richness; protects a single threatened species	Low endemism; low richness; multiple representative site
Intact large blocks; at least one > 1,000 km2	I	I	I	II	II	III
Relatively intact large blocks; at least one > 1,000 km2	I	I	II	II	III	III
Intact or relatively intact Medium-sized blocks; at least one 100-1,000 km2	I	II	II	II	III	V
Intact or relatively intact small blocks; all < 100 km2	I	II	III	II	III	V
Degraded large blocks; at least one > 1,000 km2	I	II	III	II	IV	V
Degraded medium-sized blocks; at least one 100-1,000 km2	II	III	III	III	V	V
Degraded small blocks; all < 100 km2	II	III	IV	IV	V	V
Restorable large blocks; at least one > 1,000 km2	III	IV	IV	IV	V	V
Restorable medium-sized blocks; at least one 100-1,000 km2	III	IV	V	V	V	V
Restorable small blocks; all < 100 km2	IV	IV	V	V	V	V

Next, working in subregional groups, experts assigned the subset of the 61 candidate priority sites that fell within their subregion to a cell. The assignments followed a discussion and comparison of the distinctive biodiversity features and the intactness and integrity of habitats and ecosystems of a given site in comparison to others.

The freshwater experts remarked that the extreme level of loss and degradation of Chihuahuan freshwater biodiversity warrants conserving all remaining natural systems. However, they did develop a matrix that was more general than the terrestrial matrix and assigned levels of 1 to 5 to the cells (Figure 2.3). Using the priority-setting matrix, the experts assigned scores of 1 to 5 to each of the nominated sites. After this exercise, only one site (Cuatrociénegas) received the highest score of 1, so the experts unanimously decided to raise the ranks of all other sites by 1. The priority sites were those that ranked 1 or 2. Many of these were entire catchments that contained several priority sites clustered together. The experts felt that only catchment-scale conservation can protect individual freshwater sites.

	Biological Distinctiveness		
Habitat Intactness	High richness-endemism	intermediate richness-endemism	low richness-endemism
High intactness	1	2	4
Intermediate intactness	1	3	4
Low intactness	2	3	5

Figure 2-3. Integration matrix used to rank freshwater candidate priority sites in the Chihuahuan Desert

Protected area gap analysis

Priority sites, activities, or phenomena highlighted in the ecoregion strategy that are insufficiently protected may be identified as priority for conservation action at this stage. Priority areas considered well protected are still recognized as important and should garner continuing support. However, priority gaps may warrant immediate action and investment, particularly if they are under threat.

Step 5: Conducting a threat analysis and determining ecoregion-scale threats

Workshop participants evaluated threats affecting all priority sites and ranked threats to biodiversity that were pervasive throughout the ecoregion. The top ten threats were highlighted for in-depth treatment at a second workshop focused exclusively on threats and socio-economic factors (held in November 1998).

Step 6: Developing a biodiversity vision

An important goal of ERBC is to define what success looks like from a biodiversity conservation perspective. Elements of success include: a portfolio of important sites that conserve characteristic communities and processes, key activities to increase protected area coverage and design of conservation landscapes, and mitigation of overarching threats to avoid further erosion of biodiversity.

With these factors in mind, we discussed what successful biodiversity conservation would look like over the next 20 years for the Chihuahuan as a whole and for each subregion. We compared how important biological features identified by the workshop fit into a long-term vision. This step requires a discussion of what one means by the term original habitat or biota and how far back one wants to go in restoration efforts. By the end of the workshop, experts had reached consensus on a map of critical sites for Chihuahuan conservation. To encourage greater participation in formulating the biodiversity vision, we asked each terrestrial subgroup and the freshwater group to develop their own vision and share it with the entire workshop. Each presentation described the outstanding biological features of the subregion, key sites for conservation, major threats to biodiversity that must be mitigated, a draft biodiversity vision, and potential partners in developing and achieving the vision. The biodiversity vision for the entire ecoregion then is an attempt to synthesize the results of these presentations and ensure that they reflect the original conservation targets.

The priority sites identified by the matrices constitute a system of core conservation areas that harbor representative and outstanding conservation targets. However, for the long-term persistence of biodiversity, the vision must address conservation in matrix areas, that is, in degraded lands outside core areas. Better management of these areas is needed to sustain ecological processes such as dispersal or seasonal movements of larger vertebrates. Thus, a long-term vision for conservation of the Chihuahuan Desert should consider: 1) a network of core areas that conserve intact native ecosystems and meet a suite of conservation goals, 2) linkage zones or corridors that maintain biotic interactions among core units, 3) the application of appropriate land use and wildlife practices, and 4) conservation of keystone habitats (*e.g.*, riparian habitats, springs) in matrix areas which help sustain ecological integrity across landscapes and within core areas.

An effective vision should also define benchmarks for success to achieve biodiversity targets. The vision should outline the most appropriate sequence of activities and targets. In the Chihuahuan Desert, for example, it may be easier to achieve conservation of representative biotas in some subregions than others, or easier to conserve areas rich in endemics than it will be to restore large mammal assemblages (*e.g.*, pronghorn, wolves, or elk).

Step 7: Understanding limitations

Using precautionary principles

Our approach applies a precautionary principle to ERBC. Knowledge of patterns of biodiversity, ecological processes, resiliency, and variation of natural systems is incomplete in some areas. Some of this variation is limited by inherent uncertainty in natural processes.

Furthermore, conservation guidelines based on minimum critical areas analyses (see Appendix A) assumes a more complete understanding of the above features than currently exists. As a precaution, we increased the amount of replication in the representation analyses conducted in this assessment. We also estimated landscape parameters (*e.g.*, size of habitat blocks) at levels deemed to be sufficiently buffered from natural and anthropogenic stresses (see Appendix A).

Addressing data quality

Experts acknowledged that there are uncertainties and gaps associated with available data on Chihuahuan species, taxonomy, habitats, and ecology. Particular concern was expressed regarding the paucity of biodiversity information for the Meseta Central. We resolved to identify such gaps throughout the analysis, but also to make an initial effort to identify clear biodiversity priorities for the desert based on best available information and expert assessment.

Chapter 3 The Chihuahuan Desert: A Brief Biological Overview

The Chihuahuan Desert (including the closely-related Meseta Central matorral to the south) 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 (Olson and Dinerstein 1998). The Chihuahuan covers 629,000 km^2 (243,000 sq. miles), stretching from southeastern Arizona across southern New Mexico and west Texas to the Edwards Plateau. It runs deep into Mexico, encompassing parts of Sonora, Chihuahua, Coahuila, Durango, and several other states. It is bordered by the Sierra Madre Occidental to the west and the Sierra Madre Oriental range to the east, extending as far south as San Luis Potosí and to disjunct islands of Chihuahuan vegetation in the states of Queretaro and Hidalgo (see Figure 1.1).

The landscape is a series of basins and ranges with a central highland extending from Socorro, New Mexico south into Zacatecas, Mexico. Because of its generally higher elevation, the Chihuahuan Desert is cooler and has more rainfall than other warm desert ecoregions, averaging 235 mm annually. Shrubs dominate the landscape of the Chihuahuan, with scrub communities covering 55% of the desert. The most common species are creosote bush (*Larrea tridentata*) - in many ways the defining species of the Chihuahuan Desert - tarbush (*Florensia cernua*), mesquite (*Prosopis glandulosa*), and acacia (*Acacia* spp.). Cacti and agave are also prominent; large, dense stands of prickly pear (*Opuntia phaecantha*) are common, as is lechuguilla (*Agave lechuguilla*). As one moves north from central Mexico, the desert grades from a landscape of cacti, yucca, and shrubs to a dry grassland ecosystem (MacMahon 1988). The grasslands, 20% of this desert, are often mosaics of grass and shrub, include side-oats grama (*Bouteloua curtipendula*), black grama (*Bouteloua eriopoda*), and purple three-awn (*Aristida purpurea*). Bottomlands of tobosa *(Hilaria mutica*) and big alkali sacaton (*Sporobolus wrightii*) were probably the species early Spanish explorers encountered when they excitedly reported grasses that were "belly high to a horse" (Tweit 1995).

The Chihuahuan Desert is widely recognized for its diversity and high levels of endemism in Cactaceae. As many as 350 of the 1500 known species of cacti occur here. Four other plant families - grasses, euphorbs, asters, and legumes - are not only speciose, but also show high levels of endemism across the desert's many basins. Less well-known is the diversity and endemism within the Nyctaginaceae (*Bougainvilla* family). A list of the major habitats is in Appendix A.

The functioning of the Chihuahuan Desert is dependent on its high invertebrate diversity, which is a reflection of numerous plant communities. Keystone invertebrates within the desert grasslands are the subterranean termites (order Isoptera), major consumers of dead plant material and animal dung. Fifty percent of all photosynthetically fixed carbon in desert grasslands is consumed by them (Whitford *et al*. 1995). There are also more specialized freshwater assemblages of invertebrates associated with playas, such as clam shrimp (*Eulimnadia texana*), water fleas (*Moina wierejskii*), and fairy shrimp (*Streptochephalus texanus*), upon which migrating waterfowl depend. There are others associated with soil, such as nanorchestid and tydeid soil mites, which are essential for nutrient cycling in a dry climate. An invertebrate tied to the yucca woodlands, the yucca moth (*Tegeticula yuccasella*), lays her egg in the ovary of the yucca, rolls pollen into a ball, and then inserts the ball into the flower, thereby ensuring fertilization of the seeds on which her young will feed. The semi-arid Madrean region further has the richest diversity of bee species in the world (Ayala and Bullock 1993).

Because of the desert's recent origin, few warm-blooded vertebrates are restricted to desert scrub communities. However, the Chihuahuan Desert supports a large number of wide - ranging mammals, such as the pronghorn (*Antilocapra americana*), jaguar (*Panthera onca*), and collared peccary or javelina (*Dicotyles tajacua*). Rodent species are abundant in number and kind. Kangaroo rats (*Dipodomys* spp.), pocket mice (*Perognathus* spp.), woodrats (*Neotoma* spp.), and deer mice (*Peromyscus* spp.) are among the important burrowing and grain storing mammals that contribute to the overall structure and functioning of the ecosystem. Common bird species include the greater roadrunner (*Geococcyx californianus*), curve-billed thrasher (*Toxostoma curvirostra*), scaled quail (*Callipepla squamata*), and Scott's oriole (*Icterus parisorum*). Numerous raptors inhabit the desert and include Swainson's hawk (*Buteo swainsonii*), great horned owl (*Bubo virginianus*), and the rare aplomado falcon (*Falco femoralis*) and zone-tailed hawk (*Buteo albonotatus*).

The Chihuahuan Desert herpetofauna is more strongly associated with the region than are mammals and birds. Reptile diversity is among the highest of all desert ecoregions. Several lizards are endemic, including the Texas banded gecko (*Coleonyx brevis*), reticulated gecko (*C. reticulatus*), greater earless lizard (*Cophosaurus texanus*), several species of spiny lizards (*Sceloporus* spp.), and marbled whiptails (*Cnemidophorus tigris marmoratus*). Two other whiptails (*C. neomexicanus* and *C. grahami*) occur as all-female parthenogenic clones in select disturbed habitats (Degenhardt *et al*. 1996). Representative snakes include the Trans-Pecos ratsnake (*Elaphe subocularis*), Mexican garter snake (*Thamnophis eques*), and whipsnakes (*Masticophis taeniatus* and *M. flagellum lineatus*) (Brown 1994). Endemic turtles include the Bolson tortoise (*Gopherus flavomarginatus*), a unique aquatic box turtle (*Terrapene coahuila)* and several softshell turtles.

The Rio Grande (Río Bravo del Norte), fed by its major tributaries the Pecos River and the Río Conchos, is the only major through-flowing stream in the Chihuahuan. The larger Río Grande system is home to native minnow, sucker, catfish, killifish, and sunfish species, two species of gar (*Lepisosteus oculatus*, *L. osseus*), and a rare sturgeon (*Scaphirhynchus platorhynchus*). Rivers draining into the interior, such as the Río Nazas located north of Durango, contain unique assemblages of minnows, suckers, and pupfish. Isolated basins, such as the Tularosa in New Mexico and Cuatrociénegas in Coahuila, have given rise to numerous endemic fish species including several pupfish (*Cyprinodon* spp.), cichlids (*Cichlasoma* spp.) and poeciliids (*Gambusia marshi* and *G. longispinis*) (Miller 1977, Minckley 1977). What most strongly distinguishes the freshwater biota of the Chihuahuan Desert is not the number of species, but the high degree of local endemism, a globally outstanding feature.

In sum, the Chihuahuan Desert is home to a staggering diversity of species. At the time of this writing, a survey of the entire ecoregion is not yet complete, but the U.S. portion of the Chihuahuan (which makes up less than a third of the desert's total area) contains approximately 2263 species of vascular plants, over 100 species of mammals, over 100 species of reptiles, 250 bird species, 20-25 amphibian species, and 250 species of butterflies. The levels of endemism in cacti, euphorbs, composites, legumes, grasses, and plants in the Nyctaginaceae are very high, with high replacement of species from basin to basin.

As important as the diversity of species is the Chihuahuan Desert's great diversity of habitats. Forested mountain ranges, rise abruptly like sky islands on a desert sea, each home to a unique mix of desert and montane plant and animal species. These mixed conifer forests and oak woodlands comprise approximately 7% of the Chihuahuan Desert. In the northern desert, Spanish explorers marveled at the vast grasslands of black grama, blue grama, and big alkali sacaton. In New Mexico and Coahuila, wind-blown gypsum soils form dunescapes of white sand, a rare and seemingly inhospitable habitat type that has given rise to plant species found nowhere else. In the isolated basin of Cuatrociénegas, spring fed pools of warm freshwater nurture communities of endemic stromatolites, fish, and snails, resembling coral reefs in the heart of the desert. In parts of the Meseta Central matorral, minute changes in moisture or temperature from one valley to the next give rise to distinct plant communities.

Unfortunately, the ecoregion is heavily degraded. Historical accounts report that in the mid-1800s the native grasslands were lush and relatively free of shrubs. Riparian areas were lined with gallery forests and unchanelled streams often spread out to form wetland systems (*ciénegas*). Pronghorn, black-tailed prairie dog (*Cynomys ludovicianus*), and Mexican wolf (*Canis lupus baileyi*) were abundant. Today, native shrubs dominate throughout, including former grasslands, savanna, and riparian and wetland areas. Populations of native grasses, overgrazed and deprived of their natural, fire-based disturbance regime, are disappearing. In southern New Mexico, around Las Cruces, for example, the desert floor is covered with little more than creosote and fluffgrass (*Dasyochloa pulchella*). Most of the riparian forests and ciénegas have disappeared, victims of over-grazing, heavy erosion, and excessive water diversion for agriculture. Many perennial streams and springs are now only seasonally wet as a result of degraded soil and upland vegetation conditions (Dick-Peddie 1993). Pronghorn and prairie dogs are scarce, and the Mexican wolf and grizzly bear are extirpated (Bahre 1995).

Virtually the entire ecoregion has been heavily grazed. Before introduction of domestic livestock, desert scrub was more limited in range, contained a more diverse assemblage of species, and supported a dominant grass layer. Between 25-50% of current scrublands may have once been grasslands. Today, the landscape is characterized by shrub communities of creosote bush, mesquite, and acacia that occur either in vast expanses or pockets within other communities of grassland or yucca woodland. At least 40% of the ecoregion is a matrix of these shrub-dominated communities. Currently, around 20% is dominated by grasslands, often with a strong shrub component. Drastic alteration in species composition of the grasslands has occurred, with native species often replaced by a few species of low-growing or unpalatable grasses (Brown 1995). In some areas, little grass cover remains. Approximately 5% of the ecoregion is yucca woodland and *crasicaule*, a habitat rich in agaves, yucca, and cacti.

Fields cleared for irrigated agriculture have destroyed thousands of hectares of native grassland and floodplain. Over-pumping of groundwater for agriculture and use by growing urban areas is severely affecting flows of Chihuahuan Desert rivers, including the San Pedro, Pecos, Río Grande, Río Conchos, Río Nazas, Río Extorax, and Río Aguanaval. De-watering of rivers and streams, coupled with damage from grazing, has severely degraded much of the freshwater and riparian habitats in the ecoregion. These weakened riparian communities have subsequently become invaded by salt cedar (*Tamarix ramosissima*), a highly aggressive exotic shrub. This shrub will also invade intact, healthy riparian communities.

Chapter 4 Biological Distinctiveness of the Chihuahuan Desert

Introduction

A rigorous analysis of biological distinctiveness is the foundation of an ERBC strategy. It enables conservationists to:

- delineate the biological features of an ecoregion for a given major habitat type to enable comparisons at continental and global scales (*i.e.*, being able to compare the Chihuahuan Desert to other xeric ecoregions in the Nearctic, Neotropical, or Afrotropical realms),
- define priority sites and processes that sustain biodiversity, and
- articulate how priority sites address biodiversity conservation targets.

The first part of this chapter describes the features that designate the Chihuahuan Desert biota as globally outstanding. The second section presents the results of an analysis of nominated sites that help to identify candidate priority sites. The third section provides an overview of the candidate priority sites by subregion and how they contribute to addressing the conservation targets outlined in the Approach (Chapter 2) and form the core of subregion strategies.

1. Globally outstanding features of the ecoregion

Based on available data, the diversity of the flora and fauna of the Chihuahuan Desert appears to be unrivaled among desert ecoregions of the Nearctic and Neotropics. From a global perspective the biodiversity features that most distinguish the Chihuahuan ecoregion complex are the overall high diversity for many desert taxa; the high degree of local endemism across basins and ranges (*i.e.*, beta diversity); the high degree of endemism in specialized habitats such as gypsum dunes; and the globally high levels of endemic cacti. The Chihuahuan freshwater biota is globally outstanding because of its complexity, high degree of endemism, and the evolutionary processes expressed in the Cuatrociénegas Basin. Moreover, the persistence of sizable prairie dog colonies with good restoration potential represents an unusual ecological phenomena at a continental scale.

Globally, only the Namib-Karoo of southern Africa and the Great Sandy-Tanami Desert ecoregion of central Australia may match or exceed the richness and endemism of the Chihuahuan's biota (Olson and Dinerstein 1998). The reptile fauna - a highly diverse taxonomic group in deserts and other arid habitats - provide clear evidence of the paramount importance of these three ecoregions (Table 4.1). More thorough inventories of the Mexican portion will probably elevate the Chihuahuan desert to second place among xeric ecoregions for reptile diversity just behind the Namib-Karoo. In terms of diversity at the family level, we know that the Chihuahuan exceeds the Great Sandy-Tanami.

The broad latitudinal extent of the Chihuahuan and its proximity to diverse ecoregions-subtropical conifer forests, subtropical thickets, and temperate grasslands-help contribute to its species richness.

Within the ecoregion, the most distinct priority sites are complexes of mountains, valleys, and rivers that often occur along ecoregion boundaries.

The degree of local endemism is pronounced for a desert. This pattern is a result of the isolating effects of complex basin and range physiography, dynamic changes in climate over the last 10,000 years, and the presence of gypsum outcrops, saline playas, and other inhospitable habitats that have led to colonization and persistence of specialist species with restricted ranges. Taxa exhibiting high levels of local endemism include cacti, spurges, asters, cichlid and cyprinid fishes, aquatic pulmonate snails, aquatic reptiles, butterflies, spiders, scorpions, ants, lizards, and snakes.

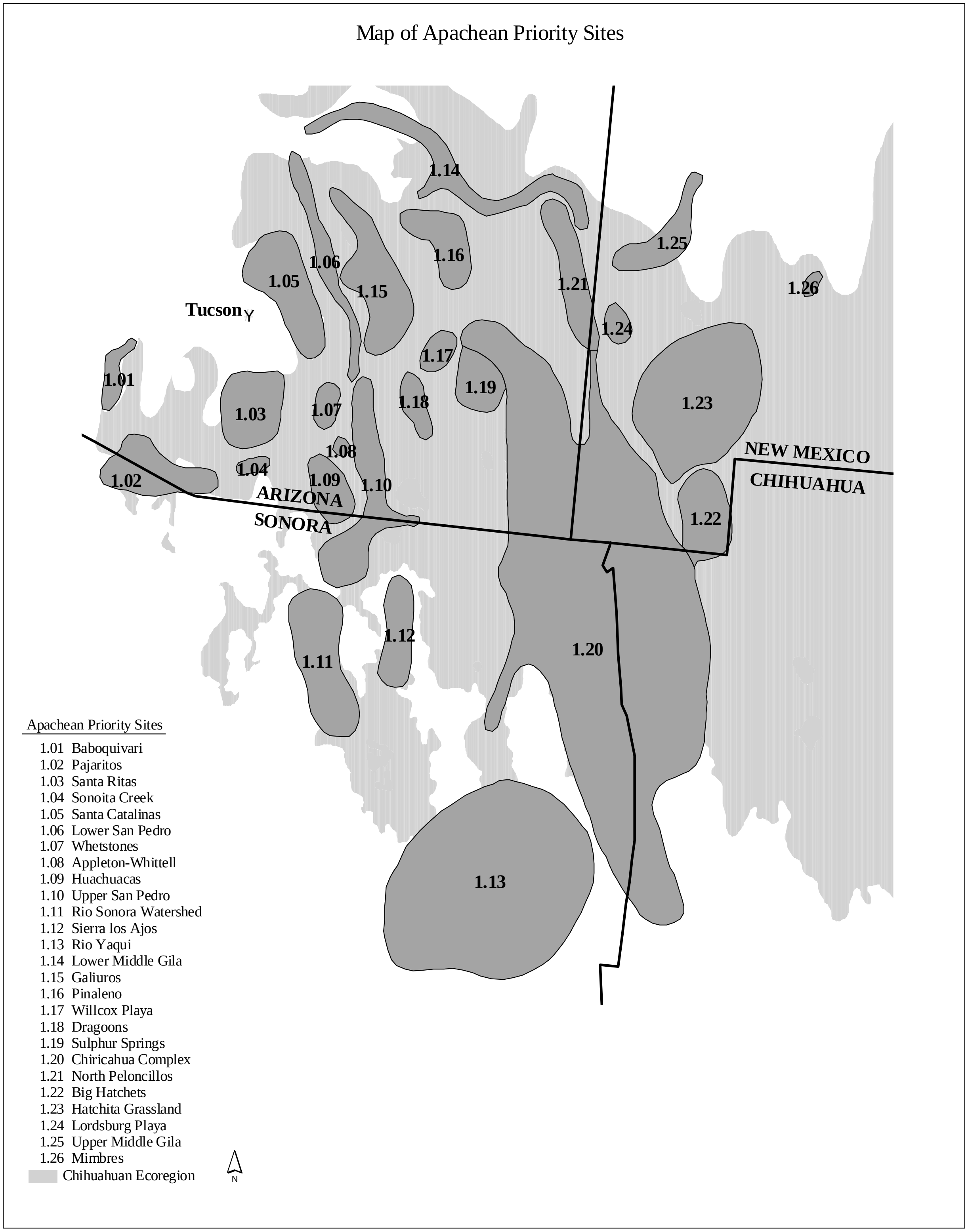
The Cactaceae, a conspicuous component of the Chihuahuan flora, is restricted to the New World (with exceptions in Sri Lanka, West Africa, and Madagascar). With perhaps one-fifth of all the world's cacti occurring here, the Chihuahuan Desert is an arena for a prolific evolutionary display in this family of succulents. Among the 22 plant genera that contain at least 20 species, four are cacti (Table 4.2); two cacti genera, *Coryphantha* and *Opuntia*, are among the five most speciose in the entire flora.

But it is not only the numerical abundance of cacti that is so distinctive. Distribution of cacti illustrate a defining feature of the Chihuahuan Desert-the high turnover of species with distance and along gradients (Figure 4.1). The replacement of cacti species from one basin to another offers an instructive rule for conserving Chihuahuan Desert biological diversity: incorporate patterns of beta-diversity into the design of a comprehensive conservation strategy. Some valleys support the highest concentrations of endemic cacti in the world. Other endemism hotspots for cacti include the Tehuacán Valley of southern Mexico, and the northern Monte ecoregion of the Southern Cone of South America, but levels of endemism are thought to be lower than in the Chihuahuan Desert. The clustering of highly endemic cacti in several distinct units also illustrates another principle: the need to give increased attention to particular foci of range-restricted species.

The isolation of many Chihuahuan Desert montane habitats, particularly uplands that support conifer forests, has led to differentiation among populations and species in a range of taxa. These sky islands typically harbor biotas characteristic of more northern climes or adjacent mountainous ecoregions.

The isolation and challenging conditions of the region's limited freshwater springs and streams has promoted a high degree of endemism in aquatic groups. The extraordinary freshwater species radiations and local endemism of Cuatrociénegas represent a globally outstanding phenomenon, the freshwater 'Galapagos' of the Americas. Local endemism can be extreme with fish and snail species being restricted to only a few small pools. High endemism of obligate freshwater taxa is found elsewhere in the Chihuahuan Desert complex as well; in the Mapimí area, defined by the Río Nazas, 50% of the fish fauna may be endemic.

Figure 4-1.Geographical distribution of endangered cacti in the Chihuahuan Desert ecoregion



Reptiles in Chihuahuan Desert ecoregion (US only)		Reptiles in Great Sandy-Tanami Desert ecoregion		Reptiles in Namib Desert, Kaokoveld, and Nama Karoo ecoregions	
Total[1] - 103 species in 14 families		**Total - 122 species in 8 families**		**Total - 156 species in 19 families**	
	Species		**Species**		**Species**
Crocodiles	**0**	**Crocodiles**	**0**	**Crocodiles**	**1**
Turtles/Tortoises	**9**	**Turtles/Tortoises**	**0**	*Crocodylidae (Crocodiles)*	1
Trionychidae (Soft-shelled Terrapins)	1	**Lizards**	**96**	**Turtles/Tortoises**	**7**
Chelydridae (Snapping Turtles)	1	*Gekkonidae (Geckos)*	26	*Testudinidae (Land Tortoises)*	5
Emydidae (Box/Water Turtles)	5*	*Agamide (Dragon Lizards)*	14	*Trionychidae (Soft-shelled Terrapins)*	1
Kinosternidae (Musk/Mud Turtles)	2	*Varanidae (Monitor Lizards)*	10	*Pelomedusidae (Side-necked Terrapins)*	1
		Scincidae (Skinks)	41	**Lizards**	**103**
Lizards	**43**	*Pygopopidae (Snake-Lizards)*	5	*Gekkonidae (Geckos)*	40
Gekkonidae (Geckos)	4*	**Snakes**	**26**	*Agamide (Dragon Lizards)*	5
Scincidae (Skinks)	5	*Typhlopidae (Blind Snakes)*	5	*Varanidae (Monitor Lizards)*	2
Anguidae (Alligator Lizards et al.)	1	*Boidae (Pythons)*	6	*Scincidae (Skinks)*	21
Helodermatidae (Venomous Lizards)	1	*Elapidae (Elapid Snakes)*	15	*Lacertidae (Lacertids)*	17
Iguanidae (Iguanids)	20*	**Total**	**122**	*Gerrhosauridae (Plated Lizards)*	5
Teiidae (Whiptails et al.)	12*			*Cordylidae (Girdled Lizards)*	10
Snakes	**51**			*Chamaeleonidae (Chameleons)*	3
Elapidae (Elapid Snakes)	2			**Snakes**	**45**
Colubridae (Colubrids)	39*			*Typhlopidae (Blind Snakes)*	2
Leptotyphlopidae (Slender Blind Snakes)	2			*Boidae (Pythons)*	2
Viperidae (Vipers)	8			*Elapidae (Elapid Snakes)*	10
Total	**103**			*Leptotyphlopidae (Thread Snakes)*	4
				Atractaspididae (African Burrowing Snakes)	2
				Colubridae (Typical Snakes)	24
				Amphisbaenidae (Worm Lizards)	1

*family contains a Chihuahuan endemic species (5 total endemic species in the ecoregion)

[1] – The US only makes up 1/4 of the ecoregion, and due to the ecoregion's high beta diversity, one expects to encounter species in the Central Chihuahuan and Meseta Central subregions that do not occur north of the international border. Based on the total number of species in the US and the number of endemics and wide-ranging species, a conservative estimate of an additional 35-40 species is likely to be encountered, raising the total number of reptile species to around 140.

Table 4-1. A comparison of reptile diversity among the three richest desert ecoregions of the world

Table 4-2. Chihuahuan plant genera which contain over 20 species. Those marked with an asterisk belong to the cacti family (derived from the Flora of the Chihuahuan Desert by J. Henrickson and M. Johnston in press)

Genus of species	Family	Number
Agave	Agavaceae	21
Asclepias	Asclepiadaceae	21
Astragalus	Fabaceae	33
Brickellia	Asteraceae	31
Bouteloua	Poaceae	23
Cheilanthes	Pteridaceae	26
Coryphantha*	Cactaceae	41
Dalea	Fabaceae	47
Echinocereus*	Cactaceae	23
Eriogonum	Polygonaceae	25
Eupatorium	Asteraceae	22
Euphorbia	Euphorbiaceae	61
Ipomoea	Convolvulaceae	24
Mammillaria*	Cactaceae	31
Muhlenbergia	Poaceae	34
Nama	Hydrophyllaceae	24
Oenothera	Onagraceae	21
Opuntia*	Cactaceae	39
Perityle	Asteraceae	22
Polygala	Polygalaceae	23
Quercus	Fagaceae	40
Salvia	Lamiaceae	36

The Chihuahuan Desert still harbors some areas that support relatively intact landscapes, primarily in montane regions. However, many degraded lowland habitats have good potential for restoration, assuming source pools for native species are well protected and management plans promote a return to appropriate grazing, fire, and water regimes.

Wolves (*Canis lupus*) and grizzly bears (*Ursus horribilis*) were extirpated in this century and no truly intact vertebrate assemblages remain. However, several sites do retain the remaining complement of larger vertebrates, including top predators such as puma, jaguar, and golden eagles. Extant prairie dog colonies also serve as keystone habitats for eventual restoration of native grassland ecosystems, complete with pronghorn, golden eagles, aplomado falcons, coyotes, badgers, and wolves. In the past, the Chihuahuan was one of a few ecoregions where grizzly bears, wolves, and jaguar could be found at the same locality.

Migratory routes for a broad range of taxa depend upon seasonal availability of resources in the Chihuahuan Desert. Many migratory bird species continue to use riparian and montane habitats in the Chihuahuan as feeding and resting habitats, and several bat species track flowering cacti over large areas in early summer. Monarch butterflies rely on the riparian vegetation of several Chihuahuan passes to rest during their migration.

Some distinctive habitat types in the Chihuahuan include yucca woodlands, playas, gypsum grasslands, gypsum dunes, scrubs dominated by arborescent cacti, and a diverse array of desert freshwater habitats, best illustrated by the unique Cuatrociénegas springs. Cuatrociénegas is home to the only aquatic box turtle (*Terrapene coahuila*), a local endemic, and the only known fish (*Cichlasoma minckleyi*) to have two co-occurring morphs which feed on algae and snails, respectively. The Madrean coniferous forests once supported populations of the world's largest woodpecker, the Imperial, now believed extinct.

2.a. Nominated Sites

Regional experts nominated 299 sites worthy of consideration in an ERBC strategy (Table 4.3). Here we summarize overall distributions by subregions (Figure 4.2) of nominated sites based on the analyses of patterns shown by six taxa. In each of the four subregions, freshwater species account for the highest or second highest total of nominated sites, followed closely by plants. Maps and lists of nominated sites for each of the six taxon groups are presented elsewhere (Appendix B).

Table 4-3. Number of sites nominated for each taxon displayed by subregion

Taxon group	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	**Total**
Birds	13	23	8	3	**47**
Herpetofauna	4	7	3	9	**23**
Invertebrates	6	9	7	4	**26**
Mammals	3	13	6	5	**27**
Freshwater	27	33	17	20	**97**
Plants	16	34	13	16	**79**
Total	**69**	**119**	**54**	**57**	**299**

Degree of overlap among nominated sites by terrestrial taxon specialist groups

Forty-two of the 69 Apachean sites are terrestrial; 16 were nominated by one taxon group of experts whereas the other 26 sites were nominated by more than one taxon group. Eighty-six of the 119 Northern Chihuahuan sites are terrestrial; six were nominated by only one taxon group and 80 were nominated more than once. Thirty-seven of the 54 Central Chihuahuan sites are terrestrial; four were nominated by only one taxon group, and 33 were nominated more than once. Thirty-seven of the 57 Meseta Central sites were terrestrial; all were nominated by more than one taxon group.

Achieving representation of terrestrial habitat types

We can examine the extent to which nominated sites address the conservation goal of representation of all terrestrial habitat types (Table 4.4). Among the four subregions, all major habitat types are represented at least once unless the habitat type does not occur in the subregion (*e.g.*, the absence of dunes in several of the subregions). There are high levels of replication among mixed conifer forests and riparian woodlands in some subregions. This skew is a reflection of the high levels of beta diversity associated with the upland conifer zone and the keystone nature of riparian woodlands. At least among nominated sites, initial goals of representation seem to be met. An even higher level of representation exists than is apparent from Table 4.4 because the large complexes-identified in all subregions but the Apachean-contain examples of several habitat types.

Table 4-4. Representation of terrestrial habitat types among nominated sites

Habitat Type	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	**Total**
Mixed Conifer Forest	15	13	11	6	**46**
Woodlands & Chaparral	7	7	6	12	**32**
Riparian Woodland	10	17	1	2	**30**
Playas	4	6	1	1	**12**
Grasslands	5	20	2	5	**32**
Desert Scrub	0	12	11	10	**33**
Dunes	0	8	0	0	**8**
Large Complexes	1	3	5	1	**9**
Total	**42**	**86**	**37**	**37**	**202**

Achieving representation of freshwater habitat types

Freshwater experts assessed representation of habitat types among the 79 candidate priority sites by categorizing them using the list presented in Appendix A. Many of these sites were located within larger catchments. In many cases, only conservation on the scale of catchments can effectively protect individual freshwater sites. All habitat types are well represented (many sites received multiple habitat designations), with the lone exception of playas. To remedy this, several additional playas were designated as candidate sites. Several other candidate sites required further exploration. Few subterranean sites were identified because knowledge about subterranean biota was lacking.

Importance of other biological features in the identification of nominated sites

Some sites may show low levels of richness or endemism for a particular habitat type within a subregion. However, other biological features-ecological and evolutionary phenomena, intact biotas, higher taxonomic diversity, large-scale phenomena such as migrations-may warrant their inclusion as nominated sites. A total of 255 sites was nominated because of high richness, endemism, or both, for one or more taxa (Table 4.5). Many of these same sites, but also some new sites, were nominated for other reasons. A combined 154 sites were nominated to address other conservation targets besides richness and endemism.

Figure 4-2. Chihuahuan Desert ecoregion complex with subregions

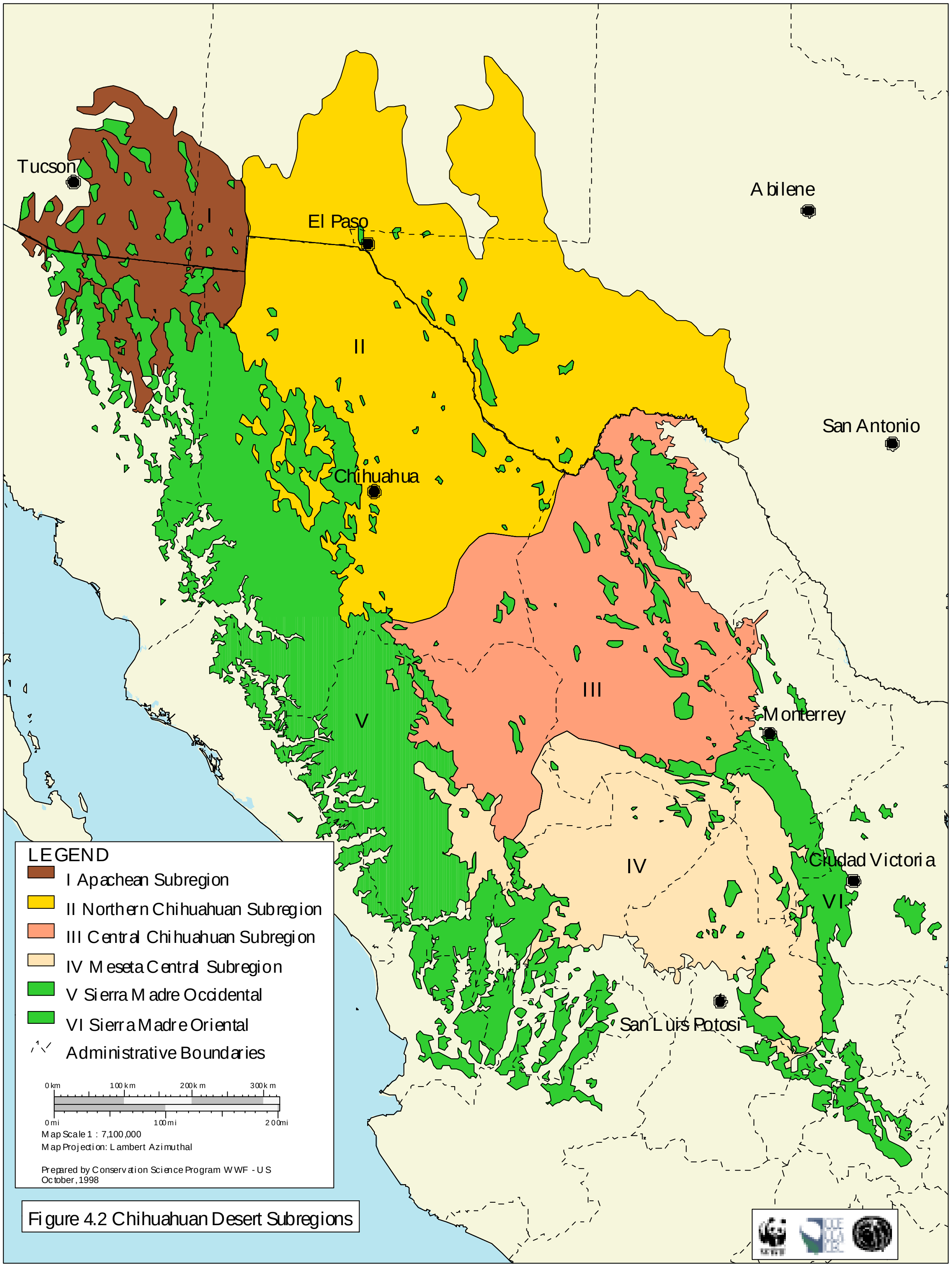


Figure 4.2 Chihuahuan Desert Subregions

Figure 4-3. Names of candidate terrestrial priority sites and map (see following page for map)

Site#	Site Name
1.01	Baboquivari
1.02	Pajaritos
1.03	Santa Ritas
1.04	Sonoita Creek
1.05	Santa Catalinas
1.06	Lower San Pedro
1.07	Whetstones
1.08	Appleton-Whittell-Canelo Hills
1.09	Huachuacas
1.10	Upper San Pedro
1.11	Río Sonora Watershed
1.12	Sierra Los Ajos
1.14	Lower Middle Gila
1.15	Galiuros
1.16	Pinaleño
1.17	Willcox Playa
1.18	Dragoons
1.19	Sulphur Springs
1.20	Chiricahua Complex
1.21	North Peloncillos
1.22	Big Hatchets
1.23	Hatchita grassland
1.24	Lordsburg Playa
1.25	Upper Middle Gila
1.26	Mimbres
2.01	Sierra del Nido
2.02	Rio Grande-El Paso to Amistad
2.03	Rio Grande-Elephant Butte to El Paso
2.04	Guadalupe-Carlsbad
2.05	Davis-Chinatis Mts.

Site #	Site Name
2.06	Devil's River
2.07	Big Bend
2.08	Chihuahuan Grasslands
2.09	Tularosa
2.10	Pecos River
2.11	Alta Bavicora
2.12	La Perla
2.13	Mescalero Dunes
2.14	Samalayuca Dunes
2.15	Conchos River
2.16	Marathon Basin
2.17	Sierra Blanca
2.18	Rio Grande-Above Elephant Butte Dam
3.01	Complejo Mapimí
3.02	Complejo de Sierras del Carmen
3.03	Cuatrociénegas
3.04	Sierra de la Paila
3.05	Sierra Santa Fe de Pino
3.06	Sierra de Menchaca
3.07	Sierra de la Gloria
3.08	Sierra de las Minas Viejas
4.01	Altiplano Mexicano Nordoriental
4.02	Huizache-Cerritos
4.03	Querétaro
4.04	Peco de Teyra
4.05	Órganos Malpais
4.06	Laguna de Santiaguillo
4.07	Río Nazas Basin
4.08	Saltillo-Monterrey
4.09	Sierra de Picachos

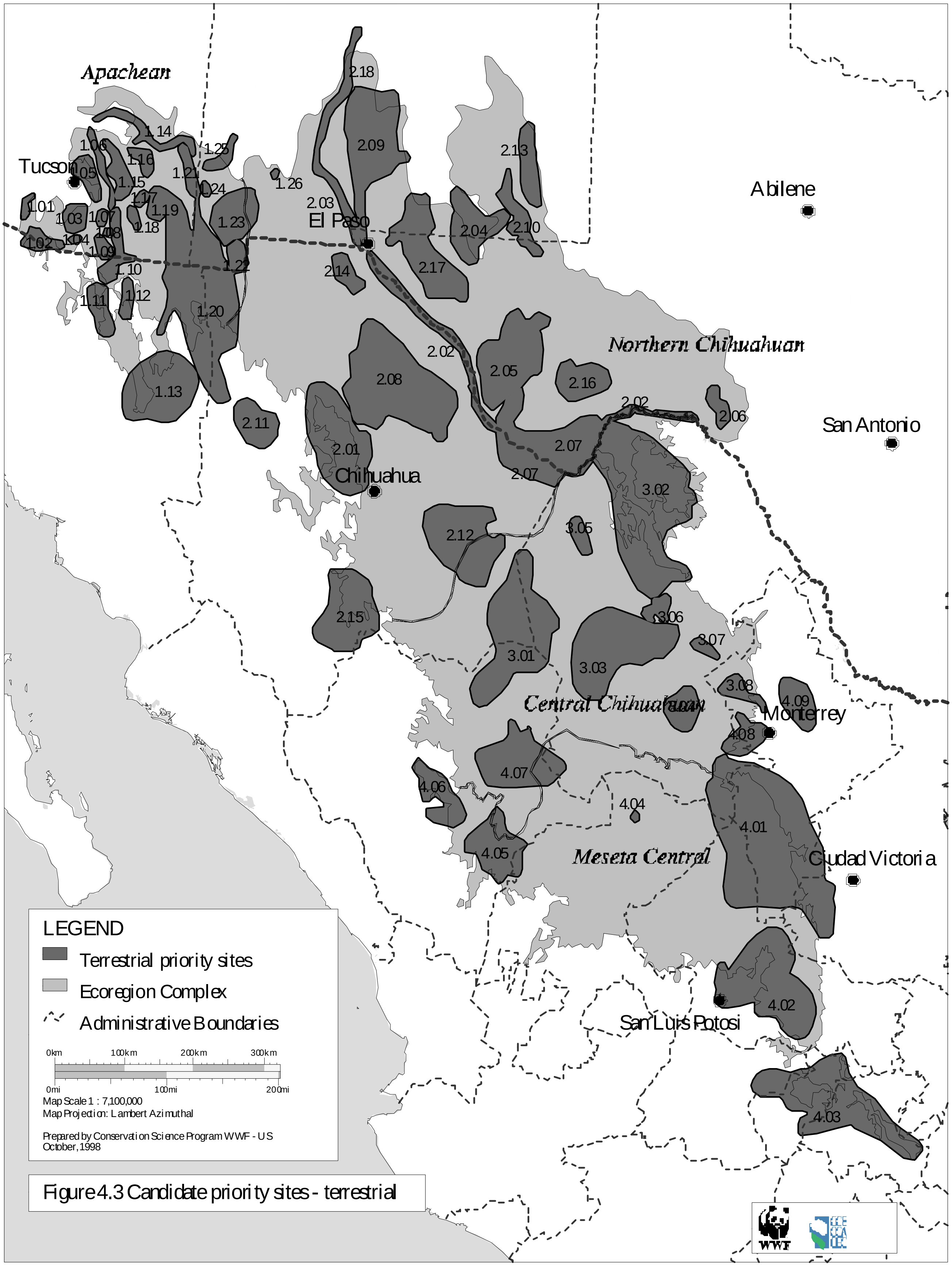


Figure 4.3 Candidate priority sites - terrestrial

Table 4-5. Criteria for selection of terrestrial nominated sites by subregion (many sites were chosen for more than one criterion)

Criteria	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	**Total**
Richness	37	34	14	27	**112**
Endemism	26	53	36	28	**143**
Ecological phenomena	38	42	17	8	**105**
Intact biota	2	19	7	0	**28**
Assemblages	0	1	1	2	**4**
Evolutionary phenomena	4	2	1	2	**9**
Large-scale phenomena	4	6	2	4	**8**
Needs further study	1	1	0	1	**3**

2.b. Synthesis of nominated sites to create candidate priority sites

We synthesized data layers from each taxon group to identify areas of spatial overlap and discordance among nominated sites (Appendix A Figure A-3). The 299 sites were condensed to 61 terrestrial candidate priority sites (Figure 4.3) using a set of objective decision rules (Box 2.2).

Among the 61 terrestrial candidate priority sites, 11 (16%) were considered as high priority for all five taxon groups (excluding freshwater taxa for this analysis). At the other extreme, 16 candidate priority sites (26%) were selected because of only a single taxon. Four of the 61 areas were neither extraordinary in their levels of species richness nor endemism but were selected to ensure better representation of habitats or to address other biological targets such as phenomena.

The 11 candidate priority sites that were considered high priority for all five taxa (excluding freshwater) were unevenly distributed among the four subregions. The Apachean has the most candidate priority sites (26) but only two of the 11 sites exhibit maximum overlap (sites 1.03 and 1.20). The Central Chihuahuan subregion, in contrast, has only eight of the 61 candidate priority sites but three exhibiting maximum overlap (3.01, 3.02, and 3.03).

3. Biological distinctiveness of the subregions

Below is a summary of biological distinctiveness by subregion and outstanding features at specific sites. For freshwater biodiversity, candidate priority sites are described for the entire ecoregion.

Apachean subregion

The Apachean has the highest proportion of grasslands (45%) among the subregions and the highest percentage of montane chaparral, forest, and woodland habitats (10%). The desert scrub component covers approximately 33% of the landscape. Rivers and springs arise from the waters of the Sierra Madre Occidental ecoregion and the sky islands, however riparian habitat is less than 1% of the total land cover.

Overall, Apachean candidate priority sites were selected largely for their distinctive montane assemblages and areas of relatively intact habitat. Out of a total of 26 sites, 14 are either isolated sky islands or northern extensions of the Sierra Madre Occidental. Montane sites were primarily selected for their unusual mixture of species with affinities to the Sierra Madre Occidental, Rocky Mountains, Sonoran Desert, and Chihuahuan Desert. The seven sites that are riparian communities were all selected for the presence of representative habitat types and their role in ecological processes, such as flooding and migration. The two playa sites were selected for their importance as migratory stopovers for waterfowl, raptors, and cranes. Grassland sites were selected because of intactness and species assemblages.

Local endemism in the Apachean subregion is most pronounced in the sky islands and playas. Some reptiles and amphibians restricted to sky island habitats include the ridge-nosed rattlesnake (*Crotalus willardi*), twin-spot rattlesnake (*C. pricei*), cat-eyed snake (*Leptodeira septentrionalis*), Yarrow's spiny lizard (*Sceloporus jarrovii*), Chiricahua leopard frog (*Rana chiricahuaensis*), and canyon spotted whiptail (*Cnemidophorus burti*). Within the playas, several endemic plants and invertebrates are uniquely adapted to seasonal inundation and alkaline conditions such as Griffith's saltbush *(Atriplex torreyi* var. *griffithsii*).

Species richness in some taxa in the Apachean may be higher than in the other subregions. The confluence of Sonoran, Sierra Madre Occidental, Arizona Mountains, and Chihuahuan Desert ecoregions blends a diversity of subtropical and temperate taxa. Sycamore Canyon, a riparian area within the Pajarito-Atasco Mountains (1.02) contains at least 593 species of plants and 200 species of butterflies. A rich assemblage of reptiles along Antelope Pass in the Peloncillo Mountains (1.20) contains the highest documented lizard diversity in the United States. Willcox Playa (1.17) is the highest recorded site diversity of tiger beetles (family Cincindelidae) in the world.

Several of the sky islands have escaped extensive resource exploitation. The Galiuro Mountains (1.15), the Whetstone Mountains (1.07), Peloncillos and Animas Mountains (1.20), and the Dragoon Mountains (1.18) contain examples of Madrean evergreen woodland and grama grassland habitats, despite many decades of timber extraction and grazing. Although the Chihuahuan Grasslands in site 1.20 are heavily grazed and degraded, a remarkable assemblage of vertebrates is associated with the black-tailed prairie dog colony at Janos, Chihuahua. This is the largest remaining prairie-dog colony in North America. Ferruginous hawk (*Buteo regalis*), long-billed curlew (*Numenius americanus*), burrowing owl (*Athene cunicularia*), swift fox (*Vulpes macrotis*) and pronghorn (*Antilocapra americana*) are among a number of species that rely on the prairie-dog colony for prey, habitat, or forage.

Large scale migrations of waterfowl, shorebirds, raptors, and cranes depend upon shallow playa waters as migratory stopovers. Willcox Playa (1.17), Lordsburg Playa (1.24), Upper San Pedro River (2.10), and Playas Playa (within site 1.22) are critical links for birds on both northern and southern migration routes. Perhaps the critical stopover hotspot of the ecoregion is the riparian woodland of the Upper San Pedro (2.10) which serves as a corridor for up to four million neotropical migrants and is also important for nesting and wintering habitat. Locally, riparian woodlands help regulate other processes, such as river temperature, flooding intensity, soil retention, and evaporation rates.

Riparian and wetland habitats are increasingly rare in the Apachean subregion because of human activities. Although altered, the Rio Piedras Verdes (within site 1.20) sustains many invertebrate species dependent on riparian vegetation, including the viceroy butterfly (*Limenitis archippus*), and a local lycaenid butterfly (*Apodemia phyciodoides).* The wetlands of the Rio Yaqui headwaters, also in site (1.20), and Willcox Playa (1.17) are reduced in area but maintain some species assemblages associated with marsh habitats. Lower San Pedro (1.06), Upper San Pedro (1.10), Rio Yaqui (1.13), Sonoita Creek (1.04), the Lower Middle Gila River (1.14), and Upper Middle Gila River (1.25) are priority sites selected largely for their remaining riparian habitats.

Northern Chihuahuan subregion

The Northern Chihuahuan subregion is a landscape dominated by Chihuahuan desert scrub, representing approximatley 50% of the total cover. This subregion may have once supported up to 50% more grasslands than it does today. Only 25% of this subregion is currently grassland. Of the 18 priority sites selected, six were selected because of high quality grasslands with a largely intact biota. Although less then 5% of the ecoregion consists of montane and woodland habitat types, five sites characterized by higher elevation communities were selected on the basis of intact habitats, species assemblages, and endemism. Four riparian sites were selected as representative habitats and for their roles in maintaining ecological processes. The two dune sites and a montane lake site were selected on the basis of distinctive and representative habitat types, and the presence of dune endemics.

Localized endemism commonly occurs in several taxa in the Northern Chihuahuan subregion where complex basin and range physiography promotes isolation. At least four endemic plant species are known from each priority site containing a mountain range: the Chisos Mountains in Big Bend, (2.07), the Organ Mountains (2.09), the Glass Mountains (2.16), the Sierra del Nidos (2.01), the Davis-Chinati Mountains (2.05), and the Guadalupe-Carlsbad Escarpment (2.04). *Coryphantha* spp. (Cactaceae) and *Perityle* spp. (Asteraceae) show pronounced geographic differentiation and a high degree of endemism. Big Bend (2.07) also supports relatively intact floristic assemblages and harbors some of the few populations of larger vertebrates in the subregion.

Intact habitats are surprisingly frequent in this subregion. The Northcentral Chihuahuan Grasslands (2.08) are an unusual example of relatively intact grama grasslands that have supported decades of livestock grazing. Nesting aplomado falcon (*Falco femoralis*), frequent wildfire, and an abundance of kangaroo rats (*Dipodomys* spp.), are evidence of low human impacts and a functioning native ecosystem. Stream and springs, however, are highly degraded in this site. Many of the montane and woodland sites in protected areas, such as the Guadalupe Mountains-Carlsbad Escarpment (2.04), Chisos Mountains (2.07), Organ and San Andres Mountains (2.09), and Davis-Chinati Mountains (2.05) retain intact habitats of pine-oak woodlands and coniferous forests. United States federal and state parks protect these sites from logging, as do military installations and other protective designations.

The species assemblages are noteworthy due to their intactness or their unusual make-up. The reptile assemblages of Big Bend (2.07) are truly remarkable. Intact desert scrub, woodland, and grassland habitats are occupied by a wide array of species including 34 species of snake, 21 species of lizard, and five species of turtle. Though heavily altered, Mescalero Dunes (2.13) mixes biotas characteristic of the Chihuahuan Desert with the Desert Short Grasslands ecoregion (Ricketts *et al*. 1999). The lesser prairie-chicken (*Tympanuchus pallidicinctus*), sand dune lizard *(Sceloporus graciosus arenicolous*), swift fox (*Vulpes macrotis*), and pronghorn antelope (*Antilocapra americana*) create an unusual and threatened assemblage of grassland dependent vertebrates.

This subregion's role in providing stepping stones for migratory species has gone largely unrecognized. The Jornada Bat Caves, within the Tularosa Basin (2.09) site, is a migratory stopover for at least four million Mexican free-tail bats (*Tadarida brasiliensis*). Neotropical migratory birds utilize remaining riparian corridors along the Pecos River (2.10) and the Rio Grande-El Paso to Amistad (2.02) sites. With restoration of riparian habitat, these corridors could support a much higher number of birds. Alta Bavicora (2.11) is the only large, natural lake in the subregion, and is a critical migratory stopover for cranes, waterfowl, shorebirds, and raptors. Human-made impoundments along the Rio Grande have become important wintering habitats for migratory waterfowl.

Ecological processes within grasslands help sustain this subregion's overall physical and biological integrity. Sierra Blanca (2.17) is an example of a vast grassland with low fragmentation, a relatively natural fire regime, and an assemblage of burrowing rodents, including prairie dogs. Combined, these factors regulate such important processes as water infiltration, soil development and productivity, species diversity, and microbiotic crust formation. La Perla (2.12), Northcentral Grasslands (2.08), and Northern Jornada grasslands (within site 2.09) are similarly important.

Another component to the extraordinary richness of the Chihuahuan Desert is the occurrence of species representative of other ecoregions. Along the Devil's River of site (2.06) are northern range limits of two subtropical species, Mexican white oak (*Quercus polymorpha*) and the jaguarundi (*Felis yagouaroundi*). This riparian corridor blends biota representative of the Chihuahuan Desert, Tamaulipan, and Edwards Plateau ecoregions. The occurrence of fireflies (Lampyridae) and other eastern North American invertebrates in the Davis Mountains (2.05) reflects a mesic-adapted assemblage long isolated by changes in regional climates. The range of many neotropical migratory birds that breed in forests of eastern North America extend into the riparian forests of the Pecos River (2.10). Blue Jay (*Cyanocitta cristata*), Yellow-throated Vireo (*Vireo flavifrons*) and White-eyed Vireo (*V. griseus*) are among the eastern songbirds found in the cottonwood-willow forests.

Two rare habitats-the gypsum dunes of White Sands National Monument within the Tularosa Basin (2.09) and the mineral outcrop of Caballos Noviculite in Marathon Basin (2.16)-both support unusual assemblages of plant and vertebrate species and several endemic soil invertebrates. Saline-adapted species occur in playas of Tularosa Basin (2.09) and Salt Flat, east of the Guadalupe Escarpment (within site 2.04).

Central Chihuahuan subregion

Lying in the rainshadow of the Sierra Madre Oriental, the Central Chihuahuan Desert is one of the driest subregions. The valleys are lower (700 m - 1,400 m) than the other subregions, and the mountain ranges are not as high, resulting in less orographic precipitation. Most of the soils are derived from limestone. Only a few perennial streams or lakes are known and most basins drain internally. Desert scrub covers 60% of the subregion, including yucca woodlands and cactus scrub habitat types. Semi-desert grasslands constitute just 8% of the subregion but are believed to have once been more extensive. Grasslands have been replaced or become dominated by scrub because of centuries of frequent grazing and changes to fire regimes. Agricultural lands account for 14% of the land cover, and woodlands a sparse 3%. Playas constitute a surprising 8% of the land, concentrating in the La Laguna region.

The Sierra de Parras, Sierra Guadalupe and the Río Nazas separate the Central Chihuahuan subregion from the Meseta Central to the south. The mountain ranges and river create a dispersal barrier for some mammals and mark the limit of the range for others. For example, the western mastiff bat (*Eumops perotis*), yellownose cotton rat (*Sigmodon ochrognathus*) and whitetail antelope groundsquirrel (*Ammospermophilus interpres*) have their southern distributional limits in the Central Chihuahuan, whereas other mammals (*Sigmodon leucotis*, *Sorex saussuri*, and *Dipodomys phillipsi*) reach their northern limits.

At least 100 endemic plant species have been recorded. Plant endemism in the subregion is highest within Cuatrociénegas (3.03), a *bolsón* in central Coahuila. Roughly forty plant species may be endemic to the desert scrub and gypsum dune lowlands, and ten species to woodlands and forests of the Sierra de la Madera. Along with several canyons in the eastern Meseta Central subregion, the Cuatrociénegas basin represents one of the world's richest foci for locally endemic cacti. This unusually high number of endemic species may be due to the complex soil and microclimate conditions, the long-term stability of conditions, and isolation of the *bolsón*.

Distinctive *crasicaule* - cacti dominated shrublands - and yucca woodlands occur throughout the subregion. *Crasicaule* occurs in pockets within Cuatrociénegas (3.03) and Mapimí (3.01). Excellent examples of yucca woodlands are found in the Sierra de las Minas Viejas (3.08). The gypsum dunes of Cuatrociénegas host a surprising number of unique gypsum-adapted plant species. The Sierra de la Gloria site (3.07) contains an unusual assemblage of pine-oak woodlands with an abundance of palms and cacti. Chihuahuan Desert and Tamaulipan elements blend on this small limestone cordillera.

Bird assemblages within the Sierras del Carmen and Santa Rosa (3.02) present a mix of biogeographic affinities. Here one finds the northern goshawk (*Accipiter gentilis*)-a species more typical of northern conifer forests-the Montezuma Quail (*Cyrtonyx montezumae*) of Madrean oak woodlands, and Audubon's oriole (*Icterus graduacauda*), a subtropical species that typically nests in dense, humid evergreen forests but found here in semiarid pine-oak woodlands.

The spectacular phenomenon of the monarch butterfly migration occurs within the forests of the Sierra de La Paila (3.04) and in riparian scrub of several mountain passes just north of Saltillo. Extremely high numbers of butterfies congregate at these sites. The Sierra Santa Fe del Pino (3.05) provides an important corridor for bat migrations. Bird migration routes within the Sierras del Carmens and Santa Rosa (3.02) run along corridors of woodland and forested habitats.

The priority sites at Sierra Santa Fe del Pino (3.04), Cuatrociénegas (3.03), Mapimí (3.01), and Sierra del Carmen and Santa Rosa (3.02) all retain large tracts of intact desert scrub, grassland, woodland, and montane habitats. The Sierra de la Menchaca (3.06) has also had little human disturbance and contains intact pine and oak woodland forests. Their remoteness and inaccessibility has protected them to date from heavy grazing or mining. The Central Chihuahuan subregion has a higher proportion of intact habitats than the other three subregions. Sites selected for the presence of representative species assemblages were limited to Mapimí, Sierras del Carmen and Santa Rosas, and Cuatrociénegas (3.03).

All three of these sites are large complexes of mountains, valleys, grasslands, and scrublands, increasing the level of representation among habitat types within the subregion.

All eight of the priority sites contain montane or woodland habitat types. These higher elevation communities were selected on the basis of intactness, and their value as key sites will surely increase when much needed biological inventories are completed. Several sites were selected for their outstanding ecological phenomena, including 1) the Sierras del Carmen and Santa Rosas (3.02) site which maintains relatively intact large vertebrate assemblages and functional predator-prey interactions; and 2) the grasslands of Mapimí (3.01) site, which hosts many wintering grassland birds, abundant burrowing rodents and associated predators, and relatively natural fire regimes. Cuatrociénegas (3.03) was identified as a globally important site for pronounced radiations and other complex evolutionary phenomena.

Meseta Central subregion

The Meseta Central is dominated by a large plateau, with internally drained basins from 1,550 m to 2,100 m in elevation, and is generally higher and cooler than the Central Chihuahuan subregion. The biota is influenced by subtropical range extensions from the east and south. The biota of the Meseta Central is poorly known relative to the other subregions. Experts at the workshop stressed the need for further inventories of plants and invertebrates, particularly in light of the continuing habitat loss.

Land cover estimates of the Meseta Central indicate that 56% of the subregion is dominated by desert scrub communities. Playas cover 3% of this subregion and grasslands are found over 13%. This subregion contains the highest proportion of agriculture at 23% of land cover. Woodlands are limited to just 2.5% of the total area.

The Meseta Central harbors one of the greatest concentrations of species of cacti in the world, with pockets of numerous local endemics along its eastern margins. For example, within the Altiplano Mexicano Nordoriental (4.01), 8 % of 72 cacti species are endemic, and Huizache-Cerritos (4.02) has at least 14 species of endangered species of cacti including several local endemics. The cacti diversity of the Querétaro Desert (4.03), an arid zone disjunct from the Chihuahuan Desert, also supports a wealth of cacti species.

Río Nazas (4.07) supports an exceptional set of long disjunct plant genera, among them *Siphonoglossa*, *Justicia*, and *Henricksonia*. A new plant family, the Setchylonthusaceae, has recently been described.

Yucca woodlands and *crasicaule*, two distinctive Chihuahuan habitats, reach their widest distribution in the Meseta Central. *Crasicaule* is the dominant community type of Querétaro (4.03), Huizache-Cerritos (4.02), and Laguna de Santiaguillo (4.06).

Only two sites contain relatively intact habitat, Altiplano Mexicano Nordoriental (4.01) and Peco de Teyra (4.04). The granite peak of Peco de Teyra has had little human disturbance and only light grazing by goats. Areas of intact grasslands and yucca woodland south of Saltillo (*e.g.*, site 4.01) have escaped major alteration and degradation as have chaparral sites near Aramberri. High degree of habitat loss and fragmentation throughout the subregion are the underlying reasons so few sites contain intact habitats.

The southern canyons of the Altiplano Mexicano Nordoriental (4.01) support a relatively intact predator assemblage, the only known example in the Meseta Central and one of the few in the ecoregion. Jaguars (*Panthera onca*), mountain lion (*Felis concolor*), and bobcat (*Lynx rufus*) inhabit canyons and foothills of the Sierra Madre Oriental. South of Saltillo and within the Altiplano Mexicano Nordoriental (4.05) occur some of the last remaining Mexican prairie dog (*Cynomys mexicanus*) colonies. Associated vertebrate species include mountain plover (*Charadrius montanus*), ferruginous hawk, swift fox (*Vulpes macrotis*), aplomado falcon, golden eagle, and the rare Worthen's sparrow. Bats are known to migrate through the pine-oak woodlands of Órganos-Malpais (4.05). The long-tongued bat (*Leptonycteris spp.*) and California myotis *(Myotis californicus)* have been recorded at this site. The Laguna de Santiaguillo (4.06) is a critical migratory and wintering stopover for shorebirds, waterfowl, and raptors.

Freshwater biodiversity

Freshwater Priorities

In a desert environment, fresh water is a critical resource, both for humans and for terrestrial and aquatic species. The aquatic species present today are the "survivors" of a more diverse biota that flourished before climate shifts transformed the Chihuahuan region into its present desert state (Smith and Miller 1986). As a result of this desiccation, combined with complex tectonic events, many freshwater habitats are isolated and reduced in size, and display high levels of endemism. For this reason, prioritizing freshwater sites in the region is simultaneously simple and difficult: it is simple because freshwater habitats are relatively rare, and it is difficult because so many of these are both biologically distinct and highly threatened. Furthermore, protection of these habitats will generally require working at the scale of the watershed, as well as taking poorly understood groundwater flows into account. Because terrestrial, and particularly riparian, species depend on the water feeding these aquatic habitats, there is high overlap between freshwater and terrestrial priority sites.

The following overview of freshwater priority sites is organized by habitat type, with examples of sites representing each habitat type described briefly.

Rivers and streams

Despite its xeric nature, the Chihuahuan Desert has many perennial and ephemeral rivers and streams, their waters originating in large part at high elevations or in distant places (Smith and Miller 1986). Many Chihuahuan running waters experience a biannual cycle of flooding, with high flows occurring in the spring due to run-off from high-elevation snowmelt and then in the summer due to monsoons. In general, headwater streams tend to have more predictable and less fluctuating flow regimes than larger downstream tributaries (Smith and Miller 1986). Especially where flow is more erratic, flows may be dampened or cease altogether between often torrential wet periods, leaving behind intermittent pools.

The aquatic fauna has evolved to live under these extreme circumstances. In terms of numbers of species, cyprinids (minnows) and catostomids (suckers) dominate in these habitats, which have historically also supported representatives from a dozen other fish families. Many of these species are derived from the Mississippi River fauna, though there are also elements from the Neotropics and the Northwest, as well as endemic Chihuahuan species. The pluvial Rio Grande previously covered much of what is today the Chihuahuan desert, and hydrologic connections allowed exchanges of species. Today, the smaller, now-disjunct river basins have markedly high endemism levels for their numbers of species. The resiliency of the aquatic fauna is also notable.

Large Rivers

Priority areas containing large river habitat are the Rio Grande/Río Conchos (5.10) and Bavispe (5.07). The Rio Grande is considered one of North America's most endangered rivers as a result of degraded water quality and water withdrawals. The river still supports pockets of native fauna along the 835-km reach located within the Chihuahuan Desert. Because 80% of instream flow is diverted for agricultural use, this area was selected as a priority site largely for its restoration potential. The Río Conchos supports an impressive species assemblage that includes a number of endemic fish species. The Bavispe, which drains into the Río Yaqui and also contains perennial and ephemeral stream habitats, is believed to harbor a diverse and relatively intact assemblage of fish species that reflect pristine conditions. However, the site needs much more investigation.

Perennial Streams

Perennial streams are especially important for the survival and resiliency of aquatic fauna in xeric regions. Often they are refuges from which species recolonize more temporary habitats. Some of the perennial streams selected as highest priority include the Upper Yaqui (5.02), San-Pedro–Aravaipa (5.03), Papigochic (5.08), Upper Nazas (5.19), Mezquital (5.21), Upper Conchos (5.35) and Upper Gila (5.37).

The Río Mezquital, a perennial river that flows to the Pacific Ocean, supports seven endemic fish species, some with affinities with the Rio Grande fauna. The Mezquital is also the northern range of some southern Mexico species (Minckley et al. 1986). The headwaters of the Río Conchos (5.35) is a refuge for an endemic fish assemblage (8-10 fish), and also supports populations of river otter (*Lutra canadensis*) and beaver (*Castor canadensis*). Overgrazing and introduced species in this region have imperiled all fish species at the site.

Perennial streams are often associated with springs, ephemeral streams, *ciénegas*, and subterranean habitats, making strict classification of a site into one habitat type difficult. A good example is the Pecos River (5.15). It was selected as a priority in part for the processes that support a diverse aquatic fauna within gypsum springs, wetlands, and riverine habitats. The river is fed mainly by springs and supports a species-rich assemblage of native and endemic fish. Many spring snails are also found in the region.

Ephemeral Streams

Ephemeral streams connect habitats that are disjunct during drier periods of the year, expanding available habitat and allowing species to move between areas. They also provide habitat, forage and travel routes for terrestrial species. Xeroriparian areas have been shown to support 5 to 10 times the avian population densities and species diversity of surrounding desert uplands (Johnson and Haight 1985). Ephemeral streams are found in the following highest priority sites: Upper Yaqui (5.02), Bavispe (5.07), Papigochic (5.08), Pecos River (5.15) and Upper Gila (5.37).

A perennial stream bordered by ciénegas throughout much of its extent, the Upper Yaqui also has many ephemeral sections. The ephemeral and perennial reaches of the Upper Yaqui harbor assemblages of restricted fish species, including Yaqui chub (*Gila purpurea*), Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), Yaqui catfish (*Ictalurus pricei*), and Yaqui and Bavispe suckers (*Catostomus bernardini*, *C. leopoldi*). Similarly, a mosaic of habitats including ephemeral streams characterizes the Upper Gila (5.37), which has headwaters both in high-elevation mountains and low desert areas. The upper Gila River system contains several endemics, including the Gila trout (*Onchorhynchus gilae*), Gila chub (*Gila intermedia*) and two endemic spring snails.

Figure 4-4. Names of freshwater priority sites and map (see following page for map)

Site #	Site Name
5.01	Willow Spring
5.02	Upper Yaqui
5.03	San Pedro-Aravaipa
5.04	Upper Santa Cruz
5.05	Río Sonora
5.06	Zona Carbonifera
5.07	Bavispe
5.08	Papogochic
5.09	Devil's River
5.10	Rio Grande/Río Conchos
5.11	Rio Grande-Southern New Mexico
5.12	Mimbres
5.13	Guzmán
5.14	Bustillos
5.15	Pecos River
5.16	Bavicora
5.17	Panuco
5.18	Tularosa Basin
5.19	Upper Nazas
5.20	Laguna de Santiaguillo
5.21	Río Mezquital
5.22	La Concha
5.23	Aguanaval
5.24	Parras
5.25	Chorro
5.26	Potosí
5.27	Iturbide
5.28	Sandía
5.29	Sauz Basin
5.30	Cuatrociénegas
5.31	Venado
5.32	Media Luna/Río Luna
5.33	Río Cadena
5.34	Extorax
5.35	Upper Conchos
5.36	San Diego
5.37	Upper Gila River

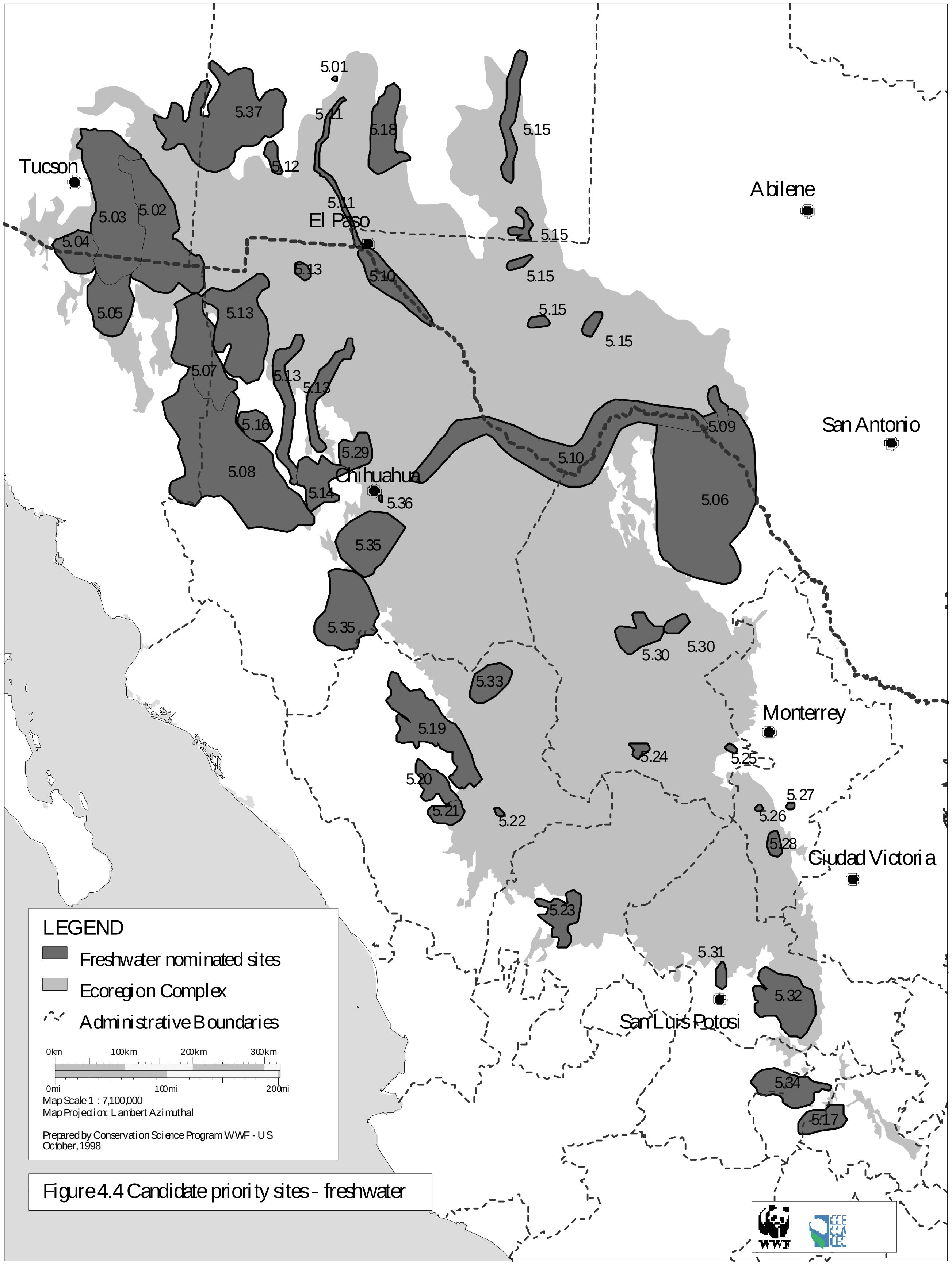


Figure 4.4 Candidate priority sites - freshwater

Springs

Springs play a vital role in the aquascape of the Chihuahuan Desert, providing the source for many perennial streams. They also are often the sole localities of highly endemic species that have evolved to survive in their unique environments. Pupfish of the genus *Cyprinodon*, and livebearers of the genus *Gambusia*, dominate the endemic fish fauna of springs in North America's desert Southwest. Extraction of water from springs and underlying aquifers has caused the wholesale elimination of habitat, and industrial and agricultural runoff have led to water quality degradation. Exotic species are more easily able to thrive in disturbed spring habitats and have excluded natives. Thus, the aquatic fauna inhabiting springs is often vulnerable due to both its own highly endemic nature and the susceptibility of spring habitats to disturbance.

Warm Springs

Some aquatic species of the Chihuahuan Desert have the unique ability to tolerate extremely high temperatures in thermal springs. For example, in San Diego Springs (5.36), the bighead pupfish (*Cyprinodon pachycephalus*) and an undescribed *Gambusia* species survive in water temperatures as high as 43^{o} to 44^{o} C, the highest known temperatures inhabited by freshwater fish in the world. This spring also harbors a sphaeromatied isopod and two hydrobiid snail species. La Concha (5.22), located at the edge of an elevated lava deposit at 2,100 m, is an example of a large thermal spring. The springs of La Concha harbor two local endemic fish derived from the Río Nazas fauna, and several basin endemics including *Etheostoma* spp. and *Cyprinodon nazas*.

Cool Springs

Springs dominate the aquatic habitats of Zona Carbonifera (5.06) and Media Luna/Río Verde (5.32). Zona Carbonifera (5.06), a subterranean aquifer with associated caves and springs, is suspected to contain many unknown species in addition to the Devil's River minnow (*Dionda diaboli*), platyfish (*Xiphophorus meyeri)*, sand shiner (*Notropis stramineus)*, and endemic isopods and amphipods. The Media Luna/Río Verde (5.32) site is an immense freshwater spring with numerous smaller and semi-independent springs in the vicinity, extending over a surface area of approximately 10,000 km^2. Rare and endemic fish species such as Media Luna killie (*Cualac tessellatus*), bluetail splitfin (*Ataeniobius toweri*), flatjaw minnow (*Dionda mandibularis*) and bicolor minnow (*D. dichroma*) inhabit the springs located in this area.

Springs are only one of a variety of habitats represented in the Pecos River site (5.15). Springs distributed along the Pecos River include the world's only known population of the Leon Spring pupfish (*Cyprinodon bovinus*) in Diamond Y Spring. Rattlesnake Springs, which is also found within the Pecos River (5.15) site, is a migration stopover for and home to about 250 species of birds.

Unregulated groundwater extraction is causing habitat fragmentation and drying up of springs at several priority sites. For example, two endemic and critically imperiled fish in the splitfin (Goodeidae) family, as well as a rare freshwater shrimp, inhabit springs in the Venado (5.31) site. Sandía (5.28) has springs and a lagoon that once supported four endemic species of fish and three endemic species of shrimp. All are now extinct. The site still contains eight endemic species of snails in monophyletic groups and three endemic crayfish. Restoration of the original springs by limiting groundwater extraction will be necessary for the survival of extant species at these and other priority spring sites.

Lagunas

Lagunas, small pond-like bodies of water connected to a larger body of water, occur throughout the Chihuahuan Desert, often in association with other habitat types. The two priority lagunas in the Chihuahuan Desert are home to native fish assemblages and are wintering areas or stopovers for migratory birds. Laguna de Santiaguillo (5.20) has rare *Cyprinodon* and *Gila* species, along with three endemic fish species that are apparently derived from the Rio Grande fauna. Bavicora (5.16), an ephemeral lake and wetland complex, supports a fish assemblage distinguished by relatively high endemism, including a yet undescribed trout. The Bavicora site is in need of further biological inventories.

Ciénegas

A ciénega is a marshy area created by the presence of seepage or springs, often with standing water and abundant vegetation. Ciénegas are present in the following highest priority sites in the Chihuahuan Desert: Willow Spring (5.01), the Upper Yaqui (5.02), San Pedro-Aravaipa (5.03), Pecos River (5.15), Cuatrociénegas (5.30), Media Luna/Rio Verde (5.32), and Upper Gila (5.37).

Cuatrociénegas (5.30), unparalleled in its aquatic species richness, is a globally outstanding site that takes its name from its dominant habitat type. The basin supports at least sixteen native fish, including eight endemic species. Fishes occupy springs, spring-fed rivers, marshes, playa lakes, ephemeral pools, and artificial canals (Minckley 1984).

Twelve crustaceans are known from the Cuatrociénegas basin. Many are endemic, including the cirolanid isopods (*Speocirolana thermydronis*, *Sphaerolana interstitialis*, and *Sphaerolana affinis*), one stenasellid isopod (*Mexistenasellus coahuila*), and two endemic hadzioid (weckeliid) amphipods, (*Mexiweckelia colei*) and the monotypic *Paramexiweckelia particeps* (Cole 1984).

Five of the nine hydrobiid snail genera in Cuatrociénegas are endemic – a degree of higher-level endemism that is extraordinary. These nine genera represent thirteen species, of which nine are endemic (Hershler 1984).

Riparian, semiaquatic, and aquatic reptiles and amphibians comprise 40% of the basin's herpetofauna. Thirteen riparian lizards, skinks, snakes, and toads occur here. Six semi-aquatic species are also found, including the ground skink (*Sincella lateralis*); the world's only aquatic box turtle (*Terrapene coahuila*); three garter snakes, including *Thamnophis proximus*; and the massasauga (*Sisturus catenatus*). The six aquatic species are the endemic black softshell turtle (*Apalone ater*), spiny softshell turtle (*Apalone spiniferus*), pond slider (*Trachemys scripta*), plain-bellied water snake (*Nerodia erythogaster*), diamondback watersnake (*Nerodia rhombifera*), and a species of frog within the *Rana pipiens* complex. While only two of the mesic-adapted species are endemic, the richness and taxonomic diversity of the assemblage is remarkable within the desert environment (McCoy 1984).

Table 4-6. Freshwater prioirty site names and their biodiversity features

Site #	Site Name	Richness	Endemism	Phenomena	Species	Habitat
5.01	Willow Spring		1 spring snail		*Pyrgulopsis chupadera*	spring (only known site)
5.02	Upper Yaqui	high - fish, snails, frogs	6 regional fish 1 local snail	intact assemblage of fish	Yaqui chub, Yaqui sucker, Yaqui topminnow and one monotypic genus - ornate minnow	ciénegas, streams, rivers
5.03	San Pedro-Aravaipa	high only in Aravaipa		Complete assemblage of desert fish in Aravaipa	Loach minnow, spikedace, roundtail and speckled chub, Sonora & desert sucker, longfin dace	Streams and rivers
5.04	Upper Santa Cruz		1 regional fish		Gila topminnow	ciénegas
5.05	Río Sonora		2 fish		*Catostomus wigginsi* and *Gila eremica*	ciénegas and river
5.06	Zona Carbonifera	high - isopods fish, amphipods	2 locals, 1 regional	ecosystem processes & assemblages	*Diando diaboli*, *Notropis stramineus*, *Xiphophorus meyeri*	aquifer, springs, caves
5.07	Bavispe	High	6 regional endemics	intact assemblage	Yaqui catfish , Bavispe & Yaqui sucker, beautiful shiner, roundtail chub, a trout, Mexican stoneroller	river
5.08	Papogochic			intact assemblage	beautiful shiner, Mexican stoneroller, Yaqui sucker & catfish, roundtail chub, a trout	barrancas
5.09	Devil's River	high - 16 spp. fish	regional & local endemics	intact assemblage	16 spp. of native fish	riverine
5.10	Rio Grande/Río Conchos	Moderate	regional endemics	Conchos has partially intact fish assemblage	Blue sucker, Chihuahua shiner, etc.	riverine
5.11	Rio Grande-Southern New Mexico	Moderate	2 reg., 1 local (silvery minnow)	assemblages, large-scale potential	silvery minnow, Rio Grande shiner, speckled chub	riverine
5.12	Mimbres		1 regional fish, 1 local snail, 1 regional frog		Chihuahua chub, spring snail, Chiricahua leopard frog	ciénegas, river
5.13	Guzmán	13 fish	5 basin endemic fish, 1 local isopod	intact assemblages	4 undescribed species. Also *Notropis bocagrande*, *N. formosus*, Chihuahua chub, fathead & bullhead minnow + 6 more species	ciénegas, springs, river
5.14	Bustillos	Moderate	regional	assemblage good	*Gila intermedia*, *Notopis formosus*, *Cyprinodon* spp.	lake
5.15	Pecos River	high	high local and regional fish and snails	ecological processes, assemblages	12 natives, 2 local endemics, 3 endemic snails, water snakes, river cooter	é, riverine, springs
5.16	Bavicora	High	regional endemics		*Cyprinodon* spp., *Gila* spp., Mexican stoneroller	lacustrine
5.17	Panuco		4 endemic fish		*Xiphophoros* radiation	river
5.18	Tularosa Basin	Low	1 endemic pupfish		*Cyprinodon tularosa*	springs, riverine
5.19	Upper Nazas	High	high	assemblages & endemism		river
5.20	Laguna de Santiaguillo		moderate			lake
5.21	Río Mezquital					moderate
5.22	La Concha			representative habitat, rare species	*Cyprinodon alvarezi*, *Etheosoma* spp., *Cyrpinodon nazas*	thermal spring
5.23	Aguanaval		several fish		Cyprinides	riverine
5.24	Parras		1 regional endemic	endemism, beta diversity	*Gila nigrescens*, 1 shrimp	river
5.25	Chorro		1 endemic fish		*Gila modesta*	springs, stream
5.26	Potosí	Moderate	2 reg. endemic fish, 1 local shrimp		*Megupsilon aporus*, *Cyprinodon alvarez*, *Caubracilus alvarezi*	spring
5.27	Iturbide		1 fish		*Gila* spp. undedscribed	stream
5.28	Sandía	once very rich	endemic shrimp, snails, fish	endemism, distinct assemblages, monotypic genus	several species extirpated	basin, springs
5.29	Sauz Basin	High	high	Intermediate characteristics in *Notropis*	*Notropis lutrensis, Cyprinodon* sp, *Gila* spp.,	basin-shallow lake

Site #	**Site Name**	**Richness**	**Endemism**	**Phenomena**	**Species**	**Habitat**
5.30	Cuatrociénegas	very high: fish, reptiles, mollusk	very high, >23 endemic mollusks, 12 endemic fish, 2 endemic turtles	globally outstanding endemism & radiations		thermal springs, creeks, lakes
5.31	Venado		2 fish, 1 shrimp		Goodeidae spp.	springs
5.32	Media Luna/ Río Luna	high: reptiles, fish, plants	high	intact assemblages and endemism	*Cualac tessellatus*, *Carpa quijarona*, *Ataeniobius toweri*, *Dionda dichroma*, *D. mandibularis*, + 5 more	hot springs, river, lake
5.33	Río Cadena		four fish	relict fauna from Rio Grande		stream and shallow lake in closed basin
5.34	Extorax		moderate	low	low	moderate
5.35	Upper Conchos		Rio Conchos endemics	Rio Conchos assemblage		riverine refugia
5.36	San Diego	moderate: fish, snails, mollusks, isopods	endemics include 2 fish, 2 snails, 1 isopod	hottest temperatures supporting fish in the world.	*Cypinodon pachycephalus*, *Gambusia* spp.	spring
5.37	Upper Gila River	warm and cold freshwater fish faunas	5 regional endemics	intact assemblage	spikedace, loach minnow, Gila chub, speckled dace, Gila trout,	rivers, ciénegas

Chapter 5 Conservation Status of the Chihuahuan Desert

Introduction

Human activities over the last few centuries have resulted in extensive alteration of natural habitats across the Chihuahuan Desert. Changes in grazing and fire regimes and depletion and diversion of water sources are the major drivers in this process. Relatively intact habitats, those in a pristine state, are now rare and primarily restricted to montane areas, inaccessible slopes, the harsh environments of gypsum dunes and saline playas, and undisturbed springs.

The extensive loss of natural water sources for agricultural, industrial, and domestic uses by human populations, its diversion, and the onslaught of numerous introduced aquatic species, have caused the Chihuahuan aquatic biota to be one of the most threatened in the world. The acute loss of riparian habitats and water sources has reduced the range and population densities of many native terrestrial vertebrates and invertebrates dependent on them for water, refuge, or habitat during some portion of their life history.

Desert grassland quality and area have been drastically reduced since the onset of European settlement in the ecoregion (Dick-Peddie 1993). While bison inhabited this region within the past 1000 years, evidence that large grazing herbivores played a dominant role in maintaining these grasslands, as they did in the Great Plains, is not strong (Parmenter and Van Devender 1995, Monger *et al*. 1998). Instead, the Chihuahuan Desert grasslands are the result of a dynamic interaction of climate, granivory, herbivory, and fire. These processes produced a mosaic of grassland, shrubland, and savanna that has fluctuated greatly in character and extent over the last 10,000 years. The processes governing the condition of these vegetation communities have been altered in the last 500 years of settlement, primarily as a direct result of livestock grazing. Historic and, in some cases, contemporary overgrazing is the single most important factor triggering the most serious and pervasive changes in grassland quality. Overgrazing can be defined as the repeated removal of above-ground biomass and disturbance of the soil surface leading to reduced plant vigor and increased mortality. Overgrazing is often associated with increased soil erosion, further reducing the potential for re-establishment of grassland species. Concurrent with the loss of grasslands has been increased erosion and reduction in grassland dependent species (MacMahon 1988).

Assessing degradation of desert habitat

The use of new tools to assess the conservation status of the Chihuahuan Desert is a topic of great conservation interest. During this assessment, we tried to compare expert evaluation of effects of grazing on landscape parameters to inferences derived from satellite data and ground-truthing efforts (Box 5.1). Early results are mixed as to the accuracy of interpreting satellite imagery for this purpose.

Intact assemblages of larger native vertebrates, particularly in lowland habitats, are now rare and isolated. Brown bears, wolves, bison, pronghorn, bighorn sheep, and large cats have been eliminated from all or most of their range. Prairie dog colonies and their distinctive associated fauna were once

Box 5-1. Use of Landsat Thematic Mapper satellite imagery for estimating habitat quality in large arid ecoregions.

Thomas Allnutt & David Olson, Conservation Science Program, World Wildlife Fund

Interpretations of satellite imagery permit quantification of loss and degradation of forest cover across large ecoregions. How useful is satellite imagery for the same purpose as deserts and grasslands? To date, asssessments of habitat quality in arid regions have relied on expert opinion because the use of remote sensing at large spatial (ecoregion) scales is in a preliminary stage. A major impediment is the inability to detect spectral signatures of intact communities rather than overall range conditions. This study was designed to measure the potential correlation of degree of intactness or degradation to spectral signatures of particular habitat types within and across different basins (*i.e.*, multiple TM scenes). Here we summarize preliminary results-a collaborative effort of NASA-Goddard Space Flight Center, World Wildlife Fund, and The Nature Conservancy.

The study has five steps: image acquisition and registration, preliminary field survey, image analysis and classification, field validation, and final analysis. Thematic Mapper data for several widely dispersed areas of the Chihuahuan Desert were coarsely registered using 1:50,000 scale topographic maps for use in the field. A preliminary field survey was undertaken to ground-truth the imagery. WWF staff and experts in Chihuahuan Desert ecology visited several dozen sites, focusing on desert scrub and desert grassland habitat, the two most prevalent habitat types in the region. At each location, information was collected on several intactness variables, such as the presence of indicator species, erosion features, and the extent of ground cover. The satellite scenes were then geographically registered using ground control points in preparation for classification of the image into habitat and intactness class types. The classification strategy employed a hybrid unsupervised/supervised approach. First, the image was stratified into broad habitat types: desert scrub, desert grass, or neither, using an unsupervised algorithm. In the supervised component of the study, field data serves as input or "training" data to further divide these classes according to degree of intactness.

Several factors may contribute to variation in the spectral reflectance of desert landscapes at regional scales. These include: the degree of intactness and variability in species assemblages, ground cover, and heterogeneity (*i.e.*, diversity of species and structure); soil type and erosion features; slope location within basins; condition of vegetation due to season; rainfall events; availability of water; or regional variation in habitat structure due to gross biogeographic and biophysical changes across whole basins.

Preliminary results suggest that TM has only limited utility *at regional scales*. Differences between intact and degraded desert habitat are sometimes subtle, often requiring the trained eye of a biologist. Thus, similarity in spectral signatures is not surprising. A further complication is that vegetation cover can be sparse even in pristine sites, thereby allowing the satellite signal to be dominated by soil and geomorphological information rather than by vegetation. Initial results do allow separation of intact and degraded areas on a scene-by-scene basis, particularly for *tobosa* grasslands. Degradation is visible in individual scenes, such as changes across fencelines as a result of restriction from grazing, livestock paths, and erosion halos around water sources. Whether these features help to classify accurately whole TM scenes and to predict quality across the entire desert is unclear.

Because some of the world's most biologically distinct deserts and arid grasslands are often large and inaccessible by road, use of remote sensing to assess current conditions and to monitor trends in habitat quality would greatly enhance ERBC. But our initial analysis suggests that major investment of resources into using TM for assessing intactness of *large* arid ecoregions is unwarranted until further advances are made. Reliance on expert assessments of high quality areas and detailed TM analyses at much smaller spatial scales (scenes) remain the most cost-effective approach for targeting intact native habitats for conservation action.

extensive, but now occur only in a few highly limited and degraded areas. The ecoregion-wide eradication of burrowing and grazing mammals, particularly prairie dogs, has caused dramatic impacts to the landscape. Changes in soil properties, community structure, and species assemblages within grasslands have been significantly altered, and their extent and quality have been reduced, particularly black grama grasslands. Fragmentation of habitats through urban development, roads, fences, and conversion has curtailed the seasonal and nomadic movements of ungulates and their associated predators. Habitat loss and hunting have contributed to widespread loss of larger native vertebrates.

Intensive harvesting and poaching of rare cacti, birds, and reptiles for the wildlife trade is extirpating many populations and driving a number of species towards extinction.

Fortunately, the original terrestrial habitats have high restoration potential if source pools of native species persist, water sources are renewed, and grazing and fire regimes are brought back within natural ranges of variation. Characteristic species assemblages, community types, and ecological processes still persist across the desert. Community composition and vertical structure can recover provided livestock management practices are modernized. Irreversible impacts do occur, such as when high stocking rates are coupled with drought over an extended period of time, forcing a shift to mesquite or creosote bush dominance. The loss of montane forests because of logging, burning, and grazing is also more difficult to reverse. But the ingredients for long-term conservation are present. Large blocks of habitat, although many degraded, occur in each subregion. Some of the best examples of larger blocks of intact ecosystems are the Chiricahua Complex (1.20), Tularosa Basin (2.09), Sierras del Carmen and Santa Rosa (3.01), and the Altiplano Mexicano Nordoriental (4.02) (Figure 5.1). If properly conserved, these are the foundations upon which future restoration efforts can build.

The following sections provide a detailed assessment of the conservation status of each subregion. We present summary data on the overall trajectory of the subregion and important landscape features and processes (habitat loss, habitat degradation, fragmentation, heavily altered areas, presence of large blocks of intact habitat, exploitation of flora and fauna, and degree of protection). We provide examples of status and threats in selected priority sites that are characteristic of the subregion and likely to form part of the core ERBC strategy. The priority sites mentioned in this chapter refer to sites identified in Figures 4.3 and 4.4. More detailed information on the conservation status features for each site is presented elsewhere (Appendices 3, 4, and 5).

Conservation status of the Apachean subregion

Overview

Among the four subregions, the Apachean has the highest proportion of grasslands (approximately 45%) and the highest percentage of montane and woodland habitats (approximately 10%). It is also the smallest subregion and contains the highest amount of protected area coverage on a per unit area basis. Protected areas are well represented at higher elevations, but virtually all of the accessible areas are subject to domestic grazing. While there are several private freshwater preserves owned by The Nature Conservancy, aquatic habitats are on average worse off than terrestrial. Natural habitats as a whole are highly fragmented and corridors among many of the unique sky islands are lacking.

Habitat Loss

Remarkably, less than 6% of the subregion has been converted to agricultural uses. But the vast majority of non-cultivated lands are subjected to livestock grazing. Fortunately, important grassland sites have suffered the least amount of habitat loss (Table 5.1), perhaps because while grazing changes the *quality* of habitat available for other species, the overall species assemblages and habitat processes persist. Woodland and montane sites have lost habitat primarily because of timber harvest and road construction. Riparian sites are in serious trouble. Extreme loss of these keystone habitats is attributed to clearing of *bosques*, water diversions, direct loss through cattle grazing, and indirect losses through erosion.

Habitat degradation

Habitat degradation is most pronounced in riparian sites, all of which are degraded. Livestock grazing is a primary cause of degradation through direct consumption of vegetation and the shearing of steambanks by cattle. Important playa sites are largely intact but their associated *ciénegas* are often pumped dry or grazed. Woodlands are chiefly degraded by roads, mining, and livestock grazing. Two of the three most important grassland sites are severely degraded by current and historic grazing practices. As a result, large expanses of grass-dominated blocks have shifted to mosaics of desert scrub dominated by creosote bush and acacia.

Habitat fragmentation

Natural habitats in the subregion as a whole are highly fragmented. Among priority sites fragmentation is low within half of the sites, moderate in five others, and high in six sites (five riparian and one grassland). Land use in the valleys ranges from agriculture to urban sprawl to pastureland. Corridors among the sky islands are patchy, narrow, or lacking. Recreation and home-building in the sky islands reduces habitat, increases fire risk, and fragments former expanses of higher elevation communities. A U.S. Interstate bisects the subregion, which is a major barrier to movement of larger vertebrates.

Heavily altered areas

Rivers and springs arising from the waters of the Sierra Madre Occidental and its satellite sky islands to the north support intensive agriculture in bordering valleys. Apple orchards in Casas Grandes, Chihuahua, cotton and alfalfa near Safford, Arizona, and chile peppers grown in the Playas Valley near

Lordsburg, New Mexico are among the most intensive water users and these areas are the most heavily altered of the subregion. While only 6% of the Apachean subregion has been converted to agriculture, the industry's dependence on limited water has far-reaching consequences for aquatic organisms. The copper mine in Cannanea, Sonora, is the largest in Mexico. Mining operations, tailings, and high water use of the headwaters of the San Pedro have heavily altered this area.

Large blocks of habitat

Nine of the seventeen upland priority sites contain blocks of relatively intact habitat greater than 1,000 km^2 (Table 5.1) (Figure 5.1). Six low-elevation riparian sites evaluated as priority sites in the biological distinctiveness analysis lack large blocks of remaining habitat.

Degree of protection

Approximately 15% of the region falls into the gap category 1, as a result of the two Riparian National Conservation Areas managed the BLM, two National Wildlife Refuges, the privately owned Gray Ranch, and well-managed wilderness areas (Table 5.1 and Appendix E). Many of the sky island forests in the U.S. Coronado National Forest and Bureau of Land Management lands have U.S. Wilderness Areas and Area of Critical Environmental Concern status. However, grazing is still allowed under these designations. Overall, applying gap categories 1 & 2, 7.6% of the Apachean subregion has special management status for natural resources.

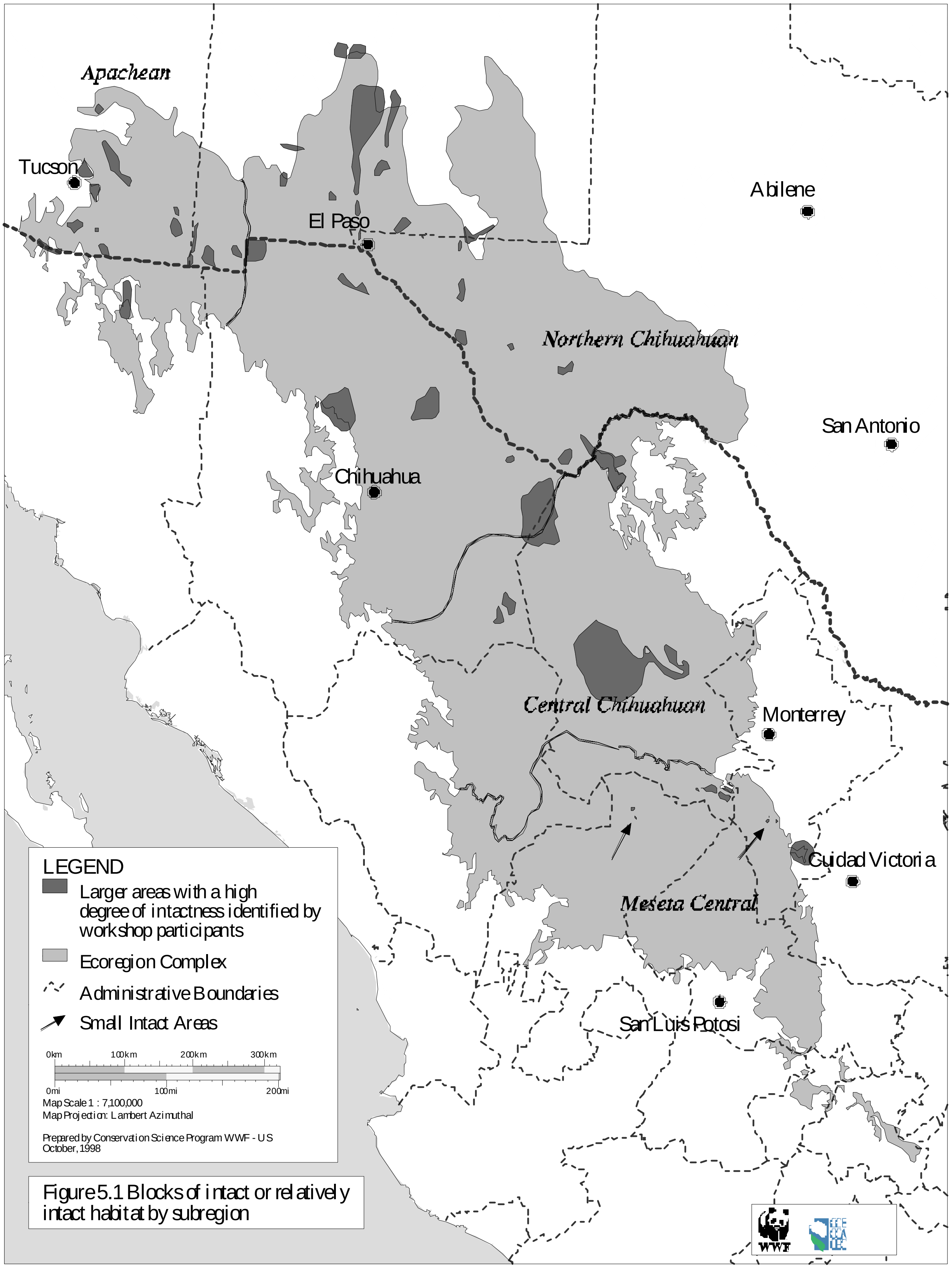


Figure 5-1. Blocks of intact or relatively intact habitat by subregion

Exploitation of flora and fauna

Reptile and invertebrate collecting occurs in the Chiricahua-Animas-Peloncillo-Sierra Madres complex (site 1.20). Prairie dog poisioning is also a serious threat. Overall, exploitation is low in the subregion.

Examples of status and threats in selected candidate priority sites

In the entire Chihuahuan Desert, only three examples of subalpine coniferous forest, characterized by the presence of Engelmann spruce (*Picea engelmanni*) and corkbark fir (*Abies lasiocarpa*) have been documented: the Pinaleño Mountains (1.16), the Santa Catalina Mountains (1.05), and the Chiricahua Mountains (part of site 1.20). The Pinaleño Mountains (1.16) as a whole are moderately fragmented by timber harvest, roads, residential development, and a large astronomy observatory. Species and ecological processes have not been heavily affected. Development pressures within habitat types, however, is more acute. Conversion of natural blocks of habitat by logging and home building erodes the representation of the ecoregion's high elevation habitats normally associated with ecoregions further north.

The Upper San Pedro (1.10) is one of the most important remaining riparian forests in the ecoregion, but it has been substantially altered by a variety of uses during the last 150 years. Felling of cottonwoods, heavy concentrations of livestock in the channels and wetlands, upland erosion from mining, timber harvest, and livestock grazing have degraded this keystone habitat. The U.S. portion, about 60%, is protected from grazing as a National Conservation Area managed by the Bureau of Land Management. This portion has had a dramatic shift in community composition with livestock exclusion. The portion in Mexico, about 40%, is unregulated and is under traditional pressures, including water diversion for agriculture and the clearing of riparian vegetation for agricultural crops.

The Chiricahua-Peloncillo-Sierra Madre Complex (1.20) spans the range in habitat quality. It contains three disjunct sites with large blocks of intact habitat: the Peloncillo Mountains, the Chiricahua Mountains in the U.S., and several mountain ranges comprising the Northern Sierra Madre of Mexico. Highly degraded grasslands occur in the intervening valleys. Woodlands and forests are connected by relatively intact corridors. *Ciénega* and riparian habitats in Mexico appear to have had fewer alterations than the same habitat types in the U.S.. Wetlands surrounding Ascension, Chihuahua, are associated with the Río Casas Grandes and are an important wintering ground for ducks, geese, and cranes. Most of the wetlands in the area are drained for agriculture. Groundwater levels have dropped significantly in U.S. wetlands from agricultural uses as well, including the San Simon Cienega. The largest remaining black-tailed prairie dog colony is found near the village of Janos, Chihuahua. This colony is highly threatened by potato farming and overgrazing of cattle.

The Peloncillo Range supports an oak-pine woodland that has experienced lighter degradation. Roads, fences, small homesteads, and light densities of cattle are among the few human-caused intrusions. A patchwork of private and federal lands restricts public access. Five Wilderness Study Areas totaling 70,000 ha, and two Areas of Critical Environmental Concern, 36,800 ha, provide an anchor for conservation efforts. A high proportion of the privately held lands are owned by members of the Malpais Borderlands Group, whose future conservation easements will help protect biodiversity over the long term. Near the Peloncillos are the Animas Mountains, outliers of the Sierra Madre range to the south, which have been privately owned for centuries. The light degradation and low degree of habitat loss and fragmentation are attributed to light cattle densities. The mountains are currently managed by the Animas Foundation, and The Nature Conservancy retains a conservation easement. Some of the Animas grasslands are utilized for grazing by the Malpais Borderlands Group.

The third expanse of intact habitat encircles the higher elevations of the Chiricahua Mountains, a montane coniferous forest with relict populations of corkbark fir (*Abies arizonica*) and Engelmann spruce (*Picea engelmanii*). Inaccessbility has protected this rugged area from large-scale timber harvest. Three disjunct wilderness areas, totaling 47,000 ha, are managed by the Coronado National Forest. Wildlife exploitation in the U.S. ranges is low. Collection of rare or endemic reptiles for trade currently has low impact on populations. The effects of collection of invertebrates for biological supply companies are unknown and require investigation. Poaching of deer, bear, and antelope within the Mexico portion of this site is high.

The Hatchita Grasslands (1.23) were once extensive and dominated by prairie dogs. After their eradication, modern ranching techniques were brought in (including fencing and fire suppression). Tobosa swales, of low palatability to livestock, are still a dominant feature in basins. However, the uplands surrounding the swales are near monocultures of creosote bush. The processes and species that once dominated these grasslands can be restored if they are better protected and connected to the more intact, species-rich grasslands of the Animas and Playas Valleys.

Conservation status of the Northern Chihuahuan subregion

Overview

The Northern Chihuahuan Desert is the most populated subregion and includes a number of major urban areas: El Paso, Texas; Las Cruces, Alamogordo, and Socorro, New Mexico; Ciudad Chihuahua, Ciudad Juarez, Ciudad Camargo, Jimenez, Ciudad Delicias, and Parral, Chihuahua, and Torreon, Coahuila. Development in urban areas has led to habitat loss, degradation, and fragmentation of surrounding terrestrial and freshwater habitats. Outside U.S. urban areas, the landscape is managed for livestock grazing by state and federal land agencies. In Mexico, most land is either privately held or managed by *ejidos*. Livestock grazing is the primary land use.

Remaining natural habitats in priority sites are surrounded by a matrix of degraded grama grasslands and desert scrub. Approximately 50% of the subregion is Chihuahuan desert scrub and approximately 25% is semi-desert grassland and Plains-Great Basin grasslands. Woodlands and mixed-conifer forests occupy about 10% of the subregion.

Intensive agriculture is dependent on groundwater pumping around Deming, New Mexico, Fort Stockton and Pecos, Texas, and Villa Ahumada and Gomez Farias, Chihuahua. Water diversions along the Rio Grande, Pecos River, and Río Conchos also support intensive agriculture. Water diversion has had a devastating effect on freshwater biodiversity. Species have become extinct before they have been described and catalogued.

Table 5-1. Conservation status of candidate priority sites in the Apachean subregion. Information not available for Rio Sonora Watershed (1.11), Sierra Los Ajos (1.12), and Yaqui River (1.13). Mod=moderate

Site#	Site Name	Conservation Status	Habitat Loss	Degradation	Habitat Frag.	Causes	Large Intact Habitat Blocks?	Type of Protection	Poaching/ trade
1.01	Baboquivari	altered	mod.	mod.	low	grazing in uplands	no	federal	low
1.02	Pajaritos	altered	low	mod.	mod.	roads, mining, grazing	yes	federal	low
1.03	Santa Ritas	intact	low	low	low	grazing, roads	yes	federal	low
1.04	Sonoita Creek	altered	mod.	high	mod.	grazing, upstream diversions	no	TNC & state	low
1.05	Santa Catalinas	altered	mod.	mod.	low	recreation, timber, urban growth, grazing	yes	federal	low
1.06	Lower San Pedro	heavily altered	high	high	high	water diversions, grazing	no	none	low
1.07	Whetstones	intact	low	mod.	low	grazing	no	federal	low
1.08	Appleton-Whittell	intact	low	low	low	historic grazing, upstream water diversions	no	Audubon	low
1.09	Huachuacas	intact	low	mod.	low	recreation, roads, grazing	no	TNC & federal	low
1.10	Upper San Pedro	heavily altered	high	high	mod.	unprotected reaches in Mexico	no	federal	low
1.14	Lower Middle Gila	heavily altered	high	high	high	water diversions, grazing, clearing	no	federal	low
1.15	Galiuros	intact	low	low	low		yes	TNC & federal	low
1.16	Pinaleño	altered	mod.	mod.	mod.	timber, grazing, roads, recreation	no	federal	low
1.17	Willcox Playa	intact	low	low	low	groundwater pumping	no	federal	low
1.18	Dragoons	intact	low	low	low	grazing	yes	federal	low
1.19	Sulphur Springs	altered	low	high	high	grazing	no		low
1.20	Chiricahua Complex	altered	low	high	mod.	grazing, altered fire, agricultural conversion, roads, timber	yes	Animas Fdn federal	mod.
1.21	N. Peloncillos	intact	low	mod.	low	grazing	yes	federal	low
1.22	Big Hatchets	intact	low	mod.	low	grazing	yes	federal	low
1.23	Hatchita grassland	altered	high	high	high	grazing, altered fire, loss of prairie dog, groundwater loss	yes	federal	low
1.24	Lordsburg Playa	intact	low	low	low	grazing	no	federal	low
1.25	Upper Middle Gila	altered	high	high	high	grazing, water diversions	no	federal	low
1.26	Mimbres	heavily altered	high	high	high	grazing, water diversions	no	TNC	low

Habitat loss

Nine of the eleven upland priority sites are largely intact, and habitat loss is considered to be low (Table 5.2). The Mescalero Dunes (2.13) is the only upland site that suffers from a high degree of habitat loss. A gridwork of roads and drill pads created by oil and gas companies has resulted in habitat loss and fragmentation. Riparian sites and other lowlands areas are heavily altered throughout the subregion, their associated water sources tapped for municipal and agricultural needs.

Habitat degradation and fragmentation

Degradation in the upland priority sites is widespread because of livestock grazing. Seven of the ten upland sites show moderate levels of degradation where historic semi-desert grasslands were heavily grazed and converted to scrub communities. The Marathon Basin (2.16) and the Davis-Chinati Mountains Complex (2.05) face threats from subdivision into small ranches.

Estimates of the original extent of grassland cover for the subregion range from 40-70%. Historic accounts of black grama and other grass species dominating the region indicate that the 25% grassland cover today is a drastic reduction in overall grassland extent. Black grama is negatively affected by intensive grazing coupled with drought. Overall, grasslands today are altered, lacking critical keystone species such as prairie dogs but they retain many other important species and processes such as other burrowing rodents and fire. Restoration of many degraded grassland habitats is possible; however, former grama grasslands now degraded to mesquite dunes should be considered permanently altered.

Riparian habitat loss and fragmentation

Seven of the 18 sites are riparian or wetland sites; each is highly fragmented, with the exception of the Devil's River (2.06), the lower part of which is nonetheless flooded by Amistad Reservoir. Six of the riparian sites have lost substantial amounts of habitat and are subjected to damming and water diversions. In this century, irrigation systems and flood control have permanently altered the riparian character of the Rio Grande, sites [(2.02), (2.03), and (2.18)], and the Río Conchos (2.02).

Large blocks of habitat

The upland sites contain relatively intact habitat blocks greater than 1,000 km^2 (Table 5.2, Figure 5.1), particularly within U.S. national parks and White Sands Missile range, as well as privately run ranches in Chihuahua.

Degree of protection

All but the Marathon Basin (2.16), North-Central Chihuahuan Grasslands (2.08), and La Perla (2.12) contain some degree of state or federal protection within the site. In the subregion overall, 1.6% falls into gap category 1 protection (Box 7.2 and Appendix E). Three U.S. National Parks contribute significantly to this protection for upland sites. The Nature Conservancy owns several freshwater preserves as well. A high percentage of public lands are managed as Areas of Critical Environmental Concern and Wilderness but in these areas livestock grazing is permitted. The total area falling into gap categories 1 & 2 is 5.9%.

Exploitation of flora and fauna

Poaching, hunting, and collection of target species is poorly documented for the subregion. Larger vertebrates, cacti, reptiles, invertebrates such as tarantulas, are targeted species.

Examples of status and threats in selected priority sites

The largest expanse of intact habitat identified in the Chihuahuan Desert occurs in the Tularosa Basin (2.09). The priority site boundary encompasses a long basin, ringed by mountains. Grasslands extend off the western mountains towards the north. The site is almost entirely in U.S. federal and state ownership, with approximately 3% in private ownership. At least 70% has been free of livestock grazing for 50 years. Regulated hunting is permitted. The area is managed by a number of different government entities including White Sands Missile Range, Holloman Air Force Base, Johnson Space Center, San Andres National Wildlife Refuge, Bureau of Land Management Wilderness Study Areas and Areas of Critical Environmental Concern, White Sands National Monument, and Texas Division of Parks and Wildlife. Habitat loss and fragmentation are limited, but roads and other infrastructure cause degradation. Exotic species such as salt cedar (*Tamarix ramosissima*) threaten riparian areas.

Conservation status of the Central Chihuahuan subregion

Overview

The Central Chihuahuan subregion supports large areas of *izotal*. Approximately 60% of the subregion is characterized by these sotol-yucca-agave scrublands as well as creosote bush and tarbush (*Larrea* sp. and *Flourensia* sp.). Only 8% of the subregion is semi-desert grasslands and less than 5% is woodland and forest.

Mining and other heavy industrial activities are concentrated on the periphery of the two large urban centers in Monclova and Torreon, Coahuila. Their effects appear to be localized. Impacts to the entire ecoregion appear to be limited however groundwater pumping in Monclova may have far-reaching impacts to Cuatrociénegas. Water diversion from the Río Nazas in Torreon has completely eliminated the shallow lakes that once characterized the basin known as La Laguna. The landscape matrix adjacent to priority sites, *izotal* and desert scrub is degraded but provides some linkages between priority sites.

Low human population and limited resource extraction have helped to conserve biological and landscape integrity. Species assemblages, communities, and ecological processes still occur intact in some areas, although goat and cattle grazing and water diversion have had widespread and pervasive effects. Federal and state protected areas are found in the Sierra del Carmens, Cañon Santa Elena, and Cuatrociénegas, however most of the lands within the protected area boundaries are privately held or controlled by *ejidos*.

Habitat loss

Most sites have been spared appreciable habitat loss (Table 5.3), however, localized, intensive resource use has dramatic impacts. Mining of gypsum and timber harvest in Sierra de la Gloria are poorly regulated and some areas have become deforested. Gypsum mines dot the subregion. Although the total area affected is quite small, the implications for biodiversity are large because of the high number of narrow endemics found in these specialized habitats. The limited agriculture in the Central Chihuahuan Desert is concentrated within riparian zones. Clearing of riparian woodlands and wetlands has had a substantial impact on wildlife, and is often a source of invasive species. Diversion of springs and streams may cause total loss of many freshwater habitats. Torreon, Coahuila, was established along a complex of large shallow lakes fed by the Río Nazas. These lakes, or lagunas, once supported high numbers of migrating shorebirds, including the endangered Whooping Crane (*Grus americana*) (Rod Drewien, personal communication). Diversions of the Río Nazas for agriculture has left these lakes completely dry.

Habitat degradation

Livestock grazing has caused habitat degradation of grasslands throughout the subregion. The Sierra de las Minas Viejas is degraded primarily by goats, whereas cattle and goats affect the other sites. Candelilla, lechugilla and guayule harvest are also sources of degradation in at least four of the priority sites.

Intact blocks of habitat

Sierra de la Gloria (3.07) is the only priority site less than 1,000 km^2. All others exceed this size threshold, indicating a high potential for biodiversity protection.

Degree of protection

Many of the priority sites have been recognized as important for conservation by state and federal agencies, but widespread formal protection is lacking. Cuatrocíenegas and Cañon Santa Elena are protected areas established by the Mexican government for the protection of flora and fauna, and are classified as IUCN category IV. Curiously, Maderas del Carmen, also an area established for the protection of flora and fauna, is considered IUCN category VI by the United Nations Environment Programme World Monitoring Conservation Centre (http://www.wcmc.org.uk).

Exploitation of flora and fauna

Hunting and poaching has eliminated pronghorn, javelina, bighorn, bears, and large cats from most of the subregion. Illegal collection of cacti and reptiles threatens many species with limited ranges and small populations.

Table 5-2. Conservation status of candidate priority sites in the Northern Chihuahuan subregion

Site#	Site Name	Conservation Status	Habitat Loss	Degradation	Habitat Fragm.	Causes	Large Intact Habitat Blocks?	Type of Protection	Poaching /trade
2.01	Sierra del Nido	intact	low	moderate	moderate	grazing	yes	federal.	high
2.02	Rio Grande-El Paso to Amistad	heavily altered	high	high	high	dams, levees, altered flood regime, upland uses	no	federal	moderate
2.03	Rio Grande-Elephant Butte to El Paso	heavily altered	high	high	high	water diversions, dams, altered flood, upland erosion, exotics, levees	no	federal	low
2.04	Guadalupe-Carlsbad	intact	low	low	low	recreation, roads, oil&gas	yes	federal	low
2.05	Davis-Chinatis Mts.	intact	low	moderate	moderate	grazing, subdivision	yes	TNC & state	low
2.06	Devil's River	intact	low	low	moderate	recreation, grazing, subdivision	no	TNC & state	low
2.07	Big Bend	inact	low	moderate	low	historic grazing, candelilla, cacti	yes	federal & state	moderate
2.08	Chihuahuan Grasslands	intact	low	low	low	poaching of deer and antelope, grazing	yes	none	moderate
2.09	Tularosa	intact	low	moderate	low	historic grazing, altered fire	yes	federal	low
2.10	Pecos River	heavily altered	high	high	high	water diversions, dams, altered flood, upland erosion, exotic spp.,	no	federal	low
2.11	Alta Bavicora	altered	moderate	high	high	timber, water use, pollution, hunting	yes	state	moderate
2.12	La Perla	altered	moderate	moderate	high	mining, agriculture, grazing, hunting	yes	none	moderate
2.13	Mescalero Dunes	altered	moderate	moderate	high	cut-off from plains, oil & gas (roads and pads), grazing	yes	federal	low
2.14	Samalayuca Dunes	intact	low	low	low	cement factories	yes	none	moderate
2.15	Conchos River	altered	high	moderate	high	grazing	no	none	high

Site#	Site Name	Conservation Status	Habitat Loss	Degradation	Habitat Fragm.	Causes	Large Intact Habitat Blocks?	Type of Protection	Poaching /trade
2.16	Marathon Basin	intact	low	moderate	low	grazing, subdivision	yes	TNC	low
2.17	Sierra Blanca	intact	low	moderate	low	grazing, sludge dumps	yes	federal & state	low
2.18	Rio Grande-Above Elephant Butte Dam	heavily altered	high	high	high	water diversions, dams, altered flood, upland erosion, exotic spp., levees	no	federal	low

Examples of status and threats in selected priority sites

The Complejo Mapimí (3.01) is somewhat intact by highly degraded by livestock grazing. The desert scrub, yucca woodlands, grama grasslands, woodlands, and forests are connected by corridors and contain diverse species assemblages. Ecological processes like fire and large-scale movements of species also appear to be relatively intact. Cattle grazing and gypsum mining have degraded some habitats and agricultural crops have eliminated portions of some grassland habitats. Mounting pressures from agriculture, livestock, and mining are of concern.

The Complejo de Sierras del Carmen y Santa Rosas (3.02) is a vast region with examples of intact woodland and forest habitats. Lower elevations, however, have been subjected to greater amounts of livestock grazing and the poaching of deer, cacti, and reptiles. Some overgrazed sites are highly degraded and irreversibly changed into desert scrub habitats.

The terrestrial component of Cuatrociénegas (3.03) is considered relatively intact. Pockets of habitat alteration occur in the valleys where grasslands and wetlands have been converted to agricultural fields. The mountain ranges are extremely rugged and difficult to access however grazing has degraded some of the desert scrub and grassland communities. Removal of cacti and reptiles by poachers is causing population declines in some species. The threat of water exploitation for agriculture is very high (see freshwater priorities).

Table 5-3. Conservation status of candidate priority sites in the Central Chihuahuan subregion

Site #	Site Name	Conservation Status	Habitat Loss	Degradation	Habitat Fragm.	Causes	Large Intact Habitat Blocks?	Type of Protection	Poaching/ trade
3.01	Complejo Mapimí	intact	low	mod.	low	Mining, agriculture, grazing, cacti trade	yes	yes	high
3.02	Complejo de Sierras del Carmen	intact	low	mod.	mod.	Grazing, poaching, cacti, bird, reptile trade	yes	yes	high
3.03	Cuatrociénegas	intact	low	mod.	low	Irrigation, grazing, mining, cacti & reptile trade	yes	yes	high
3.04	Sierra de la Paila	intact	low	mod.	mod.	Grazing, fire, candelilla harvest	yes	no	mod.
3.05	Sierra Santa Fe de Pino	intact	low	low	low	Grazing, roads	yes	no	low
3.06	Sierra de Menchaca	intact	low	low	low	Fires, mining, poaching	yes	no	mod.
3.07	Sierra de la Gloria	intact	mod.	mod.	mod.	Mining, timber, roads, cacti trade, candelilla harvest	no	no	high
3.08	Sierra de las Minas Viejas	intact	low	mod.	low	Grazing, candelilla harvest, cacti trade, poaching	yes	no	High

Conservation status of the Meseta Central subregion

Overview

Most of the Meseta Central is highly altered because of intensive agriculture in its southern half. However, to the north and east of the agricultural zone, nine priority sites were assessed as largely intact. The subregion is approximately 55% desert scrub, including yucca woodlands and *crasicaul*e. Just 13% is grassland, and less than 5% woodland and montane habitats. Agricultural lands constitute a full 23% of the total land coverage. The priority sites are found in mountainous foothills and less accessible regions. Agricultural conversion, agricultural pollutants, erosion caused by overgrazing, poor timber management practices, and poaching of cacti and wildlife species appear to be the overriding pressures on the priority sites.

Habitat loss

The priority sites have managed to remain relatively unaffected by extensive habitat loss. Five of the nine sites have low losses, three have moderate losses of habitat, primarily due to agriculture and urban growth, and one site has experienced high losses due to timber harvest (Table 5.4). Outside the priority sites, habitat loss is most evident in the large-scale agricultural areas.

Habitat degradation and fragmentation

Each site has suffered some degree of degradation, although it is considered low in the Sierra de Picachos and Peco de Teyra. Livestock grazing is the major cause of degradation. Habitat fragmentation, caused largely by roads, timber harvest, and agricultural fields, is low in four of the sites, moderate in three of the sites, and considered high in only one site.

Large blocks of habitat

All priority sites except the Peco de Teyra (4.04) have relatively intact blocks greater than 1,000 km^2.

Degree of protection

No sites fall under the IUCN I-IV category designation for protection. Within the states of San Luis Potosí and Nuevo Leon there are several state designated areas known as Zonas Sujeta a Conservación Ecológica.

Exploitation of flora and fauna

Cacti poaching is a severe problem in the subregion. The trade of birds and reptiles is also common. Mammals are collected to a lesser degree.

Examples of status and threats in selected priority sites

Within the Altiplano Méxicano Nordoriental (4.01), potato farms have fragmented grama grassland habitats. Agricultural chemicals pollute ground and surface water supplies. These heavily altered sites lie within a matrix of intact and slightly altered sites.

The Laguna de Santiaguillo (4.06) is threatened by agricultural and industrial pollutants that contaminate the waters. Additionally, groundwater pumping and dams have reduced the water level in the lake. Native species assemblages can utilize the available aquatic and semiaquatic habitats but degradation of water quality and loss of aquatic habitat are important trends to reverse.

The Órganos Malpais (4.05) is the only terrestrial site rated as altered. Intensive timber extraction, an altered fire regime, and the building of roads have fragmented the landscape and degraded habitats. Mammal and fish species are in jeopardy but there are opportunities for restoration.

Table 5-4. Conservation status of candidate priority sites in the Meseta Central subregion

Site #	Site Name	Conservation Status	Habitat Loss	Degradation	Habitat Fragmen.	Causes	Large Blocks of Intact Habitat?	Type of Protection	Poaching/ Trade
4.01	Altiplano Mexicano Nordoriental	intact	low	moderate	Moderate	farming, grazing, roads, poaching	yes	no	moderate
4.02	Huizache-Cerritos	intact	moderate	moderate	moderate	farming, timber, urban growth, mining, exotic spp., poaching, cacti, bird, mammal trade	yes	no	high
4.03	Querétaro	intact	low	moderate	low	grazing, timber, cacti, reptile trade, poaching	yes	no	high
4.04	Peco de Teyra	intact	low	low	low	Grazing	no	no	low
4.05	Órganos Malpais	altered	moderate	moderate	high	timber, roads, fire, poaching	yes	no	moderate
4.06	Laguna de Santiaguillo	intact	moderate	moderate	low	salinization, grazing	yes	no	low
4.07	Río Nazas Basin	altered	high	n/a	n/a	water pumping, poaching, grazing	yes	no	moderate
4.08	Saltillo-Monterrey	intact	low	high	moderate	urban growth, mining, water use, grazing, poaching	yes	no	moderate
4.09	Sierra de Picachos	intact	low	low	moderate	farming, ranching, poaching	yes	yes	moderate

Conservation status of freshwater biodiversity

The Chihuahuan Desert harbors one of the world's most threatened freshwater biotas. Habitat loss, degradation of water quality, and alien species continue to drive many species and communities to extinction, and diminish populations of the survivors. At least eight species of freshwater fish are now extinct as well as four species of invertebrates.

Conservation status was assessed by the experts using definitions for Intact, Altered, and Heavily Altered that were derived for freshwater systems (Appendix A). Additional information on conservation status was compiled subsequent to the workshop and was used to refine the categorizations. This included evaluation of five indicators (catchment condition, water quality degradation, alteration of hydrographic integrity, habitat fragmentation, and the impact of exotic species) to tease out the most important threats at each site. Six sites did not have enough information to make a determination of altered or intact. Only seven of all freshwater sites were intact (23%).

With at least 77% of the highly diverse freshwater sites in the Chihuahuan Desert either altered or heavily altered, conservation of habitats and improved management of water use is essential to the protection of species assemblages as well as sites that support single species of fish, aquatic invertebrates, or amphibians. Three sites were considered heavily altered: the Rio Grande/Río Conchos, the Rio Grande-Southern New Mexico, and the Upper Santa Cruz. All have heavy municipal demands as well as water withdrawals for agriculture.

Table 5-5. Conservation status of Chihuahuan priority freshwater sites. conser status =conservation status; catch. cond.=catchment condition; water degrad.=water degradation; hydro. integr.=hydrologic integrity; hab. frag=habitat fragmentation

site #	site Name	conser. status	catch. cond.	water degrad.	hydro. integr.	hab. frag.	non-natives	total	degree of protection
5.05	Río Sonora	Intact						x	Low
5.08	Papogochic							x	Low
5.14	Bustillos							x	Low
5.19	Upper Nazas	Intact						x	Low
5.22	La Concha							x	Low
5.23	Aguanaval							x	Low
5.33	Río Cadena	Altered						x	Low
5.35	Upper Conchos							x	Low
5.06	Zona Carbonifera	Altered		2				2x	Low
5.17	Panuco	Intact		1		1		2x	Low
5.21	Río Mezquital	Intact			2			2	Low
5.07	Bavispe				3			3x	Mod: MX Reserve
5.31	Venado	Altered	1	1	x	1	x	3x	Low
5.36	San Diego	Intact	1	1	0	1	0	3	Low
5.28	Sandía	Altered	x	4	x	1	x	5x	Low
5.32	Media Luna/ Río Luna	Altered	1	3	0	1	x	5x	Low
5.34	Extorax	Intact	2	1	2	1	x	6x	Low
5.09	Devil's River	Intact	2	1	2	1	1	7	Mod: TNC and state
5.18	Tularosa Basin	Altered	2	1	0	2	2	7	High: owned by U.S. military
5.27	Iturbide	Altered	3	3	0	1	x	7x	Low
5.26	Potosí	Altered	1	3	4	x	x	8x	Low

site #	site Name	conser. status	catch. cond.	water degrad.	hydro. integr.	hab. frag.	non-natives	total	degree of protection
5.30	Cuatrociénegas	Intact	1	1	2	2	2	8	Mod: federal protected areas
5.12	Mimbres	Altered	3	1	2	3		9x	Low: TNC in part
5.25	Chorro	Altered	1	1	3	1	3	9	Mod: National Park
5.13	Guzmán	Altered	3	2	3	2		10x	Low
5.16	Bavicora	Altered	3	3	2	2		10	Low: local mgmt. Plan
5.02	Upper Yaqui	Altered	3	1	3	2	2	11	Low: U.S. fed. refuge
5.37	Upper Gila River	Altered	3	2	2	3	1	11	Mod: U.S. federal laws
5.01	Willow Spring	Altered	2	3	3	4	0	12	None
5.03	San Pedro-Aravaipa	Altered	3	1	3	3	3	13	Mod: TNC, federal protection
5.15	Pecos River	Altered	2	2	3	3	3	13	Low: U.S. laws, TNC in part, U.S. refuge
5.20	Santiaguillo	Altered	3	3	3	2	2	13	Low
5.04	Upper Santa Cruz	Heavily altered	3	3	4	4		14	Low: U.S. federal laws
5.24	Parras	Altered	2	4	4	1	3	14	Low
5.29	Sauz Basin	Altered	3	2	4	3	2	14	Low
5.10	Rio Grande/ Río Conchos	Heavily altered	3	3	4	4	3	17	Low: U.S federal laws, Wild & Scenic, in part
5.11	Rio Grande-Southern NM	Heavily altered	3	3	4	4	4	18	Low: U.S. federal laws

Chapter 6 Setting Priorities for Conservation Action

Introduction

The ultimate goal of ERBC is to conserve the full expression of biological diversity in the Chihuahuan Desert. However, limited financial resources, technical capacity, and the sheer size of the Chihuahuan Desert prohibit embarking on the conservation of all candidate priority sites simultaneously. Even in small ecoregions, conservationists must face the difficult task of setting priorities to determine the timing, sequence, and level of effort for conservation action. Furthermore, all candidate sites are not equal in their contribution to biodiversity nor equally threatened or resilient. Thus, we rank candidate priority sites (Figure 4.3 and 4.4) to:

1) illustrate how data on biological distinctiveness and landscape integrity can be combined to define the portfolio of sites for ERBC,
2) prioritize where to act first, and
3) define key elements of a long-term biodiversity vision.

Terrestrial priority sites

Only the top four ranks of the priority-setting matrix (Figure 2.2) were considered as part of the portfolio (Figure 6.1). Sixteen of the 61 candidate priority sites (26%) were selected as "highest priority" or level 1. Level two, or "high priority" contained 18 sites (30%), level 3 "priority" also contained 18 sites (30%), and in level 4, or "important" sites, there were 6 (10%).

The following paragraphs and tables summarize the distribution of priority sites by subregion and realm (terrestrial or freshwater), habitat type, and biological attributes.

Distribution by subregion and realm

The Apachean subregion had the highest number of priority sites, but it had the fewest Level 1 areas (highest priority) (Table 6.1). This result is partly attributable to the degree of resolution used by the different subregion experts. The Apachean group separated disjunct mountain ranges into smaller discrete sites. The Central Chihuahuan and Meseta Central groups tended to aggregate disjunct sites into larger complexes. The Northern Chihuahuan group aggregated some and retained some smaller disjunct sites. Regardless, the Meseta Central had the highest proportion of level 1 sites followed by the Northern and Central Chihuahuan subregions. The large number of freshwater sites in the highest priority category is a reflection of the high endemism of the naturally fragmented aquatic systems of the Chihuahuan and the degree of threat to those systems.

Figure 6-1. Terrestrial priority sites and map (see map following page)

Site #	Priority Site
Highest Priority Sites- Red	
1.20	Chiricahua-Sierra Madre Complex
2.01	Sierra del Nido
2.02	Rio Grande-El Paso to Amistad
2.04	Guadalupe-Mountains-Carlsbad Escarpment
2.05	Davis-Chinati Mountains Complex
2.07	Big Bend
2.08	North-Central Chihuahuan Grasslands
2.09	Tularosa Basin
3.01	Mapimí Complex
3.02	Sierras del Carmen y Santa Rosa Complex
3.03	Cuatrociénegas Complex
4.01	Altiplano Méxicano Nordoriental
4.02	Huizache - Cerritos
4.03	Chihuahua Querétaro Desert
4.06	Laguna de Santiaguillo
4.07	Río Nazas Basin
High Priority Sites-Yellow	
1.04	Sonoita Creek
1.05	Santa Catalina Mountains
1.08	Appleton-Whittell -Canelo Hills
1.10	Upper San Pedro River
1.16	Pinaleño Mountains
1.17	Willcox Playa
1.21	Northern Peloncillo Mountains
1.22	Big Hatchet-Alamo Hueco Mountains
1.25	Upper Middle Gila River
2.11	Alta Bavicora
2.13	Mescalero Sands
2.14	Samalayuca Dunes
2.15	Conchos River Headwaters
2.16	Marathon Basin
2.17	Sierra Blanca

Site #	Priority Site
2.18	Rio Grande-Above Elephant Butte
3.04	Sierra de La Paila
3.05	Sierra Santa Fe del Pino
4.09	Sierra de Picachos
Priority Sites- Green	
1.01	Baboquivari
1.02	Pajarito-Atasco Mountains
1.03	Santa Rita Mountains
1.09	Huachuca Mountains
1.13	Río Yaqui
1.15	Galiuro Mountains
1.19	Sulphur Springs Valley Grassland
1.24	Lordsburg Playa
1.26	Mimbres River
2.03	Rio Grande-Elephant Butte to El Paso
2.06	Devil's River
2.10	Pecos River Corridor
2.12	La Perla
3.06	Sierra de Menchaca
3.07	Sierra de la Gloria
3.08	Sierra de las Minas Viejas
4.04	Pico de Teyra
4.05	Órganos Malpais
4.08	Saltillo-Monterrey Corridor
Important Sites-Blue	
1.06	Lower San Pedro River
1.07	Whetstone Mountains
1.11	Río Sonora Watershed
1.12	Sierra Los Ajos
1.14	Lower Middle Gila River
1.18	Dragoon Mountains
1.23	Hatchita Grasslands

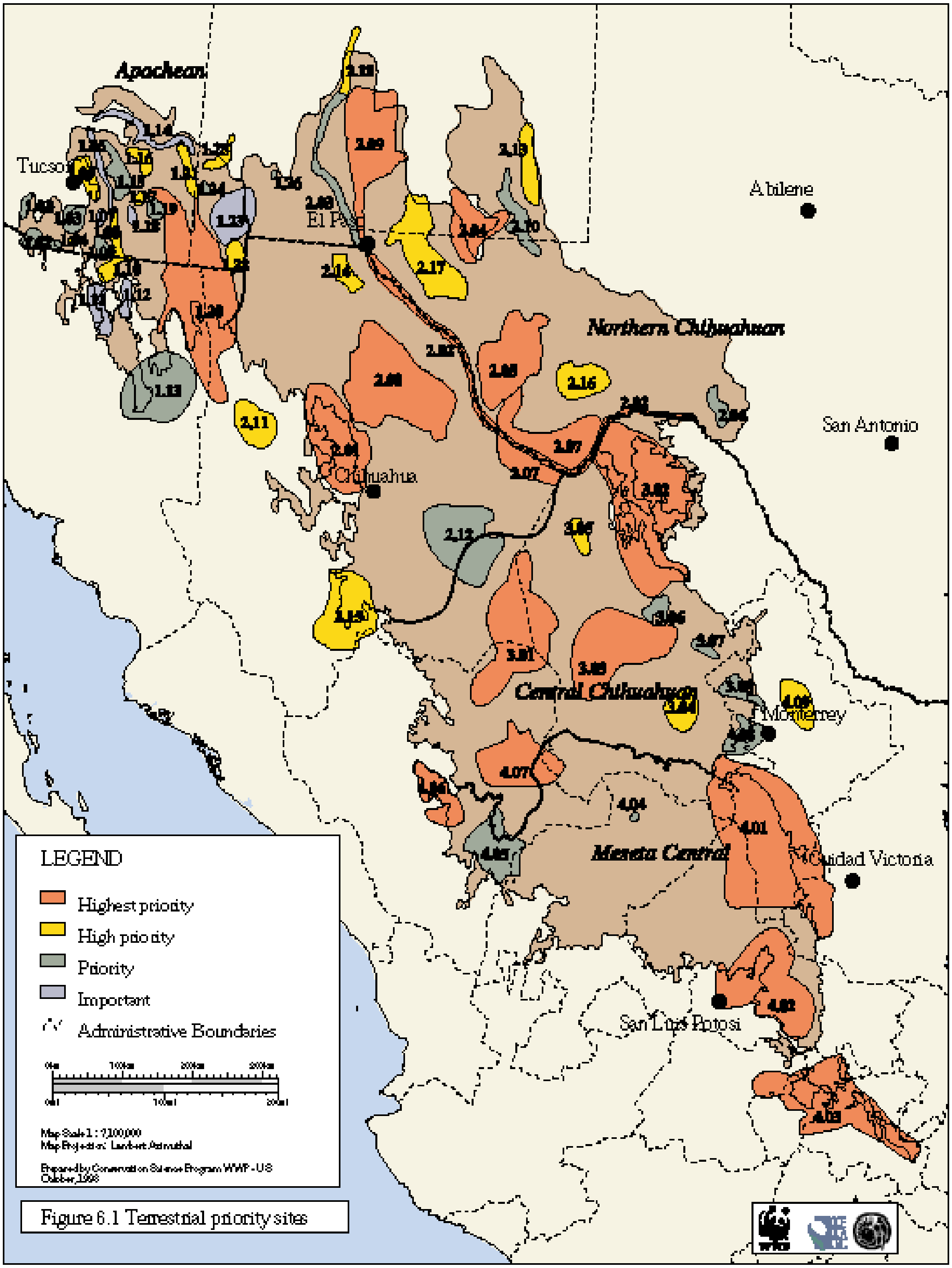


Figure 6.1 Terrestrial priority sites

Table 6-1. Number of priority sites in each subregion and level of priority for freshwater priority sites

Level of Priority	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	Freshwater	**Total**
1	1	7	3	5	14	**30**
2	8	7	2	1	10	**28**
3	10	4	3	3	7	**27**
4	7	0	0	0	6	**13**
Total	**26**	**18**	**8**	**9**	**37**	**98**

Distribution by habitat type

Every terrestrial habitat type is represented among the priority sites identified, and a minimum goal of at least three sites per habitat type was achieved within the ecoregion (excepting dunes, see below)(Table 6.2). Mixed conifer and riparian habitats account for nearly 50% of priority sites, reflecting high levels of endemism in the former and keystone habitats in the latter. There is also a strong latitudinal trend with mixed conifer, riparian, and grassland habitats dominant in the north and desert scrub more common in the southernmost subregion (Meseta Central).

The level of representation of habitat types corresponds closely to the actual extent of those habitats within each subregion. For example, one would expect to find more woodlands in the Apachean subregion than in the Meseta Central. Some habitat types are quite limited in distribution (*e.g.*, dunes) across the entire ecoregion or absent in some subregions (*e.g.*, riparian areas in the Central Chihuahuan). Large complexes contain multiple habitat types and increase the level of representation. They also fill in gaps where it appears that some habitat types have low or no representation within the subregion. Subsequent algorithm-based studies may be useful as a check to ensure a higher level of representation for certain habitats.

Table 6-2. Number of priority sites in each subregion by habitat type and for the entire ecoregion

Habitat Type	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	**Total for ecoregion**
Riparian	7	6	0^{ϕ}	1	**14**
Woodlands	5	0	1	1	**7**
Mixed conifer	8	3	3	1	**15**
Grassland	3	4	0	0^{ϕ}	**7**
Dunes	0^{ϕ}	1	0^{ϕ}	0^{ϕ}	**1**
Desert scrub	0^{ϕ}	0	1	4	**5**
Playas	2	1	0^{ϕ}	1	**4**
Large complexes	1	3	3	1	**8**

Habitat Type	Apachean	Northern Chihuahuan	Central Chihuahuan	Meseta Central	**Total for ecoregion**
Total	**26**	**18**	**8**	**9**	**61**

$^{\phi}$ = indicates that a reasonably sized example of this habitat type does not occur in the subregion. For example, dunes are rare across much of the desert.

Distribution by biological attribute

Overall, four features dominated the selection of priority sites: representation of habitat types, species assemblages, ecological and evolutionary phenomena, and intact habitats (Table 6.3). Sites critical for maintaining ecological processes and large-scale phenomena were also important. A number of priority sites require more detailed biological inventories. Representation of distinct species assemblages was the most commonly selected attribute for freshwater areas and in all subregions excepting the Central Chihuahuan.

Table 6-3. Number of priority sites in each subregion selected for a particular biological attribute (more than one attribute was given for most sites)

Attribute	Apachean	Northern	Central	Meseta Central	Freshwater	**Total**
Representation of habitat types	12	4	0	1	11	**28**
Representation of species assemblages	12	8	3	6	22	**51**
Representation of ecological and evolutionary phenomena	8	5	0	1	11	**25**
Intact habitat	6	5	4	1	15	**31**
Critical for ecological processes	3	5	1	1	7	**17**
Critical for large-scale phenomena	3	7	3	2	1	**16**
Genetic resources	0	0	0	0	0	**0**
Education value	0	0	0	0	0	**0**
Ecosystem services	3	0	0	2	0	**5**
Biological inventory	4	1	5	0	3	**13**

Freshwater priority sites

The freshwater group devised their own matrix, and assigned priority scores to each of their nominated sites (Figure 6.2). Those with scores of 1 or 2 were selected as priority sites.

Distribution by habitat type

Most freshwater priority sites were associated with multiple habitat types (Appendix D Table D-1). Low gradient perennial streams had the highest representation among priority sites, with 20 occurrences. This was followed by low salinity cool springs (18 sites), medium gradient perennial streams (15 sites), and ciénegas (14 sites). Neither high salinity cool springs nor high gradient ephemeral streams were represented at any sites, due to the extreme rarity of their occurrences and their low biodiversity value. For similar reasons, only one site contained a temporary laguna. Large rivers were represented by only two sites, both as a result of the fact that these habitats are rare in the Chihuahuan, and because they have been highly degraded. Finally, subterranean habitats, which are likely important within the Chihuahuan, were only represented by two sites, due to the fact that there was not sufficient expertise among the workshop experts to identify biodiversity hotspots for that habitat type.

Distribution by biological attribute

By virtue of the Chihuhuan Desert's aridity, freshwater habitats are naturally scarce. The isolation of many freshwater habitats, particularly those associated with springs, has led to the evolution of distinct forms in a large number of habitats. With human activities making intact freshwater habitats and biotas increasingly rare, those that remain are, by definition, high priority areas. The majority of freshwater priority sites, therefore, are recognized for their representative species assemblages, intact and rare habitats, and evolutionary or ecological phenomena (Appendix D).

Overlap of terrestrial and freshwater priority sites

Terrestrial and freshwater taxa differ so strongly in their biogeography that we used separate ecoregions to reflect distributions of communities. Not surprisingly, degree of overlap among priority areas is uneven (Figure 6.3). Twenty-four freshwater priority sites overlap by at least 50% with a neighboring terrestrial site. Thirteen freshwater priority sites are spatially discordant from terrestrial sites. The Apachean subregion and the Meseta Central exhibit the most spatial overlap of freshwater and terrestrial sites.

The Northern and Central Chihuahuan subregions show less spatial overlap. Most important is that 13 of the 16 (81 %) highest priority (Level 1) terrestrial conservation sites overlap with freshwater priority sites. These areas of overlap are important targets for immediate action in an emerging ERBC strategy.

Priority sites and their contributions to the Chihuahuan ERBC strategy

One of the most important steps of ERBC is to be able to articulate how priority sites contribute to the greater ecological integrity of the entire ecoregion. This information is essential when presenting a portfolio to donors and decision-makers or to justify the selection of sites to local stakeholders. We have summarized the contribution of each of the 98 priority sites (61 terrestrial and 37 freshwater) to an ERBC strategy (Appendix D). Detailed information on the biodiversity features of the priority sites is presented elsewhere (Appendix F).

Figure 6-2. Freshwater priority sites and map (see map on following page

Site #	Priority Site
Highest Priority	
5.02	Upper Yaqui
5.03	San Pedro-Aravaipa
5.06	Zona Carbonifera
5.07	Bavispe
5.08	Papogochic
5.09	Devil's River
5.15	Pecos River
5.19	Upper Nazas
5.21	Mezquital
5.30	Cuatrociénegas
5.32	Media Luna/Río Verde
5.35	Upper Conchos
5.37	Upper Gila River
High Priority	
5.04	Upper Santa Cruz
5.05	Río Sonora
5.10	Rio Grande/Río Conchos
5.11	Rio Grande-Southern New Mexico
5.13	Guzmán
5.17	Panuco
5.22	La Concha
5.23	Upper Aguanaval

Site #	Priority Site
5.33	Río Cadena
5.34	Extorax
5.36	San Diego
Priority Site	
5.01	Willow Spring
5.12	Mimbres River
5.15	Bavicora
5.18	Tularosa Basin
5.20	Laguna de Santiaguillo
5.29	Sauz Basin
5.31	Venado
Important Site	
5.14	Bustillos
5.24	Parras
5.25	Chorro
5.26	Potosi
5.27	Iturbide
5.28	Sandía

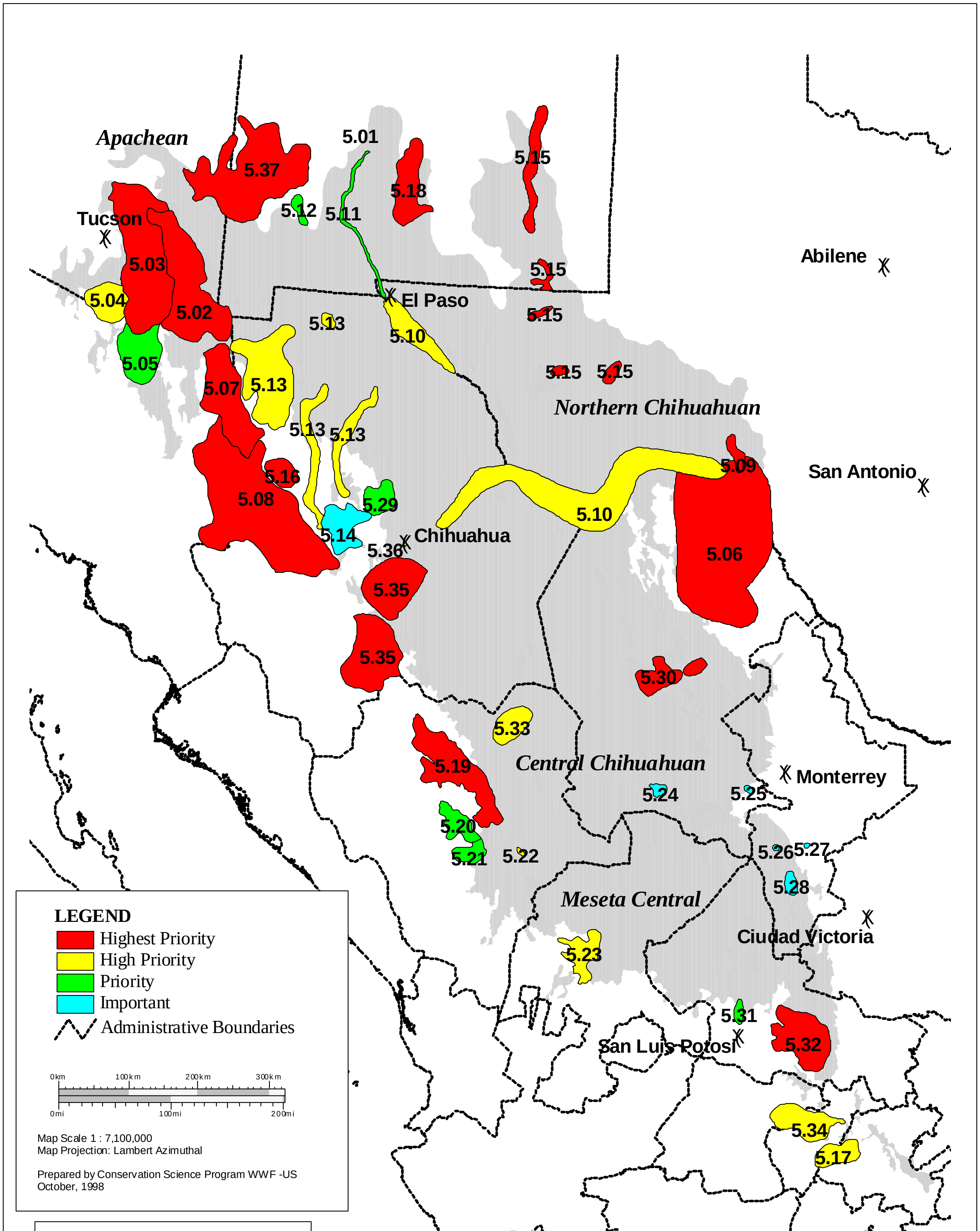
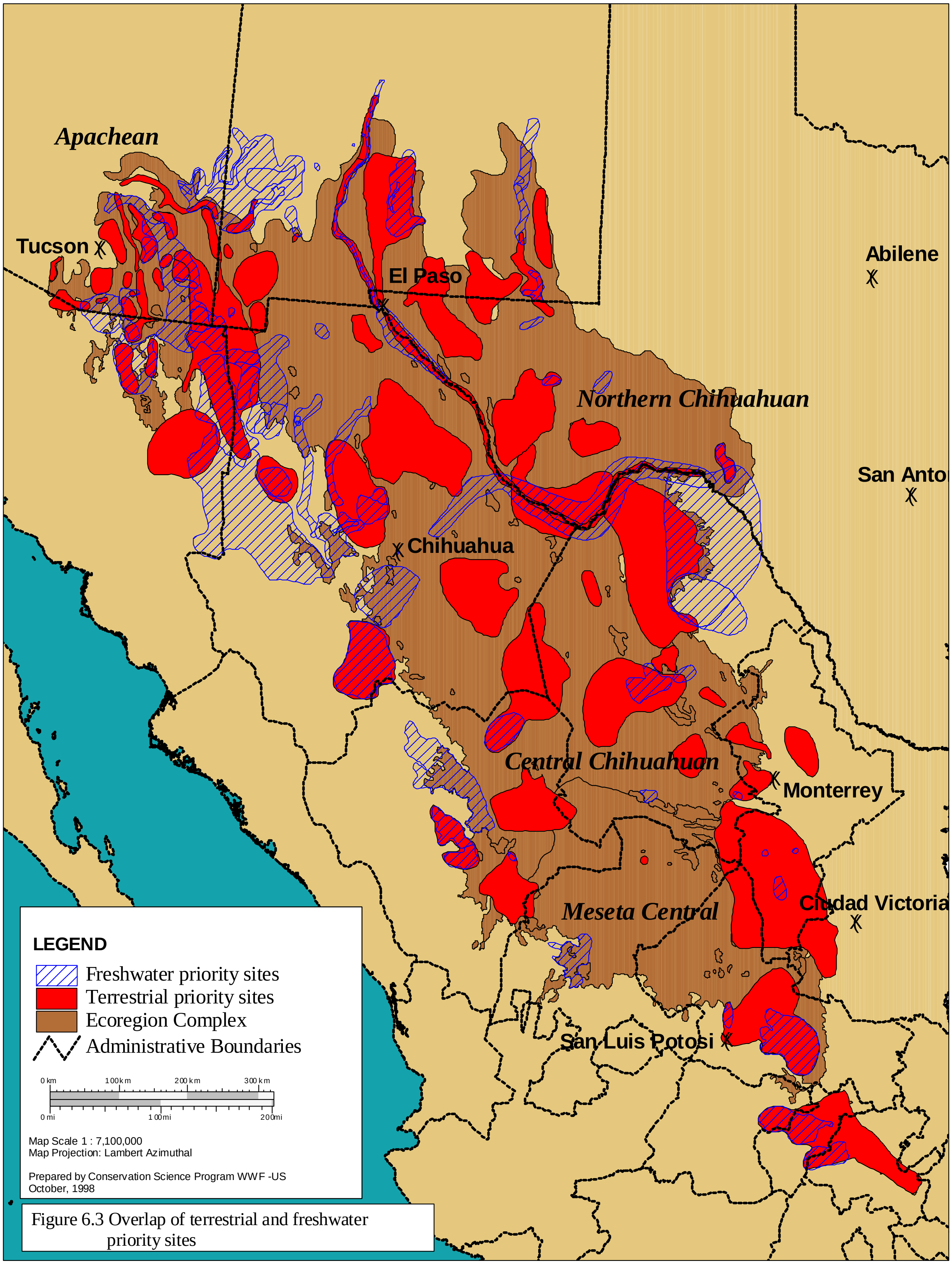


Figure 6.2 Freshwater priority sites

Figure 6-3. Overlap of terrestrial and freshwater priority sites



Chapter 7 Gap Analysis: Degree of overlap of terrestrial and freshwater priority sites with U.S. and Mexican protected areas and CONABIO priority sites

Introduction

Protected areas are the cornerstone of biodiversity conservation. Many sensitive species and habitats persist only in places where human activities are restricted. Often, protected areas support the only remaining source populations of endangered species and sites where reproduction exceeds mortality. Habitats outside protected areas may be no more than sinks, where populations disperse but do not recruit young in adequate numbers to replace themselves. Gap analysis becomes a fundamental step in ERBC because it illustrates the degree of overlap of outstanding biological features, potential source populations, and protection units. The first part of this chapter describes the results of a gap analysis for the Chihuahuan Desert. This gap analysis is based on the WCMC data from 1993 and a review of current management plans and protection levels of private and public lands in the U.S. and Mexico.

A second type of overlay analysis is also useful: the comparison of priority sites selected by previous workshops or assessments. Few ecoregions are a *tabula rasa* for priority-setting; there usually exists one or more published or unpublished attempts to set conservation priorities, even if only at very coarse scales. All ERBC efforts should build on such efforts, but also state clearly any differences in methodology, conservation goals, targets, or scale. In the second part of this chapter, we compare the results of our assessment with another conducted previously by CONABIO in the Mexican portion of the ecoregion.

Priority-setting for conservation in Mexico is part of the mandate of CONABIO, the Comisión Nacional para el Conocimiento y uso de la Biodiversidad. Between 1993 and 1994, CONABIO held meetings with experts in a wide range of fields to establish a consensus of priority sites for terrestrial biodiversity that would frame CONABIO's conservation efforts (Figure 7.1). Features such as the presence of endemic or rare species, high species richness, fragile ecosystems, sustainable use values, and biogeographic importance were used to delineate the CONABIO priority sites. An analogous freshwater priority site map was completed in 1998 (Figure 7.2). The CONABIO priority-setting exercises brought together experts from all over Mexico, but Chihuahuan expertise was limited to a few individuals. In this current exercise, a much larger group of experts was assembled to focus on a more limited geographic area. Many of the Mexican Chihuahuan experts who participated in the CONABIO workshops also participated in the Monterrey workshop.

Overlap analysis of protected areas and priority sites

The Chihuahuan Desert ecoregion contains few protected areas designed primarily for conservation of biodiversity, *i.e.* those classified as IUCN categories I-IV (Table 7.1 and Box 7.1) or gap categories 1 & 2 (Thompson *et al*. 1996). Only 1.0%, just 6,323 km^2 of the ecoregion, is under strict protection using gap category 1 only. On federal lands in the U.S., a variety of special management areas confer varying levels of protection, such as Research Natural Areas, typically less than 10,000 hectares, and National

Parks, often greater than 100,000 hectares which both occur in the highest category of gap protection (Box 7.2). In gap category 2, Areas of Critical Environmental Concern and Wilderness Study Areas may have strong legal protection and management but continue to permit livestock grazing. A scant 3.6% (22,411 km^{2}) of the Chihuahuan Desert has some form of conservation management using the gap analysis definitions, which were admittedly designed to categorize lands only in the U.S..

The areas of gap categories 1 & 2 protect a wide representation of habitat types, including riparian, montane, and scrub communities, however, grasslands are underrepresented. Special management areas within freshwater priority sites (Figure 7.3) are widespread and fall within most of the major drainages. Public lands with special management for aquatic habitats are the San Bernadino, Bitter Lakes, and Bosque del Apache National Wildlife Refuges, Pecos River ACEC, San Pedro and Gila River Riparian National Conservation Areas, Gila Lower Box, Pecos River/Canyons Complex and Overflow Wetlands, and the Pecos Bluntnose Shiner Critical Habitat. The Nature Conservancy, the vanguard of freshwater protection on private lands in the Chihuahuan Desert, owns and manages 13 preserves along springs and rivers (Appendix E). The effort to protect freshwater rivers, streams, *pozas* (small ponds), or basins, must intensify, however, since the Chihuahuan may be the most globally distinct arid ecoregion in terms of freshwater biodiversity (Olson and Dinerstein 1998).

IUCN designations used to define protected areas around the world (Box 7.1) are helpful when considering a cross-border analysis of protection, but they do not provide a category for private lands in the US with conservation easements or military lands that might have high standards for resource management. Nevertheless, the U.S. portion holds all of the protected areas within IUCN level I that fall within the highest priority sites, even though: 1) 75% of the ecoregion is in Mexico, and 2) the Apachean subregion contains only one highest priority site.

Of all the protected areas, 56 fall within the Apachean, 67 occur in the Northern Chihuahuan, and 3 occur in the Central Chihuahuan subregions (Table 7.1 and Appendix E). Eight of the 37 freshwater sites have some form of protection, including the Rio Grande, which has Wild & Scenic River status in its lower reaches. In the Northern Chihuahuan 10 of 18 sites have protected areas within them, and in the Apachean, 19 of the 26 priority sites have protection. Protected areas with accompanying area size and IUCN and gap categories occur in Appendix E.

There is an obvious lack of representation of protected areas throughout the four subregions. The Central Chihuahuan subregion is home to Cuatrociénegas, which is both a terrestrial and freshwater highest priority site, and its IUCN category is IV. The Cañon Santa Elena Área Protegida de Flora y Fauna is also IUCN category IV. The Maderas del Carmen Área Protegida de Flora y Fauna is rated an IUCN category VI (Appendix E).

The Meseta Central subregion, home to some of the world's rarest cacti, is completely without rigorous biodiversity protection. While it contains several Zonas Sujeta a Conservación Ecológica, these state defined regions have varying levels of management standards.

Box 7-1. IUCN Protected Areas Management Categories

Founded in 1948, the World Conservation Union (IUCN) is a unique world partnership of governments, government agencies and non-government organizations working together to conserve the integrity and diversity of nature, and to ensure that any use of natural resources is equitable and ecologically sustainable. The IUCN promotes a common approach to the world's environmental pressures, and acts as a global advocate for the environment. One of the IUCN's initiatives is to classify the different kinds of protected area found around the world. Their classification includes:

Strict Nature Reserve/Scientific Reserve (1) To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.

National Park (2) To protect outstanding natural and scenic areas of national or international significance for scientific, educational, and recreational use. These are relatively large natural areas not materially altered by human activity where extractive resource uses are not allowed.

Natural Monument/Natural Landmark (3) To protect and preserve nationally significant natural features because of their special interest or unique characteristics. These are relatively small areas focused on protection of specific features.

Managed Nature Reserve/Wildlife Sanctuary (4) To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment where these may require specific human manipulation for their perpetuation. Controlled harvesting of some resources can be permitted.

Protected Landscapes and Seascapes (5) To maintain nationally significant natural landscapes which are characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal life style and economic activity of these areas. These are mixed cultural/natural landscapes of high scenic value where traditional land uses are maintained.

Resource Reserve (6) To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning. This is a `holding' category used until a permanent classification can be determined.

Anthropological Reserve/Natural Biotic Area (7) To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology. This category is appropriate where resource extraction by indigenous people is conducted in a traditional manner.

Multiple Use Management Area/Managed Resource Area (8) To provide for the sustained production of water, timber, wildlife, pasture and tourism, with the conservation of nature primarily oriented to the support of the economic activities (although specific zones may also be designated within these areas to achieve specific conservation objectives).

In sum, the current configuration of protected areas in the Apachean and Northern Chihuahuan subregions provides a base for further conservation and increased protection. In the Central Chihuahua subregion, the protected areas must increase levels of protection to address fundamental goals of ERBC: giving greater attention to patterns of beta-diversity, conserving large landscapes, and creating landscapes where the evidence of human activity is scarce (Chapter 2). Establishing sites that protect biodiversity in the Meseta Central is essential for successful ERBC. The extraordinary beta-diversity of the Chihuahuan-distributed along basins, isolated springs, gypsum habitats, and mountain ranges-requires a network of reserves distributed widely to capture the complex distributional patterns of many narrow range endemic species. The need to conserve large landscapes is equally ignored in that the median size of the protected areas that overlap with the 16 highest priority sites is only 204 km^2.

Box 7-2. GAP Categories

The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. Lands are categorized relative to management status- the degree to which an area is managed to maintain biodiversity.

Management Status 1-

An area with an active management plan in operation that is maintained in its natural state and within which natural disturbance events are either allowed to proceed without interference or are mimicked through management. Most national parks, Nature Conservancy preserves, some wilderness areas, Audubon Society preserves, some US Fish and Wildlife Service National Wildlife Refuges (e.g., Oregon Islands, Ash Meadows), and Research Natural Areas are included in this class.

Management Status 2-

An area that is generally managed for its natural values, but which may receive use that degrades the quality of natural communities that are present. Most wilderness areas, US Fish and Wildlife Service Refuges managed for recreational uses, and Bureau of Land Management Areas of Critical Environmental Concern are included in this class.

Management Status 3-

Most nondesignated public lands, including US Forest Service, Bureau of Land Management and state park lands. Legal mandates prevent permanent conversion to anthropogenic habitat types (with some exceptions, such as tree plantations) and confer protection to populations of Federally listed endangered, threatened, and/or candidate species.

Management Status 4-

Private or public land without an existing easement or irrevocable management agreement that maintains native species and natural communities and which is managed primarily or exclusively for intensive human activity. Urban, residential and agricultural lands, public buildings and grounds, and transportation corridors are included in this class.

Gap categories were assigned to all areas of the Chihuahuan Desert with special management plans or conservation easements (Appendix E). The process was designed for U.S. land ownership.

Overlap analysis of CONABIO sites and priority sites

There is a relatively high degree of overlap among CONABIO priority sites and priority sites identified in this assessment, despite differences in scale (all of Mexico vs. one ecoregion complex) and number of experts between the two exercises (Figures 7.4 and 7.5). Here we summarize patterns of overlap for terrestrial and freshwater biodiversity.

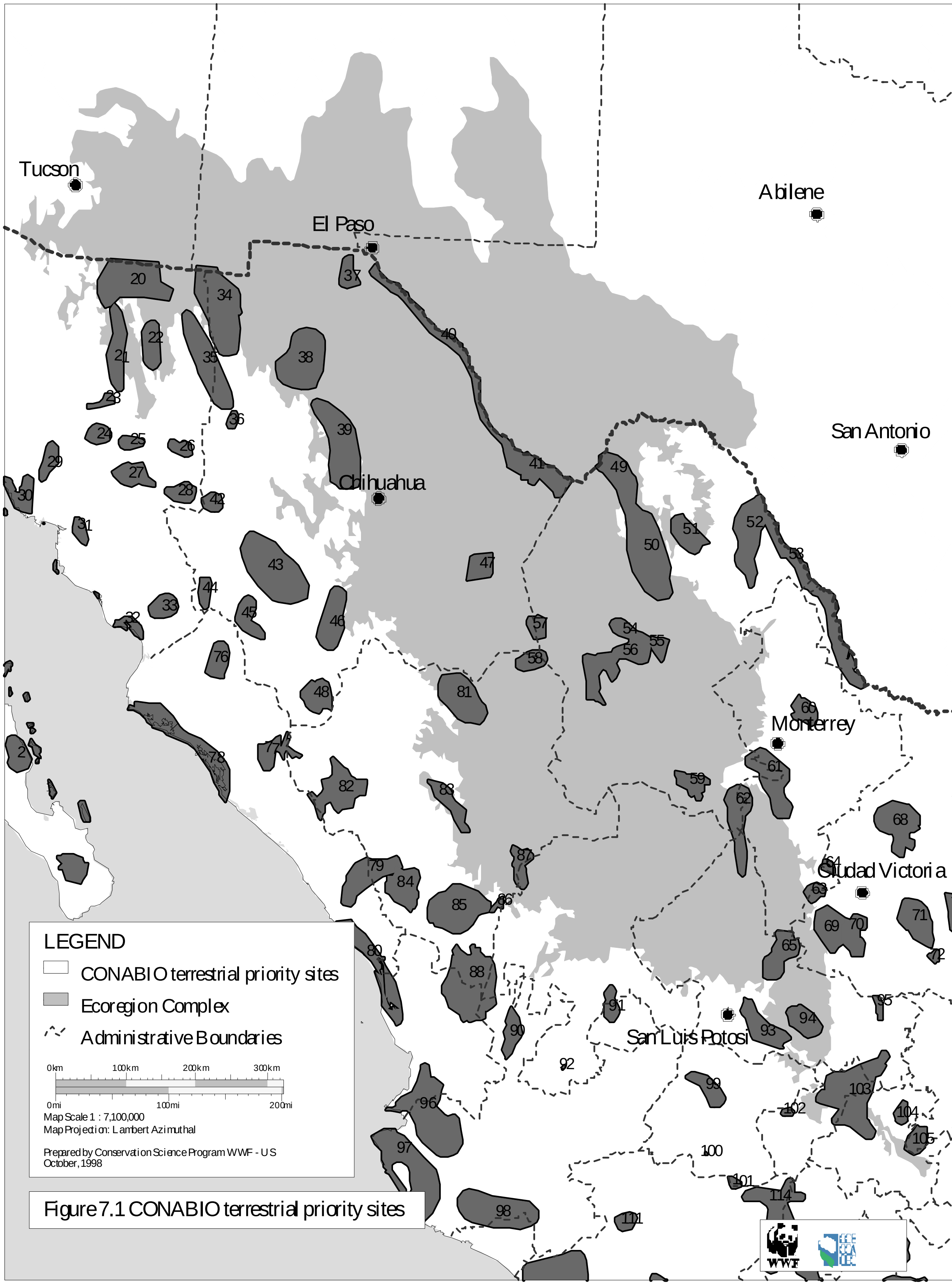


Figure 7-1. CONABIO terrestrial sites

Figure 7-2. CONABIO freshwater priority sites & map (see map following page)

1. Sierra La Laguna
2. Sierra El Mechudo
3. Planicies de Magdalena
4. Sierra La Giganta
5. El Vizcaíno - El Barril
6. Sierras La Libertad - La Asamblea
7. Valle de los Cirios
8. San Telmo - San Quintín
9. Punta Banda - Eréndira
10. Santa María - El Descanso
11. Sierra San Pedro Mártir
12. Sierra de Juárez
13. Delta del río Colorado
14. Gran Desierto de Altar - El Pinacate
15. Bahía de San Jorge
16. Sierras El Álamo - El Viejo
17. Sierra Seri
18. Cajón del Diablo
19. Sierra Libre
20. Sierra El Bacatete
21. Las Bocas
22. Marismas Topolobampo - Caimanero
23. San Juan de Camarones
24. Río Humaya
25. San José
26. Guadalupe y Calvo - Mohinora
27. Barranca Sinforosa
28. Rocahuachi - Nanaruchi
29. Lago Los Mexicanos
30. Alta Tarahumara - Barrancas
31. Sierra Álamos - El Cuchujaqui
32. Cañón de Chínipas
33. Basaseachic
34. Babícora
35. Cuenca del río Chico - Sirupa
36. Yécora - El Reparo
37. San Javier - Tepoca
38. Sierras El Maviro - Santo Niño
39. Sierra Mazatán
40. Cañada Mazocahui
41. Cananea - San Pedro
42. Sierras Los Ajos - Buenos Aires - La Púrica
43. Sahuaripa
44. Bavispe - El Tigre
45. Sierra de San Luis - Janos
46. Pastizales del norte del río Santa María
47. Sierra del Nido - Pastizal de Flores Magón
48. Médanos de Samalayuca
49. Cañón de Santa Elena
50. El Berrendo
51. Laguna Jaco
52. Mapimí
53. Cuchillas de la Zarca
54. Santiaguillo
55. Río Presidio
56. Pueblo Nuevo
57. Guacamayita
58. La Michilía
59. Cuenca del río Jesús María
60. Sierra los Huicholes
61. Marismas Nacionales
62. Sierra Vallejo - río Ameca
63. Chamela - Cabo Corrientes
64. Manatlán - Volcán de Colima
65. Sierra de Morones
66. Sierra Fría
67. Sierra de Órganos
68. Sierra La Fragua
69. Cuatrociénegas
70. Sierra de la Madera
71. Sierras La Encantada - Santa Rosa
72. Sierra Maderas del Carmen
73. Sierra El Burro - río San Rodrigo
74. Cinco Manantiales
75. Matorral tamaulipeco del bajo río Bravo
76. Sierra Picachos
77. Sierra Bustamante
78. La Popa
79. Sierra La Paila
80. Tokio
81. El Potosí - Cumbres de Monterrey
82. Cañón de Iturbide
83. Laguna Madre
84. Sierra de San Carlos
85. Puerto Purificación
86. San Antonio - Peña Nevada
87. El Huizache
88. Pastizales gipsófilos de Matehuala
89. Valle de Jaumave
90. El Cielo
91. Sierra de Tamaulipas
92. Encinares tropicales de Loma Las Pitas y Sierra Maratines
93. Rancho Nuevo
94. Cenotes de Aldama
95. Laguna de San Andrés
96. Sierra Abra - Tanchipa
97. Llanura del río Verde
98. Sierra de Álvarez
99. Sierras Santa Bárbara - Santa Rosa
100. Cerro Zamorano
101. Sierra Gorda - río Moctezuma
102. Bosques mesófilos de la Sierra Madre Oriental
103. Laguna de Tamiahua
104. Encinares tropicales de la planicie costera veracruzana
105. Cuetzalan
106. La Malinche
107. Sierra Nevada
108. Ajusco - Chichinautzin
109. Nevado de Toluca
110. Sierra de Chincua
111. Cerro Ancho - Lago de Cuitzeo
112. Hoya Rincón de Parangueo
113. Cerro Viejo - Sierras de Chapala
114. Tancítaro
115. Sierra de Coalcomán
116. Infiernillo
117. Sierra Madre del Sur de Guerrero
118. Cañón del Zopilote
119. Sierra Nanchititla
120. Sierras de Taxco - Huautla
121. Valle de Tehuacán - Cuicatlán
122. Pico de Orizaba - Cofre de Perote
123. Dunas costeras del centro de Veracruz
124. Humedales del Papaloapan
125. Cerros Negro - Yucaño
126. Sierras Triqui - Mixteca
127. El Tlacuache
128. Bajo río Verde
129. Sierra Sur y costa de Oaxaca
130. Sierras del Norte de Oaxaca - Mixe
131. Sierra de los Tuxtlas - Laguna del Ostión
132. Selva Zoque - La Sepultura
133. El Triunfo - La Encrucijada - Palo Blanco
134. El Mozotal
135. Tacaná - Boquerón
136. Selva espinosa Alto Grijalva - Motozintla
137. El Momón - Montebello
138. Lacandona
139. Bosques mesófilos de los Altos de Chiapas
140. Huitepec - Tzontehuitz
141. La Chacona - Cañón del Sumidero
142. El Manzanillal
143. Lagunas de Catazajá - Emiliano Zapata
144. Pantanos de Centla
145. Petenes - Ría Celestum
146. Dzilam - Ría Lagartos - Yum Balam
147. Sian Ka'an - Uaymil - Xcalak
148. Río Hondo
149. Zonas forestales de Quintana Roo
150. Sur del Punto Put
151. Silvituc – Calakmul

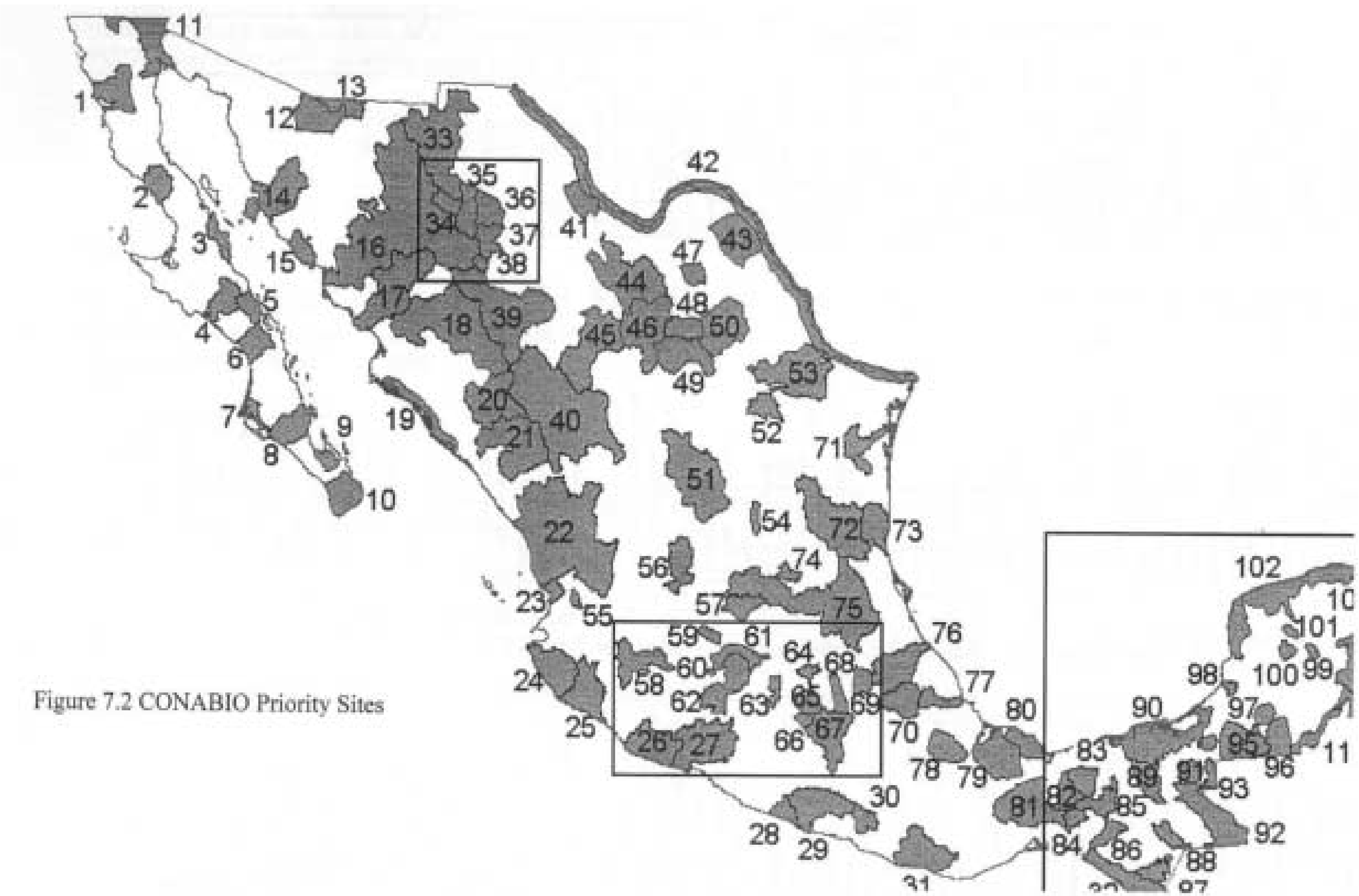


Figure 7.2 CONABIO Priority Sites

Table 7-1. Multi-scale analysis of protected areas in the Chihuahuan Desert ecoregion (all areas are in km^2)

Protected Areas within IUCN Categories I-IV

	Entire Ecoregion	Apachean subregion	Northern Chihuahuan subregion	Central Chihuahuan subregion	Meseta Central subregion	16 highest priority terrestrial sites
Size of region	**629,000**	**64,000**	**295,000**	**150,000**	**120,000**	**195,000**
Total number of protected areas	**121**	**52**	**69**	**0**	**0**	**34**
Size of protected areas	**12,140**	**3,300**	**8,840**	**0**	**0**	**7,140**
Percent of area protected	**1.9%**	**5.1%**	**3.0%**	**0%**	**0%**	**3.7%**
Mean size of protected areas	**100**	**63**	**128**	**0**	**0**	**204**
Median size of protected areas	**20**	**29**	**15**	**0**	**0**	**20**

Protected Areas within GAP Categories 1& 2

	Entire Ecoregion	Apachean subregion	Northern Chihuahuan subregion	Central Chihuahuan subregion	Meseta Central subregion	16 highest priority terrestrial sites
Size of region	**629,000**	**64,000**	**295,000**	**150,000**	**120,000**	**195,000**
Total number of protected areas	**137**	**62**	**75**	**0**	**0**	**38**
Size of protected areas	**22,350**	**5,000**	**17,420**	**0**	**0**	**17,000**
Percent of area protected	**3.5%**	**7.8%**	**5.9%**	**0%**	**0%**	**8.7%**
Mean size of protected areas	**160**	**78**	**235**	**0**	**0**	**435**
Median size of protected areas	**19**	**21**	**16**	**0**	**0**	**27**

Figure 7-3. Overlap of terrestrial and freshwater priority sites with protected areas

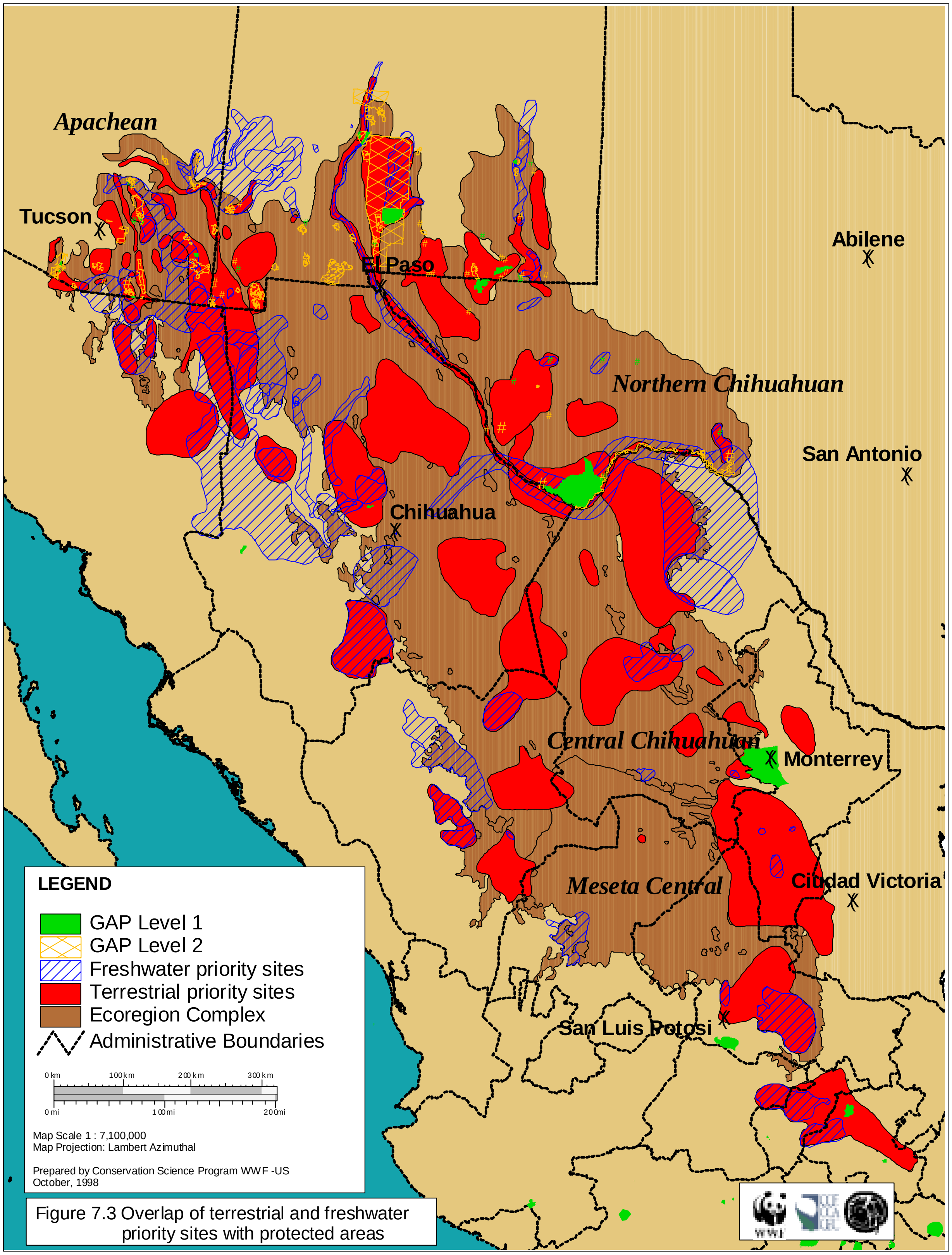


Figure 7.3 Overlap of terrestrial and freshwater priority sites with protected areas

Figure 7-4. Overlap of terrestrial priority sites with terrestrial CONABIO priority sites in the Mexican portion of the ecoregion

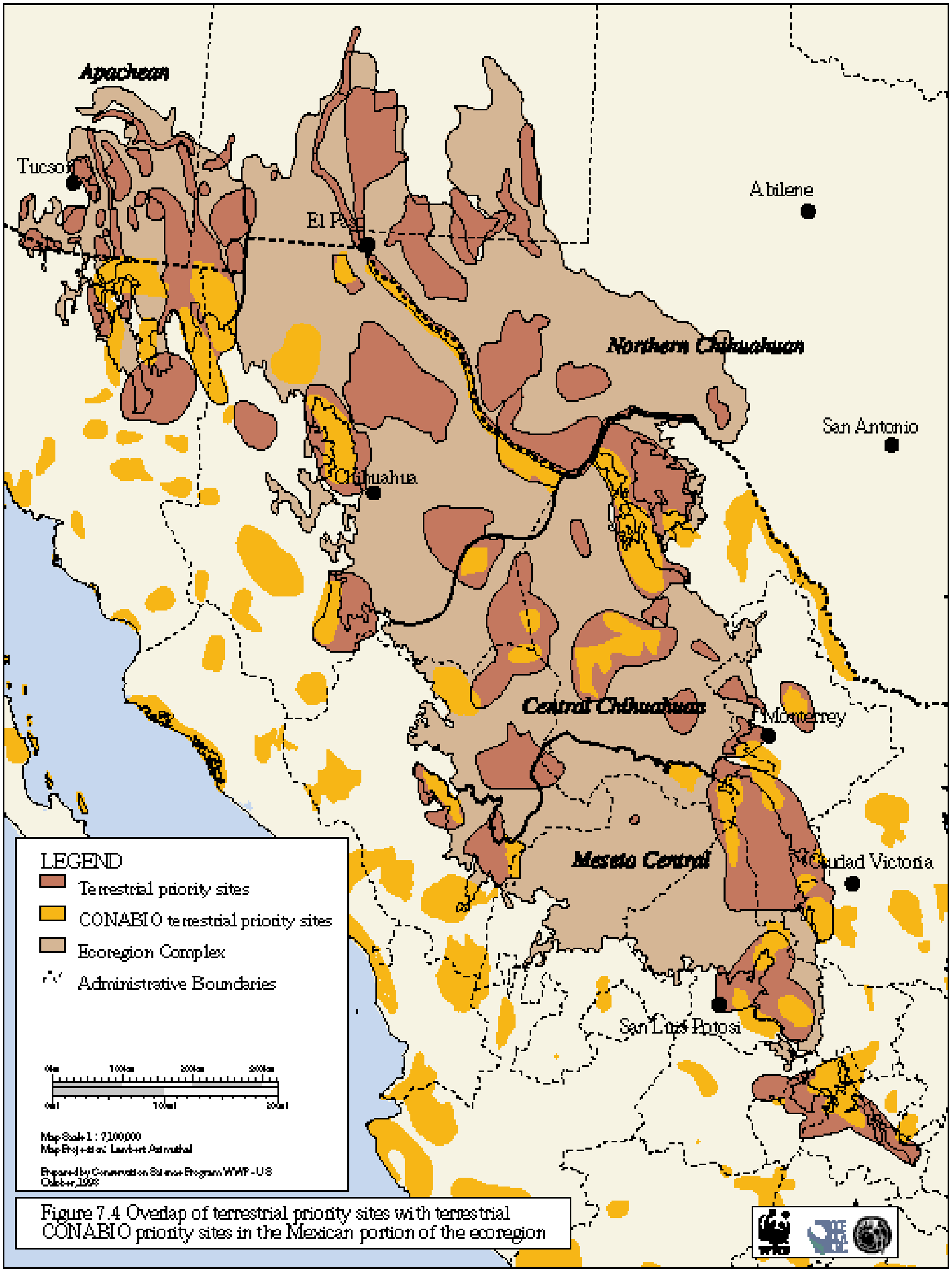


Table 7-2. Overlap between terrestrial candidate priority sites (Level 1) and CONABIO terrestrial priority sites

Subregion	Terrestrial Candidate Priority Site Name - Number	CONABIO Priority Site - Number
Apachean	Chiricahua-Peloncillo - 1.20	Sierra de San Luis-Janos - 34
Apachean	Chiricahua-Peloncillo - 1.20	Río Bavispe - 35
Northern Chihuahuan	Sierra del Nido - 2.01	Sierra del Nido-Pastizal de Flores Magon - 39
Northern Chihuahuan	Rio Grande-El Paso to Amistad - 2.02	Boquillas del Carmen - Rio Grande - 40
Northern Chihuahuan	Big Bend - 2.07	Cañon de Santa Elena - 41
Central Chihuahuan	Mapimí Complex - 3.01	Lagunas de Jago – 57
Central Chihuahuan	Mapimí Complex - 3.01	Mapimí – 58
Central Chihuahuan	Mapimí Complex - 3.01	(portion of) Cuchillas de la Zarca - 81
Central Chihuahuan	Sierras del Carmen and Santa Rosa - 3.02	Sierra Maderas del Carmen - 49
Central Chihuahuan	Sierras del Carmen and Santa Rosa - 3.02	Sierra de Santa Rosa - 50
Central Chihuahuan	Sierras del Carmen and Santa Rosa - 3.02	(portion of) Río San Rodrigo- El Burro - 51
Central Chihuahuan	Cuatrociénegas - 3.03	Sierra de la Madera - 54
Central Chihuahuan	Cuatrociénegas - 3.03	Cuatrociénegas – 55
Central Chihuahuan	Cuatrociénegas - 3.03	Sierra la Fragua – 56
Meseta Central	Altiplano Mexican Nordoriental - 4.01	(portion of) Sierra de Artega - 61
Meseta Central	Altiplano Mexican Nordoriental - 4.01	Tokio – 62
Meseta Central	Altiplano Mexican Nordoriental - 4.01	San Antonio Pena Nevada - 63
Meseta Central	Altiplano Mexican Nordoriental - 4.01	Puerto Purificacion - 64
Meseta Central	Altiplano Mexican Nordoriental - 4.01	Valle de Jaumave – 69
Meseta Central	Huizache-Cerritos - 4.02	(portion of) El Huizache - 65
Meseta Central	Huizache-Cerritos - 4.02	(portion of) Sierra de Alvarez - 93
Meseta Central	Huizache-Cerritos - 4.02	Llanura del Río Verde - 94
Meseta Central	Queretaro - 4.03	Cerro Zamorano - 102
Meseta Central	Queretaro - 4.03	(portion of) Cañones de Afluentes del Penuco - 103
Meseta Central	Queretaro - 4.03	(portion of) Huayacocotla - 105
Meseta Central	Cuenca del Río Nazas - 4.07	Laguna de Santiaguillo - 83

Terrestrial overlap analysis

Of the sixteen highest priority terrestrial conservation sites (red polygons in Figure 6.1), 13 of them occur in Mexico. Eleven of those thirteen sites contain at least one CONABIO site (Table 7.2, Figure 7.4). Two priority conservation sites (North-Central Chihuahuan Grasslands (2.08) and Cuenca del Rio Nazas (4.07) do not overlap with any CONABIO sites.

A total of 26 CONABIO sites overlap with the eleven highest priority terrestrial sites. A majority of these occur in the Central Chihuahuan (9) and Meseta Central (12) subregions. These two subregions account for 21 CONABIO sites, and seven of the 16 highest priority sites, yet they contain only one protected area. This finding further strengthens the need for increased protection in areas where CONABIO sites overlap with highest priority terrestrial sites.

Freshwater overlap analysis

In April 1998, CONABIO staged a freshwater biodiversity workshop involving forty-five specialists representing a wide range of governmental, academic, and non-governmental institutions. The goal was to identify basins important for freshwater biodiversity throughout Mexico. This workshop complemented the Chihuahuan workshop, and identified 109 catchments important for freshwater biodiversity. Similar to the terrestrial analysis, an overlap analysis of the freshwater priority sites with CONABIO freshwater sites displayed a relatively high degree of concordance (Figure 7.5). One major difference between the two priority setting exercises is that the CONABIO workshop identified catchment areas, whereas the Chihuahuan workshop primarily identified specific sites within catchment areas. The Chihuahuan workshop identified 37 freshwater priority sites, thirty of which occur in Mexico. Of these, twenty-two overlap with nineteen CONABIO priority sites (Table 7.3). Among the eight sites that show no overlap, four occur in the environs of Monterrey and involve small, localized areas (Priority sites 5.24, 5.26, 5.27, and 5.28). Four additional sites show no overlap with CONABIO sites (5.02, 5.05, 5.23, and 5.33).

The overlap analyses of priority sites and protected areas-as determined by CONABIO and this assessment-paint a picture of an extraordinarily diverse desert ecoregion, with a clear sense of where biological priorities are, but vastly inadequate efforts in place to conserve these resources. The need to greatly improve the protected area network looms as one of the major tasks of future ERBC efforts on the ground. The zones of overlap among freshwater and terrestrial priority sites identify good places to start (Fig. 6.3).

Figure 7-5. Overlap of freshwater priority sites with freshwater CONABIO priority sites

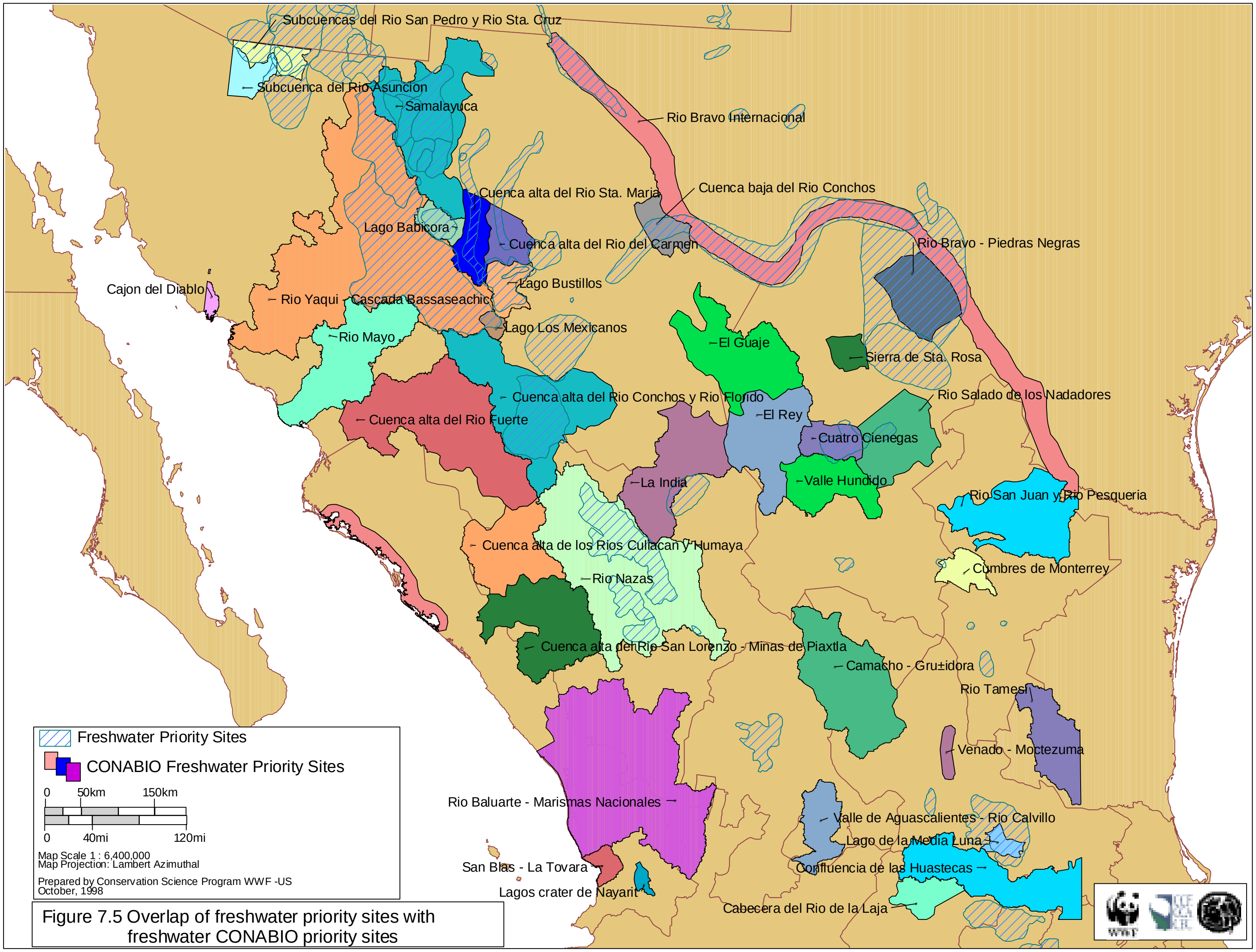


Figure 7.5 Overlap of freshwater priority sites with freshwater CONABIO priority sites

Table 7-3. Overlap between freshwater candidate priority sites (Level I) and CONABIO freshwater priority sites

Freshwater Priority Site - Number	CONABIO Priority Site - Number
San Pedro - Aravaipa - 5.03	Subcuencas del Río San Pedro y Río Sta. Cruz - 13
Upper Santa Cruz - 5.04	Subcuencas del Río San Pedro y Río Sta. Cruz - 13
Zona Carbonifera - 5.06	Río Bravo Internacional - 42
Zona Carbonifera - 5.06	Río Bravo - Piedras Negras - 43
Bavispe - 5.07	Río Yaqui - Cascada Basaseachic -16
Papigochic - 5.08	Río Yaqui - Cascada Basaseachic -16
Papigochic - 5.08	Río Mayo – 17
Rio Grande & Río Conchos - 5.10	Cuenca baja del Conchos - 41
Rio Grande & Río Conchos - 5.10	Rio Bravo Internacional - 42
Guzman Basin - 5.13	Río Yaqui – Cascada Basaseachic -16
Guzman Basin - 5.13	Samalayuca –33
Guzman Basin - 5.13	Lago Babicora – 34
Guzman Basin - 5.13	Cunca alta del Río Sta. Maria -35
Bustillos - 5.14	Laguna Bustillos – 37
Bustillos - 5.14	Lago Mexicano – 38
Bavicora - 5.16	Río Yaqui – Cascada Basaseachic -16
Panuco - 5.17	Confluencia de las Huastecas - 75
Upper Nazas - 5.19	Río Nazas – 40
Laguna de Santiaguillo - 5.20	Río Nazas – 40
Mezquital - 5.21	Río Nazas – 40
La Concha - 5.22	Río Nazas – 40
Chorro - 5.25	Cumbres de Monterrey - 52
Sauz Basin - 5.29	Cuenca alta del Río del Carmen - 36
Sauz Basin - 5.29	Laguna Bustillos – 37
Cuatrociénegas - 5.30	Cuatrociénegas – 48
Cuatrociénegas - 5.30	Río Salado de Nadadores - 50
Venado - 5.31	Lago de la Media Luna - 74
Media Luna - Rio Verde - 5.32	Confluencia de las Huastecas - 75
Extorax - 5.34	Confluencia de las Huastecas - 75
Upper Conchos - 5.35	Río Conchos – Río Florido - 39
San Diego - 5.36	Lago Mexicano - 38

Chapter 8 Threat Analysis

Introduction

Major threats to biodiversity affect multiple sites simultaneously. Overgrazing of livestock or diversion of water is a problem across all subregions and at many priority sites within them. A hypothesis of ERBC is that addressing threats that occur over large spatial scales is a more cost-effective approach than addressing threats on a site-by-site basis. Whereas some threats are local, such as the introduction of exotic fish species in native freshwater communities, mitigation of other serious threats may require intensive lobbying to enforce existing laws or pass new legislation. These efforts are likely to occur in the capitals of U.S. and Mexican states and far from the priority sites.

Social scientists, economists, and anthropologists might view threats from a different perspective than biologists. Thus, it is imperative that biological assessments for ERBC address threats in order to help guide the work of the interdisciplinary ERBC team. For example, the effects of degradation and fragmentation of terrestrial habitats may be less apparent to non-scientists than to biologists because the effects are often only apparent on longer time scales. Similarly, the need to sensitize non-scientists to the global importance of the fish species endemic to rather ordinary looking desert pools is crucial to successful ERBC in the Chihuahuan Desert ecoregion. Finally, a description of the original state of the habitats is also important to convey to non-scientists.

Threats will be considered in much greater detail in future workshops that include experts from a variety of disciplines. However, the experts at this workshop have the best perspective on how these threats directly or indirectly affect biodiversity, and the cumulative nature of these threats.

We asked regional experts to rank the importance of overarching threats to biodiversity, and to rank levels of threat to the priority sites identified in this document. Description of threats within each subregion is presented in Appendix C. Specific threats affecting priority sites are listed in Appendix F.

Overarching threats to terrestrial and freshwater biodiversity

Two overarching threats to biodiversity-water mismanagement and growing human populations-were unanimous choices and another nearly so (overgrazing and overbrowsing) (Table 8.1). The top five threats were tabled for more in-depth analyses and policy papers to be presented at a subsequent socio-economic workshop.

The results were as follows:

Table 8-1. Overarching threats to biodiversity in the Chihuahuan Desert

Threat	Votes received
Water mismanagement	Unanimous
Growing human population	Unanimous
Overgrazing and overbrowsing	41
Agricultural expansion	29
Lack of law enforcement	24
Introduced and exotic species	22
Lack of perspective in land use planning	18
Lack of environmental education	16
Overcollection of biota	14
Air and water pollution	11
Urbanization	10
Logging	10
Illegal poaching	9
Unsustainable harvest of native species	9
Altered fire regime	7
Pesticides	5
Loss of indigenous knowledge	5
Road construction, road density	4
Pathogens/disease/parasites	3
Fuel wood harvest	2
El Niño	1
Mining	0
Uncontrolled recreation	0
Toxic waste disposal	0
Inadequate laws	0

Levels of threat at terrestrial and freshwater priority sites

Whereas a particular threat may operate over many sites, the cumulative effect of several threats at a single site can place the biodiversity it contains in grave danger. A summary of priority ranks and threat levels (high, medium, low and unknown) shows that an unacceptably high percentage of Level 1 and 2 priority sites have a high or medium level of threat (Table 8.2). Overall, 24% of priority sites have a high threat level, 43% have a medium threat level, and 25% of priority sites have a low threat level.

Table 8-2. Summary of priority ranks and threat levels

Priority rank	Threat level	Number of sites
1	High	16
1	Medium	12
1	Low	1
1	Unknown	1
2	High	2
2	Medium	14
2	Low	9
2	Unknown	3
3	High	3
3	Medium	13
3	Low	10
3	Unknown	1
4	High	3
4	Medium	3
4	Low	5
4	Unknown	2

The visual depiction of levels of threat applied to terrestrial priority sites show that Mexican sites are on average more threatened than U.S. sites (Figure 8.1). Freshwater sites are on average more threatened than terrestrial sites (Figure 8.2).

Figure 8-1. Levels of threat for terrestrial priority sites and map (see map following page)

Site#	Site Name
1.01	Baboquivari
1.02	Pajaritos
1.03	Santa Ritas
1.04	Sonoita Creek
1.05	Santa Catalinas
1.06	Lower San Pedro
1.07	Whetstones
1.08	Appleton-Whittell-Canelo Hills
1.09	Huachuacas
1.10	Upper San Pedro
1.14	Lower Middle Gila
1.15	Galiuros
1.16	Pinaleño
1.17	Willcox Playa
1.18	Dragoons
1.19	Sulphur Springs
1.20	Chiricahua Complex
1.21	North Peloncillos
1.22	Big Hatchets
1.23	Hatchita grassland
1.24	Lordsburg Playa
1.25	Upper Middle Gila
1.26	Mimbres
2.01	Sierra del Nido
2.02	Rio Grande-El Paso to Amistad
2.03	Rio Grande-Elephant Butte to El Paso
2.04	Guadalupe-Carlsbad
2.05	Davis-Chinatis Mts.
2.06	Devil's River

Site#	Site Name
2.07	Big Bend
2.08	Chihuahuan Grasslands
2.09	Tularosa
2.10	Pecos River
2.11	Alta Bavicora
2.12	La Perla
2.13	Mescalero Dunes
2.14	Samalayuca Dunes
2.15	Conchos River
2.16	Marathon Basin
2.17	Sierra Blanca
2.18	Rio Grande-Above Elephant Butte Dam
3.01	Complejo Mapimí
3.02	Complejo de Sierras del Carmen
3.03	Cuatrociénegas
3.04	Sierra de la Paila
3.05	Sierra Santa Fe de Pino
3.06	Sierra de Menchaca
3.07	Sierra de la Gloria
3.08	Sierra de las Minas Viejas
4.01	Altiplano Mexicano Nordoriental
4.02	Huizache-Cerritos
4.03	Querétaro
4.04	Peco de Teyra
4.05	Órganos Malpais
4.06	Laguna de Santiaguillo
4.07	Río Nazas Basin
4.08	Saltillo-Monterrey
4.09	Sierra de Picachos

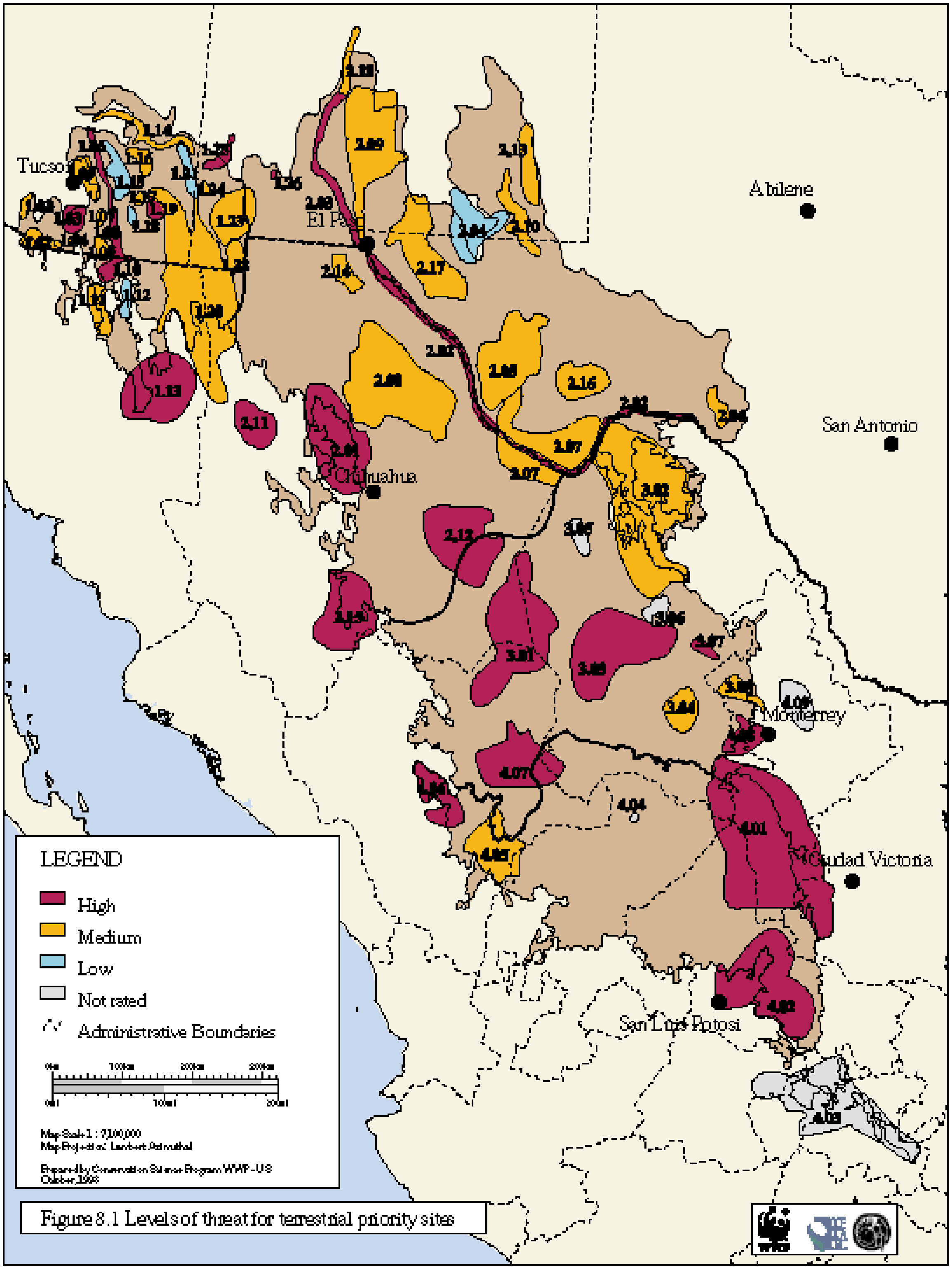


Figure 8.1 Levels of threat for terrestrial priority sites

Figure 8-2. Levels of threat for freshwater priority sites and map (see map following page)

Site #	Site Name
5.01	Willow Spring
5.02	Upper Yaqui
5.03	San Pedro- Aravaipa
5.04	Upper Santa Cruz
5.05	Río Sonora
5.06	Zona Carbonifera
5.07	Bavispe
5.08	Papogochic
5.09	Devil's River
5.10	Rio Grande/ Conchos
5.11	Rio Grande-So. NM
5.12	Mimbres
5.13	Guzmán
5.14	Bustillos
5.15	Pecos River
5.16	Bavicora
5.17	Panuco
5.18	Tularosa Basin
5.19	Upper Nazas
5.20	Laguna de
5.21	Río Mezquital
5.22	La Concha
5.23	Aguanaval
5.24	Parras
5.25	Chorro
5.26	Potosí
5.27	Iturbide
5.28	Sandía
5.29	Sauz Basin
5.30	Cuatrociénegas
5.31	Venado
5.32	Media Luna/Río Luna
5.33	Río Cadena
5.34	Extorax
5.35	Upper Conchos
5.36	San Diego
5.37	Upper Gila River

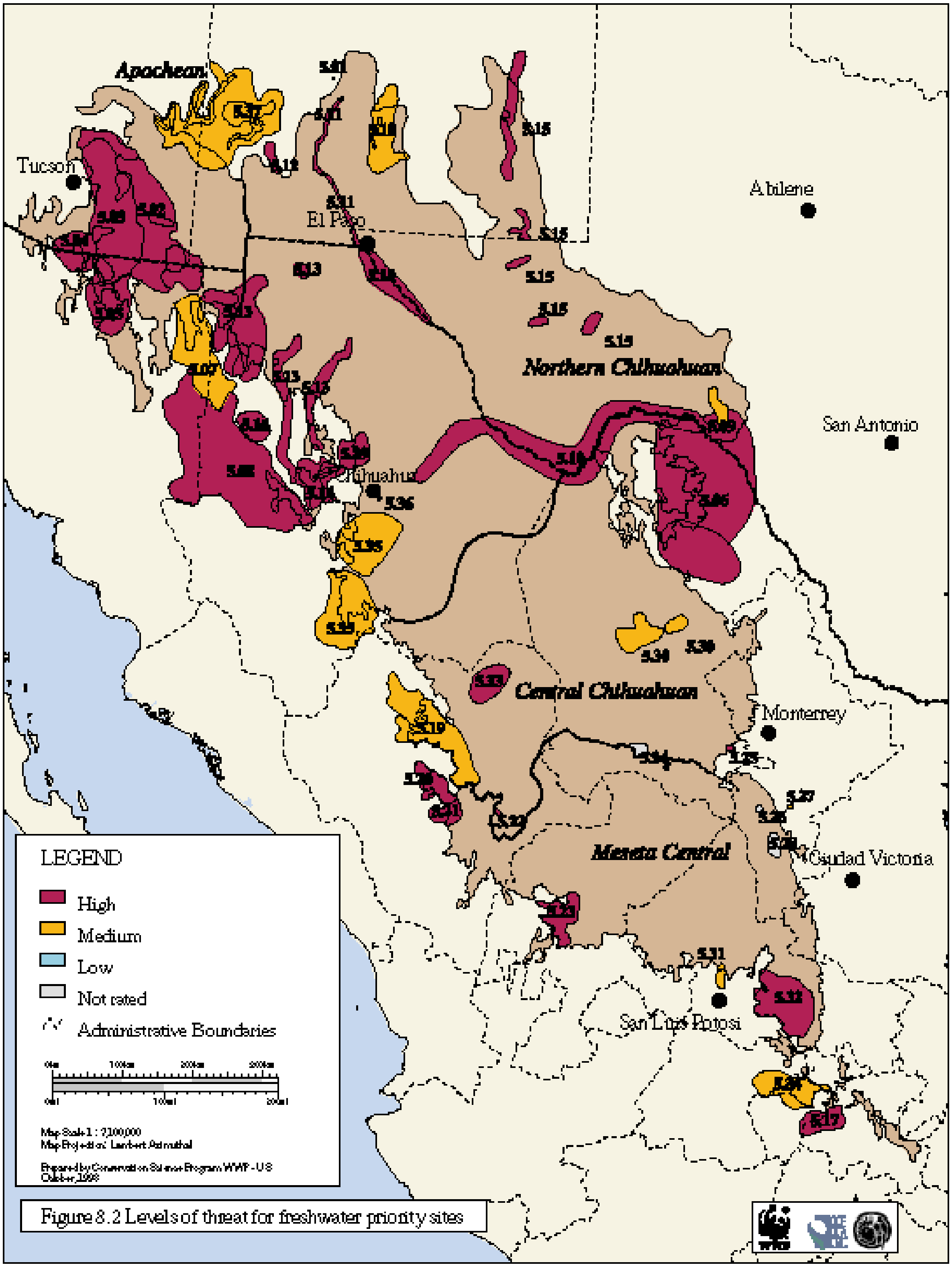


Figure 8.2 Levels of threat for freshwater priority sites

Chapter 9 Towards generating a biodiversity vision for the Chihuahuan Desert

Introduction

The core of a biodiversity vision for the Chihuahuan Desert's terrestrial landscape, its rivers, and springs must be visionary, focusing on what this ecoregion should look like 50 years hence rather than accepting what remains on the map today. Creating a vision requires conservationists to define what success looks like on spatial and temporal scales more grand than they normally contemplate. This step also requires us to define what we mean by the term original habitat or biota, and how far back we can go in restoration efforts. In the case of the Chihuahuan, as will be described below, a biodiversity vision requires nothing short of the return of the full complement of large mammals that played a prominent role in ecosystem structure and functioning.

A biodiversity vision is essential because it helps us to move beyond a business-as-usual approach to conservation. It serves as a touchstone to ensure that the biologically important features identified in this assessment remain the core conservation targets throughout the ERBC process. Even when we respond to local emergencies, a biodiversity vision provides a useful framework for interpreting threats to the integrity of the entire ecoregion rather than to individual sites.

Crafting a biodiversity vision is a daunting task, but there are several important features that make erecting a biodiversity vision for the Chihuahuan a plausible activity rather than an exercise in idiocy. For example, much of the ecoregion is only sparsely populated. The likelihood that remote areas will become increasingly depopulated over coming decades as people relocate closer to cities and towns may reduce pressures on the more intact and vulnerable sites. The resiliency of some of these habitats-particularly in the face of overgrazing by livestock-suggests that better stewardship could lead to rapid positive changes in habitat quality. Provided bold leadership, restoration of grasslands and other terrestrial habitats could occur on a timescale much faster than we realize. However, without immediate efforts to address water diversion, pumping, and overallocation and the introduction of non-native species, the chance to restore the biological tapestry of freshwater systems will ultimately fail. Thinking on a 50 year time frame does not mean that one can wait 50 years to address the most immediate and least reversible threats to biodiversity.

Defining success and the elements of a biodiversity vision

Defining success for the Chihuahuan Desert begins with the conservation in perpetuity of its 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 desert.

The restoration of landscapes and communities builds on these core features. This includes:

- 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 gypsophyllous habitats that have been degraded.

Another element of the vision is to manage large ‘conservation landscapes’ of sufficient size and connectivity to maintain important ecological processes and wide-ranging species. This includes restoration of populations of:

- Mexican wolves,
- mountain lion,
- jaguar,
- pronghorn, and
- aplomado falcons.

Through the protection or conservation management of these large landscapes, managed in collaboration with a variety of stakeholders, important gaps in the protected area network of this ecoregion will be addressed.

Finally, conservation of sites important to hemispherical and regional migrants that spend part of their lives in the Chihuahaun desert and other parts of their life histories in adjacent or distant ecoregions will be addressed. These migrants include:

- birds,
- bats and
- butterflies.

For conservation at an ecoregion scale to succeed, the overarching threats identified in this assessment-overallocation and diversion of water resources, overpopulation in sensitive areas, overgrazing and overbrowsing of native plant communities, and lack of enforcement of existing laws-must be addressed and mitigated in a timely manner. Within a decade, educators, officials, local leaders, and NGOs must sensitize and win support from a cross-section of communities who understand and value the biodiversity in their backyard because of the ecological services it provides as well as its intrinsic value.

Specific elements of the vision

In this section we elaborate on the specific biological elements of the biodiversity vision.

Areas of high endemism for cacti and other endemic plants are a top priority for protection because such foci represent one of the most outstanding biodiversity features of the Chihuahuan Desert at a global scale. Adequate reserves may have to encompass whole basins or ranges for area endemics or complexes of local endemics. At other sites, very local endemics are restricted to single valleys, dunes, or hillsides. Hernandez and Barcenas (1995) have identified two highest priority areas for endemic cacti, Huizache and Tolimán in the Meseta Central, containing 13 and 14 endemic species, respectively. Four high priority areas were also identified-Cuatrociénegas, Matehuala, Doctor Arroyo, and Mier y Noriega-holding 10-12 species each. All six of these localities are captured within the priority sites identified in this assessment.

Gypsum dunes and other communities on gypsum soils predictably harbor a large number and proportion of unusual endemic plants and invertebrates. Thus, the cessation of mining activities and strict conservation of these rare and limited habitats is a critical conservation goal. The major gypsophyllous communities are included in priority sites.

The globally rare assemblages of freshwater fish and snail species inhabiting the Cuatrociénegas basin are a critical priority. No other freshwater system, particularly one found in deserts, displays the extraordinary local endemism, adaptations, and radiations seen in the basin's fauna. The Chihuahuan Desert's freshwater biota as a whole is also unusual in that it has many localized faunas restricted to individual springs, streams, and rivers spread throughout the region. The great age of the area and isolation of basins has contributed to this pattern. A majority of the region's desert springs and streams suffer from a host of threats including water extraction and the invasion of exotic species, both problems that need immediate action to forestall any further extinctions.

The conservation community should champion *the restoration of flora and fauna associated with prairie dog colonies*. The Chihuahuan Desert is one of the last places in North America to conserve this formerly widespread, but distinctive, ecological phenomenon. Several priority sites still harbor a number of habitats and biotic elements that can act as source pools for restoration of these extraordinary ecosystems. It is hard to imagine a Chihuahuan biodiversity strategy being assessed as successful without at least a few extensive prairie dog colonies and their associated flora and fauna (*e.g.*, burrowing owls, pronghorn, ferruginous hawks, falcons, etc.) restored to an original state.

Representation of all major plant communities in the four biogeographic subregions has been largely addressed through the selection process for priority sites. If conservation areas are designed within each of these priority sites at some point, additional attention to representation of habitat types, and associated distinctive biotas, should occur.

Effective conservation of representative desert plant communities can occur only if pervasive overgrazing and overbrowsing by domestic livestock are controlled, and riparian and aquatic habitats restored.

Management of large 'conservation landscapes' of sufficient size and connectivity to maintain the important ecological processes and wide-ranging species characteristic of this region. This includes restoration, where appropriate, of populations of area-limited species such as Mexican wolves, mountain lion, jaguar, ocelot, pronghorn antelope, and aplomado falcons. Through the protection of these large conservation landscapes, managed in collaboration with a variety of stakeholders, important gaps in the protected area network of this ecoregion will be addressed.

Finally, the vision will include *conservation of sites important to hemispherical 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, such as migratory birds, bats, and butterflies. Montane forests, riparian corridors, playas and lakes, and pine-oak woodlands, and desert scrub are among the communities hosting these transitory populations.

Where to focus first

In any priority-setting effort, the most fundamental question to ask is, "How does this exercise guide us to be more strategic in our efforts to conserve biodiversity?"

1) From a list of 299 *nominated* sites, we were able to identify 61 terrestrial and 37 freshwater *priority sites* that address the conservation targets outlined in the approach (Chapter 2).

2) Among the 61 terrestrial sites, we can prioritize even further to identify 16 areas (highest priority terrestrial Level I) many of which overlap with CONABIO sites, that are of continental and global importance (Table 9.1).

3) Few of these 16 sites are offered effective protection. Thus, immediate efforts should concentrate on designing large conservation landscapes around these 16 sites that conserve distinctive elements of biodiversity and maintain connectivity. These landscapes should possess large core areas that protect biodiversity, and buffer areas and corridors that allow for limited use depending on the sensitivity of the local biotas.

4) The extremely low level of protection requires that another immediate task is to undertake a comprehensive effort to plan an ecoregion-scale network of protected areas that conserves patterns of beta-diversity and maintains linkages to adjacent ecoregions.

5) For freshwater biodiversity, an immediate goal is to improve the management of water resources in and around the highest priority areas.

6) Another freshwater target would be to remove alien species from isolated pozas and other spring, lake, and riparian habitats where possible, and where they pose an immediate threat to rare native biotas.

7) All of these immediate measures are designed to save source pools for future restoration efforts. A good place to start would be in intact areas exhibiting the greatest degree of overlap of highest priority terrestrial and freshwater sites (a comparison of Figure 9.1 and Figure 7.3). Conservation efforts made today will pay huge dividends later for ERBC by increasing the probability of successful restoration.

A priority for the coming decade

For both terrestrial and freshwater biodiversity, a set of restoration targets with a clear timetable must be formulated within the next few years. For the long-term persistence of biodiversity, degraded lands outside of the core areas need to be able to sustain ecological processes such as dispersal or seasonal movements of larger vertebrates. A long-term vision for conservation of the Chihuahuan Desert will promote the application of "biodiversity friendly" land use and wildlife practices and conservation of keystone habitats (*e.g.*, riparian habitats, springs) in matrix areas. This effort will help sustain ecological integrity across landscapes and within core areas.

Figure 9-1. Intact habitats within priority sites and map (see map following page; red=highest priority; yellow=high priority; green=priority; blue=important)

Highest Priority Sites
1.20 Chiricahua-Peloncillo-Sierra Madre Complex
2.01 Sierra del Nido
2.02 Rio Grande-El Paso to Amistad
2.04 Guadalupe-Mountains-Carlsbad Escarpment
2.05 Davis-Chinati Mountains Complex
2.07 Big Bend
2.08 North-Central Chihuahuan Grasslands
2.09 Tularosa Basin
3.01 Mapimí Complex
3.02 Sierras del Carmen y Santa Rosa Complex
3.03 Cuatrociénegas Complex
4.01 Altiplano Méxicano Nordoriental
4.02 Huizache - Cerritos
4.03 Chihuahua Querétaro Desert
4.06 Laguna de Santiaguillo
4.07 Río Nazas Basin

High Priority Sites
1.04 Sonoita Creek
1.05 Santa Catalina Mountains
1.08 Appelton-Whittell Research Ranch-Canelo Hills
1.10 Upper San Pedro River
1.16 Pinaleño Mountains
1.17 Willcox Playa
1.21 Northern Peloncillo Mountains
1.22 Big Hatchet-Alamo Hueco Mountains
1.25 Upper Middle Gila River
2.11 Alta Bavicora
2.13 Mescalero Sands
2.14 Samalayuca Dunes
2.15 Conchos River Headwaters
2.16 Marathon Basin
2.17 Sierra Blanca
2.18 Rio Grande-Above Elephant Butte
3.04 Sierra de La Paila
3.05 Sierra Santa Fe del Pino
4.09 Sierra de Picachos

Priority Sites
1.01 Baboquivari
1.02 Pajarito-Atasco Mountains
1.03 Santa Rita Mountains
1.09 Huachuca Mountains
1.13 Río Yaqui
1.15 Galiuro Mountains
1.19 Sulpher Springs Valley Grassland
1.24 Lordsburg Playa
1.26 Mimbres River
2.03 Rio Grande-Elephant Butte to El Paso
2.06 Devil’s River
2.10 Pecos River Corridor
2.12 La Perla
3.06 Sierra de Menchaca
3.07 Sierra de la Gloria
3.08 Sierra de las Minas Viejas
4.04 Pico de Teyra
4.05 Órganos Malpais
4.08 Saltillo-Monterrey Corridor

Important Sites
1.06 Lower San Pedro River
1.07 Whetstone Mountains
1.11 Río Sonora Watershed
1.12 Sierra Los Ajos
1.14 Lower Middle Gila River
1.18 Dragoon Mountains
1.23 Hatchita Grasslands

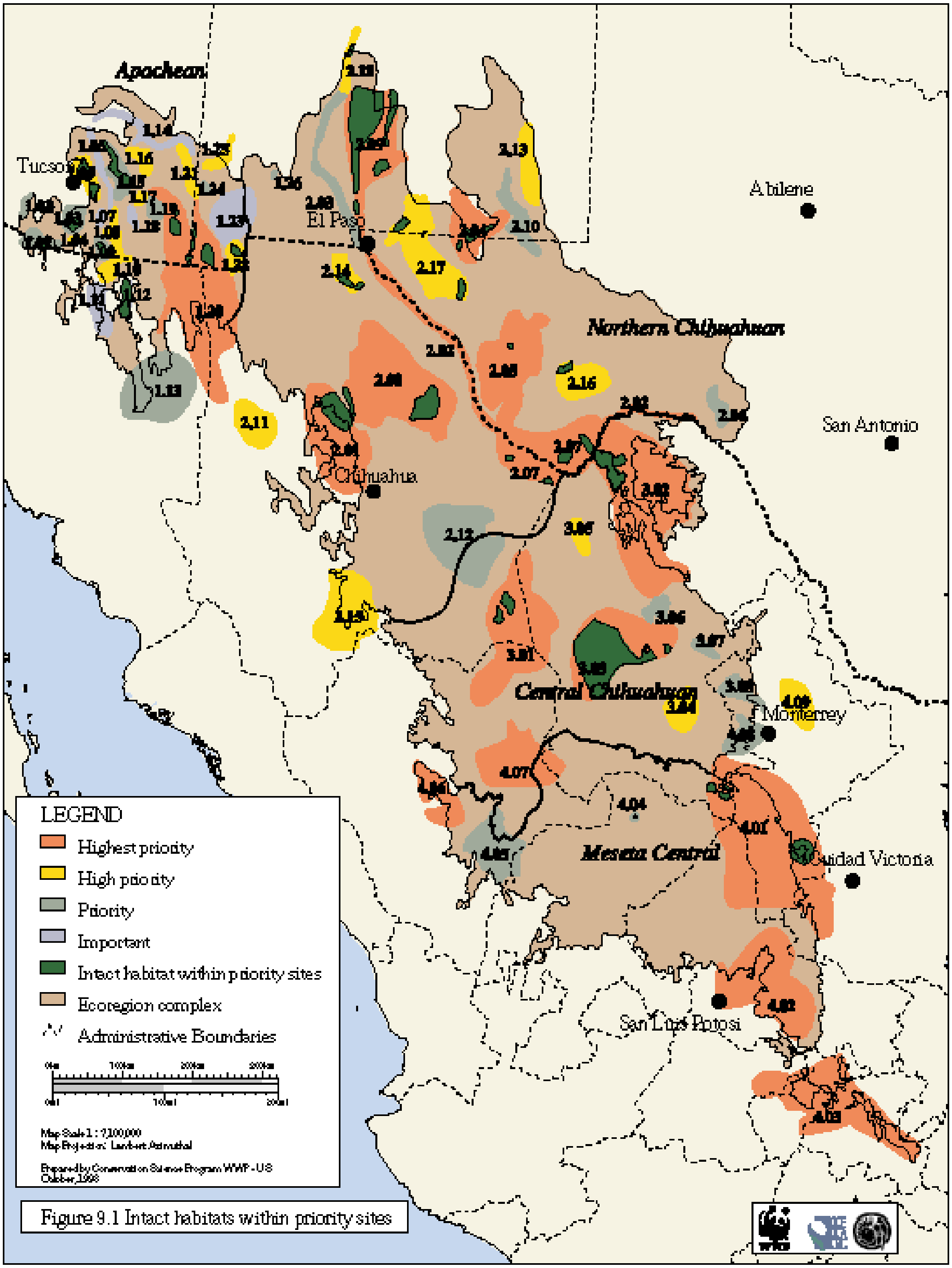


Figure 9.1 Intact habitats within priority sites

Defining success by subregion and for freshwater biodiversity

Local experts and conservation biologists with broad experience in the ecoregion are invaluable stakeholders in the process of creating a biodiversity vision. To this end, we built our draft vision by synthesizing summary reports from biologists and conservationists representing each of the four subregions and freshwater biodiversity. These are presented below. Each group was asked to summarize: the outstanding biodiversity features and priority sites of their area, how these sites contribute to conserving distinct aspects of Chihuahuan biodiversity, the threats impinging on these sites or across the subregion, conservation activities most needed, what a vision should include based on a 20 year timetable, and potential partners in implementing the biodiversity vision. These presentations were invaluable as they provided regional perspectives and helped inform everyone of the most salient conservation issues affecting the ecoregion. They also provide a finer level of resolution for crafting a biodiversity vision.

Apachean subregion (presented by Dr. Charles Curtin, Biology Department, University of New Mexico.)

The outstanding biodiversity features of the Apachean are the Madrean Sky Islands (particularly the Chiricahua and Peloncillo mountains), the playas, and the wetlands complexes of the Gila River.

The subdivision has very high mammal, reptile, and arthropod diversity, with many endemics. Habitats range from Chihuahuan desert scrub to subalpine. Extremely high levels of beta-diversity occur due to elevation and topography, ranging from desert scrub and *ciénegas* in lowlands, to woodlands and grasslands in mid-elevations, to montane forest in the highest elevations. Threats to biodiversity in the Apachean subdivision include altered fire regimes, exotic species (particularly salt cedar in the riparian areas), home construction, and ground water depletion. Another problem is that the long-time land stewards in the U.S. section of the subregion are aging, presenting the danger that their intimate knowledge and care of the land could give way to increased exploitation.

The biodiversity vision for this subregion includes: restoring the ecological role of fire throughout the area, re-watering wetland complexes, maintaining habitat linkages in the core areas, stopping subdivisions for housing, and establishing a seamless integration of resource management on both sides of the border.

Potential partners in developing and achieving this vision are:

The Nature Conservancy, Santa Fe, NM
New Mexico Natural Heritage Program, Albuquerque, NM
Animas Foundation, Animas, NM
Wildlands Project, Tucson, AZ
Quivera Coalition, Santa Fe, NM
Southwest Environmental Center, Las Cruces, NM
Malpai Borderlands Group, Animas, NM
Southwestern Center for Biological Diversity, Tucson, AZ
Forest Guardians, Santa Fe, NM
Center for Ecologia, Sonora
GilaWatch, Silver City, NM

Society for Range Management NM Chapter
People for the West
New Mexico Cattlegrowers
Sonoran Institute

Northern Chihuahuan subregion (Delivered by John Karges, The Nature Conservancy of Texas)

The outstanding biodiversity features of the Northern Chihuahuan include riparian areas/gallery forests, montane habitats, springs-*ciénegas*, grasslands, headwaters of watersheds, range limits and boundaries of many species, migratory and wintering birds, and flyway boundary interfaces with Central Plains and Rocky Mountains flyways.

Threats include air pollution, agriculture, lack of surface water quality and quantity, overgrazing, fuel wood collection, altered fire regimes, exotic game introductions, and urban expansion.

Important components of a long-term vision include: the sustainable use of water resources, enlightened management of range lands, improved funding for resource management on public lands, better environmental education and technology transfer in rural areas, effective monitoring of keystone species and the suite of species dependent on them, effective stewardship and law enforcement, improved monitoring of migratory bird species, and provision of economic incentives, such as tax credits, for conservation.

Some information gaps include knowledge of concentrated food resources for migratory birds, missing keystone species, an information exchange across the border, a mollusk inventory, and a Big Bend to Juárez inventory of the Rio Grande (Río Bravo).

The biodiversity vision for this subregion is based on: no net loss of biodiversity and genetic variation; no net loss of grasslands; restoration of critical habitats, particularly streams and *ciénegas*; and the establishment of eight conservation preserves, regardless of ownership. There is great potential for a reserve system from Sevilleta Refuge, near Albuquerque, through the Turner Ranches, White Sands Missile Range, Fort Bliss, the Jornada Experimental Range, and the Davis Mountains. This very large conservation landscape would anchor conservation of biodiversity in this subregion.

Potential partners in developing and achieving this vision are:

PROFAUNA, A.C. Chihuahua
The Nature Conservancy of Texas and New Mexico, Santa Fe, NM & San Antonio, TX
National Park Conservation Associations for Big Bend, Guadalupe Mountains, White Sands, and Carlsbad Caverns
Sierra Club
Southwest Environmental Center, Las Cruces, NM
Rio Grande Restoration, Taos, NM
El Paso Audubon Society, El Paso, TX
Rio Bosque, Center for Ecological Restoration, El Paso
Forest Guardians, Santa Fe, NM

Peregrine Fund, Boise, ID
Ducks Unlimited Mexico
Turner Foundation
T&E, Inc.
Unidos para Conservacion Barrengo
Texas Organization for Endangered Species
Watchlist
Chihuahuan Desert Nature Park
Colorado Bird Observatory, Brighton, CO
El Paso Native Plant Society
NM Native Plant Society, Las Cruces, NM
Mesilla Valley Audubon Society, Las Cruces, NM

Central Chihuahuan subregion (Delivered by Dr. Tom Wendt, Herbarium Curator, University of Texas, Austin)

This subregion contains desert scrub habitat of the highest quality in the ecoregion. Several priority sites contribute to a core ERBC strategy. Of these, Cuatrociénegas had the highest rating. The bolson and gypsum features along with the upland habitats of the Sierra de la Madera create a site supporting many endemics. Cuatrociénegas was a refugium during the Pleistocene for desert species. Another priority site, the Sierra del Carmen-Sierranillos Burros-Valle Encantada complex, approaches Cuatrociénegas in distinctiveness. The complex is characterized by high species richness and an interesting phytogeography. Species of the eastern deciduous forests, northern grasslands, and western pine forests converge in this complex. There is a mosaic of habitats, and some impressive grasslands. A third core site is the Bolson de Mapimí, a largely intact area with high rates of endemism. This site contains good examples of *tobosa* grasslands, pine forest, gypsum flats, and montane communities of the Sierra de Paila create a mosaic of habitats. There are also some degraded blocks within the Bolson, but it remains extremely interesting for biodiversity. There are no major riparian areas in this subregion.

Currently, threats and habitat alteration are relatively low compared to subregions with higher urban densities. Over the long term, the growing industrial pressure in Coahuila and Nuevo Leon are the greatest threats. These are the most important industrial centers in Mexico. Data gaps are hindering proper management of natural resources. Exotic species, salt cedar in particular, threaten the area. Illegal hunting and collection of reptiles and cacti are also problems. Mining and human-caused fires are visible impacts. Lack of continuity of conservation programs has hampered protection of biodiversity.

The biodiversity vision for this subregion includes many of the core priority sites which are refugia for endemism. Because a number of areas are still relatively intact, a vision of success might be to keep the sites looking like they do today. For this to occur, efforts must be made to keep urban growth from affecting the surrounding natural resources. Decreasing grazing pressure by goats would help in restoration of degraded blocks. Improved grazing management and restriction in sensitive areas is essential in Cuatrociénegas and Mapimí. Conservation strategies should emphasize restoration of benign grazing regimes, protection and maintenance of freshwater habitats and riparian areas, and the development of corridors and linkages among priority sites.

On a more local scale, the control of gypsum mining, and its relocation away from known sites of endemism is an imperative. Increased public education and involvement at the local level is a priority. The Sierra del Carmens could be a model for protected areas across the ecoregion.

Potential partners in developing and achieving this vision are:

PROFAUNA, A. C. Coahuila
Ducks Unlimited
Ducks Unlimited of Mexico
Institute Nacional Ecologia
Friends of Mesquite
The Nature Conservancy
Sierra Club
National Parks and Conservation Association
Museo de las Casas in Monterrey, NL
Desert Fishes Council

Meseta Central subregion (Delivered by Julian Trevino Villareal, Universidad Autonoma de Tamaulipas)

Outstanding areas for biodiversity include: the Altiplano Mexicano, which covers numerous habitat types of the Chihuahuan Desert including grasslands, halophytes, scrub, and gypsophiles; the canyons of Sierra Madre Oriental with endemic gypsophyllous plants; prairie dog towns in grasslands; and endemic cacti throughout. Huizache-Cerritos has many freshwater resources and is high in cacti endemism. There have been few studies of this area. Queretaro has high cacti diversity. Originally, this zone was not included in the Meseta Central. Sierra Picacho is a classic example of true Chihuahuan Desert communities. The corridor between Monterrey and Saltillo has a great diversity of plants and is an obvious conservation target.

Not enough experts were present for a completely informed discussion of the Altiplano Mexicano. There are great data gaps in Zacatecas and Durango. These areas, including Rio Nazas, need inventories.

Threats include agriculture, goat grazing, cattle grazing, cacti removal, and pressures from increasing human population.

The biodiversity vision for this subregion includes: conservation of the richest foci for endemism of cacti in the world, protection of extensive desert scrub, and conservation of freshwater assemblages.
Potential partners in developing and achieving this vision are:

Private landowners
Universidad Autonoma Nuevo León
UAC
State governments
Associacion de Ecología de Sierra Madre
CONABIO

CONACYT
SEMARNAP
UNAM
Bioconservacion, A.C.

Freshwater biodiversity (Presented by Dr. Salvador Contreras-Balderas, Facultad de Ciencias Biologias, Universidad Autonoma de Nuevo Leon)

Almost the entire ecoregion was once drained by the Rio Grande, and the outstanding freshwater biodiversity in the ecoregion is a result of natural fragmentation of the pluvial basin, which has led to speciation within many small areas. More than 170 species of fish occur in the Chihuahuan Desert. There are at least thirty-five undescribed species. In the last ten years, ten more species have been discovered. There are seventeen extinct species of fish, six having gone extinct in the last ten years. Given the extreme local endemism of freshwater biota, coupled with the severity of threats facing it, the freshwater group was uncomfortable with establishing priority sites. If twenty areas have endangered, endemic fish, how do you decide which to protect? The group felt that each freshwater site was a priority.

For these reasons, all water in the ecoregion must be effectively managed. This includes groundwater, a resource that is difficult to monitor. Underground fauna should be used to assess aquifer health.

Freshwater habitats are beseiged by a number of interrelated threats. Areas of the Chihuahuan are experiencing increases in industrial development, agriculture, and logging. Threats stemming from agriculture include pumping of groundwater, extraction of surface water, and dams on rivers and streams in the U.S. and in central Mexico. Maquilas (factories) pollute surface and groundwater and must have restrictions put on them. Logging, in addition to causing increases in sedimentation and other pollutants, is leading to a loss of rainfall through deforestation. Furthermore, exotic species outcompete native fish. Water sources are far from each other, and the quality of monitoring data from site to site varies tremendously. Data sharing is also difficult.

A vision of conservation success must include no more extinctions, sustainable water use, and less aggressive development.

Potential partners in developing and achieving this vision are:

Southwestern Center for Biodiversity
New Mexico Riparian Council
Pecos River Native Riparian Restoration Organization
Instituto Nacional de Ecologia
Desert Fishes Council
ProFauna
UANL
Sonoran Institute
Wetlands International-Americas
CONABIO
SEMARNA

UNAM
USFWS
Ducks Unlimited
North America Wetland Conservation Council
The Nature Conservancy

Next steps

The biodiversity vision and biological assessment form the basis for developing the conservation plan for the ecoregion. The vision is informed by socio-economic assessments now underway. Taken together, these complementary approaches will help shape the course of conservation efforts in the ecoregion for years to come.

A more specific step is to refine the landscapes recommended for immediate conservation action.
The map of priority terrestrial and freshwater sites marks an attempt to synthesize several data layers of biodiversity features. Some of these priority sites are very large and represent educated approximations of the boundaries of distinct communities, relatively intact areas, or areas over which certain processes operate. The next phase of ERBC is to design conservation landscapes at these sites and identify linkage habitats for maintaining large-scale ecological processes (Box 9.1). Groups such as the Wildlands Project and their collaborators have pioneered such approaches (Holdsworth and Humphrey 1998). Addressing spatially intensive processes, such as climate change and the persistence of wide-ranging species, can only be accomplished by designing conservation efforts at the landscape scale.

Another step might be to conduct algorithm-based representation analyses to revisit the selection of priority sites. These computer-based techniques have been applied successfully in several parts of the world exhibiting high beta-diversity, such as the fynbos region of South Africa and New South Wales in Australia. These approaches can assess where priority sites are complementary, additive, or redundant. However, algorithms typically focus only on distributions of species and not on other features that this assessment identifies as conservation targets: intact biotas and habitats, conservation of ecological and evolutionary phenomena, ecological processes, or sites important for hemispherical migrants. Thus, computer-driven analyses will not replace expert opinion in providing a more complete ranking of the biodiversity features of an ecoregion.

Box 9-1. Designing conservation landscapes in the Chihuahuan Desert

The workshop process has identified a network of core areas that address many important conservation goals. This is a critical first step, but some conservation goals address phenomena that operate at larger spatial scales than individual sites. Two examples are the movement of wide-ranging large carnivores and the potential shifting of communities with climate change. To address these goals, we must design and restore appropriate linkage habitats and corridors between priority sites at large spatial scales, what we term here conservation landscapes.

Much research and many guidelines are available on the most effective features and designs of linkage areas for promoting different phenomena (*e.g.*, Noss 1992, Soulé and Noss 1998). For example, some dispersing large predators of the Chihuahuan (*e.g.*, wolves, bears, puma, and jaguars) will not survive in linkage areas if there are insufficient resources or habitat available, or they will be inhibited from entering corridor habitats if certain features are absent or disturbances are too great. Typically, higher elevation and riparian areas are identified as potential corridors because such areas are often most feasible to designate for conservation purposes. However, lowland habitats are likely to have been equally or more important corridors in many ecoregions prior to their alteration in many parts of the world. Wherever possible, conservation landscapes should combine lowland and montane areas, even if the lowland elements require extensive restoration.

Biodiversity visions must embrace conservation landscapes that incorporate a combination of core conservation areas-some encompassing large wilderness areas-that meet representation and other goals. Such areas can be adjacent to buffer zones that permit limited resource use. They should also be linked, where possible, by corridor habitats that allow for the movement of species and communities among core areas. Corridors are most important for linking smaller reserves where species populations have lower probabilities of persistence in isolation, or between larger reserves that still maintain populations of sensitive larger vertebrates. Some areas may require restoration to enhance the ecological integrity of existing habitat blocks, provide additional habitat area for species with large area requirements, or to link core conservation areas. Many approaches to establishing core, buffer, and linkage habitats exist, such as the establishment of national, state, and private protected areas, agency stewardship zones, Wild and Scenic Rivers (U.S.), and mitigation of disturbances and fragmentation activities in corridors. Any combination of these approaches will work as long as the critical biological concerns are addressed.

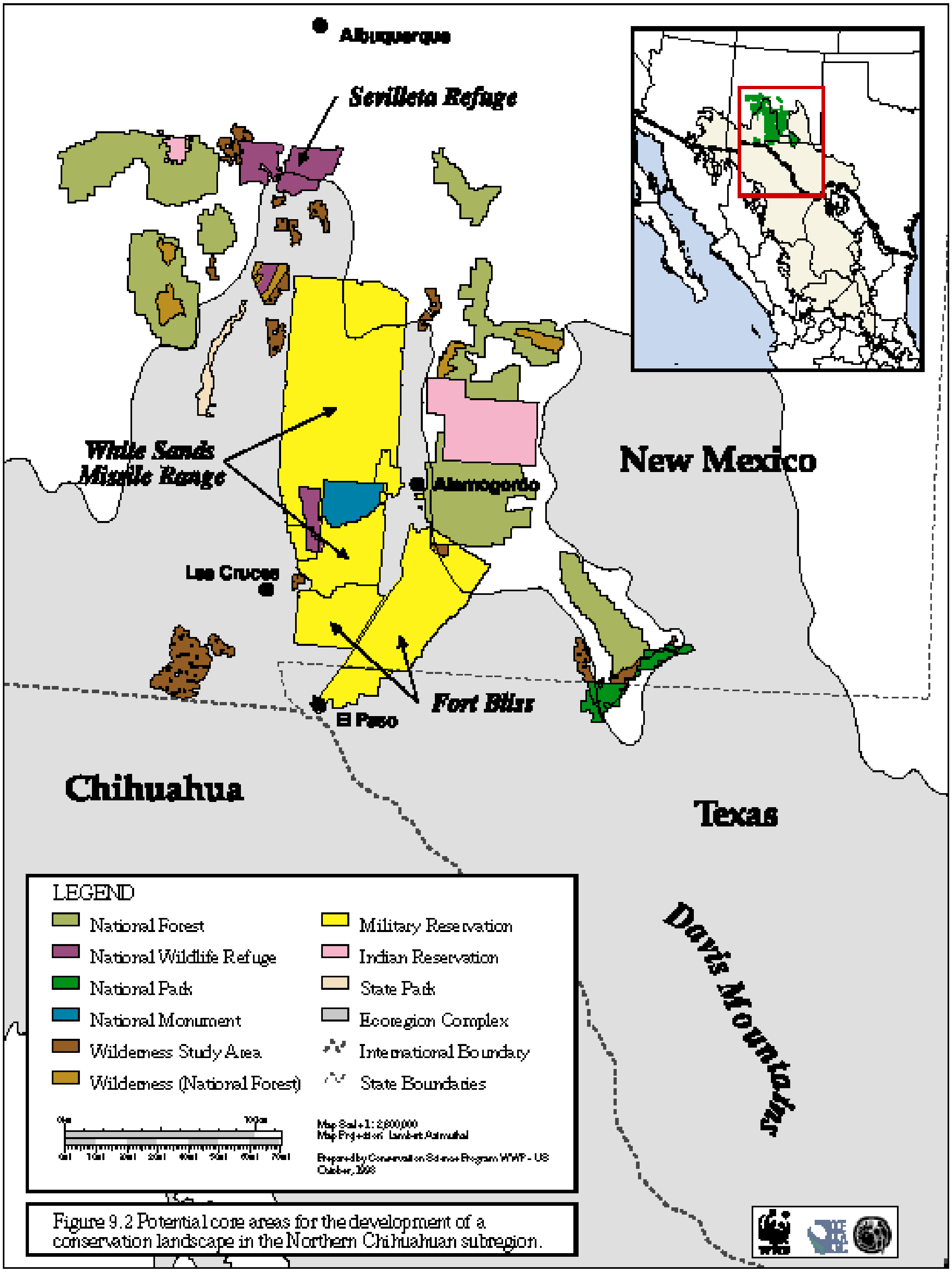
Designing conservation landscapes within the Chihuahuan Desert should begin now. There is great potential for a reserve system from Sevilleta Refuge, near Albuquerque, through the Turner Ranches, White Sands Missile Range, Fort Bliss, the Jornada Experimental Range, and the Davis Mountains (Figure 9.2). This very large conservation landscape would anchor conservation of biodiversity in this subregion. This region would incorporate 3 terrestrial priority sites into its matrix: Tularosa Basin (2.04), Guadalupe Mountains-Carlsbad Escarpment (2.09) and the Sierra Blanca Complex (2.17). Potential partners in the design effort may include: the Wildlands Project, who have pioneered landscape-scale conservation; the Conservation Biology Institute; Defenders of Wildlife; The Nature Conservancy, and other groups.

Testing the rigor of a biological assessment and biodiversity vision

One way to evaluate the rigor of a biological assessment and a biodiversity vision is to compare how effectively they address biological criteria identified by independent experts. We applied criteria furnished by Dr. Gordon Orians to the Chihuahuan Desert biological assessment. The details of this audit are presented in Appendix H. Overall, there is good concordance with the criteria outlined by other authorities on ERBC and the issues addressed in this assessment. This document will undergo further peer review from experts who were unable to attend the workshop as well as workshop participants.

As partners in the conservation of one of the world's most biologically rich warm deserts, citizens of the United States and Mexico have a joint global responsibility before them. Conserving the biological features outlined in this document form the foundation of a biodiversity vision and will set an example for other nations to follow in the long-term conservation of arid ecosystems.

Figure 9-2. Potential core areas for the development of a conservation landscape in the Northern Chihuahuan subregion



Appendix A Summary of Approach

Developing an ERBC strategy

Biologists involved in ERBC must address three primary issues to identify conservation priorities:

- geographic patterns of biodiversity,
- the long-term persistence of biodiversity based on the size and integrity of habitat blocks across the ecoregion, and
- the conditions required to maintain ecological and evolutionary processes at large spatial scales.

The particular emphasis allocated to these issues will vary among ecoregions, depending largely on the major habitat type to which they belong. For example, accurate mapping of geographic patterns of biodiversity would be a prominent activity in biologically complex ecoregions such as tropical moist forests but less so in more uniform ecoregions dominated by boreal forests and taiga. Similarly, the variability of resources may be prominent in tundra-a habitat type characterized by periodic fluctuations of vertebrate populations-but less noticeable in stable, tropical montane environments.

Clearly, each ecoregion is defined by specific biodiversity characteristics that must be addressed in an ERBC strategy. But the major elements of a biological assessment-the conservation goals and targets presented in Chapter 3-are the same for all. This section describes those major elements in greater detail within the context of developing ERBC for the Chihuahuan Desert.

Perhaps the greatest challenge is that the majority of ecoregions around the world suffer from limited data on distribution and occurrences of important elements of biodiversity. Because threats to biodiversity are so grave and the need for conservation action so urgent, conservationists cannot wait until better data become available, but must rely on a combination of indicators, predictive models, and targeted surveys to make the best decisions possible with limited time and resources. For those ecoregions rich in biodiversity data, more sophisticated analyses are possible. While ERBC in data-rich vs. data poor ecoregions will require some different techniques to delineate patterns of biodiversity and landscape integrity, we reiterate that the biological goals and targets will still be the same.

A set of issues must be flagged early on in the process for discussion by the ERBC team. These include: the minimum level of representation required to capture and maintain patterns of biodiversity, ranking of units in terms of priority and distinctiveness, the importance of habitats and taxa as proxies for overall patterns, and the balance between distinctiveness and viability of sites and areas. In the following sections we have tried to address each topic. A more detailed treatment is forthcoming (Olson, et al. ecoregion guidelines).

We propose the following six step process for developing an ERBC strategy.

Step 1: Understanding and mapping ecoregion-wide patterns of biodiversity

A. Conducting representation analyses: an overview

In every ERBC strategy, distinct biogeographic units-either assemblages or communities, within each ecoregion-must be represented in a network of core conservation areas. These units ideally would be determined through formal analyses based on inventories and some indication of relative abundance. However, the reality is that sufficient distributional data to perform these analyses are lacking for most parts of the world. Therefore, plans must often rely on indicator taxa or other proxies, such as habitat types, uncommon soil types or geology, or biophysical features like mountain ranges or endorheic (closed-basin) catchments, which typically support distinctive biotas. For example, isolated tall mountains in xeric landscapes often harbor endemics. Gypsum, saline, limestone, or ultramafic soils typically support specialized plants and high levels of endemism in a variety of taxa. Therefore, when biodiversity distribution data are poor, planners can use other features as indicators to help identify priority areas in representation analyses. There may be cause to conduct rapid, standardized surveys in cases where data are urgently needed. Such surveys would not be general inventories, but rather targeted sampling efforts to measure differences among biogeographic units.

Where adequate data on taxa distribution are lacking, effective representation guidelines can be derived by using subregions and habitat types. However, the degree to which habitat types will function as proxies of distinctive species assemblages depends on the uniqueness of their biotas. However planners choose to delineate such units, they should remember that the overall goal is to identify a set of distinct biogeographic entities that reflect the distribution of biodiversity. In the first stage of determining appropriate levels of representation, planners should use maps of original patterns of biodiversity (*i.e.*, vegetation and habitats), and not limit themselves to the present distribution of remaining native habitats.

A clear set of decision rules can make representation analyses more objective and transparent (Chapter 3, Box 3.3). Each ERBC effort should agree on decision rules, *a priori*, before conducting the analysis. To achieve minimum levels of representation in some biologically complex ecoregions is a difficult but essential task. To do less is to return to business-as-usual in conservation planning.

In ecoregions characterized by high rates of beta diversity and local endemism, representation analyses need to be conducted at a relatively fine level of geographic resolution. This may require many core conservation areas widely distributed over the landscape. In complex ecoregions, it may be appropriate to conduct representation analyses at the site scale. The Australian and South African approaches-emphasizing efficiency, flexibility, and irreplacibility (*e.g.*, complementarity, representation, optimality models, CODA,)-are useful for identifying sets of priority habitat blocks. These techniques are largely restricted to data-rich areas (Pressey 1996).

For many regions where data in museums or the literature are inadequate or outdated, we do not have the time or resources to conduct comprehensive field, museum, and literature surveys given the urgency of threats and decision-making. Thus, another important tool for representation analyses are predictive models. These models help us to estimate the distribution of important biodiversity features based on accessible data (*e.g.* rainfall, seasonality, soils, topography).

1. Defining the Ecoregion and subregions

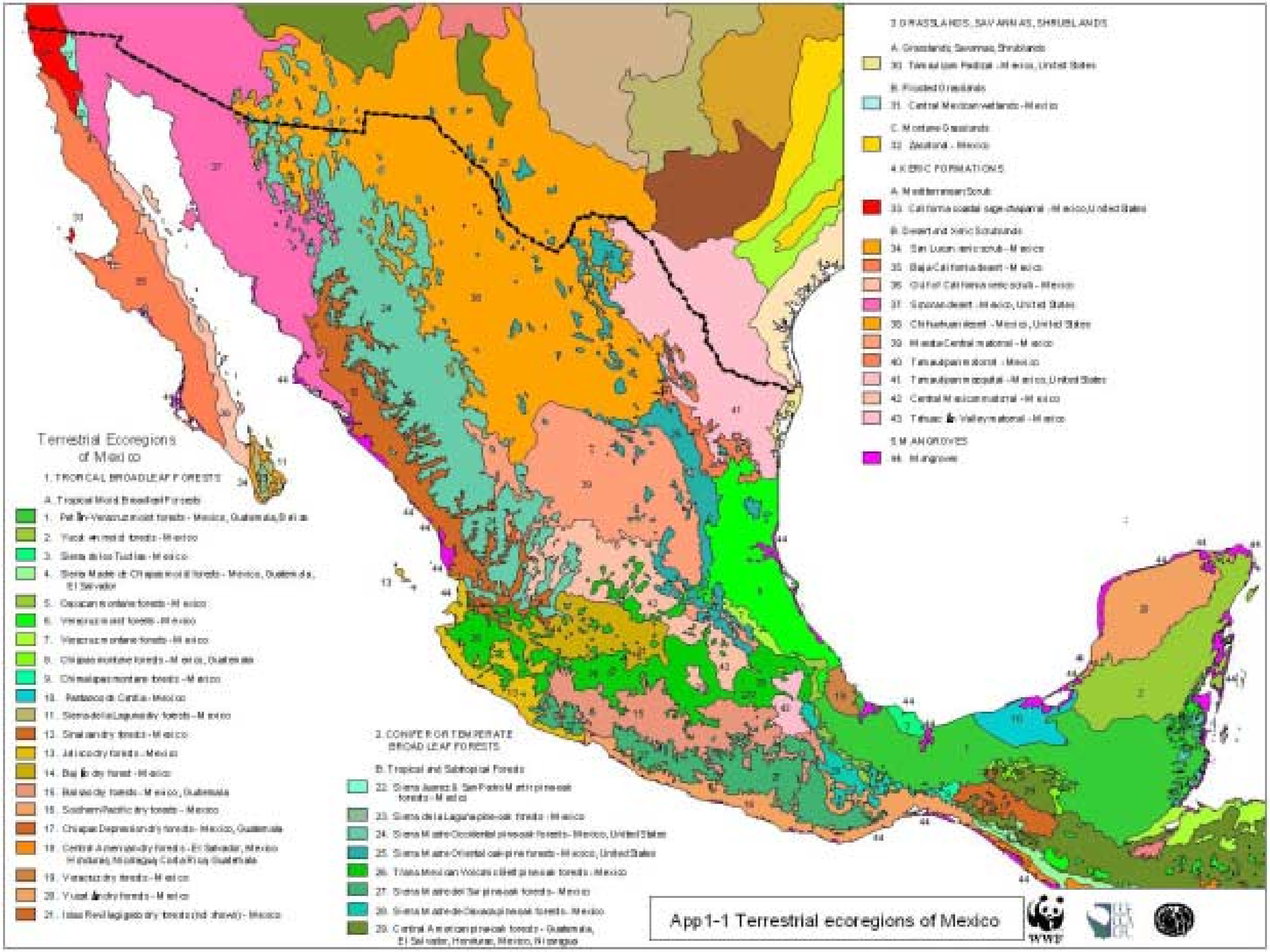
The biogeographic unit used in this analysis was the Chihuahuan Desert Ecoregion Complex (Figure A-1). The overall boundary of the Chihuahuan ecoregion in Mexico was developed by the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) (Figure 3.1). The ecoregion boundaries largely follow habitat classifications developed by the Mexican geographic and natural resource agencies (SEMARNAP and INEGI) using ground-truthed remotely sensed data. The ecoregion boundaries for the portion of the Chihuahuan Desert ecoregion in the United States is based on a WWF ecoregion map for the United States developed by Ricketts *et al*. (1999), a system largely derived from Omernik (1995) and Kuchler (1964). Matching of WWF and TNC terrestrial ecoregion classifications with the CONABIO ecoregion map for Mexico was carried out at a workshop sponsored by The Nature Conservancy.

There exist a variety of different interpretations of what constitutes Chihuahuan biodiversity and where it is distributed. Our desire for a comprehensive look at Chihuahuan biodiversity led us to evaluate two ecoregions together, the Chihuahuan Desert and the Meseta Central, amalgamated as an ecoregion complex. Similarly, the northwestern Chihuahuan Desert (Apachean section) is considered by some biologists as a distinct unit. From a biogeographic perspective, one can also consider the Madrean Sky Islands as a northern extension of the Sierra Madre Occidental, surrounded by lowland Chihuahuan Desert (Figure 3.2). The various montane areas of the northeastern Chihuahuan ecoregion are often regarded as a northern extension of the Sierra Madre Oriental.

For the purposes of the ERBC strategy, we considered the Meseta Central, the Madrean Sky Islands, Apachean region, and the montane areas of the northeast as part of the Chihuahuan Desert ecoregion complex because of important biological and ecological linkages. We agreed also to consider natural communities outside the Chihuahuan ecoregion that are strongly 'Chihuahuan' in character. One exception was the Tehuacán Valley, an isolated xeric region in the state of Oaxaca that has strong biogeographic linkages to the Chihuahuan Desert and Meseta Central ecoregions. The Tehuacán Valley ecoregion is quite distinct biologically, supporting an extraordinary level of plant richness and endemism in a relatively small area. It warrants its own intensive conservation effort.

The variation of habitats within the Chihuahuan Desert suggested the need to further divide the ecoregion into subregions. The assumption is that in very large ecoregions exhibiting a clear latitudinal gradient, subregions will support different assemblages of species in similar habitat types. For example, representation rules might dictate at least one example of desert grassland from each subregion in the portfolio of priority sites for the whole ecoregion. The delineation of biogeographic subregions was based on the judgement of experts at the CONABIO workshops including their evaluation of existing biogeographic analyses of Mexico; The subregion boundaries were further revised by experts at the Chihuahuan workshop.

Appendix Figure A-1 Terrestrial ecoregions of Mexico



The experts agreed on four terrestrial subregions: the Meseta Central (sometimes referred to as the Saladan), the Central Chihuahuan (also called the Mapimian), the Northern Chihuahuan (sometimes referred to as the Trans-Pecos), and the Apachean. The subregions were then used in the representation analysis.

There was concern that many disjunct habitats that were Chihuahuan in character fell outside of these areas. Experts agreed to consider these areas in their analysis if they felt it was appropriate. Peripheral areas included sites such as the Devils River and Mescalero Sands. At the Devil's River, three ecoregions come together. The Edwards Plateau vegetation primarily occupies the tops of the plateaus and the higher elevation canyons. The Tamaulipan thorn scrub is mainly on the lower elevation flats and gentle slopes. Chihuahuan Desert shrublands are found on xeric slopes, usually between the Edwards Plateau uplands and the Tamaulipan lowlands. The experts further agreed not to be bound by ecoregion lines if a site or area of outstanding biodiversity straddled an ecoregion boundary.

The terrestrial biogeographic subregions were not considered suitable for the freshwater analysis, as they do not tend to represent patterns of freshwater biodiversity, which are more closely tied to catchments. Freshwater ecoregions of the Chihuahuan Desert area, as delineated by Abell *et al*. (2000), have a combined perimeter that differs from that of the terrestrial Chihuahuan Desert complex (Figure A-2). We examined all portions of freshwater ecoregions that are within the desert complex or that drain into it, but we did not focus on those areas that are both outside and downstream of the complex. For instance, the lower Río Grande/Río Bravo is part of a long freshwater ecoregion stretching all the way to Big Bend, but we did not attempt to identify sites along the river's southernmost reach, which falls outside the Chihuahuan Desert. On the other hand, experts could have identified sites on the upper Río Grande/Río Bravo or its headwaters, which are upstream of the desert.

2. Determining representative habitats

We asked workshop participants to briefly review a proposed classification of terrestrial and freshwater habitat types to guide them through representation analyses. The scheme synthesizes several different habitat classifications (*e.g.*, Rzedowski 1994, INEGI habitat classes, Henrickson and Johnston, in press, etc.). It s intended to streamline conservation planning and not to replace more comprehensive analyses of Chihuahuan vegetation or habitats from which they are derived. We asked experts for recommendations where classes should be lumped, split, or renamed. Several classifications prompted debate, particularly definitions of some desert scrubs and montane habitats. However, recognizing that a debate about Chihuahuan habitat types could dominate the entire workshop, the experts agreed by consensus vote to adopt the proposed classification with some revisions (Table A2.1 and A2.2).

Appendix Table A2.1 Terrestrial habitat types of the Chihuahuan Desert used in the representation analysis

I. Desert Scrub and Woodlands
- A. *Larrea* desert scrub (*matorral desertico micrófilo*)
- B. Desert scrub (*lechugillal, matorral desertico rosetófilo*)
- C. Yucca woodland (*izotal, matorral desierto rosetófilo*)
- D. *Izotal* (*Dasylirion-Yucca-Agave*)
- E. *Prosopis* scrub (*matorral espinoso*)
- F. Alkali scrub (*matorral halófito*)
- G. Gypsophilous scrub (*matorral gipsofilo*)
- H. Arborescent Cactus Scrub (*matorral sarcocrasicaule, garambullal*)
- I. Lowland riparian woodland (*vegetacion riparia de tierra bajo: bosque*)
- J. Playas

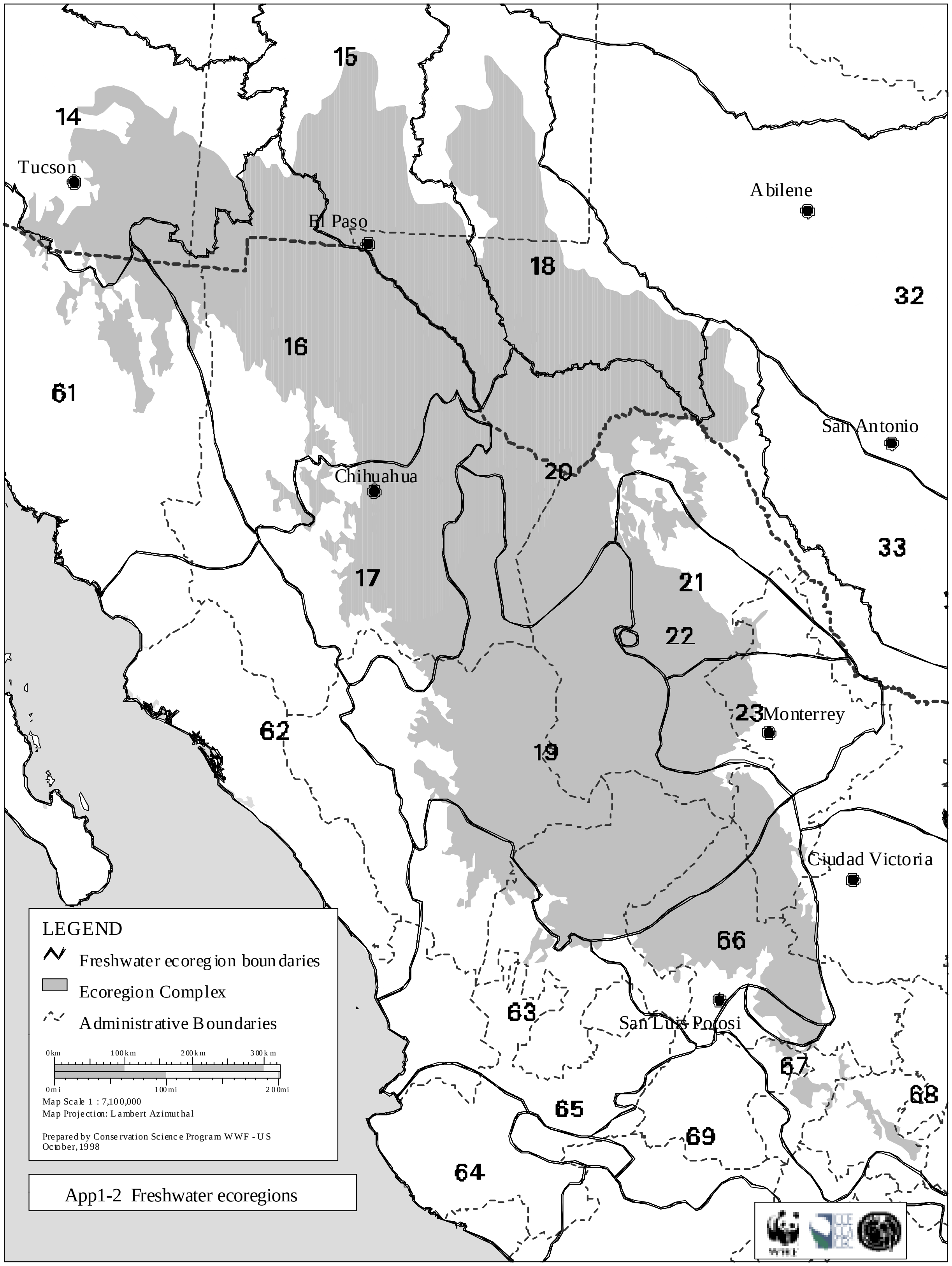
II. Grasslands
- A. Grama grassland (*pastizal mediano abierto*)
- B. Sacaton grassland (*zacatonal*)
- C. Tobosa grassland (*pastizal de tobosa, baja con tobosal*)
- D. Yucca grassland (*pastizal abierto*)
- E. Gypsum grassland
- F. Lowland riparian marshlands (*vegetacion subaquatica de tierra bajo*)

III. Montane Chaparral and Montane Woodlands
- A. Montane chaparral (*chaparral*)
- B. Juniper-pinyon woodland (*bosque de pino pinonero, bosque de esclero aciculifolio*)
- C. Pine-oak woodland (*bosque de encino, bosque de pino-encino*)
- D. Mixed-conifer forest (*bosque de Oyamel*)
- E. Montane deciduous woodland (*bosque de galeria*)

A list of major freshwater habitat types was generated at the start of the workshop, and these were used subsequently for the representation analysis. Eight major habitat categories were identified, five of which were divided into subcategories, for a total of 15 habitat types (Table A2.2).

Appendix Table A2.2 Freshwater habitat types in the Chihuahuan Desert used in the representation analysis

I.	Warm springs	V.	Ephemeral streams
	A. high salinity		A. high gradient
	B. low salinity		B. medium gradient
II.	Cool springs		C. low gradient
	A. high salinity	VI.	*Lagunas*
	B. low salinity		A. permanent terminal
III.	Large rivers & floodplain		B. temporary
IV.	Perennial streams	VII.	*Ciénegas*
	A. high gradient	VIII.	Subterranean habitats
	B. medium gradient		
	C. low gradient		



Appendix Figure A-2 Freshwater ecoregions

B. Identifying distinctive or important areas for indicator taxa

We analyzed patterns of biodiversity across the four subregions-Apachean, Northern Chihuahuan, Central Chihuahuan, and Meseta Central-and the freshwater ecoregions that intersect the Chihuahuan. The terrestrial experts divided themselves up according to five broad taxonomic groups: plants, invertebrates, herpetofauna, birds, and mammals. The freshwater experts worked as a team throughout the workshop. The approach taken by the freshwater team for this portion of the analysis was identical to that for the terrestrial groups, with the exception that the freshwater experts considered all freshwater taxa simultaneously.

The experts first drew polygons on maps around areas they considered to contain outstanding biodiversity features. Examples include foci of species richness and endemism, unique higher taxa, and rare or outstanding ecological or evolutionary phenomena. They also identified areas that were believed still to support relatively intact assemblages of different taxa (Figure A-3). Each group identified distinct sites for its taxon and completed summary description sheets for each. These sheets contained information on specific biodiversity features and primary threats. Neither the scale of the analysis nor the available time permitted the delineation of exact boundaries of sites. The result was a set of maps of nominated sites for consideration as conservation priorities.

We summarize some attributes of important biodiversity features considered in describing nominated sites:

Species richness

Richness foci can occur at the scale of either areas (*e.g.*, whole mountain ranges, subranges, whole or partial basins) or sites (*e.g.*, single valleys or valley complexes, springs, mountain peaks or small ranges, gypsum dunes, smaller areas within basins). We targeted two levels of richness: very high richness (top 10% of richest sites) and high richness (top 20% of richest sites). The experts made comparisons only among assemblages within the Chihuahuan ecoregion complex, and not among assemblages in different ecoregions such as the Sonoran or Tehuacán Deserts.

Species endemism

Endemism foci at the scale of either areas or sites were drawn on the maps. We targeted identification of sites considered to possess very high endemism or high endemism. Again, experts made comparisons only among assemblages within the Chihuahuan ecoregion complex. We recommended that experts focus on species that are endemic to biogeographic subregions, such as the Meseta Central, or to more localized areas such as ranges, basins, or dune systems. Species endemic to the whole Chihuahuan ecoregion and distributed widely across it offer little discrimination among priority sites. An exception would be species restricted to specialized or patchy habitat types, such as gypsum dunes, that have localized distributions wherever such habitats occur.

Unique higher taxa

We requested experts to identify areas or sites that contain a significant number of unique higher taxa (*e.g.*, families, genera) or representatives of primitive or relict lineages.

Rare or outstanding ecological and evolutionary phenomena

We also considered sites that harbor extraordinary or rare examples of ecological or evolutionary phenomena. Examples might include the pronounced radiations, unusual adaptations, and highly local endemism of the biota of the Cuatrociénegas Valley, or the presence of relatively intact vertebrate faunas with top predators such as puma, jaguar, and a full range of prey species. Across the Chihuahuan and in many other ecoregions, intact biotas were once widespread but now constitute rare ecological phenomena. Another example of ecological phenonomena is prairie dog colonies, now restricted to only a few limited areas. They are often associated with a relatively complex assemblage of plants and large vertebrates. We emphasized phenomena that involve many different taxa, rather than a single taxon.

Critical sites for the maintenance of large-scale ecological phenomena

Experts were asked to identify sites that may be particularly important for maintaining large-scale ecological phenomena such as migrations of raptors, songbirds, shorebirds, bats, or invertebrates. Clearly, many of these phenomena operate over broad landscapes, but this task is intended to identify those sites that may be particularly critical, such as certain wetlands, riparian woodlands, concentrations of flowering plants (for migrating nectar-feeding bats), or forest patches.

Gaps in biodiversity information

We asked the experts to identify sites where data are inadequate to assess their biological value. These sites are in need of taxonomic inventories for effective conservation planning.

C. Synthesizing nominated sites based on taxonomic priorities

From the taxon specialist groups, participants then reorganized themselves according to subregional expertise and reviewed the nominated sites for each taxon for each subregion. They then synthesized this taxonomic information to identify candidate priority sites. They wrote descriptions of each candidate priority site and summarized the conservation targets emphasized in their selection (Box 3.1). Experts also provided more detailed information for specific sites in terms of their outstanding biodiversity features, habitat status, and short and long-term threats.

Habitat representation analysis

The experts conducted a coarse analysis to ensure that all habitats were represented by the candidate priority sites. The habitat representation rules we used are listed in Chapter 3 (Box 3.3). If a habitat type was poorly represented within a subregion, the portfolio was reevaluated and revised to meet representation goals. The freshwater group evaluated their priority sites in terms of their efficacy in representing the full range of freshwater habitats, but did not consider subregions separately.

Step 2: Determining minimum area requirements for maintaining viable populations and processes

Representation must be accompanied by conservation of habitats or sites of sufficient size to promote persistence of native biota over the long-term (as determined through persistence analyses in the next step). Thus, in Step 2 we look at where native habitats remain and determine what kind of features promote the long-term persistence of different elements of biodiversity.

For all ecoregion analyses, it is important to identify as accurately as possible those landscape features associated with minimum size requirements for conserving important elements of biodiversity. In other words, how large does a block of grassland have to be to conserve a viable population of top predators, species with large home ranges, or wide-ranging species that follow patchy resources? What constitutes an effective size of a habitat type for conserving distinct plant and invertebrate assemblages in areas where larger vertebrates have been largely extirpated?

Ecoregion planners need to formally associate different landscape features with their effectiveness for conserving different elements of biodiversity including specific guilds, habitats, or phenomena. One way to approach this is to focus on area-dependent species, such as top predators, wide ranging herbivores, or species dependent on metapopulations specialized on patchy habitats. One can estimate the total area needed to maintain a viable population of the species at several levels (*e.g.*, long-term persistence = 500 pairs; short-term persistence = 50 pairs; short-term source pool < 10 individuals). The assumption behind this approach is that if plans can meet the requirements of species requiring large areas, they will also conserve adequate habitat and resources for a wide range of other species and phenomena with smaller area requirements.

Another consideration are habitat types or phenomena that require certain minimum areas to be maintained over time, such as natural fire regimes, or habitats characterized by mosaics of many different successional phases. Plans also must consider the area needed to be maintained as core areas (strict protection) versus areas of restricted resource use. Some species will require strictly protected areas as source pools because of their sensitivity to disturbance.

Each ERBC strategy must also consider the importance of replication of distinctive units. Conservation theory suggests that the probability of “global” persistence increases significantly when three or more examples of a “unit” (*e.g.*, species populations, habitats) are effectively conserved. The planning team must decide how much to invest in replication relative to representation (*e.g.*, conserving many different kinds of units) or maximization of persistence features for a single unit (*e.g.*, invest in increasing the size of a single block).

In summary, ecoregion planners should develop, *a priori*, minimum habitat areas and other landscape-level feature requirements necessary to conserve different elements of biodiversity (*e.g.*, species, habitat types, processes, assemblages). The analysis for this step was only conducted in a cursory manner for the Chihuahuan Desert. It is an important part of the biological assessment but time constraints precluded deriving minimum critical sizes prior to or during the workshop. This is an issue that should be reexamined in future iterations of the analysis. As a proxy, many of the highest priority areas identified (Chapter 6) are extremely large. Conservation at the scale of thousands and in some cases tens of thousands of km^2 will likely be adequate to address minimum size requirements for some area-limited species and certain ecological processes.

After the analyses of patterns of biodiversity (representation and important areas), we evaluated the proposed priority areas to ensure that larger-scale ecological processes and phenomena will be maintained. At global and continental scales, some specific sites may be particularly important for migratory birds, mammals, or invertebrates. Within ecoregions, certain habitats or linkages may be critical for maintaining seasonal movements of species, promoting ecological processes such as dispersal, or providing spatial and temporal refugia from short and long-term disturbances. For example, a primary target for some ecoregions may be the conservation of intact altitudinal gradients, or wide blocks of intact habitat or riparian corridors connecting large core reserves. Specific phenomena for the Chihuahuan desert ecoregion include: seasonal migrations of songbirds, shorebirds, raptors, and sparrows; migration corridors for monarch butterflies and sphingid moths; seasonal movements of bats tracking flowering cacti; altitudinal movements of birds and larger vertebrates between lowland and montane habitats; and dispersal corridors among mountain ranges for larger vertebrates. Addressing these issues is one of the primary reasons to undertake ecoregion-scale conservation.

Step 3: Evaluating persistence of species and habitat integrity

In ecoregions already subjected to widespread habitat degradation, planners must evaluate characteristics of remaining blocks of habitat that strongly influence their ability to maintain important elements of biodiversity. These landscape features include: shape (configuration), degree of fragmentation, level of degradation and isolation, status of neighborhood patches of habitat, and adjacent or intervening land use (linkage analyses).

Here we tried to identify where native biodiversity has the greatest chance of persistence over the long-term. Essentially, our focus was on landscape features and landscape-level threats in order to better understand what threats are most important and where we can most effectively conserve biodiversity. Such information is used to assess the ecological integrity of proposed priority sites, inform habitat representation analyses about the quality of different sites, and to help identify larger areas of intact habitat which may have been missed in the priority site identification process.

We asked the experts to review maps depicting remaining habitat and classify blocks using three general classes of intactness: intact habitat, altered habitat, and heavily altered habitats. Definitions for each of the intactness levels are provided below. In theory, the entire Chihuahuan ecoregion can be divided into areas representing each category of intactness.

We focused on identifying the intact habitats and partially degraded habitats (areas that still support much biodiversity and have good restoration potential). In part, this was because we were constrained by time and were primarily interested in the most intact categories to help identify priority sites and areas. However, degraded areas with unique biodiversity have a role to play in maintaining many species and ecological processes. The conservation needs of these areas were addressed on the last day of the workshop during the discussion of ecoregion-wide threats (*e.g.*, grazing policies). Moreover, rare habitat types whose only examples are extensively degraded warrant immediate conservation attention to ensure representation of their biodiversity value.

Persistence value analyses help define the ecological integrity of a habitat block or adjacent set of blocks. They provide two sets of rankings. First, they evaluate persistence based on current conditions, or a 'snapshot' of landscape parameters. Second, these snapshot rankings can be modified based on estimates of longer-term threats (*e.g.*, 5-10 year) to each habitat block to produce an assessment of long-term persistence. The cumulative effects of perceived threats can be estimated for three primary impacts: habitat loss, habitat degradation, and wildlife exploitation (see Ricketts *et al*. 1999). It should be kept in mind our confidence in estimates of future threat may vary significantly because of the fluidity and complex synergies of human activities. Thus, it may be best to limit this phase of the analysis to snapshot rankings, and bring in future threat to help identify investment or action priorities after biodiversity conservation priorities have been established.

Definitions of categories of intactness

Persistence analyses require a definition of what constitutes intact habitat. We propose a three-class system in which terrestrial and freshwater habitat areas are categorized as intact, altered (*i.e.*, degraded), or heavily altered. Intact habitat represents relatively undisturbed areas that maintain most original ecological processes and by communities supporting most of their original suite of native species. Altered habitat represents areas more substantially affected by human disturbance, but which still have the potential to sustain species and processes. Heavily altered habitat represents areas that have been degraded to the point of retaining little or no potential value for biodiversity conservation without long-term and extensive restoration. The experts discussed the definitions and made modifications appropriate to the Chihuahuan Desert. The definitions for intactness used as guidelines at the workshop are as follows:

Broadleaf and conifer forests

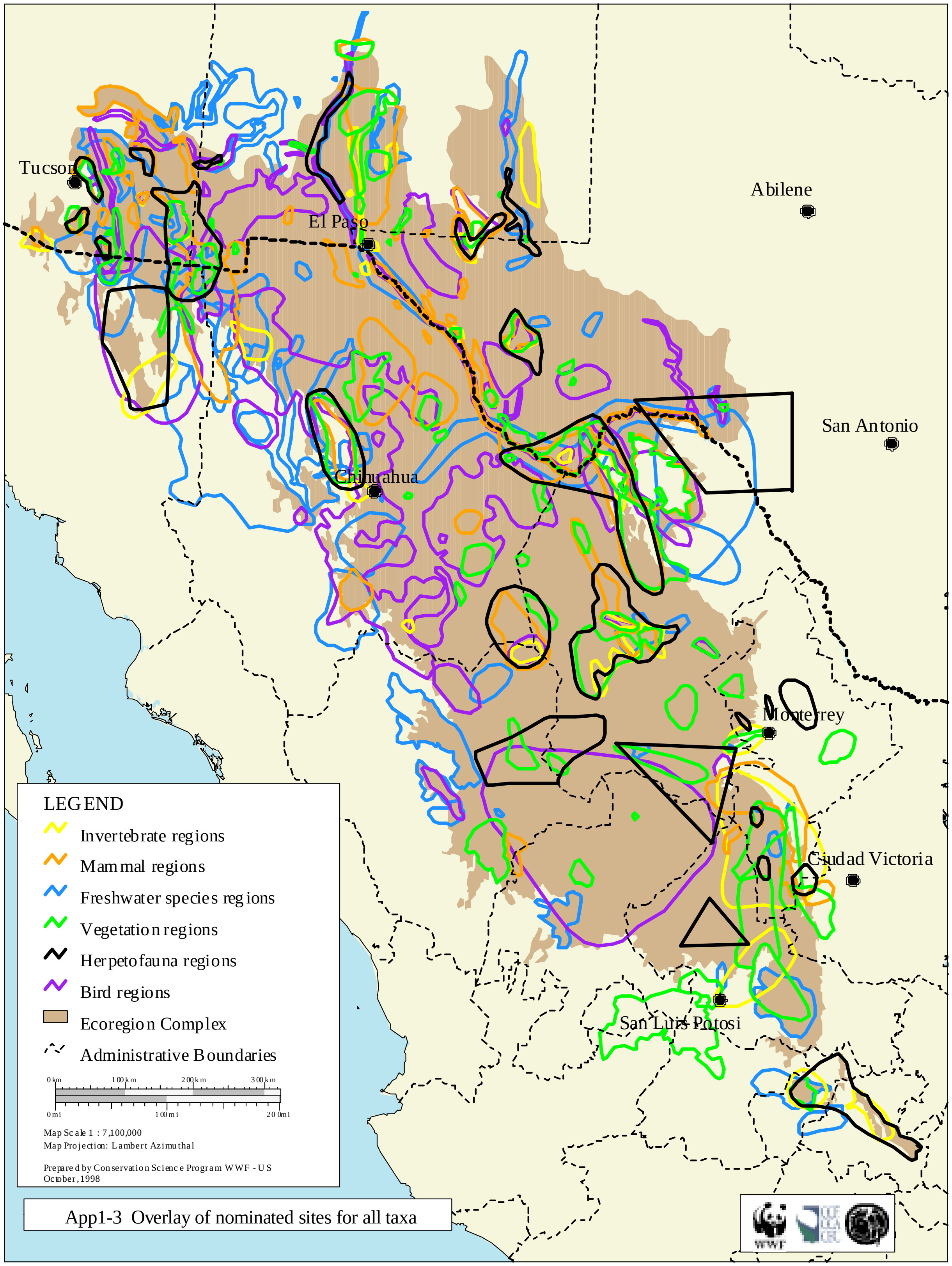
- Intact: Canopy disturbance through human activities such as logging is restricted to less than 10% of defined habitat block. Understory largely undisturbed by timber extraction, intensive management, or grazing. Natural fire regimes still present. Although large mammals and birds may presently be absent from some blocks of habitat because of exploitation, insufficient area, or diminished resources, such blocks sustain many native communities and populations of plant, invertebrate, and vertebrate species and associated ecological processes.

- Altered: Canopy and understory significantly disturbed by human activities, but habitat remains suitable for some native species. Species composition and community structure are altered, and a large proportion of native species are absent but likely to return given sufficient time for recovery and adequate source pools. Examples include: large expanses of selectively logged forests; forests in which natural fires have been suppressed; areas where clearcuts cover are limited to between 10% and 25% of the landscape and patterned to facilitate natural ecological processes and recolonization; and 100 year old clearcuts that have been allowed to regenerate and contain adequate source pools for restoration.
- Heavily Altered: Habitat almost completely altered. Substrate alteration, exotic species introduction, and distance from source pools make recovery of original habitat unlikely without

large and expensive restoration efforts. Examples include: urban and suburban development, forests converted to pasture or cropland, extensive clearcuts, and intensively managed plantation forests.

Grasslands, xeric shrublands/deserts

- Intact: Habitat remains unplowed or unaltered by major changes in hydrologic patterns. The full suite of native plant species is still present, each in abundances within its natural range of variation. Successional patterns follow natural cycles (*e.g.*, grazing by domestic livestock has not had a major effect on species composition or seral stages). Natural fire regimes are still present. Although large mammals and birds may presently be absent from some blocks of habitat due to exploitation, insufficient area, or diminished resources, such blocks still sustain many native communities and populations of plant, invertebrate, and vertebrate species and associated ecological processes.
- Altered: Heavy grazing has altered dominance patterns of plant species. Some exotic species are present and surface water patterns may be altered, but the substrate has not been disturbed or plowed. Natural fire regimes have been largely suppressed. Original habitat is likely to return with time, moderate restoration, and adequate source pools.
- Heavily Altered: Habitat is almost entirely altered, such as by human development, plowing, or crop cultivation. Native species are almost entirely replaced by exotics and crops. Surface water patterns have been extensively altered. Natural fire regimes have been completely suppressed.



Appendix Figure A-3 Overlay of nominated sites for all taxa

Freshwater

- Intact: Upstream land uses such as grazing, logging, urbanization, or agriculture are limited or well-managed. Habitats are largely undisturbed by altered hydrographic integrity, pollution, fragmentation, or other forces. Few exotic species are established, and native species face little or no exploitation pressures. Although large fish or aquatic reptiles may presently be absent from some habitat where they originally occurred due to exploitation, insufficient area, or diminished resources, such areas sustain many native communities and populations of plant, invertebrate, and vertebrate species and their associated ecological processes.
- Altered: Human disturbance has extirpated many sensitive species, but habitat remains suitable for some native species. Species composition and community structure are altered, but native species are likely to return given sufficient time for recovery and adequate source pools. Examples are freshwater systems receiving point-source pollution, stream reaches isolated by lowhead dams, and areas where riparian cover has been removed.
- Heavily Altered: Many species are already extirpated or extinct. Habitat is almost completely altered. Surrounding land development, the presence of large permanent structures altering hydrographic integrity, established exotic species, and consistently poor water quality make recovery of original habitat unlikely without large and expensive restoration efforts. Examples are dewatered or heavily channelized streams in areas of agricultural development, or highly polluted lakes in industrial or urban areas.

Step 4: Identifying priority sites

Candidate sites were prioritized by locating each site in a matrix of biological features and habitat integrity, and assigning different combinations a different priority level. Highest priority sites were identified from this process. These priority sites represent the core of an ecoregion-scale conservation strategy.

For terrestrial sites, we developed a matrix for addressing prioritization of sites based on the integration of two variables: landscape integrity and biological distinctiveness (Figure 3.2). Landscape integrity was divided into three main categories: intact or relatively intact, degraded, and highly degraded but still restorable. Each of these three categories was further subdivided into three size categories: habitat blocks > 1,000 km^2, habitat blocks >100 km^2 but <1,000 km^2, and habitat blocks < 100 km^2. Biological distinctiveness ranged from sites that supported high levels of endemism or rare communities or important ecological and evolutionary processes at one end of a spectrum to multiple sites that support similar species and communities.

We asked participants to break into four groups and assign priority of importance to each cell with a ranking of 1 through 5. We averaged the scores assigned by each group to the cells of the matrix to develop a final ranking.

The ranks were defined as follows:

1= sites of global (highest) priority that form the core of a Chihuahuan conservation strategy
2= sites of high priority that also contribute to a Chihuahuan conservation strategy
3= sites of regional priority that should be considered in a Chihuahuan strategy
4= sites that are important in state conservation strategies (*e.g.*, Arizona, Coahuila)
5= sites of lower priority that support communities or processes conserved in multiple sites across the subregion or ecoregion.

The sites were then fitted to the matrix and assigned ranks that were subsequently color coded and mapped. Sites that were identified as lower priority were dropped from the final list of priority sites.

The freshwater group devised their own matrix, similar to the terrestrial in its basic form, but without the subdivisions that were not applicable to freshwater habitats (Figure 3.3). Using the priority-setting matrix, the freshwater experts assigned scores of 1-5 to each of the nominated sites. After this exercise, only one site (Cuatrociénegas) received the highest score of 1, so the experts unanimously decided to raise the ranks of all other sites by 1. Those nominated sites ranked 1 or 2 were selected as priority sites. In the view of the freshwater experts, virtually all important freshwater sites in the Chihuahuan Ecoregion Complex have such high levels of endemism that it is difficult to prioritize among them at a scale lower than catchments. As a result, many of the freshwater priority sites are catchments in which several nominated and priority sites are clustered together.

Protected area gap analysis

Protected areas are the cornerstone of biodiversity conservation. Many sensitive species and habitats only persist in places where human activities are restricted. Often, protected areas support the only remaining source populations of endangered species-sites where reproduction exceeds mortality. Habitats outside protected areas may be no more than sinks, where populations disperse but do not recruit young in adequate numbers to replace themselves. Gap analysis becomes a fundamental step in ERBC because it illustrates the degree of overlap of outstanding biological features, potential source populations, and protection units.

A second type of overlay analysis is also useful: the comparison of priority sites selected by previous workshops or assessments. Few ecoregions are a *tabula rasa* for priority-setting; there usually exists one or more published or unpublished attempts to set conservation priorities, even if only at very coarse scales. All ERBC efforts should, wherever appropriate, build on such efforts, but also state clearly any differences in methodology, conservation goals, targets, or scale.

Priority sites, activities, or phenomena highlighted in the ecoregion strategy that are insufficiently protected may be identified as priority for conservation action at this stage. Priority areas considered well protected are still recognized as important and should garner continuing support. However, priority gaps may warrant immediate action and investment, particularly if they are under threat.

Step 5. Threat assessment

Next, we conducted a threat assessment of priority sites. We hoped to be able to characterize the 'threat trajectories' of the priority sites in order to help us determine the best timing and sequence of conservation activities. This threat assessment is intended to: 1) gauge the urgency for conservation action, 2) assess the presumed ecological integrity of sites over the next two decades, and 3) help determine the kinds of interventions needed at each site and across the ecoregion.

Threat analyses are inherently complex because they may affect ecosystems directly or indirectly, individually or in a cumulative manner. The effects of some threats are also poorly understood. To evaluate as objectively as possible the range and severity of threats facing the ecoregion, we categorize them into three major types for terrestrial biodiversity: conversion threats, degradation threats, and wildlife exploitation threats. For freshwater biodiversity, the three major categories were: catchment-scale threats, habitat threats, and biota threats. Each category is assigned points based on the anticipated severity and the time-frame over which the threat is expected to occur. This analysis is a coarse assessment that treats only the aggregate effects of the threats in each class, not individual sources (*e.g.* individual timber sales, proposed mine sites, etc.).

For both terrestrial and freshwater habitats, we used an index of 0-100 points to determine pending threats to a site. Points were attributed to three major categories of terrestrial threat as follows: conversion threats (maximum 50 points), degradation threats (maximum 30 points), and wildlife exploitation threats (maximum 20 points). Conversion threats were weighted most heavily because the effects of habitat conversion are generally more far-reaching and difficult to reverse than either degradation or wildlife exploitation. For freshwater, catchment-scale threats could receive a maximum of 40 points, while the other two categories had a maximum of 30 points each. This weighting was based on the assumption that catchment-scale threats can be more difficult to mitigate. Based on the tables that follow, experts can assign the appropriate points for each of the threat types to each site. The general level of threat can be estimated from the point totals:

70-100	High Threat
20-69	Medium Threat
0- 20	Low Threat

The first table below lists some of the types of threats to terrestrial habitats in each category. The second table illustrates the points assigned to each category depending on the intensity and timeframe of the anticipated threats.

A. Type of threat

*Categories for threats***:**

Conversion threats

- intensive logging & associated road building
- intensive burning or grazing leading to habitat loss (particularly in riparian areas)
- agricultural expansion & clearing for development
- permanent alteration from burning

Degradation threats

- pollution, *e.g.*, oil, pesticides, herbicides, mercury, heavy metals, defoliants
- burning frequencies and intensities outside of the natural range of variation
- loss of habitat, resources, or individual organisms from introduced species
- fuelwood extraction
- unsustainable extraction of non-timber products
- grazing patterns, frequencies, and intensities outside the natural range of variation
- road building & associated erosion and landslide damage
- off-road vehicle damage
- selective logging
- excessive recreational impacts

Wildlife Exploitation

- hunting and poaching
- unsustainable extraction of wildlife and plants as commercial products
- harassment & displacement by commercial and recreational users

B. Intensity & Time frame

Category	**Description**	**Points**
Conversion threats		
1	Threat(s) may significantly alter 25% or more of remaining habitat within 20 years	50
2	Threat(s) may significantly alter between 10% and 24% or more of remaining habitat within 20 years	20
3	Threat(s) may significantly alter between 5% and 9% or more of remaining habitat within 20 years	10
4	No conversion threat(s) recognized for ecoregion	0

Category	**Description**	**Points**
Degradation Threats		
1	High: Many populations of native plant species experiencing high mortality and low recruitment due to degradation factors. Succession and disturbance processes significantly altered. Low habitat quality for sensitive species. Abandonment and disruption of seasonal/migratory/breeding movements. Pollutants and/or linked effects widespread in ecosystem (*e.g.*, recorded in several trophic levels).	30
2	Medium: populations of native plant species experiencing significant mortality and poor recruitment due to degradation factors. Succession and disturbance processes modified. Some	

	abandonment and underuse of seasonal/migratory/breeding movements by species. Pollutants and/or linked effects commonly found in target species or assemblages.	15
3	No degradation threats recognized for ecoregion	0

Wildlife Exploitation

1	High intensity of wildlife exploitation in region with elimination of local populations of most target species imminent or complete.	20
2	Moderate levels of wildlife exploitation, populations of game/trade species persisting but in reduced numbers	10
3	No wildlife exploitation recognized for ecoregion	0

Threats to freshwater habitats are generally similar, but with some important differences:

A. Type of threat

Categories for threats:

Catchment-scale threats (land cover change)

- intensive logging & associated road building
- intensive grazing, particularly in riparian zone
- agricultural expansion & clearing for development
- urbanization and associated changes in runoff

Habitat threats

- degraded water quality (*e.g.* point or nonpoint source pollution; changes in temperature, pH, DO, other physical parameters; sedimentation and/or siltation)
- altered hydrographic integrity (flow regimes, water levels), resulting from dams, withdrawals, channelization, etc.
- habitat fragmentation, from dams or other barriers to dispersal and general movement
- reduced organic matter input
- additional habitat losses, such as siltation of spawning grounds
- excessive recreational impacts

Biota threats

- unsustainable fishing or hunting
- unsustainable extraction of wildlife as commercial products
- competition, predation, and infection by established exotic species

B. Intensity & Time frame

Category	**Description**	**Points**
Catchment threats		
1	Threat(s) may significantly alter 25% or more of catchment within 20 years	40
2	Threat(s) may significantly alter between 10% and 24% or more of catchment within 20 years	25
3	Threat(s) may significantly alter between 5% and 9% or more of catchment within 20 years	10
4	No catchment-scale threat(s) recognized for ecoregion	0
Habitat threats		
1	High: Many populations of native species experiencing high mortality and low recruitment due to habitat degradation. Low habitat quality for sensitive species. Abandonment and disruption of migratory/breeding movements. Pollutants and/or linked effects widespread in ecosystem (*e.g.*, recorded in several trophic levels).	30
2	Medium: populations of native species experiencing significant mortality and poor recruitment due to degradation factors. Succession and disturbance processes modified. Some abandonment and underuse of migratory/breeding movements by species. Pollutants and/or linked effects commonly found in target species or assemblages.	15
3	No degradation threats recognized for ecoregion	0
Biota threats		
1	High intensity of wildlife exploitation and/or disturbance by exotics in region.	30
2	Moderate levels of wildlife exploitation and/or disturbance by exotics.	15
3	No wildlife exploitation or exotics recognized for ecoregion	0

The threats to each priority site were scored using the above criteria, and each was assigned a threat ranking of high, medium, low or unknown.

Experts estimated the most significant ecoregion-wide threats to biodiversity and ecological integrity. We first listed wide-ranging threats to Chihuahuan biodiversity. After the experts agreed to an initial list of 25 threats (some nominees were dismissed as degradation effects rather than threats driving that degradation), each expert was instructed to vote for five that they considered the most pernicious threats to biodiversity in the Chihuahuan Desert. Biologists have the best perspective on how these threats directly or indirectly impact biodiversity. Analyses of the correlation among threats as well as their proximate and ultimate nature are needed.

Step 6: Developing a biodiversity vision

An important goal of ERBC is to define what success looks like from a biodiversity conservation perspective. Elements of success include: a portfolio of important sites that conserve characteristic communities and processes, key activities to increase protected area coverage and design of conservation landscapes, and mitigation of overarching threats to avoid further erosion of biodiversity.

With these factors in mind, we discussed what successful biodiversity conservation would look like over the next 20 years for the Chihuahuan as a whole and for each subregion. We compared how important biological features identified by the workshop fit into a long-term vision. By the end of the workshop, experts had reached consensus on a map of critical sites for Chihuahuan conservation. To encourage greater participation in formulating the biodiversity vision, we asked each terrestrial subgroup and the freshwater group to develop their own and share it with the entire workshop. Each presentation described the outstanding biological features of the subregion, key sites for conservation, major threats to biodiversity that must be mitigated, a draft biodiversity vision, and potential partners in developing and achieving the vision. The biodiversity vision for the entire ecoregion then is an attempt to synthesize the results of these presentations and ensure that they reflect the original conservation targets (Box 3.1).

The priority sites identified by the matrices constitute a system of core conservation areas that harbor representative and outstanding conservation targets. However, for the long-term persistence of biodiversity, the vision must address conservation in matrix areas, that is, in degraded lands or multiple use lands outside core areas. Better management of these areas are needed to sustain ecological processes such as dispersal or seasonal movements of larger vertebrates. Thus, a long-term vision for conservation of the Chihuahuan Desert should consider: 1) a network of core areas that conserve intact native ecosystems and meet a suite of conservation goals, 2) linkage zones or corridors that maintain biotic interactions among core units, and 3) the application of certain landuse and wildlife practices and conservation of keystone habitats (*e.g.*, riparian habitats, springs) in matrix areas which help sustain ecological integrity across landscapes and within core areas.

An effective vision should also define benchmarks for success to achieve biodiversity targets. The vision should outline the most appropriate sequence of activities and targets. In the Chihuahuan Desert, for example, it may be easier to achieve conservation of representative biotas in some subregions than others, or easier to conserve areas rich in endemics than it will be to restore large mammal assemblages.

Ecological integrity of whole ecoregions

Much work needs to be done in delineating reserve networks and corridors at regional scales. Some of this important work has already been initiated in detail in the Apachean region by the Wildlands Project. Through this workshop, the participants reached consensus on a map of critical core conservation areas for Chihuahuan conservation. Future analyses must identify important linkage corridors, buffer areas, and appropriate landuse practices and threat mitigation.

Next Steps: Conservation feasibility analyses

The Chihuahuan workshop is a first step in a process to develop a comprehensive strategy for conservation of the full range of the ecoregion's biodiversity. Ultimately, in order to determine when and where to take conservation action, we will need to evaluate social, political, economic, and cultural forces at work. For any conservation strategy of this magnitude to be effective, it must be developed in cooperation with stakeholders from all points of the geographic and political compass. Any such strategy, however, must be guided by biological conservation priorities, providing a roadmap for conservation action and a set of long-term conservation objectives.

Conservation planners can estimate the appropriate timing and sequence of investments through detailed assessments and predictive models of human infrastructure, land use patterns, and other political, social, cultural, and economic data layers. Information on roads, population centers and movements, land use patterns, and other human-related features can be used to estimate where alteration and degradation of natural communities will be most intense in the future. Political and social analyses can help identify where conservation opportunities are greatest. Recognizing specific patterns of disturbance can also help prioritize areas for conservation investment. In some cases, working in high priority areas identified in the biodiversity analysis may be extremely difficult or dangerous. Conservation planners should monitor these high priority areas and be prepared to initiate conservation activities if conditions change.

The analysis of social, political, economic, or cultural data should only be brought into the analysis after the biological priorities have been determined. Detailed analyses of these factors are most usefully conducted at the scale of the high priority biological sites or subregions after these have been identified. Experts in feasibility issues should focus on the following questions:

- Can we augment the biological analyses by identifying ecoregion-wide, relatively coarse databases that provide information on general threats to sites within ecoregions, particularly as they apply to habitat loss, habitat degradation, and wildlife exploitation?

- How can we achieve biodiversity conservation objectives (see fundamental goals, general targets) through interventions that positively influence political, social, economic, and cultural factors at site or subregional scales? In some cases, external threats will have to be addressed, but often these are not necessarily geo-referenced to individual sites.

Thus, specialists in feasibility analyses will be primarily active in developing effective tools and approaches at the site or subregional level in collaboration with local field staff and experts. Some specialists will focus on affecting change in ecoregion-wide forces that degrade biodiversity such as commercial logging, fishing, grazing, mining, and oil exploitation.

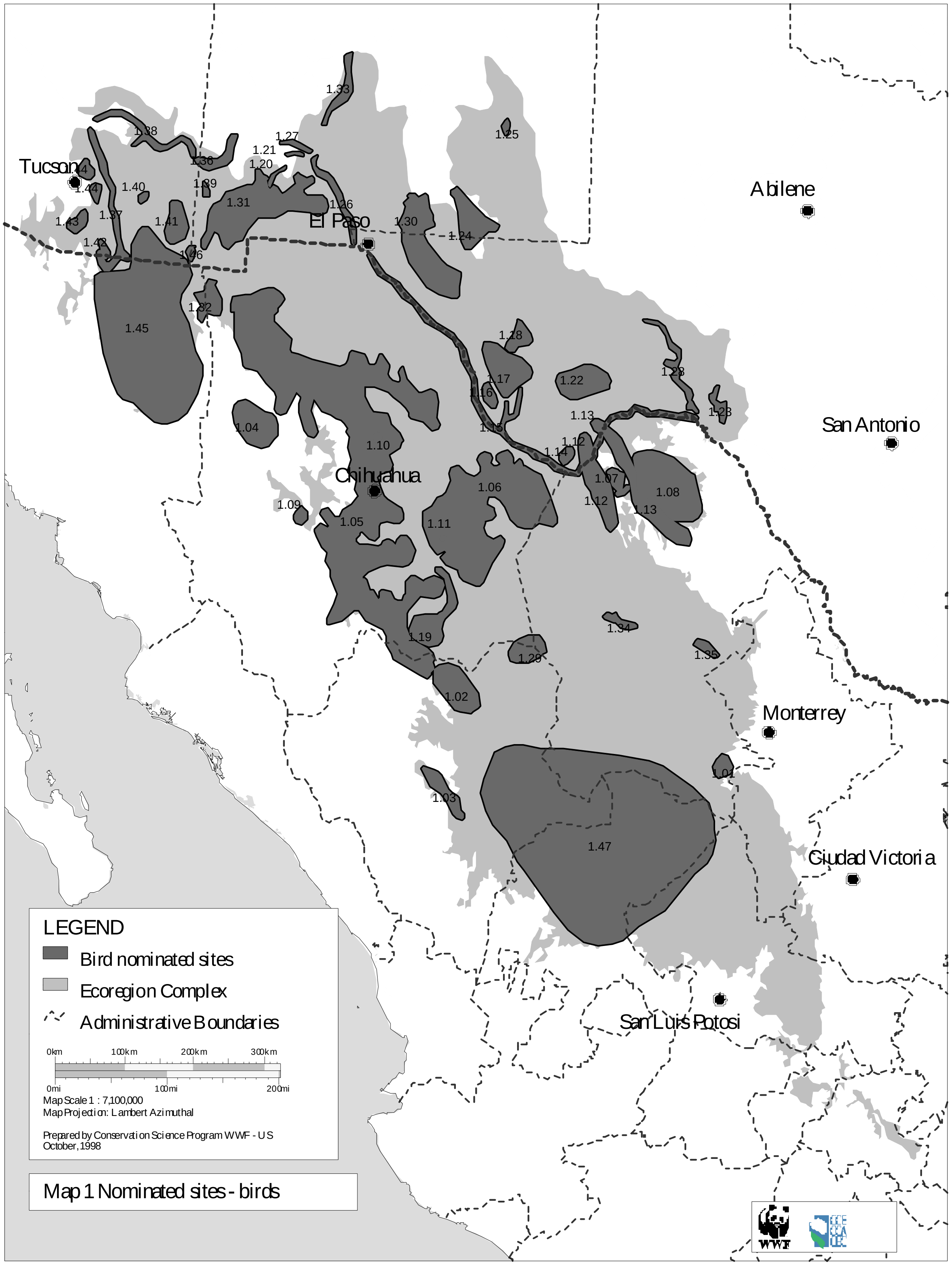
Appendix B   Nominated Sites within the Chihuahuan Desert

We analyzed patterns of biodiversity across the four subregions—Apachean, Northern Chihuahuan, Central Chihuahuan, and Meseta Central—and the freshwater ecoregions that intersect the Chihuahuan. The terrestrial experts divided themselves up according to five broad taxonomic groups: birds, herpetofauna, invertebrates, mammals, and plants. The freshwater experts worked as a team throughout the workshop.

The experts first drew polygons on maps around areas they considered to contain outstanding biodiversity features. Examples include foci of species richness and endemism, unique higher taxa, and rare or outstanding ecological or evolutionary phenomena. They also identified areas that were believed to still support relatively intact assemblages of different taxa. Neither the scale of the analysis nor the available time permitted the delineation of exact boundaries of sites. The result was a set of maps of nominated sites for consideration as conservation priorities.

Map 1 (following page) contains the bird nominated sites, and the key to the nominated site names is listed below:

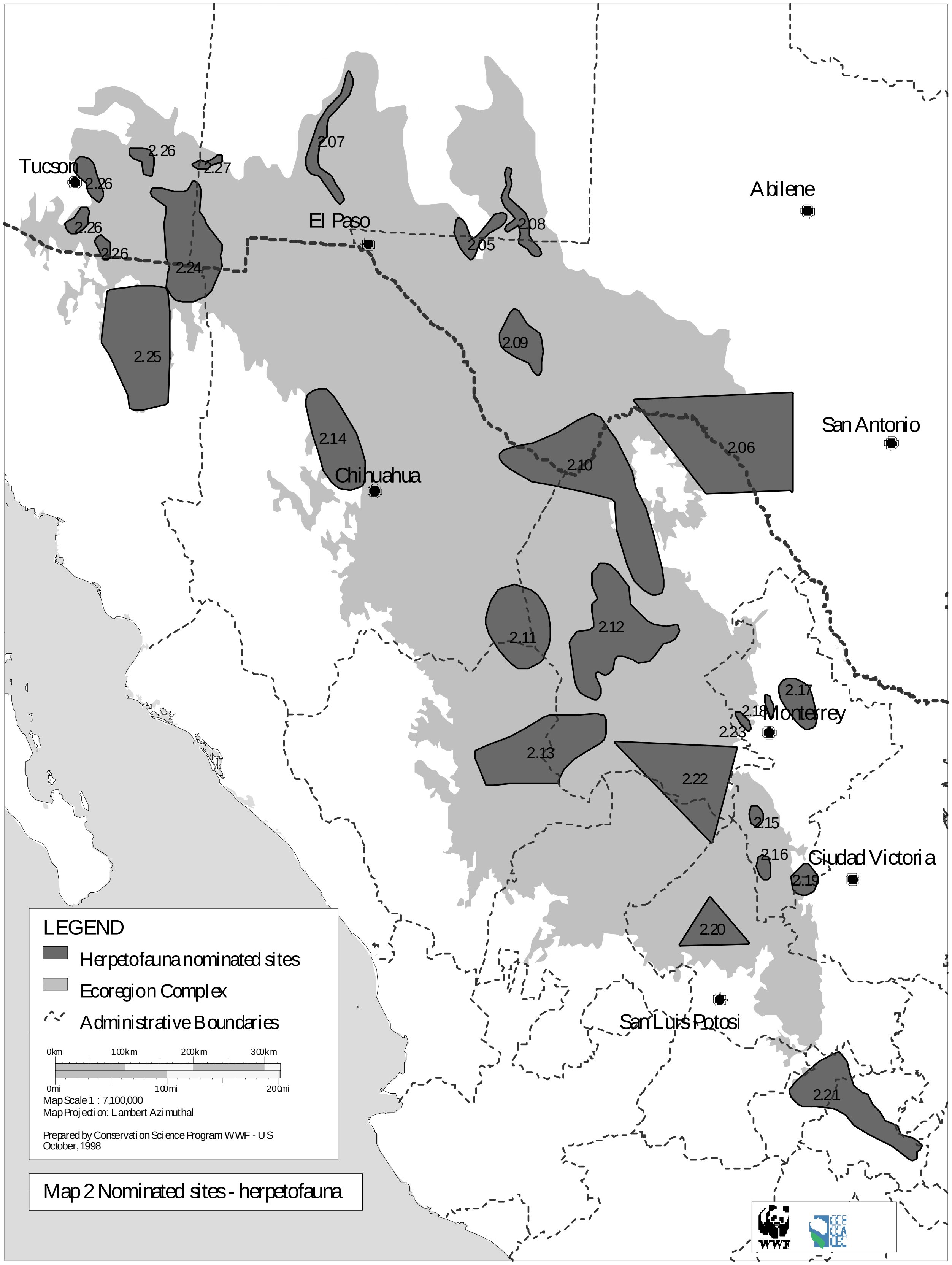
Bird Nominated Sites	Nominated Site Names	Bird Nominated Sites	Nominated Site Names
1.01	Los Angeles	1.25	Bitter Lake
1.02	Cuchillas de la Zarca	1.26	Lower Middle Rio Grande
1.03	Laguna de Santiaguillo	1.27	Animas Creek
1.04	Babicora	1.28	Lower Pecos River
1.05	Chihuahuan Grasslands	1.29	Mapimi Bioshpere Reserve
1.06	Perla Grassland	1.30	Otero Mesa
1.07	Maderas del Carmen	1.31	Deming Grasslands
1.08	Sierranillas del Burro	1.32	Janos Prairie Dogtown
1.09	Laguanas Mexicanos	1.33	Middle Rio Grande
1.10	El Cuervo	1.34	Sierra del Madera
1.11	Los Ajos	1.35	Sierra la Gloria
1.12	Sierra del Carmen Corridor	1.36	Lower Gila Box
1.13	Burros Corridor	1.37	San Pedro River
1.14	Chisos Mts.	1.38	Lower Gila River
1.15	Rio Grande	1.39	Lordsburg Playa
1.16	Chinati Mts.	1.40	Willcox Playa
1.17	Marfa Flats	1.41	Chiricahua Mts.
1.18	Davis Mts.	1.42	Huachuca Mts.
1.19	Rio Florida Basin	1.43	Santa Catalina Mts.
1.20	Mimbres River	1.44	Santa Rita Mts.
1.21	Percha Creek	1.45	Apachean-Sonoran Ecotone
1.22	Marathon Basin	1.46	Peloncillo Mts.
1.23	Devils River	1.47	Meseta Central
1.24	Guadalupe Mts.		



Map 1 Nominated sites - birds

Map 2 (following page) contains the herpetofauna nominated sites, and the key to the nominated site names is listed below:

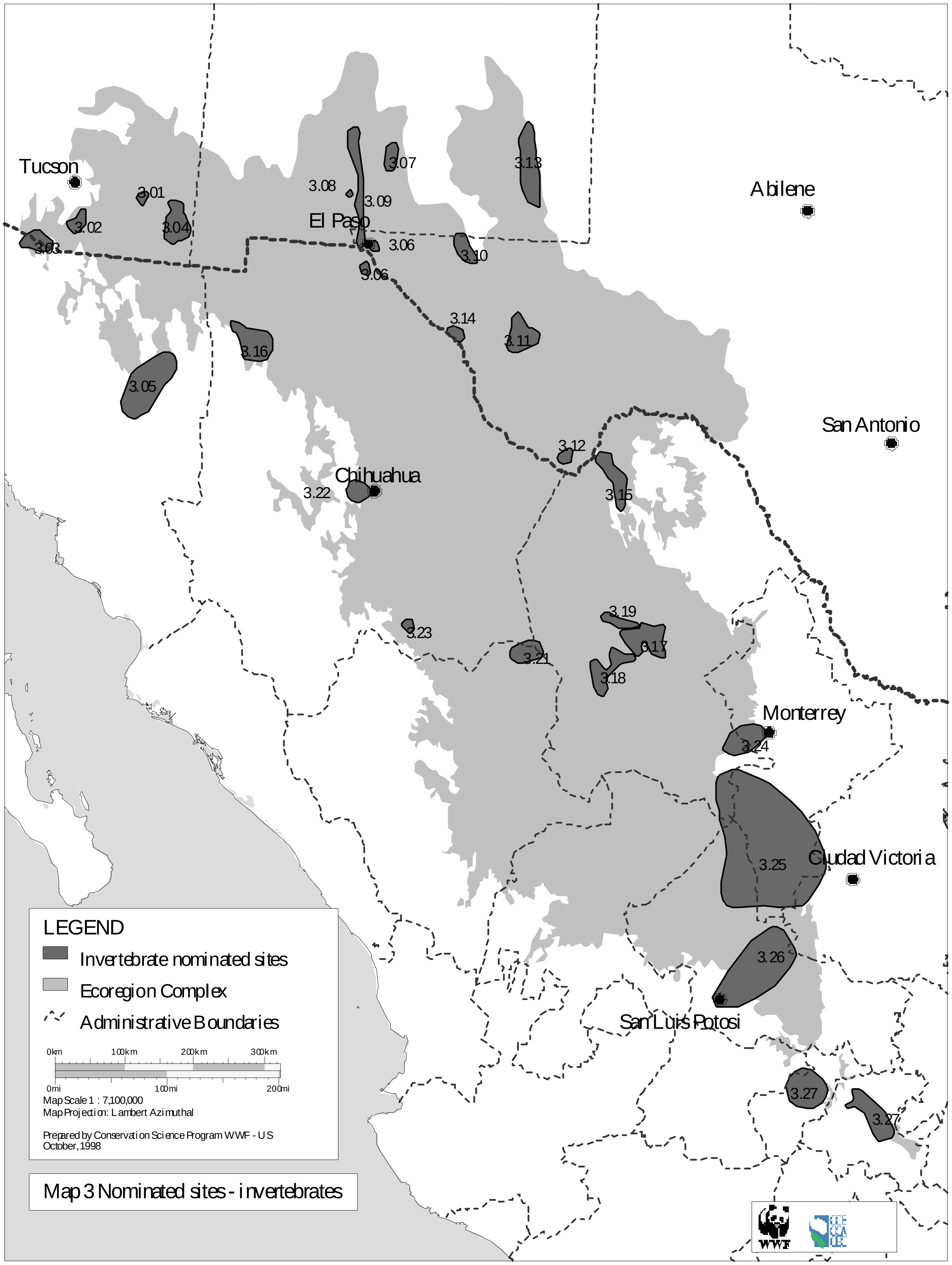
Herpetofauna Nominated Sites	Nominated Site Names
2.05	Guadalupe Mts.
2.06	Acuna-Del Rio
2.07	Middle Rio Grande
2.08	Middle Pecos Corridor
2.09	Davis Mts.
2.10	Big Bend Complex
2.11	Bolson de Mapimi
2.12	Cuatros Cienegas
2.13	Rio Nazas
2.14	Sierra del Nido
2.15	Cerro Potosi
2.16	Sandia
2.17	Picachos
2.18	Sierra Las Gomas
2.19	Zaragosa-Pena Nevada
2.20	Charcas
2.21	Chihuahuan Isolates
2.22	Concepcion del Oro-Sierra del Paila
2.23	La Popa
2.24	Chiricahua/Peloncillo/Animas Complex
2.25	Sierra del Tigre
2.26	Pinaleno-Santa Rita-Huachuca-Santa Catalinas
2.27	Gila Lower/Middle Box



Map 2 Nominated sites - herptofauna

Map 3 (following page) contains the invertebrate nominated sites, and the key to the nominated site names is listed below:

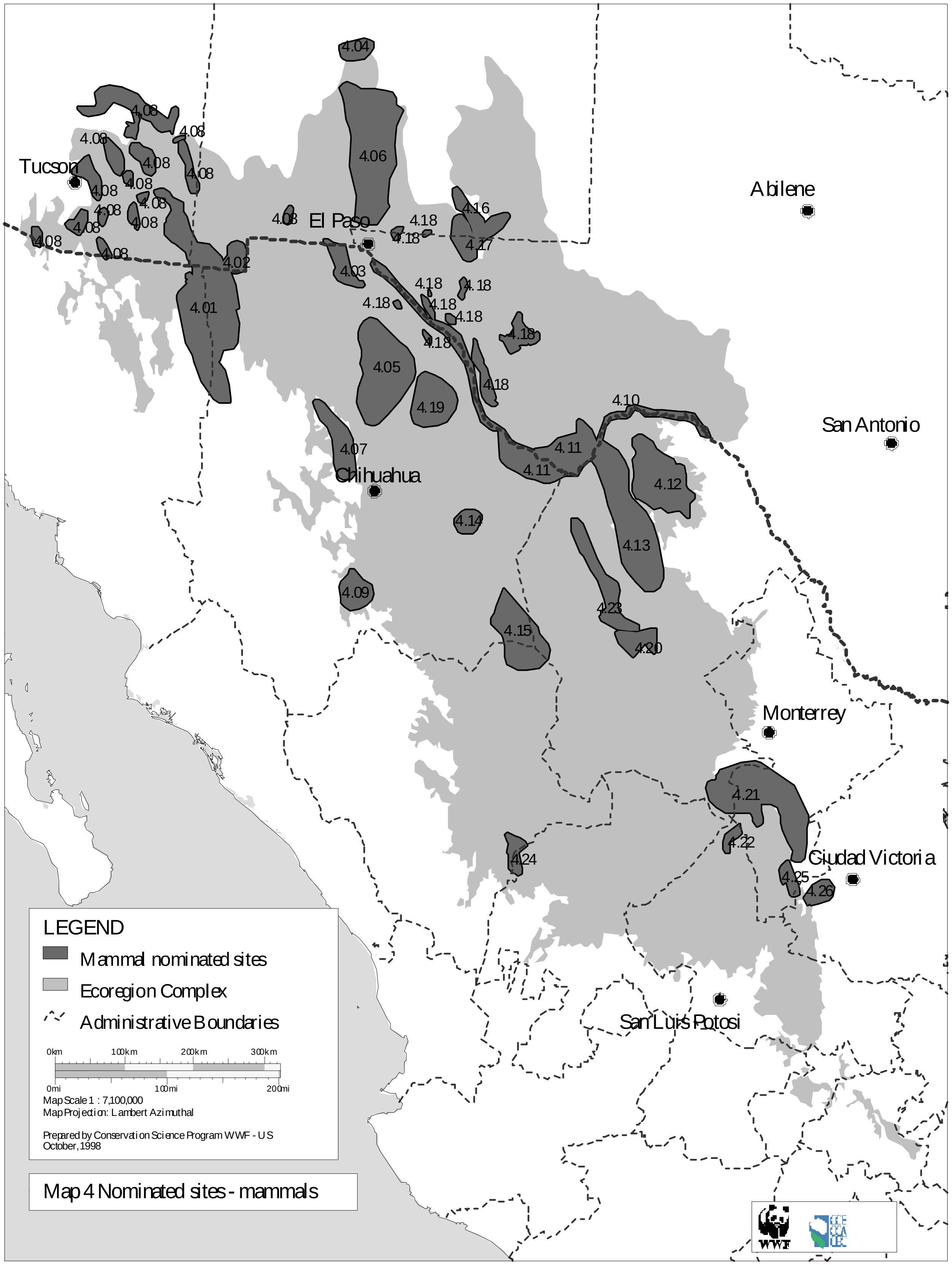
Invertebrate Nominated Sites	Nominated Site Names
3.01	Willcox Playa
3.02	Santa Rita Mts.
3.03	Pena Blanca Lake
3.04	Chiricahua Mts.
3.05	Rio Yaqui
3.06	Salamayuca Sand Dunes
3.07	White Sands National Mon.
3.08	Isaack's Lake
3.09	Franklin/Organ/San Andres Mts.
3.10	Salt Flat
3.11	Davis Mts.
3.12	Chisos Mts.
3.13	Mescalero Sands
3.14	Indio Mt. Research Station
3.15	Sierra del Carmen
3.16	Janos
3.17	Cuatrocienegas
3.18	Valle el Sobaco
3.19	Sierra la Madera
3.20	Animas Mts.
3.21	Mapimi Biosphere Reserve
3.22	Majalca to Riva Palacio
3.23	Hidalgo de Parral
3.24	Saltillo to Monterrey
3.25	Matehuala
3.26	Cerritos
3.27	Chihuahuan Isolates



Map 3 Nominated sites - invertebrates

Map 4 (following page) contains the mammal nominated sites, and the key to the nominated site names is listed below:

Mammal Nominated Sites	Nominated Site Names
4.01	Sierra Madre Occidental
4.02	Alamo Hueco Mts-Big Hatchets
4.03	Samalayuca Dunes
4.04	Sevilleta
4.05	El Sueco
4.06	Armendaris/White Sands Missile Range/Jornada
4.07	Sierra del Nido
4.08	Sierra Madre Occidental
4.09	Nonoaba
4.10	Rio Grande
4.11	Canon Santa Elena
4.12	Serranias del Burro
4.13	Sierras del Carmen-Santa Rosa
4.14	La Perla
4.15	Mapimi Biosphere Reserve
4.16	Guadalupe Mts.
4.17	Guadalupe Lowlands
4.18	Texas Mt. Islands
4.19	Coyame
4.20	Cuatrocienegas
4.21	Los Angeles
4.22	Prairie Dog Colony
4.23	Sierra la Madera
4.24	Sierra de Organos
4.25	Aramberri
4.26	Miquihuana

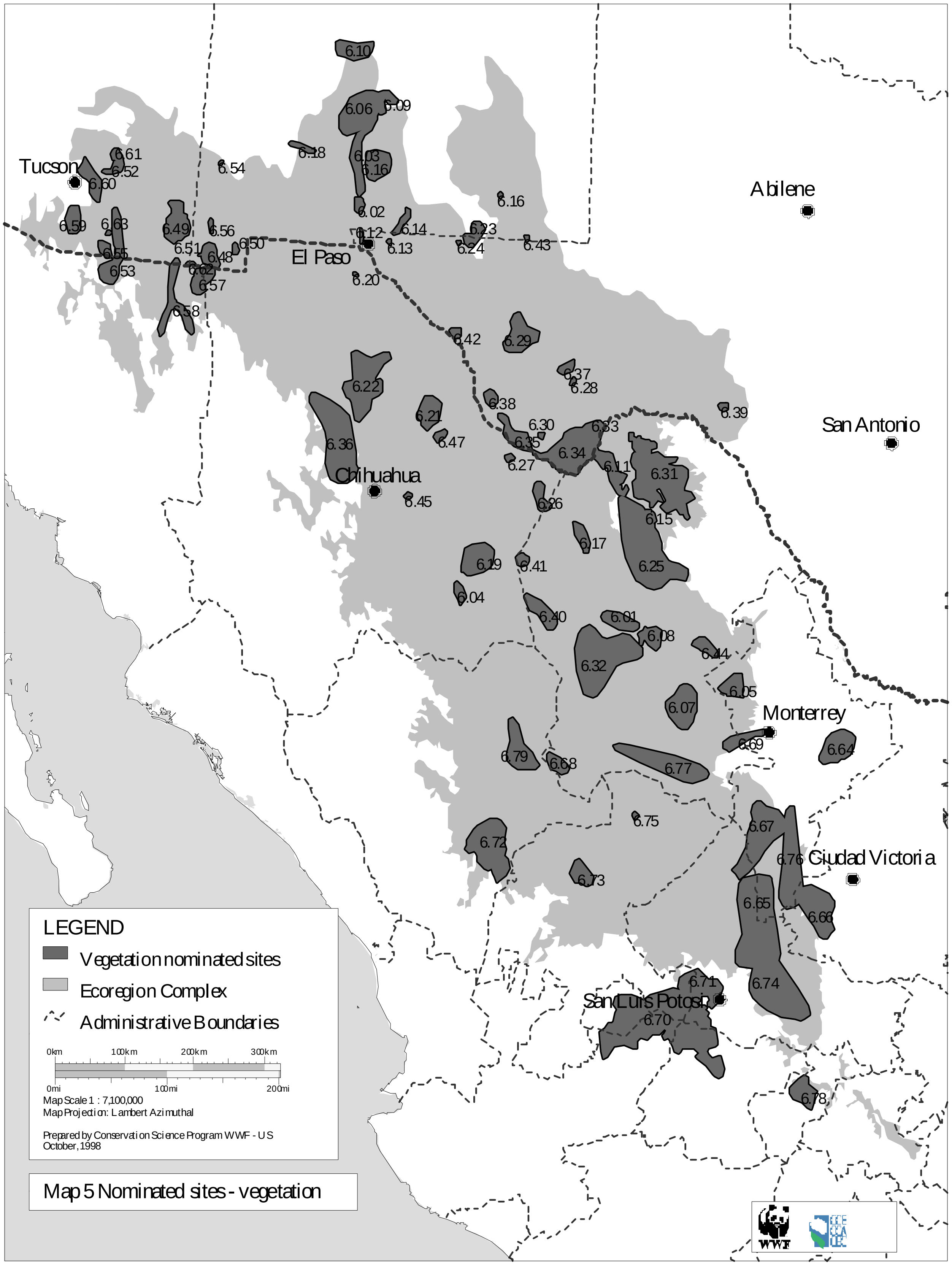


Map 4 Nominated sites - mammals

Map 5 (following page) contains the plant nominated sites, and the key to the nominated site names is listed below:

Mammal Nominated Sites	Nominated Site Names	Mammal Nominated Sites	Nominated Site Names
6.01	Sierra de la Madera	6.41	Laguna de Jaco
6.02	Organ Mts.	6.42	Indio Mts.
6.03	San Andres Mts.	6.43	Cedar Canyon
6.04	Sierra de las Pampos	6.44	Sierra de la Gloria
6.05	Sierra de Mina	6.45	San Diego de Alcala
6.06	Northern Jornada Basin	6.46	Seven Rivers
6.07	La Paila	6.47	Ojinaga Gypsum
6.08	Cuatrocienegas	6.48	Animas Mts.
6.09	Oscura Mts.	6.49	Chiricahua Mts.
6.10	Sevilleta	6.50	Big Hatchets
6.11	Sierra del Carmens	6.51	Gray Ranch Cienega
6.12	Franklin Mts.	6.52	Muleshoe Preserve
6.13	South Hueco Mountains	6.53	San Pedro River
6.14	Otero Mesa	6.54	Red Rock
6.15	Rincon de Maria	6.55	Huachuca Mts.
6.16	White Sands National Monument	6.56	Animas Valley
6.17	Sierra Santa Fe del Pino	6.57	San Luis Mts.
6.18	Animas Creek	6.58	Upper Yaqui
6.19	Bajio del Gringo	6.59	Santa Rita Mts.
6.20	Samalayuca Mt.	6.60	Santa Catalina Mts.
6.21	Tinaja Verde	6.61	Galiurus
6.22	El Sueco	6.62	Guadalupe Canyon
6.23	Guadalupe Mts.	6.63	Appleton-Whittell Research Ranch
6.24	Guadalupe Dunes	6.64	Corredor Teran
6.25	Sierra Santa Rosa	6.65	Huizache-Matehuala
6.26	Sierra Hechicerros	6.66	Valley de Jaumave
6.27	Sierra Rica	6.67	San Vicente
6.28	Marathon Basin	6.68	Sierra de Jímulco
6.29	Mt. Livermore	6.69	Monterrey to Saltillo
6.30	Fizzle Flat	6.70	
6.31	Serranias del Burros	6.71	San Luis Potosi
6.32	Sierra de la Fagua	6.72	Zona de Malpais de Durango
6.33	Black Gap	6.73	Rio Gaste Nopaleas
6.34	Big Bend	6.74	Sierra de Guadalcazar
6.35	Big Bend Ranch	6.75	Pico de Teyra
6.36	Sierra del Nido	6.76	Galeana-Dr. Arroyo-Miquihuana
6.37	Glass Mts.	6.77	Sierra de Parras & El Jabali

Mammal Nominated Sites	Nominated Site Names	Mammal Nominated Sites	Nominated Site Names
6.38	Mesquite Ranch	6.78	Valles de Penamiller & Pena Blanca
6.39	Devils River	6.79	Rio Nazas-Sierra del Rosario
6.40	Santa Mojada-Laguna del Rey		



Map 5 Nominated sites – vegetation

Appendix C : Current and future threats to biodiversity of priority sites

I. Threats by subregion

a. Apachean subregion

The most significant threats to biodiversity are associated with urban growth and rural subdivision. Agriculture alters biodiversity within all riparian sites of the subregion. Livestock grazing occurs throughout, degrading native plant communities and damaging or destroying riparian habitat and freshwater springs.

Pollution

Pollution was assessed as having significant impacts at three of the 26 sites. The Santa Catalina Mountains (1.05) near Tucson, Arizona suffers from urban and industrial air pollution. The Chiricahua-Animas-Sierra Madre Complex (1.20) and Upper San Pedro (1.10) is vulnerable to groundwater contamination created by copper mines and mills.

Agriculture

The influences of agriculture were significant in 42% of the Apachean sites. All of these sites are associated with playas, wetlands, rivers and streams. Water diversions from channels and groundwater pumping reduce soil moisture available to riparian and wetland species and alter habitat in the Chiricahua-Peloncillo-Sierra Madre Complex (several rivers and *ciénegas*) (1.20), Sonoita Creek (1.04), Lower San Pedro River (1.06), Upper San Pedro River (1.10), Lower Middle Gila River (1.14), Willcox Playa (1.17), Big Hatchets-Alamo Huecos (Playas Playa) (1.22), Lordsburg Playa (1.24), Upper Middle Gila River (1.25), and Mimbres River (1.26). On the river sites, levees and channels restrict meandering. *Bosque* clearing occurs on the floodplains of the Lower Middle Gila River (1.14), Upper Middle Gila River (1.25), and the Mimbres River (1.26).

Development

Thirteen of the sites (50%) are subject to the impacts of urban development or subdivision within rural communities. The Baboquivari Mountains (1.01), Pajarita-Atasco Mountains (1.02) are in the vicinity of Nogales, Arizona and Nogales, Sonora. The Santa Rita Mountains (1.04), and the Santa Catalina Mountains (1.05), are near Tucson, Arizona. The Upper San Pedro River (1.10) and Huachuca Mountains (1.09) are close to Sierra Vista, Arizona. The Mimbres River (1.26) is adjacent to Silver City, New Mexico. Urbanization along foothills and floodplains in these sites fragments wildlife corridors and restricts movement of wide ranging vertebrates. Each of these communities pumps groundwater, altering riparian vegetation. In more rural areas, subdivision of large ranches into smaller parcels with homes, fragments and degrades grasslands and foothill landscapes. This process is occurring in the Whetstone Mountains (1.07), Sonoita Creek (1.04), the Dragoon Mountains (1.18), Sulphur Springs (1.19), and the Chiricahua-Peloncillo-Sierra Madre (1.20). In the Pinaleño Mountains (1.16), the Mount Graham Observatory destroyed subalpine forest habitat.

Timber harvest

Timber extraction occurs in six (23%) of the sites. The sites with intensive timber harvest are the Santa Catalina Mountains (1.05), Rio Sonora Watershed (1.11), Sierra Los Ajos (1.12), Río Yaqui (1.13), Pinaleño Mountains (1.16), and the Chiricahua-Peloncillo-Sierra Madre Complex (1.20). Fuelwood collection is common in the Pajarita-Atasco Mountains (1.02), Lower Middle Gila River (1.14), the Lower San Pedro River (1.06) and the Huachuaca Mountains (1.09).

Alteration of fire regimes

Marked consequences of fire suppression are evident in 23% of the sites. Riparian sites Sonoita Creek (1.04), and Upper San Pedro River (1.10) burn much hotter than did historic fires. Suppression in woodlands alters composition, increasing juniper species, and reduces water infiltration. Because whole watersheds are affected by changes in fire regimes, increased flooding severity and sediment transport is evident on the Mimbres River (1.26), and Upper Middle Gila River (1.25). Within the Chiricahua-Peloncillo-Sierra Madre Complex (1.20), fuel build up from fire suppression leads to extremely hot and intensive fires.

Livestock Grazing

Livestock grazing effects 85% of the priority sites in the Apachean subregion. The Sonoita Creek (1.04) site receives increases in flood water due to poor infiltration in its upper watershed, a result of soil compaction and loss of herbaceous cover from grazing. Springs, creeks, and streams in the Huachuca Mountains (1.09) and the Big-Hatchet Alamo Hueco Mountains (1.22) exhibit signs of trampling and siltation from livestock use. Continuous grazing during periods of drought dramatically reduces herbaceous cover and creates conditions suitable for shrub or exotic species invasions. Check dams and watering holes across the Northern Peloncillos (1.21) alter natural hydrologic regimes. Along the Lower Middle Gila (1.14) and the Mimbres River (1.26) riparian woodlands are replaced with pastures.

Illegal hunting and poaching

Direct exploitation of wildlife is relatively low with just 19% of the sites affected by poaching, hunting, collection, or eradication of species. Within the Chiricahua-Peloncillo-Sierra Madre Complex (1.20), the illegal collection of herpetofauna and invertebrates may significantly reduce local populations. Black-tailed prairie dogs are shot and poisoned in the Chiricahua Complex, as well.

Mining

Mining is patchy throughout the subregion, with 19% of the sites containing some form of hard rock or sand and gravel extraction. In the Pajarita-Atasco Mountains (1.02), roads to mines cause fragmentation of woodlands. Mining or mineral exploration also occurs in the Dragoon Mountains (1.18), the Chiricahua-Peloncillo-Sierra Madre Complex (1.20), Big Hatchet-Alamo Huecos (1.22) and the Northern Peloncillo Mountains (1.21).

Exotic species

Twenty-three percent of the sites suffer from introductions of exotic species. While most exotic species in the subregion are found along riparian sites, two upland sites, Santa Rita (1.03) and Sulphur Springs Valley (1.19) contain extensive areas of Lehmann's lovegrass (*Eragrostis lehmanniana*). Sonoita Creek (1.04) has a large component of Johnson grass (*Sorghum halapense*) and tree of heaven (*Ailanthus altissima*). Salt cedar (*Tamarix* sp.) is an aggressive invader within the Upper Middle Gila (1.25) and the Lower Middle Gila (1.14).

Recreational Activities

Several of the sky islands are popular recreational sites (26% of all sites). Facilities such as campgrounds, trails, roads, stores, and parking lots reduce and fragment habitat. Human disturbances to wildlife occur throughout. The sites threatened most by recreational activities and development are Pajarita-Atasco (1.02), Santa Rita Mountains (1.03), Santa Catalina Mountains (1.05), Whetstone Mountains (1.07), Huachuca Mountains (1.09), and the Chiricahua-Peloncillo-Sierra Madre Complex (1.20).

Military Acitivites

A military installation in the Huachuca Mountains (1.09) has resulted in habitat loss and road development.

b. Northern Chihuahuan subregion

Livestock grazing, fire suppression, and urban development appear to be the primary causes of biodiversity loss in the Northern Chihuahuan subregion. Riparian habitats have been particularly effected.

Pollution

Municipal wastes, agricultural run-off, industrial pollutants, and mining contaminants are found scattered in nine of the eighteen sites. All three Rio Grande sites (2.02, 2.03, 2.18), the Pecos River (2.10), Conchos River (2.15), and Alta Bavicora (2.11) carry high levels of contaminants. The three sites associated with the Big Bend area, Big Bend (2.07), Davis-Chinati Mountains (2.05), and Marathon Basin (2.16), all suffer from air pollution.

Agriculture

The impacts of agriculture range from complete loss of natural communities and associated species, fragmentation of landscape through habitat conversion, roads, fences, and vehicular traffic, pumping groundwater or diverting river water, and river channelization. Eleven of the eighteen sites in this subregion are directly impacted by agriculture. These included the three Rio Grande sites (2.02, 2.03, 2.18), the Pecos River (2.10), Conchos River (2.15), Alta Bavicora (2.11), and the Devil's River (2.06), and grasslands associated with La Perla (2.12), and Davis-Chinati Mountains (2.05), and Guadalupe Mountains (2.04), and Northcentral Chihuahua Grasslands (2.08).

Development

Ten of the eighteen sites are threatened with development, which includes urban expansion in the region of El Paso/Ciudad Juárez. These sites are Rio Grande-El Paso to Amistad (2.02), Rio Grande-Elephant Butte to El Paso (2.03), and Samalayuca Dunes (2.14). Subdivision of large ranches into small, fenced lots causes fragmentation of habitats and hastens of the loss of native communities in the Guadalupe-Carlsbad (2.04), Davis-Chinati (2.05), Devil's River (2.06), Marathon Basin (2.16), Big Bend (2.07) and Sierra del Nido (2.01) sites.

Timber harvest

Only three sites appear to affected by timber harvest: Sierra del Nido (2.01), Conchos River Headwaters (2.15), and Alta Bavicora (2.11), all within the Sierra Madre Occidental of Mexico. Clearcuts and road building eliminate and fragment forest habitat, as well as cause stream erosion. Timber regulations exist but may be inadequately enforced.

Alteration of fire regimes

Altered fire regimes within the northern Chihuahuan subregion are primarily the result of fire suppression. Intensive grazing practices that prevent the buildup of fuels in grasslands have altered natural fire patterns in six of the sites: Sierra del Nidos (2.01), Big Bend (2.07), Northcentral Chihuahuan Grasslands (2.08), Guadalupe Mountains-Carlsbad Escarpment (2.04), Tularosa Basin (2.09), and Sierra Blanca (2.17). Woodland sites have experienced an increase in juniper density. These sites contain grasslands or woodlands adapted to a more frequent fire regime than currently occurs. Roads and the increase of desert scrub can prevent the movement of fire into areas that actually have adequate fuel loads. Within two Rio Grande sites, (2.02) and (2.18), invasions of two exotics, salt cedar (*Tamarix* sp.) and Russian olive, create dense understories of highly volatile fuels that have increased the intensity and area of natural or arson caused fires.

Livestock grazing

Grazing practices incompatible with native grassland or shrubland phenologies are found on all sites except Devil's River (2.06), Pecos River (2.10), Samalayuca Dunes (2.14), and the Rio Grande-Above Elephant Butte (2.18). Cattle, sheep, and goats are often not rotated frequently or are returned to areas before plants have been given an adequate opportunity for regrowth and the storage of reserves. This pattern occurs throughout the Chihuahuan Desert and is prevalent on fourteen of eighteen priority sites in this subregion. Consequences of inappropriate grazing practices are: the direct mortality of plant species; their replacement with aggressive, deep rooted shrub species; the loss of cover and canopy for grassland-dwelling fauna; increases in erosion in uplands and riparian areas; and fragmentation and habitat loss through infrastructure development such as fencing, roads, water developments, and corrals.

Illegal hunting and poaching

Deer hunting out of the regulated season occurs on La Perla (2.12), Tularosa Basin (2.09), Davis-Chinati Mountains (2.05), Sierra de Nido (2.01), Northcentral Chihuahuan Grasslands (2.08), and Big Bend (2.07). Additionally, waterfowl are illegally hunted at Alta Bavicora (2.11) and black bear are taken from the Sierra del Nido (2.01). Reptiles and cacti are illegally removed from Big Bend (2.07) and Marathon Basin (2.16).

Mining

Hardrock mining occurs in the Conchos River Headwaters (2.15). Within the Samalayuca Dunes (2.14), sand is removed for cement production. Oil and gas exploration and pumping causes fragmentation within Pecos River (2.10) and Mescalero Sands (2.13) sites, as well as habitat loss along drilling pads.

Exotic Species

The introduction of non-native plant species to the riparian areas of this subregion has resulted in a shift in community composition, from cottonwood-willow dominated woodlands to thickets and strands dominated by introduced salt cedar and Russian olive. Cottonwood and willow often remain as relict individuals. Soil salinity levels typically increase after these invasions. The six riparian sites, including Tularosa Basin (2.09) and Rio Grande-El Paso to Amistad (2.02) suffer from severe infestations of salt cedar. Vertebrate exotics include feral sheep and pig populations within the Northcentral Chihuahuan Grasslands (2.08), burros in Big Bend (2.07), and oryx in the Tularosa Basin.

Recreational activities

Guadalupe Mountains-Carlsbad Escarpment (2.04), Davis-Chinati Mountains (2.05), Devil's River (2.06), and Big Bend (2.07) all contain state or federal recreation developments. Campgrounds, roads, and trails eliminate patches of habitat. The presence of humans disrupts wildlife movements.

Military activities

Flyovers by military jets occurs in the Guadalupe Mountains-Carlsbad Escarpment (2.04) and Big Bend (2.07). Airforce bombing ranges, missile launch sites, and army roads in Tularosa Basin (2.09) and Sierra Blanca (2.17) are sources of disturbance in grasslands and scrublands. However, in some military areas, incendiary activities often help maintain relatively natural fire regimes.

c. Central Chihuahuan subregion

Livestock grazing practices that alter natural communities are widespread. Agricultural effects such as habitat loss, water diversion, and salinization are most prevalent in the Cuatrociénegas basin. Mining of gypsum and other minerals occurs throughout the region, with varying degrees of impact. The mining of gypsum dunes can quickly lead to species extinctions because of the extreme local endemism in plants.

Pollution

Mapimí (3.01) and Sierra de la Gloria (3.07) are the two sites where pollution threats are most evident. Runoff and drift of agricultural chemicals contaminates the soil and groundwater.

Agriculture

Within Mapimí (3.01) and Cuatrociénegas (3.03) agricultural practices have converted grasslands and shrublands to crops. Water use for agriculture in Cuatrociénegas (3.03) has reduced surface and groundwater supplies and reduced water quality. Water diversions into canals and ditches and the pumping of groundwater have altered wetland habitats and caused fragmentation.

Development

Only two sites in this subregion are significantly threatened by urban development. Sierra de las Minas Viejas (3.08) and Sierra de la Gloria (3.07) are reported to have housing developments and an increase in roads.

Timber harvest

The harvesting of wood in an unsustainable manner occurs in half of the subregion sites. In the Sierras del Carmen and Santa Rosa Complex (3.02), intensive wood exploitation results in loss of woodlands, erosion, and habitat fragmentation. The Sierra de la Madera surrounding Cuatrociénegas suffers from erosion and poor water retention, impacting the basin below. Timber extraction in Sierra de la Gloria (3.07) and Sierra de la Paila (3.04) fragments wooded communities and disrupts wildlife populations.

Alteration of fire regimes

Montane forests and woodlands suffer from human-caused fires, particularly in the Sierra de la Paila (3.04) and Sierra de Menchaca (3.06).

Livestock grazing

Sierras Menchaca and de la Gloria (3.06 and 3.07) are the only two sites that do not experience intensive livestock grazing. Cattle are present in the other six sites, but in the Sierras del Carmen and Santa Rosa Complex (3.02) and Sierra de las Minas Vieja (3.08), goats are the primary grazers.

Illegal hunting and poaching

All eight sites are subjected to poaching of mammals and the trade of cacti and wildlife. In Sierras del Carmen and Santa Rosa (3.02), birds and reptiles are harvested and sold. The unsustainable harvest of guayule, candelilla, and lechuguilla is practiced here, as well as in Sierra de la Paila (3.04), Sierra de la Gloria (3.07), and Sierra de las Minas Viejas (3.08).

Mining

Gypsum mining occurs in five of the sites, and the effects are particularly pronounced in Mapimí (3.01). The gypsum dunes of Cuatrociénegas (3.03) and deposits of gypsum in Sierra de la Paila (3.04), Sierra de la Gloria (3.07), and Sierra de Menchaca (3.06) are mined for the construction and pharmaceutical industry.

Exotic species

Plants introduced to Cuatrociénegas (3.03), primarily in wetland habitats, have displaced native species and altered habitat composition. Water hyacinth, an aggressive invader, was recently documented in the basin.

Recreational activities

Unregulated recreational activities are reported for Mapimí (3.01), Sierra Santa Fe del Pino (3.05) and Sierra de Menchaca (3.06).

d. Meseta Central subregion

Six of the eight priority sites are evaluated as highly threatened. Pollution and agricultural impacts appear to be more severe in this subregion. Livestock grazing effects are similar to other subregions.

Pollution

Agricultural runoff contaminated with pesticide and insecticide residues cause soil and groundwater contamination. The waters of the Laguna de Santiaguillo (4.06) contaminate birds, fish and invertebrates. Agricultural chemicals are also threatening soil and water in Altiplano Mexicano Nordoriental (4.01), Chihuahuan Querétaro Desert (4.03), and Río Narizonas Basin (4.07).

Agriculture

Eight of the nine sites are impacted by agricultural activities. Órganos-Malpais (4.05) is the exception. Grasslands, shrublands, and shore lines of lakes are converted to croplands in some areas, such as the Laguna de Santiaguillo (4.06). Groundwater pumping for irrigation also reduces the lake level here. Wind erosion removes soil from abandoned or fallow fields in Chihuahuan Querétaro Desert (4.03).

Development

Urban effects are limited to three sites. Within the basin of Laguna de Santiaguillo (4.06) groundwater pumping reduces water levels in the lake. Along the Monterrey-Saltillo Corridor (4.08), urban encroachment reduces desert scrublands and introduces roads and vehicle use to the area. The growing population in the vicinity of Órganos-Malpais (4.05) has resulted in an increase in arson, road development, exotic species introduction, and off-road vehicle use.

Timber harvest

Órganos-Malpais (4.05) has lost forest habitat and is fragmented by roads and mill sites. Within the Chihuahuan Querétaro Desert (4.03), careless illegal harvests result in wind caused soil erosion and habitat fragmentation and new access roads for poachers.

Alteration of fire regimes

Fires have increased in frequency in Altiplano Mexicano Nordoriental (4.01) and Órganos-Malpais (4.05).

Livestock grazing

Seven of the nine sites are used extensively for cattle or goat grazing. Laguna de Santiaguillo and Órganos-Malpais (4.05) experience the lowest levels of grazing in the Meseta Central subregion. Huizache-Cerritos (4.02) and Río Nazas Basin are the only sites where goats are more prevalent the cattle. Grazing in Huizache-Cerritos has led to a decrease in native species and an increase in exotic species. Native pastures in Sierra de Picachos (4.09) have been replaced with plantings of exotic species. Inappropriate timing and intensity of livestock use has caused severe soil erosion within the Chihuahuan Querétaro Desert (4.03).

Illegal hunting and poaching

Illegal extraction of wildlife and plant life is a significant problem in six of the nine priority sites. In Altiplano Mexicano Nordoriental (4.01), Sierra de Picachos (4.09), and Órganos-Malpais (4.05), removal of animals for the wildlife trade and poaching animals for food is a serious problem. Within Huizache-Cerritos (4.02), cacti are removed for trade, as are small mammals and birds. In the Chihuahuan Querétaro Desert (4.03), both cacti and reptiles are removed for trade. Small mammals, mountain lions (*Felis concolor*), black bear (*Ursus americanus*), and white-tailed deer (*Oidecoileus virginiana*) are illegally hunted. Laguna de Santiaguillo (4.06) is a tremendously important lake for wintering waterfowl in the region. Illegal hunting of birds is a threat to populations.

Mining

Within Huizache-Cerritos (4.02) and Saltillo-Monterrey Corridor (4.08), gypsum and gravel mining disturbs the soil and vegetation, causing habitat loss, habitat degradation, and landscape fragmentation.

Recreational activities

At two sites-Saltillo-Monterrey Corridor (4.08) and Órganos-Malpais (4.05)-off road vehicle use by recreationists damages flora and soils.

Appendix Table C-1 Current and future threats to Chihuahuan freshwater priority sites

Site #	Name	Priority	Threats[1]	Rank	Catchment	Habitat	Biota	Total
5.02	Upper Yaqui	1	G, O, T, W, X,	H	40	30	30	70
5.06	Zona Carbonifera	1	G, P	H	40	30	0	70
5.15	Pecos River	1	W, D,M, A, X, C, Q, P, G	H	25	30	15	70
5.08	Papigochic	1	A, P, G, W, X, T	H	40	15	30	85
5.21	Mezquital	1	A, D, X, P	H	40	30	15	85
5.32	Media Luna/Rio Verde	1	A, R, P, D	H	25	30	30	85
5.04	Upper Santa Cruz	2	D, O, P, G, X	H	40	15	15	70
5.22	La Concha	2	R, A, P	H	40	30	0	70
5.33	Cadena	2	G, A, W	H	40	30	0	70
5.36	San Diego	2	D, O, G, A, R, W	H	25	15	30	70
5.05	Rio Sonora	2	W, M, O, X, G	H	40	15	30	85
5.10	Rio Grande & Rio Conchos	2	D, P, I, X, O, W	H	40	30	15	85
5.13	Guzman Basin	2	A, D, G, I, O, P, R, T, W, X,	H	40	30	15	85
5.17	Panuco	2	D, P, W	H	40	30	30	100
5.23	Upper Aguanaval	2	A, G, P, W, X	H	40	30	30	100
5.16	Bavicora	3	A, O, P, T, W,	H	40	30	0	70
5.01	Willow Spring	3	W	H	40	30	0	70
5.11	Rio Grande-Southern NM	3	C, D, G, I, O, P, Q, W, X	H	10	30	30	70
5.12	Mimbres River	3	D, G, M, O, W, X	H	40	30	15	85
5.29	Sauz Basin	3	A, D, G, O, W, X	H	40	30	15	85
5.20	Laguna de Santiaguillo	3	A, G, X	H	40	30	30	100
5.25	Chorro	4	G, R, T, W, X	H	40	30	0	70
5.14	Bustillos	4	A, G, P, W	H	40	30	15	85
5.24	Parras	4	G, W, X	H	40	15	30	85
5.26	PotosÌ	4	G, W, X	H	40	30	30	100

Site #	Name	Priority	Threats[1]	Rank	Catchment	Habitat	Biota	Total
5.28	Sandia	4	G, W	H	40	30	30	100
5.35	Upper Conchos	1	A, T	M	25	15	0	40
5.03	San Pedro-Aravaipa	1	C, D, G, M, O, X,	M	25	15	15	55
5.07	Bavispe	1	O, T, X	M	25	15	15	55
5.09	Devils River	1	D, G, O, W, X,	M	25	15	15	55
5.19	Upper Nazas	1	A, P, T, X	M	25	15	15	55
5.30	Cuatrocienegas	1	A, C, D, G, H, W, C, X	M	25	15	15	55
5.37	Upper Gila	1	A, C, D, O, W, X	M	25	15	15	55
5.34	Extorax	2	A, P, W, X	H	40	30	15	85
5.18	Tularosa Basin	3	G, V, X	M	25	0	15	40
5.31	Venado	3	G, R, W	M	40	15	0	55

[1] Threats Codes:
A=Agriculture
C=Channelization
D=Development (Urban)
F=Fire Regime Altered
G=Groundwater Pumping
H=Hunting (Unregulated or Poaching)
I=Irrigation
M=Mining
O=Overgrazing (cattle, sheep, or goats)
P=Pollution (Air or Water)
Q=Water Quantity and Quality
R=Recreation
T=Timber Harvest (Unregulated or Poorly enforced)
V=Military
W=Water Diversion
X=Exotic Species (Non-Native to Chihuahuan Desert)
Y=Indigenous harvest of resources

Overarching threats affecting freshwater biodiversity

The experts identified nineteen broad categories of human activity that currently effect biodiversity in the Chihuahuan Desert. Eleven of these activities dramatically affect freshwater ecosystems:

Timber

Timber harvesting occurs in eight sites (22%). Clear cutting and deforestation in the Sierra Madre Occidental leads to increased siltation and flooding, degrading the water quality of Upper Conchos (5.35), Bavispe (5.07), Upper Yaqui (5.02), Bavicora (5.16), Upper Nazas (5.19), Papogochic (5.08), and Guzmán (5.13) sites. Chorro (5.25) is a small watershed associated with the Sierra Madre Oriental north of Saltillo, Coahuila.

Agriculture

Agricultural activities affect 31 sites (84%) if floodplain conversion, water diversions such as dams, canals, irrigation ditches, and groundwater pumping are considered. Laguna de Santiaguillo (5.20), Extorax (5.34), Upper Aguanaval (5.23), Media Luna/Río Verde (5.32), San Diego (5.36), and Upper Conchos (5.35) contain streams, lakes, and springs that have been converted from riparian and wetland habitats to croplands. The sites not significantly affected by agriculture are Willow Spring (5.01), Upper Yaqui (5.02), Río Sonora (5.05), Panuco (5.17), Chorro (5.25), and Venado (5.31).

Groundwater pumping

The use of groundwater for agricultural purposes affects 23 (62%) of the freshwater sites. Groundwater pumping has reduced subterranean flows that traditionally fed channels, and in some cases, has eliminated entire springs and wetland systems. The Upper Yaqui (5.02), San Pedro-Aravaipa (5.03), Upper Santa Cruz (5.04), Zona Carbonifera (5.06) and Media Luna/Río Verde (5.32) are affected by the pumping of water for municipal and agricultural purposes.

Water Diversion

This broad category includes irrigation, canals, ditches, dams, and general diversion for agriculture and municipal uses. Water is diverted in 73% of the sites and all diversions are used to some degree for agricultural purposes. Channel drying, reduced water flows, channelization, altered seasonal flows, reduced flooding, modification of habitats at ditch heads, and drowning of riparian habitat at dams and reservoirs are some of the results of water diversion on Chihuahuan Desert freshwater biotas.

Channelization

Three of the sites (8%) have been channelized for flood control: the Rio Grande-Southern New Mexico (5.11), the Pecos River (5.15), and the Upper Gila (5.37). The sites can no longer support aquatic species adapted to slower waters that result from increased sinuousity, backwaters, and side channels.

Development

Fourteen sites (38%) suffer from the alteration and encroachment of floodplains for development. San Pedro-Aravaipa (5.03), Upper Santa Cruz (5.04), and Devil’s River (5.09) are three such examples.

Exotic species

Exotic, or non-native, plant and animal species currently affect twenty-three (62%) of the sites. Salt cedar (*Tamarix ramosissima*) invasions occur along eight of the sites. Salt cedar is an aggressive phreatophyte, reducing water availability as well as altering water quality by concentrating salts in the floodplain. Organic inputs to the channel are also reduced by salt cedar. Bullfrogs (*Rana catesbiana*.) in Upper Yaqui (5.02) and Pecos River (5.15) prey upon native fish. Non-native fish, such as predatory bluegill (*Lepomis macrochirus*) and carp (*Cyprinus carpio*), are a problem in San Pedro-Aravaipa (5.03), Rio Grande/Río Conchos (5.10), Upper Nazas (5.19), Parras (5.24), Chorro (5.25), and Potosí (5.26). West of the continental divide, red shiner (Notropis lutrensis), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), and small-mouth bass (*Micropterus dolomieu*) pose wide-spread threats to native fish. Non-native fish have been planted into many systems for human use, such as in Mezquital (5.21) Upper Aguanaval (5.23), and Sauz Basin (5.29). In the Pecos River (5.15), Extorax (5.34), and Cuatrociénegas (5.30) exotic fish species outcompete natives or hybridize with congeners. In the Pecos River, the exotic sheepshead minnow (*Cyprinodon variegatus*) hybridizes with the Pecos pupfish (*C. pecosensis*), a fish proposed as endangered in the U.S.. In Cuatrociénegas, the Rio Grande cichlid (*Cichlasoma cyanoguttatus pavonaceus*) and largemouth bass (*Micropterus salmoides*) are known to prey on native fish.

Livestock grazing

Both direct trampling of riparian and aquatic vegetation and degradation of whole watersheds occurs as a result of livestock grazing in thirteen (35%) of the sites. Decreases in herbaceous cover and soil compaction increase runoff, sedimentation, and flooding, and alter water quality. Decreases in infiltration also reduce the amount of water in the channel, reducing or eliminating aquatic habitats.

Mining

Mining effects occur in four sites. Along the headwaters of the San Pedro (5.03), copper mines leach contaminants into the channel. Mining also occurs along the Río Sonora (5.05), and oil and gas are pumped from within the floodplain of the Pecos River (5.15). Sand and gravel are removed from the Mimbres River (5.12), within one mile of a Chihuahua chub (*Gila nigrescens*) locality.

Pollution

Significant pollution occurs in eighteen sites (49%). Municipal and industrial pollution contaminate the Upper Santa Cruz (5.04), Zona Carbonifera (5.06), Rio Grande (5.10, 5.11), Bavicora (5.16), Iturbide (5.27), and Extorax (5.34) sites. Pesticides and insecticides contaminate river waters in the Papogichic (5.08), Rio Grande/Río Conchos (5.10, 5.11), Guzmán Basin (5.13), Panuco (5.17), Upper Nazas (5.19), Mezquital (5.21), Upper Aguanaval (5.23), La Concha (5.22), Iturbide (5.27), and Extorax (5.34) sites. Salt accumulation and increases in nitrogen are also a result of intensive agriculture. The lakes of Bustillos (5.14), Laguna de Santiaguilla (5.20) and Bavicora (5.16) are contaminated by runoff from agricultural chemicals. Media Luna/Río Verde (5.32) has become polluted by recreational activities.

Recreation

Six sites (16%) are affected by recreational activities. La Concha (5.22), Chorro (5.25), Venado (5.31), and San Diego (5.36) are all springs that are popular areas for bathing as are several springs within the Guzmán Basin (5.13). The springs of Media Luna/Río Verde (5.32) are used for swimming, and picnicking as well.

Threat Analysis

High threat rankings were assigned to twenty-seven of the thirty-seven freshwater priority sites (73%). Of these twenty-seven, six are highest priority "1" sites: Upper Yaqui (5.02), Zona Carbonifera (5.06), Pecos River (5.15), Papigochia (5.08), Mezquital (5.21), and Media Luna/Río Verde (5.32). Catchment scale alterations such as widespread clearcutting and livestock grazing, which cause increased runoff and sedimentation, as well as the expansion of agriculture, were identified as widespread and significant threats. Future threats include degraded water quality through increased salinization, altered flow regimes and water levels, dams, non-native species, and the loss of organic inputs.

Sites with the highest predicted threat ranks (100) currently suffer from highly altered catchment conditions. Panuco (5.17) and Upper Aguanaval (5.23) are priority "2" sites, Laguna de Santiaguillo (5.20) is a priority "3" site, and Potosí (5.26) and Sandía (5.28) are priority "4" sites.

No sites scored in the low threat category. But within the medium category of estimated future threat, two sites rated 40. Tularosa Basin (5.18) is located in the center of a U.S. military reservation and is not available for public use, and the Upper Conchos (5.35) is a remote site in the Sierra Madre Occidental. The Upper Conchos is also a highest priority "1" site. Within the remaining eight medium threat ranks, six sites are highest priority "1" sites.

II. Future threats to biodiversity

a. Habitat conversion threats

Nearly half (26) of the sixty-one terrestrial sites are estimated to have a conversion rate of native habitats of at least 25% over the next twenty years. The assorted causes represent a range of human social and economic endeavors such as mining, urban growth, livestock grazing, recreation, water diversions and groundwater pumping for agriculture, and pollution. Thirteen of the twenty-six sites are predicted to have concurrent high degradation, seven of these being riparian sites.

Moderate levels of conversion for eleven sites were also associated with moderate levels of predicted degradation. All eleven are upland sites without significant riparian resources, and with the exception of Samalayuca Dunes, overgrazing is a common factor.

Ten of the sites are on the low end of moderate future threats. Eight of these sites are in the U.S. and have some degree of federal protection, such as Wilderness Areas. Of the two sites in Mexico, Sierra Picacho is being considered for protective status and Sierra Menchaca is distant from urban centers and other threats.

Significant habitat conversion is not anticipated for Willcox and Lordsburg Playas, North Sierra Madre, and Pajarita-Atasco Mountains. The North Sierra Madre ratings were determined by people who did not have extensive experience in this area and were somewhat uncertain. The playas are not expected to have further degradation, since they are protected and are of little resource value, currently.

b. Degradation

Sixteen priority sites are predicted to experience a high rate of degradation over the next twenty years. Half of these are riparian sites.

Moderate degradation is estimated for thirty-four sites. Ten of these were predicted to have low rates of conversion, being upland sites without significant riparian areas and with some amount of federal protection in the U.S.. Twelve of the thirty-four moderate degradation sites are predicted to have high conversion rates, eight of these being primarily riparian.

The eleven sites predicted to have low rates of degradation are all within the U.S. and have some degree of special use designated by federal land agencies, or are owned by conservation groups. Sierras del Carmens and Eastern and Middle Sierra Madre were not expected to undergo degradation, perhaps due to their rugged inaccessiblity. All priority sites in the U.S. with no predicted significant degradation have some protection, either as conservation easements, national parks, wilderness areas, or Areas of Critical Environmental Concern. All of the sites estimated to have low degradation also had low predicted future conversion and low wildlife exploitation.

Riparian areas

Fifteen of eighteen riparian sites are expected to have high levels of conversion and seven of these will have high degradation levels. No riparian site rated low in any of the three major threat categories. The only riparian sites without predicted high conversion rates were the Pecos, Rio Grande-El Paso to

Amistad, and Lower Middle Gila River. All may have been rated low because there is currently little habitat left for conversion.

c. Wildlife Exploitation

Only ten of the sixty-one sites were rated as having high levels of wildlife exploitation over the next twenty years. All ten sites are located in Mexico. The two lake sites are expected to experience high levels of waterfowl poaching. Huizache-Cerritos (4.02) and Chihuahuan Querétaro Desert (4.03) are expected to continue as sources of reptiles and cacti for the wildlife trade. The remaining six are also expected to be exploited for game, cacti, birds, and reptiles.

Moderate levels of exploitation were predicted for thirty-eight (62%) of the sites. A broad range of exploitation activities are projected to continue including the cacti trade, harvesting and processing of candelilla and guayule, poaching of deer, prairie dogs, and pronghorn antelope, and the capture and sale of songbirds.

Low exploitation was predicted for thirteen (21%) of the sites. Twelve of these were also rated in the low or moderate threat rankings. Three of the sites in Mexico are remote and do not experience high human visitation. Three of the U.S. sites are owned, in part, by conservation groups or are managed by state resource agencies. Four have federal protection as special use areas, and three are riparian corridors that are largely depleted of their wildlife.

d. Future threats to biodiversity by site priority rank

Highest priority sites (Level 1)

Ten of the sixteen 'highest priority' sites are predicted to experience high threats to biodiversity over then next twenty years. Sites with highest predicted threat levels (100 points total) include Laguna de Santiaguilla (4.06), Huizache-Cerritos (4.02), Altiplano Mexicano Nordoriental (4.01), and Mapimí Complex (3.01). Sites that rated high future threat (total 90) are Rio Grande-El Paso to Amistad (2.02), Northcentral Chihuahuan Grasslands (2.08), and Río Nazas (4.07). Within the high threat category (total 70-85 points) are Chihuahua Querétaro Desert (4.03), Cuatrociénegas (3.03), and Sierra del Nido (2.01). All but Rio Grande-El Paso to Amistad (2.02) are entirely within Mexico. Three of these ten were selected for wetland-riparian values, two were selected for cacti endemism and richness, one is a functional, diverse grassland, one is a mountain range, and three are large valley habitat complexes. No overriding threat is common to all the sites, although prominent threats include water pollution, inappropriate grazing practices, poaching, water diversion, and exotic species introduction. They all share very low or non-existent levels of protection. Five highest priority sites were rated with moderate threat rankings. All five sites have some level of federal or private protection in the U.S. or Mexico but are not completely protected. Only one site, Guadalupe-Carlsbad, is a highest priority site with a low threat ranking. This site has substantial federal protection through the U.S. National Park Service and the U.S. Forest Service.

High priority sites (Level 2)

Within the 'high priority' designation are five highly threatened sites, all primarily riparian and all having experienced significant habitat loss and degradation. Nine sites fall into the moderate ranking.

Four sites in the low threat ranking have substantial protection from federal or private sources for the three sites in the U.S., and the site in Mexico is extremely remote.

Priority sites (Level 3)

High threat rankings were assigned to eight of the twenty 'priority' sites. Three of these are riparian sites with high demands on water and habitat. Two sites are grasslands that support livestock grazing. Nine 'priority' sites were estimated to experience moderate threat. Two of these are riparian sites and the rest are montane areas. The four mountains ranges within the U.S. are managed by federal agencies.

Important priority sites (4)

Only one site of the seven 'important' sites was rated as high threat. The Lower San Pedro (1.06) is a riparian site with high agricultural demands on instream flows. Five 'important' sites were rated as moderately threatened. One site is a grassland, one a riparian, and three are mountain sites. The Sierra Los Ajos (1.12) site is very remote and rugged and its threats are thought to be low.

Appendix Table C-2 Raw data for candidate priority sites

Sub-Region[1]	#	Candidate Priority Site Name	Reasons Selected[2]	Status[3]	Threats[4]	Rank[5]	Conversion	Degradation	Wildlife	Total	Catchment	Habitat	Biota	FTotal	Fsub	FW#	Conabio
1	1.01	Baboquivari	8,9,17	3	D, O	M	20	15	10	45							
1	1.02	Pajarita-Atatasco Mts.	9,11,17	3	R, O, D, V	M	0	15	10	35						5.04	
1	1.03	Santa Rita Mts.	9	3	X, D, R, H	H	50	30	10	90							
1	1.04	Sonoita Creek	11, 8	2	D, G, A, F, O	M	50	15	0	65						5.04	
1	1.05	Santa Catalina	8, 9, 10	2	D, R, O, P	M	20	15	10	45							
1	1.06	Lower San Pedro River	8, 9	4	A, O, W	H	50	15	10	75						5.03	
1	1.07	Whetstone Mts.	10	4	D, R, CC, O	M	20	15	10	45							
1	1.08	Appleton-Whittell Ranch	11, 9	2	none	L	10	0	0	10						5.03	
1	1.09	Huachuca Mts.	8, 9, 10	3	R, O, Z, F	M	20	15	10	45						5.03	
1	1.10	Upper San Pedro River	8, 9	2	O, G ,X	H	50	15	10	75						5.03	
1	1.11	Rio Sonora Watershed		4	O, T	M	20	0	10	30						5.05	21
1	1.12	Sierra Los Ajos	8	4	T	L	0	0	10	10						5.05	
1	1.13	Rio Yaqui	10, 17	3	T	H	50	15	10	75						5.02	
1	1.14	Gila River Corridor	16	4	O, G	M	10	15	0	40						5.37	
1	1.15	Galiuro Mts.	8, 10, 13	3	O	L	10	0	10	20						5.03	
1	1.16	Pinalenos	8	2	O, D	M	10	15	0	25						5.03	
1	1.17	Willcox Playa	9, 13, 17	2	O, A, G, V	L	0	0	0	0						5.03	
1	1.18	Dragoon Mts.	11, 9	4	O, M, D	L	10	15	10	35						5.03	
1	1.19	Sulphur Springs Valley	12	3	O, W, D	H	50	30	10	80						5.03	
1	1.20	Chiricahua-Peloncillo	11, 10, 16	1	D, CC, O, A, R, H, G, T, X, P	M	20	15	10	45						5.03, 5.07	34, 35
1	1.21	N. Peloncillo Mts.	8, 9, 16	2	O, W	L	10	0	10	20						5.37	

Sub-Region[1]	#	Candidate Priority Site Name	Reasons Selected[2]	Status[3]	Threats[4]	Rank[5]	Conversion	Degradation	Wildlife	Total	Catchment	Habitat	Biota	FTotal	Fsub	FW#	Conabio
1	1.22	Big Hatchets-Alamo Huecos	13	3	O, Z, G	M	10	15	10	35							
1	1.23	Hachita Grasslands	10	4	F, O,	M	20	30	10	60							
1	1.24	Lordsburg Playa	13, 10	3	W, G, O, A		0	0	0	0							
1	1.25	Lower & Middle Box	12, 9, 8	2	O, W, M, T, X	H	50	15	10	75						5.37	
1	1.26	Mimbres	12, 11	3	D, W, G, M, C, O, T	H	50	30	10	90						5.12	
2	2.01	Sierra del Nido	8, 11	1	T, F, O, D, H	H	50	15	20	85						5.13, 5.14, 5.29	39
2	2.02	Rio Grande-El Paso to Amistad	12, 13	1	P, Q, W, X, C, D, F, I	H	50	30	10	90						5.10	40
2	2.03	Rio Grande-Elephant Butte to El Paso	12, 13	3	D, C, D, A, I, X, O, Q, W, P	H	50	30	10	90						5.11	
2	2.04	Guadalupe Mts.-Carlsbad Escarpment	8, 9	1	R, F, W, G, O, V, D	L	10	0	0	10							
2	2.05	Davis-Chinati Mts. Complex	10, 11	1	O, F, P, R, Y, H, D, W, CC	M	20	15	10	45						5.10	
2	2.06	Devil's River	9, 12	3	G, Q, D, X, R	M	50	15	0	65						5.09	
2	2.07	Big Bend	9, 13	1	P, X, R, I, F, H, O, V, D, Q	M	10	15	10	35						5.10	41
2	2.08	North-Central Chihuahuan Grasslands	11, 13	1	X, H, F, O	H	50	30	10	90							
2	2.09	Tularosa Basin	11, 10	1	O, V, H, X, F, G,	M	10	15	10	35						5.18	
2	2.10	TX-NM Pecos River Corridor	9, 12	3	Q, I, P, X, M	M	20	30	0	50						5.15	
2	2.12	La Perla	13	3	H, O, A	H	50	15	10	75							47
2	2.13	Mescalero Sands	10, 8, 9	2	O, M	M	10	15	10	35							
2	2.11	Alta Bavicora	9, 17	2	T, O, P, W, I, A, H	H	50	15	20	85						5.16	
2	2.15	Conchos River	10, 12	2	A, T, M	H	50	30	10	90						5.35	46

Sub-Region[1]	#	Candidate Priority Site Name	Reasons Selected[2]	Status[3]	Threats[4]	Rank[5]	Conversion	Degradation	Wildlife	Total	Catchment	Habitat	Biota	FTotal	Fsub	FW#	Conabio
2	2.16	Marathon Basin	10, 9	2	I, O, D, P	M	20	15	10	45							
2	2.17	Sierra Blanco Complex	11, 13	2	O, F, R	M	20	15	10	45							
2	2.18	Rio Grande-Above Elephant Butte	9, 13, 8	2	D, G, I, C, A, X	H	50	30	0	80							
3	3.01	Mapimi Complex	13, 9	1	O, G, A, P, R, H, M	H	50	30	20	100						5.33	57, 58, 81
3	3.02	Sierras del Carmen & Santa Rosa	11, 13, 9	1	O, X, H, T, Y	M	50	0	10	60							49
3	3.03	Cuatrocienegas	9, 12	1	W, G, M, O, X, I, Y, H, T, A, Q	H	50	15	10	75						5.30	54, 55, 56
3	3.04	Sierra de la Paila	11, 17	2	O, H, F, Y, M, T	M	20	15	20	55							
3	3.05	Sierra Santa Fe del Pino	13, 17	2	O, H		0	0	0	0							
3	3.06	Sierra de Manchaca	11, 17	3			0	0	0	0							
3	3.07	Sierra de la Gloria	11, 17	3	H, M, T, A, D, Y	H	50	15	20	85							
3	3.08	Sierra de las Minas Viejas	17	3	O, Y, H, D	M	0	0	0	0							
2	2.14	Samalayuca Dunes	8	2	M, G, D	M	20	15	10	45							37
4	4.01	Altiplano Mexican Nordoriental	8, 9	1	O, A, P, H, T, F	H	50	30	20	100						5.26, 5.27, 5.28	61, 62, 63, 64, 69
4	4.02	Huizache-Cerritos	9	1	A, O, H, M	H	50	30	20	100						5.31, 5.32	65, 93, 94
4	4.03	Queretano		1	H, P, A, T, O, Y		0	0	0	0						5.17, 5.34	103, 105
4	4.04	Peco de Teyra	9	3	A, O		0	0	0	0							
4	4.05	Organos-Malpais	11, 13	3	D, F, O	M	10	15	20	45						5.22	87
4	4.06	Laguna de Santiaguillo	9, 13, 16	1	A, D, G, I, P, W	H	50	30	20	100						5.20, 5.21	88
4	4.07	Cuenca del Rio Nazas	9, 12, 16	1	I, P, O, Q, A, Y	H	50	30	10	90							

Sub-Region[1]	#	Candidate Priority Site Name	Reasons Selected[2]	Status[3]	Threats[4]	Rank[5]	Conversion	Degradation	Wildlife	Total	Catchment	Habitat	Biota	FTotal	Fsub	FW#	Conabio
4	4.08	Monterrey-Saltillo Corridor	9, 10	3	M, D, G, W, A	H	50	15	10	75						5.25	61
4	4.09	Sierra de Picachos		2	M,												60
5	5.01	Willow Spring	8	3	W	H					40	30	0	70	2		
5	5.02	Upper Yaqui	9, 11, 8	1	X, O, W, G, T	H					40	30	30	70	1		
5	5.03	San Pedro-Araivaipa	11	1	G, O, C, X, M, D	M					25	15	15	55	1		
5	5.04	Upper Santa Cruz	8, 11	2	D, O, P	H					40	15	15	70	1		
5	5.05	Rio Sonora	9, 11	2	W, M, O, X, G	H					40	15	30	85	1		
5	5.06	Zona Carbonifera	8, 12, 11	1	G, P	H					40	30	0	70	2		
5	5.07	Bavispe	8, 9	1	O, T, X	M					0	0	0	0	1		
5	5.08	Papigochia	9, 11	1	A, P, G, W, X, T	H					40	15	30	85	1		
5	5.09	Devils River	9, 11	1	W, O, X, D	M					25	15	15	55	2		
5	5.10	Rio Grande & Rio Conchos	9, 11	2	D, P, I, X, O, W	H					40	30	15	85	2		
5	5.11	Rio Grande-Southern NM	8, 13, 12	3	P, O, I, W, G, D, C, Q, X	H					10	30	30	70	2		
5	5.12	Mimbres River	9, 10	3	O, M, G, W, D, X	H					40	30	15	85	2		
5	5.13	Guzman Basin	12, 9	2	O, T, A, W, X, P, D, R, I	H					40	30	15	85	2		
5	5.14	Bustillos	9, 11	4	G, P, A, W	H					40	30	15	85	2		
5	5.15	Pecos River	9, 12	1	W, D, A, X, C, Q, P, G	H					25	30	15	70	2		
5	5.16	Bavicora	11		W, A, P, O	H					40	30	0	70	2		
5	5.17	Panuco	9, 10	2	W, P, D	H					40	30	30	100	4		
5	5.18	Tularosa Basin	10, 8	3	G, Z, X	M					25	0	15	40	2		
5	5.19	Upper Nazas	9, 10	1	A, T, X, P	M					25	15	15	55	3		
5	5.20	Laguna de Santiaguillo	10, 11, 17	3	W, A, X	H					40	15	15	70	3		

Sub-Region[1]	#	Candidate Priority Site Name	Reasons Selected[2]	Status[3]	Threats[4]	Rank[5]	Conversion	Degradation	Wildlife	Total	Catchment	Habitat	Biota	FTotal	Fsub	FW#	Conabio
5	5.21	Mezquital	8, 10, 12	1	A, D, X, P	H					25	30	15		3		
5	5.22	La Concha	17, 8, 9	2	R, A, P	H					40	30	0	70	3		
5	5.23	Upper Aguanaval	9, 10, 11	2	W, G, A, P	H					40	30	30	100	3		
5	5.24	Parras		4	W						0	0	0	0	3		
5	5.25	Chorro	17, 10	4	T, W, G	H					40	30	0	70	3		
5	5.26	Potosi	12	4	W, G						0	0	0	0	4		
5	5.27	Iturbide	8	4	W, G, P	M					40	15	0	55	4		
5	5.28	Sandia	12	4	G, W						0	0	0	0	4		
5	5.29	Sauz Basin	9	3	G, W, A, D	H					40	30	15	85	2		
5	5.30	Cuatrocienegas	10	1	W, G, H, A, D, C, X	M					25	15	15	55	3		
5	5.31	Venado	9	3	G, W, R	M					40	15	0	55	4		
5	5.32	Media Luna/Rio Verde	9, 10	1	A, R, P	H					25	30	30	85	4		
5	5.33	Cadena	9, 10, 11	2	G, A, W	H					40	30	0	70	3		
5	5.34	Extorax	9	2	P, A	M					40	30	15	84	4		
5	5.35	Upper Conchos	9, 10, 11	1	T, A	M					25	15	0	40	2		
5	5.36	San Diego	8, 9	2	D, O, G	H					0	0	0	0	2		
5	5.37	Upper Gila	9, 11	1	O, C, W, D, A, X	M					25	15	15	55	2		

[1] Subregion: 1-Apachean; 2-Northern Chihuahuan; 3-Central Chihuahuan; 4-Meseta Central

[2] Reasons for selection: 1- Richness; 2- Endemism; 3- Intact biota; 4- Species assemblages; 5- Species radiations; 6- Relictual or primitive species; 7- Large scale ecological phenomena; 8- Representative habitat types; 9- Representative species assemblages;10- Representative ecological or evolutionary phenomena; 11- Intact habitat or biota; 12- Critical for important ecological processes;13- Critical for large scale ecological phenomena; 14- Genetic resource for human utility; 15- Education value; 16- Ecosystem services

[3] Status: 1-Highest priority; 2-High priority; 3-Priority; 4-Important

[4] Threats: A- Agriculture; C- Channelization; CC- Climate Change; D- Development; F- Fire Regime Altered; G- Ground water pumping; H- Hunting: Illegal, and unregulated resource extraction; I- Irrigation; M- Mining; O- Overgrazing; P- Pollution; Q- Quality and quantity of Water; R- Recreation; T- Timber; V- Military; W- Water Diversion; X-Exotics; Y- Indigenous Harvest of cactus and other plants or animals

[5] Rank: H-High; M-Medium; L-Low

Appendix D Contributions of Priority Sites

Appendix Table D-1 Habitat types and conservation attributes of priority freshwater sites

Priority Site#	Name	Priority Rank	Habitat Type	Contribution to conservation strategy
5.01	Willow Spring	3	Ciénega	Representative habitat type containing endemic snail
5.02	Upper Yaqui	1	High, medium, and low gradient perennial streams, temporary laguna, cool springs, ciénegas; low gradient ephemeral stream	Assemblages of highly restricted endemic fish species, intact habitats.
5.03	San Pedro-Arravaipa	1	Medium and low gradient perennial streams; low salinity cool springs, ciénegas	Intact fish assemblages on Aravaipa Creek and Redfield Canyon, including populations of formerly widespread species
5.04	Upper Santa Cruz	2	Medium gradient perennial stream, Low salinity cool spring, medium gradient ephemeral spring, ciénegas	Intact habitats, rare biota
5.05	Rio Sonora	2	Medium gradient perennial stream, low salinity cool springs, medium gradient ephemeral streams, ciénegas	Relatively intact fish assemblage and habitats
5.06	Zona Carbonifera	1	Subterranean, low salinity cool springs, medium and low gradient perennial streams	Species assemblages, critical for important ecological processes, and intact habitats.
5.07	Bavispe	1	Large river, perennial and ephemeral streams	Habitat types and species assemblages are representative
5.08	Papigochic	1	Important low salinity cool and warm springs, within a basin containing a large river, and perennial and ephemeral streams.	Unique habitats, important fish species
5.09	Devil's River	1	Low gradient perennial stream	Largely intact native fauna; endemic species adapted to narrow habitat conditions
5.10	Rio Grande & Rio Conchos	2	Large rivers, low gradient perennial stream	Representative large river habitat type; Rio Conchos serves as refuge for endemics
5.11	Rio Grande-Southern New Mexico	3	Ciénega, low gradient ephemeral and perennial streams	Representation of species assemblages and habitat types, critical for large scale ecological phenomena
5.12	Mimbres River	3	Medium gradient perennial and ephemeral stream, low salinity cool springs, ciénegas, high salinity warm springs	Relatively intact species assemblages, n arrowly endemic fish and snails.
5.13	Guzman Basin	2	Low salinity cool springs, ciénegas, perennial springs, low gradient ephemeral stream, low salinity warm springs	Ecological and evolutionary processes, species assemblages
5.14	Bustillos	4	Low gradient perennial and ephemeral streams, and ciénegas, within a basin of a permanent laguna, low salinity cool springs, and low gradient ephemeral and perennial streams.	Intact fish assemblage
5.15	Pecos River	1	Perennial and ephemeral low gradient streams, warm and cool springs with high and low salinities, ciénegas,	Species endemism, relatively intact biotas
5.16	Bavicora	3	Permanent laguna	Assemblage of regional endemic species
5.17	Panuco	2	Medium gradient perennial stream	Species richness and endemism, evolutionary phenomena
5.18	Tularosa Basin	3	Low gradient perennial and ephemeral streams, low salinity cool springs; ciénegas,	Evolutionary phenomenon, representation of habitat types; species endemism
5.19	Upper Nazas	1	High and medium gradient perennial streams	Species endemism; ecological/evolutionary phenomena, intact biota

Priority Site#	Name	Priority Rank	Habitat Type	Contribution to conservation strategy
5.20	Laguna de Santiaguillo	3	Permanent laguna and high gradient perennial stream.	Ecological and evolutionary phenomena, rare and endemic species; intact habitats; need for biological inventory
5.21	Mezquital	1	Perennial stream with high, medium, and low gradients.	Rare species, ecological and evolutionary phenomena, relatively intact biota
5.22	La Concha	2	Low salinity warm spring, low and medium gradient perennial stream.	Requires biological inventory, presence of local endemics, and refuge for basin endemics
5.23	Upper Aguanaval	2	Low and medium gradient perennial stream	Supports many basin endemics, ecological and evolutionary phenomena
5.24	Parras	4	Low salinity spring and low gradient perennial stream	Extinct aquatic fauna
5.25	Chorro	4	Medium gradient perennial stream	Requires biological inventory; rare intact habitat
5.26	Potosi	4	Low salinity cool spring	Critical for important ecological processes; rare and unusual species
5.27	Iturbide	4	Low gradient perennial stream	Requires biological inventory; single locality for fish species
5.28	Sandia	4	Low salinity cool spring	Higher level taxonomic distinctiveness; high endemism in multiple taxa
5.29	Sauz Basin	3	Permanent laguna, low and medium gradient perennial streams, and low salinity cool springs	Ecological/evolutionary phenomena of two distinct species assemblages
5.30	Cuatrocienega	1	Low and high gradient perennial streams, high salinity warm springs, low salinity cool springs, ciénegas, permanent lagunas	Globally outstanding levels of endemism among numerous taxa; rare, relatively intact habitat type
5.31	Venado	3	Low salinity cool springs	Species endemism within rare groups
5.32	Media Luna/Rio Verde	1	Low salinity warm and cool springs, ciénegas, low gradient perennial stream	High levels of endemism within multiple groups; requries biological inventory
5.33	Cadena	2	Low gradient perennial stream	Representation of species assemblages, ecological and evolutionary phenomena, requires biological inventory
5.34	Extorax	2	Medium gradient perennial stream	Species richness and endemism; evolutionary phenomena
5.35	Upper Conchos	1	High gradient perennial stream	Relatively intact assemblages, including endemics, ecological and evolutionary phenomena
5.36	San Diego	2	Low salinity warm spring	Endemic fish, isopods, clams
5.37	Upper Gila	1	High salinity warm springs; warm salinity warm springs; warm salinity cool springs; high and medium gradient perennial streams; medium gradient ephemeral streams; ciénegas	Intact fish and riparian faunal assemblages

Appendix Table D-2 Distribution of freshwater priority sites among habitat types

	Habitat Type	Number of Priority Sites
I.	Warm springs	
	A. High salinity	4
	B. Low salinity	5
II.	Cool springs	
	A. High salinity	0
	B. Low salinity	18
III.	Large rivers (and associated floodplain)	2
IV.	Perennial streams	
	A. High gradient	7
	B. Medium gradient	15
	C. Low gradient	20
V.	Ephemeral streams	
	A. High gradient	0
	B. Medium gradient	5
	C. Low gradient	7
VI.	Lagunas	
	A. Permanent terminal	5
	B. Temporary	1
VII.	Ciénegas	14
VIII.	Subterranean habitats	2

Appendix Table D-3 Priority sites and their contributions to an ERBC strategy (Use figures 6.1 and 6.2 to locate terrestrial and freshwater sites respectively)

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
Apachean			
1.20	Chiricahua-Peloncillo	1	High herpetofauna, invertebrate, vegetative diversity and endemism, rare species, representative species assemblages, intact habitat
1.04	Sonoita Creek	2	Intact habitat and representative habitat types
1.05	Santa Catalina	2	Grama grasslands, representative species, habitat type, and ecological and evolutionary phenomena.
1.08	Appleton-Whittell Ranch	2	Grama grasslands, representative species assemblages, and intact habitat and biota.
1.10	Upper San Pedro River	2	Intact riparian woodland, representative habitat types and species assemblages
1.16	Pinalenos	2	Representative habitat type
1.17	Willcox Playa	2	Migratory stopover, high invertebrate diversity, critical for large scale ecological phenomena, contains representative species assemblages
1.21	N. Peloncillo Mts.	2	Representative habitat types and species assemblages
1.25	Lower & Middle Box	2	Rare riparian communities, representative habitat types and species assemblages, and critical for important ecological processes
1.01	Baboquivari	3	Representative species assemblages and habitat types
1.02	Pajarito-Atatasco Mts.	3	Contains intact habitat and representative species assemblages
1.03	Santa Rita Mts.	3	Old growth forests, distinctive herpetofauna, and representative species assemblages
1.09	Huachuca Mts.	3	Intact vegetation, representative habitat types, species assemblages, and ecological phenomena
1.13	Rio Yaqui	3	Representative ecological, evolutionary phenomena
1.15	Galiuro Mts.	3	Transition zone, critical for large scale ecological phenomena, representative habitat types
1.19	Sulphur Springs Valley	3	Critical for important ecological processes, integrity
1.22	Big Hatchets-Alamo Huecos	3	High aquatic vertebrate assemblages, well preserved communities, critical for large scale phenomena

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
1.24	Lordsburg Playa	3	Migratory stopover, critical and representative ecological-evolutionary phenomena
1.26	Mimbres	3	Partially intact habitat and biota, and critical for ecological processes, integrity
1.06	Lower San Pedro River	4	Migratory stopover, representative species assemblages, and ecological-evolutionary phenomena
1.07	Whetstone Mts.	4	Representative ecological and evolutionary phenomena
1.11	Rio Sonora Watershed	4	Biological inventories needed
1.12	Sierra Los Ajos	4	Critical for important ecological processes, integrity
1.14	Gila River Corridor	4	Provides essential ecosystem services
1.18	Dragoon Mts.	4	Intact habitat and biota, and representative species assemblages
1.23	Hachita Grasslands	4	Representative ecological-evolutionary phenomena
Northern Chihuahuan			
2.01	Sierra del Nido	1	Well protected, grizzly bear populations, representative habitat types, and intact habitat and biota
2.02	Rio Grande-El Paso to Amistad	1	Migration stopover and corridor, important bird nesting sites, critical for large scale ecological phenomena, and ecological processes
2.04	Guadalupe Mts.-Carlsbad Escarpment	1	Migration corridor, unique gypsum/saline flats, representative habitat types and species assemblages
2.05	Davis-Chinati Mts. Complex	1	Important migration corridor, intact habitat and biota, mountain endemics, and representative ecological-evolutionary phenomena
2.07	Big Bend	1	Important bird nesting sites, many endemic invertebrates, contains CONABIO site, important mammal populations, representative species assemblages, critical for large scale phenomena
2.08	North-Central Chihuahuan Grasslands	1	Important bird wintering areas, antelope populations, grama and tobosa grasslands, intact habitat, biota and critical for large scale ecological phenomena
2.09	Tularosa Basin	1	Important invertebrate diversity, intact and diverse basin & range habitat and species assemblages, representative of evolutionary-ecological phenomena

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
2.11	Alta Bavicora	2	Representative habitat types, biological inventory needed
2.13	Mescalero Sands	2	Many endemic invertebrates, representative habitat types, species assemblages, and ecological/evolutionary phenomena
2.14	Samalayuca Dunes	2	Endemic cacti, representative habitat types
2.15	Conchos River	2	Representation of ecological-evolutionary phenomena and critical for ecological processes
2.16	Marathon Basin	2	Important raptor habitat, endemic and rare cacti, representative species assemblages and ecological-evolutionary phenomena
2.17	Sierra Blanco Complex	2	Important raptor habitat, intact habitat, biota and critical for large scale ecological phenomena
2.18	Rio Grande-Above Elephant Butte	2	Important bird migration, wintering, breeding habitat, representative habitat types, species assemblages, and critical for large scale ecological phenomena
2.03	Rio Grande-Elephant Butte to El Paso	3	Critical for large scale ecological phenomena, and ecological processes
2.06	Devil's River	3	Rare and endemic species, representative species assemblages, and critical for ecological processes
2.10	TX-NM Pecos River Corridor	3	Important migration corridor, representative species assemblages, critical for important ecological processes
2.12	La Perla	3	Important bird wintering area, mammal populations, endemic grasses, critical for large scale ecological phenomena
Central Chihuahuan			
3.01	Mapimi Complex	1	Contains CONABIO sites, important herpetofauna species, gypsophilic species and endemics, representative species assemblages, critical for large scale phenomena
3.02	Sierras del Carmen & Santa Rosa	1	Bird and bat migration corridor, intact and rare habitat and communities, representative habitat types, undescribed invertebrate populations, and critical for large scale ecological phenomena
3.03	Cuatrocienegas	1	Important endemic herpetofauna, and mammal species, endemic gypsophilic species, migration corridors, representative species assemblages, critical for important ecological processes

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
3.04	Sierra de la Paila	2	Intact habitat and biota, and biological inventories needed
3.05	Sierra Santa Fe del Pino	2	Critical for large scale ecological phenomena, and biological inventories needed
3.06	Sierra de Manchaca	3	Intact habitat and biota, and biological inventories needed
3.07	Sierra de la Gloria	3	Intact habitat and biota, and biological inventories needed
3.08	Sierra de las Minas Viejas	3	Biological inventory needed
Meseta Central			
4.01	Altiplano Mexican Nordoriental	1	High invertebrate diversity and endemism, critical prairie dog and mammal populations, high cacti endemism and diversity, representative habitat types and species assemblages
4.02	Huizache-Cerritos	1	Gypsophilic, halophytic species, representative species assemblages
4.03	Queretaro	1	High cacti diversity, biological inventories needed
4.06	Laguna de Santiaguillo	1	Bird migratory stopover, CONABIO site, representative species assemblages, critical large scale ecological phenomena
4.07	Cuenca del Rio Nazas	1	High vegetative diversity and endemism, representative species assemblages, critical ecological processes
4.09	Sierra de Picachos	2	Biological inventories needed
4.04	Peco de Teyra	3	High vegetative endemism and diversity, representative species assemblages
4.05	Organos-Malpais	3	Intact habitat and biota, critical large scale ecological phenomena
4.08	Monterrey-Saltillo Corridor	3	Representative species assemblages, and ecological-evolutionary phenomena
Freshwater			
5.02	Upper Yaqui	1	High freshwater fish diversity and diverse riparian habitats, representative habitat types, species assemblages, and intact habitat and biota
5.03	San Pedro-Aravaipa	1	Intact fish fauna, habitat, and biotas
5.06	Zona Carbonifera	1	Representative habitat types, critical ecological processes, intact habitat
5.07	Bavispe	1	Intact fish assemblages, representative habitat types and species assemblages

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
5.08	Papigochia	1	Representative species assemblages and intact habitat and biota
5.09	Devils River	1	Intact native freshwater fauna and habitat, representative species assemblages
5.15	Pecos River	1	High fish and invertebrate diversity, representative species assemblages, critical ecological processes
5.19	Upper Nazas	1	Important fish fauna and endemism, representative species assemblages and ecological or evolutionary phenomena
5.21	Mezquital	1	Important fish diversity and endemism, representative habitat types and ecological-evolutionary phenomena, critical ecological processes
5.30	Cuatrocienegas	1	Unique and rare aquatic habitats, high aquatic endemism, representative ecological and evolutionary phenomena
5.32	Media Luna/Rio Verde	1	Unique aquatic habitats, important endemism, high diversity, representative species assemblages and ecological-evolutionary phenomena
5.35	Upper Conchos	1	High fish diversity and endemism, intact habitat and biota, representative species assemblages and ecological-evolutionary phenomena
5.37	Upper Gila	1	Largely intact fish and riparian faunal assemblages, representative species assemblages, mainly intact habitat
5.04	Upper Santa Cruz	2	Freshwater faunal endemism, representative habitat types and intact habitat and biota
5.05	Rio Sonora	2	Representative species assemblages and intact habitat and biota
5.10	Rio Grande & Rio Conchos	2	Important fish diversity, representative species assemblages and intact habitat and biota
5.13	Guzman Basin	2	Remnant habitat and fish communities, representative species assemblages, critical ecological processes
5.17	Panuco	2	High freshwater endemism, representative species assemblages and ecological or evolutionary phenomena
5.22	La Concha	2	Important fish endemism, representative habitat types and species assemblages, biological inventories needed
5.23	Upper Aguanaval	2	Intact habitat and biota, representative species assemblages and ecological-evolutionary phenomena

Subregion/ Site Number	Priority Site Name	Priority Status	Contribution to biological conservation strategies
5.33	Cadena	2	Intact habitat and biota, representative species assemblages and ecological-evolutionary phenomena
5.34	Extorax	2	Important fish endemism, representative species assemblages
5.36	San Diego	2	Unique aquatic habitats, important aquatic endemism, representative habitat types and species assemblages
5.01	Willow Spring	3	Representative habitat types
5.11	Rio Grande-Southern New Mexico	3	Representative habitat types, critical ecological processes, and large scale phenomena
5.12	Mimbres River	3	Representative species assemblages and ecological or evolutionary phenomena
5.16	Bavicora	3	Mainly intact habitat and biotas
5.18	Tularosa Basin	3	Representative habitat types and ecological-evolutionary phenomena
5.20	Laguna de Santiaguillo	3	Important fish endemism, intact habitat and biota, representative ecological-evolutionary phenomena, biological inventories needed
5.29	Sauz Basin	3	High freshwater faunal endemism, representative species assemblages
5.31	Venado	3	Representative species assemblages
5.14	Bustillos	4	CONABIO site, representative species assemblages
5.24	Parras	4	Important freshwater endemism, biological inventories needed
5.25	Chorro	4	Intact and rare freshwater habitat, biota, and biological inventories needed
5.26	Potosi	4	Critical for important ecological processes
5.27	Iturbide	4	Representative habitat types
5.28	Sandia	4	High freshwater faunal endemism, critical for important ecological processes

Appendix E Gap Analysis Using IUCN and Gap Categories

The data in this table were collected from published management plans and maps, as well as files and databases from the respective managing agencies. Assignment of gap protection levels follows Thompson et al. (1996), and assignment of IUCN protection levels follows guidelines established by the World Conservation Monitoring Center (www.wcmc.org.uk). Ter. Site and FW Site columns refer to Terrestrial and Freshwater Priority Sites and the number assigned to each site. Abbreviations are listed at the end of the table.

Protected Area Name	Managing Office	Gap	IUCN	Hectare	Acres	Ter. Site	FW Site
Aden Lava Flow RNA	BLM-Las Cruces	2	1a	1590	3930		
Ajos Bavispe	SEMARNAP	n/a	6	183565	453695	1.12	5.05
Alamo Mountain ACEC	BLM-Las Cruces	2	4	1089	2690	2.17	
Alamo Hueco WSA	BLM-Las Cruces	2	1b	5268	13020	1.22	
Alkali Lakes ACEC	BLM-Las Cruces	2	4	2573	6359	2.17	
Antelope Pass RNA	BLM-Las Cruces	1	4	3524	8710	1.20	
Apache Box WSA	BLM-Las Cruces	2	1b	1064	2630	1.25	5.37
Appleton-Whittell ACEC	BLM-Tucson	2	4	1271	3141	1.08	5.03
Appleton-Whittell Research Ranch	Nat'l Audubon Soct'y	1	1a	3237	8000	1.08	
Aravaipa Canyon Wilderness	BLM-Safford	2	1b	7853	19410	1.15	5.03
Aravaipa Easements	TNC-Arizona	2	n/a	139	344	1.15	5.03
Aravaipa Preserve	TNC-Arizona	1	1a	3163	7817	1.15	5.03
Baboquivari Peak Wilderness Area	BLM – Tucson	2	1b	835	2065	1.01	
Baker Canyon WSA	BLM-Safford	2	1b	1947	4812	1.20	5.02
Balmorhea State Park	TXPWD	3	6	19	46		5.15
Big Bend National Park	National Park Serv.	1	2	324150	801163	2.07	5.1
Big Bend Ranch State Park	TXPWD	2	4	113401	280280	2.07	
Big Brushy Canyon Preserve	TNC - Texas	1	1a	3976	9825	2.07	
Big Hatchets WSA	BLM-Las Cruces	2	1b	11806	29180	1.22	
Bingham Cienega Easements	TNC-Arizona	2	n/a	6	15		
Bingham Cienega Preserve	TNC-Arizona	1	1a	4	10		
Bitter Lake NWR	US-Fish & Wildlife	2	4	9927	24536		5.15
Black Gap Wildlife Management Area	TXPWD	2	4	42769	105708	2.07	
Blue Creek WSA	BLM-Las Cruces	2	1b	6027	14896	1.25	5.37
Blue Spring ACEC	BLM-Carlsbad	2	4	65	160	2.10	5.15
Bluntnose Shiner Critical Habitat	BLM-Carlsbad	2	4	81	200	2.10	5.15
Bosque del Apache	US-Fish & Wildlife	2	4	5219	12900	2.18	5.01
Bottomless Lakes State Park	NMEMNRD	3	6	566	1400		5.15
Brantley Wildlife Management Area	NMDGF	2	4	11493	28400	2.10	5.15
Buenos Aires NWR	US-Fish & Wildlife	2	4	46730	115498		
Bunk Robinson WSA	NF-Coronado	2	1b	1058	2614	1.20	
Caballo & Percha State Parks (Land)	NMEMNRD	3	6	2177	5380	2.03	5.11
Canelo Hills Easements	TNC-Arizona	2	n/a	18	44	1.08	
Canelo Hills Preserve	TNC-Arizona	1	1a	100	248	1.08	
Cañon Santa Elena	SEMARNAP	n/a	4	277092	684856	2.07	5.10
Carlsbad Caverns (with 13,405 ha	National Park Serv.	1	2	18922	46766	2.04	

Protected Area Name	Managing Office	Gap	IUCN	Hectare	Acres	Ter. Site	FW Site
wilderness)							
Carrizozo Lava Flow WSA	BLM-Roswell	2	1b	8189	20240		
Cedar Mts. WSA	BLM-Las Cruces	2	1b	6034	14911		
Central Peloncillo ACEC	BLM-Las Cruces	2	4	5159	12750	1.20	
Chandler Easement	TNC-Texas	2	n/a	284	701		5.15
Chinati Mountains State Park	TXPWD	2	4	15327	37883	2.05	
Chiricahua National Monument	US-Park Service	1	3	4849	11985	1.20	5.02
Chiricahua Wilderness	NF-Coronado	2	1b	35483	87700	1.20	5.02
Chosa Draw ACEC	BLM-Carlsbad	2	4	890	2200	2.10	
Chupadera Wilderness	Bosque del Apache NWR	1	1b	2140	5289		
City of Rocks	NMEMNRD	3	6	275	680		
Cooke's Range ACEC	BLM-Las Cruces	2	4	6943	17160		
Cornudas ACEC	BLM-Las Cruces	2	4	344	850	2.17	
Coronado National Memorial	US-Park Service	1	3	1922	4750	1.09	5.03
Cottonwood Springs Easements	TNC-Arizona	2	n/a	161	397		5.04
Cowboy Springs ACEC	BLM-Las Cruces	2	4	2727	6740	1.20	
Cuatrociénegas	SEMARNAP	n/a	4	84327	208421	3.03	5.30
Cumbres de Majalca Parque Nacional	SEMARNAP	n/a	2	781	1931	2.01	5.29
Dark Canyon ACEC	BLM-Carlsbad	2	4	599	1480	2.04	
Davis Mountains Easements	TNC-Texas	2	n/a	24846	61410	2.05	
Davis Mountains Preserve	TNC-Texas	1	1a	7283	18000	2.05	
Davis Mountains State Park	TXPWD	3	5	1096	2708	2.05	
Desert Grasslands RNAs (Pilares & Sombrero Butte)	BLM-Safford	1	1a	214	530	1.15	5.03
Devil’s River State Natural Area	TXPWD	2	4	8087	19988	2.06	5.09
Devil's Den WSA	BLM-Carlsbad	2	1b	129	320	2.04	
Diamond Y Preserve	TNC-Texas	1	1a	608	1502		5.15
Dolan Falls Preserve	TNC-Texas	1	1a	2023	5000	2.06	5.09
Dolan Falls Easements	TNC-Texas	2	n/a	5472	13522	2.06	5.09
Dos Cabezas Wilderness	NF-Coronado	2	1b	4734	11700	1.20	
Dripping Springs Natural Area	BLM-Las Cruces	1	4	1133	2800	2.09	
Elephant Butte State Park (Land)	NMEMNRD	3	6	9913	24500	2.03	5.11
Elephant Mountain Wildlife Management Area	TXPWD	2	4	9365	23147		
Floridas ACEC	BLM-Las Cruces	2	4	6336	15660		
Fort Bliss (does not include 1582 ha McGregor ACEC)	DOD	3	n/a	450600	1113695	2.09	
Fort Bowie National Historic Site	US-Park Service	2	3	405	1000	1.20	
Fort Huachuca	DOD	2	n/a	29675	73344	1.09	5.03
Franklin Mountains State Park	TXPWD	3	6	9810	24247	2.09	
Galiuro Wilderness	NF-Coronado	2	1b	30878	76317	1.15	5.03
Gila Box Riparian National Conservation Area	BLM-Safford	2	1a	8807	21767	1.14	5.37
Gila Lower Box – ACEC RNA	BLM-Las Cruces	2	1a	2626	6490	1.25	5.37
Gila Middle Box ACEC/WSR	BLM-Las Cruces	2	1a	340	840	1.25	5.37
Granite Gap WSA	BLM-Las Cruces	2	1b	708	1750		
Gray Peak WSA	BLM-Las Cruces	2	1b	5939	14678	1.20	
Gray Ranch	Animas Foundation	1	n/a	129877	321000	1.20	
Guadalupe Canyon ONA/ACEC	BLM-Safford	2	4	874	2159	1.20	5.02

Protected Area Name	Managing Office	Gap	IUCN	Hectare	Acres	Ter. Site	FW Site
Guadalupe Canyon WSA	BLM-Las Cruces	2	1b	1687	4170	1.20	5.02
Guadalupe National Park (54% wilderness –18,880 hectares)	US-Park Service	1	2	34964	86416	2.04	
Gypsum Dune Preserve	TNC-Texas	1	1a	91	226	2.04	
Hot Springs ACEC (w/ TNC Muleshoe)	BLM-Safford	1	1a	6784	16763	1.15	
Hueco Tanks	TXPWD	3	6	348	860	2.17	
Huey Wildlife Management Area	NMDGF	2	4	1133	2800	2.10	5.15
Independence Creek Preserve	TNC-Texas	1	1a	549	1358		5.15
Indian Wells Wilderness	Bosque del Apache NWR	1	1b	2079	5139		
Jornada del Muerto WSA	BLM-Socorro	2	1b	12605	31147		
La Joya Wildlife Management Area	NMDGF	2	4	1436	3550	2.18	5.01
Las Palomas Wildlife Management Area	TXPWD	2	4	842	2082	2.02	
Little San Pasqual Wilderness	Bosque del Apache NWR	1	1b	8035	19859		
Lonesome Ridge ACEC/WSA	BLM-Carlsbad	2	1b	1210	2990	2.04	
Lordsburg Playa RNA	BLM-Las Cruces	1	4	1825	4510	1.24	
Lower San Pedro Easements	TNC-Arizona	2	n/a	1065	2632	1.06	5.03
Lower San Pedro Preserve	TNC-Arizona	1	1a	803	1984	1.06	5.03
Maderas del Carmen	SEMARNAP	n/a	5	208332	514909	3.02	5.06
Mapimí Reserva de la Biosfera	SEMARNAP	n/a	5	181257	447891	3.01	
Mathers RNA	BLM-Roswell	1	4	98	241	2.13	
McGregor Black Grama Grassland ACEC	BLM-Las Cruces & DOD	2	4	1582	3910	2.17	
McKittrick Canyon WSA	BLM-Carlsbad	2	1b	81	200	2.04	
Mescalero Sands ACEC	BLM-Roswell	2	4	3191	7886	2.13	
Middle Madera Canyon	TNC-Texas	1	1a	906	2240	2.05	
Miller Peak Wilderness	NF-Coronado	2	1b	8169	20190	1.09	5.03
Mimbres River Easements	TNC-New Mexico	2	n/a	2124	5250	1.26	5.12
Mimbres River Preserves	TNC-New Mexico	1	1a	65	160	1.26	5.12
Mt. Wrightson Wilderness	NF-Coronado	2	1b	10220	25260	1.03	
Mudgett's WSA	BLM-Carlsbad	2	1b	1190	2941	2.04	
Needle's Eye Wilderness	BLM-Tucson	2	1b	3544	8760		
North Pecos River ACEC	BLM-Roswell	2	4	1359	3360		5.15
Northern Peloncillo ACEC	BLM-Las Cruces	2	4	307	760	1.21	
Oliver Lee State Park	NMEMNRD	3	6	81	200		
Organ-Franklin Mts. ACEC (does not include Dripping Springs Natural Area)	BLM-Las Cruces	2	1b	22667	56022	2.09	
Overflow Wetlands ACEC	BLM-Roswell	2	4	1209	2987		5.15
Pajarita Wilderness	NF-Coronado	2	1b	3002	7420	1.02	
Patagonia Lake State Park	AZ-State Parks	3	6	259	640		
Patagonia-Sonoita Creek	TNC-Arizona	1	1a	353	872	1.04	5.04
Patagonia-Sonoita Easements	TNC-Arizona	2	n/a	22	54	1.04	5.04
Pecos River/Canyons Complex ACEC	BLM-Carlsbad	2	4	2100	5190	2.10	5.15
Pecos River/Canyons Complex RNA	BLM-Carlsbad	1	1a	939	2320	2.10	5.15
Peloncillo Wilderness	BLM-Safford	2	1b	7865	19440	1.21	
Portal	TNC-Arizona	1	1a	11	28	1.20	
Portal Easements	TNC-Arizona	2	n/a	5	13	1.20	
Pusch Ridge Wilderness	NF-Coronado	2	1b	23035	56933	1.05	5.03

Protected Area Name	Managing Office	Gap	IUCN	Hectare	Acres	Ter. Site	FW Site
Ramsey Canyon Preserve	TNC-Arizona	1	1a	154	380	1.09	5.03
Rattlesnake Springs	TNC-New Mexico	1	1a	5	13	2.10	5.15
Red Rock Wildlife Area	NMDGF	2	4	506	1250	1.25	5.37
Redfield Wilderness Area	BLM-Safford	1	1b	2670	6600	1.15	5.03
Rincon Mt. Wilderness	NF-Coronado	2	1b	15614	38590	1.05	5.03
Rio Grande Wild & Scenic River	US-Park Service	2	5	0		2.02	5.10
Rio Vista Ranch Easement	TNC-Texas	2	n/a	5552	13722		
Robledos WSA	BLM-Las Cruces	2	1b	3718	9190		
Rock Hound State Park	NMEMNRD	3	6	101	250		
Sacramento Escarpment WSA	BLM-Las Cruces	2	1b	2171	5365		
Salt Creek Wilderness	Bitter Lake NWR	1	1b	3893	9621		5.15
San Bernadino & Leslie Canyon NWR	US Fish & Wildlife	2	4	1590	3931	1.20	5.02
San Francisco Wild & Scenic River	BLM-Safford	2	5	0			5.37
San Pedro ACEC	BLM-Socorro	2	4	486	1200		
San Pedro Riparian National Conservation Area	BLM-Tucson	2	4	19286	47668	1.10	5.03
San Rafael Easements	TNC-Arizona	2	n/a	9341	23084		5.04
Sandia Springs Preserve	TNC-Texas	1	1a	97	240		5.15
Seminole Canyon State Historical Park	TXPWD	3	6	879	2172		
Seven Rivers Wildlife Mgt. Area	NMDGF	2	4	1619	4000	2.10	5.15
Sevilleta NWR	US Fish & Wildlife	2	4	89730	221775		
Sierra Diablo Wildlife Management Area	TXPWD	2	4	4703	11625	2.17	
Soaptree SMA	BLM-Socorro	2	4	486	1200		
Sonoita State Natural Area	AZ-State Parks	2	1a	2023	5000	1.04	5.04
South Texas Hill RNA	BLM-Carlsbad	1	1a	550	1360	2.04	
Stallion SMA (includes Las Canas, & Presilla WSAs)	BLM-Socorro	2	1a	8027	19840		
Table Mountain RNA/ACEC	BLM-Safford	2	4	494	1220		
Turkey Creek Riparian ACEC	BLM-Safford	2	4	941	2326	1.16	
Upper San Pedro Preserves	TNC-Arizona	1	1a	37	91	1.10	5.03
Uvas Valley ACEC	BLM-Las Cruces	2	4	635	1570		
White Sands Missile Range (includes San Andres NWR 57215 acres)	DOD	2	n/a	828621	2048000	2.09	5.18
White Sands National Monument	US-Park Service	1	3	59288	146535	2.09	5.18
Whitmire Canyon WSA	NF-Coronado	2	1b	850	2102	1.20	
Willcox Playa ACEC	BLM-Safford	2	4	1488	3676	1.17	5.02
Wind Mtn. ACEC	BLM-Las Cruces	2	4	1014	2506	2.17	
Winder Ranch Easement	TNC-New Mexico	2	n/a	1618	4000		
Yeso Hills RNA	BLM-Carlsbad	1	1a	227	560	2.10	

Abbreviations for Gap Analysis Table

ACEC=	Area of Critical Environmental Concern (used by BLM)
AZ=	Arizona
BLM=	US Department of Interior Bureau of Land Management
DOD=	Department of Defense
INE=	Instituto de Ecologia A.C.
NF=	US Department of Agriculture National Forest
NMDGF=	New Mexico Department of Game and Fish
NMEMNRD=	New Mexico Energy, Minerals, and Natural Resources Department
NWR=	National Wildlife Refuge (US Depart.of the Interior Fish and Wildlife Service)
ONA=	Outstanding Natural Area
SEMARNAP=	Secretaría de Medio Ambiente, Recursos Naturales y Pesca
SMA=	Special Management Area
RNA=	Research Natural Area
TNC=	The Nature Conservancy
TXPWD=	Texas Parks and Wildlife Department
US Park Service=	US Department of Interior National Park Service
WSA=	Wilderness Study Area
WSR=	Wild and Scenic River

***Gap Categories*:**

The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. Lands are categorized relative to management status, the degree to which an area is managed to maintain biodiversity (Thompson *et al*. 1996).

Management Status 1-an area with an active management plan in operation that is maintained in its natural state and within which natural disturbance events are either allowed to proceed without interference or are mimicked through management. Most national parks, Nature Conservancy preserves, some wilderness areas, Audubon Society preserves, some USFWS National Wildlife Refuges (e.g., Oregon Islands, Ash Meadows), and Research Natural Areas are included in this class.

Management Status 2-an area that is generally managed for its natural values, but which may receive use that degrades the quality of natural communities that are present. Most wilderness areas, USFWS Refuges managed for recreational uses, and BLM Areas of Critical Environmental Concern are included in this class.

Management Status 3-most nondesignated public lands, including USFS, BLM, and state park lands. Legal mandates prevent permanent conversion to anthropogenic habitat types (with some exceptions, such as tree plantations) and confer protection to populations of Federally listed endangered, threatened, and/or candidate species.

Management Status 4-private or public land without an existing easement or irrevocable management agreement that maintains native species and natural communities and which is managed primarily or exclusively for intensive human activity. Urban, residential and agricultural lands, public buildings and grounds, and transportation corridors are included in this class.

IUCN ProtectedAreas Management Categories

Strict Nature Reserve/Scientific Reserve (1)
To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.

National Park (2)
To protect outstanding natural and scenic areas of national or international significance for scientific, educational, and recreational use. These are relatively large natural areas not materially altered by human activity where extractive resource uses are not allowed.

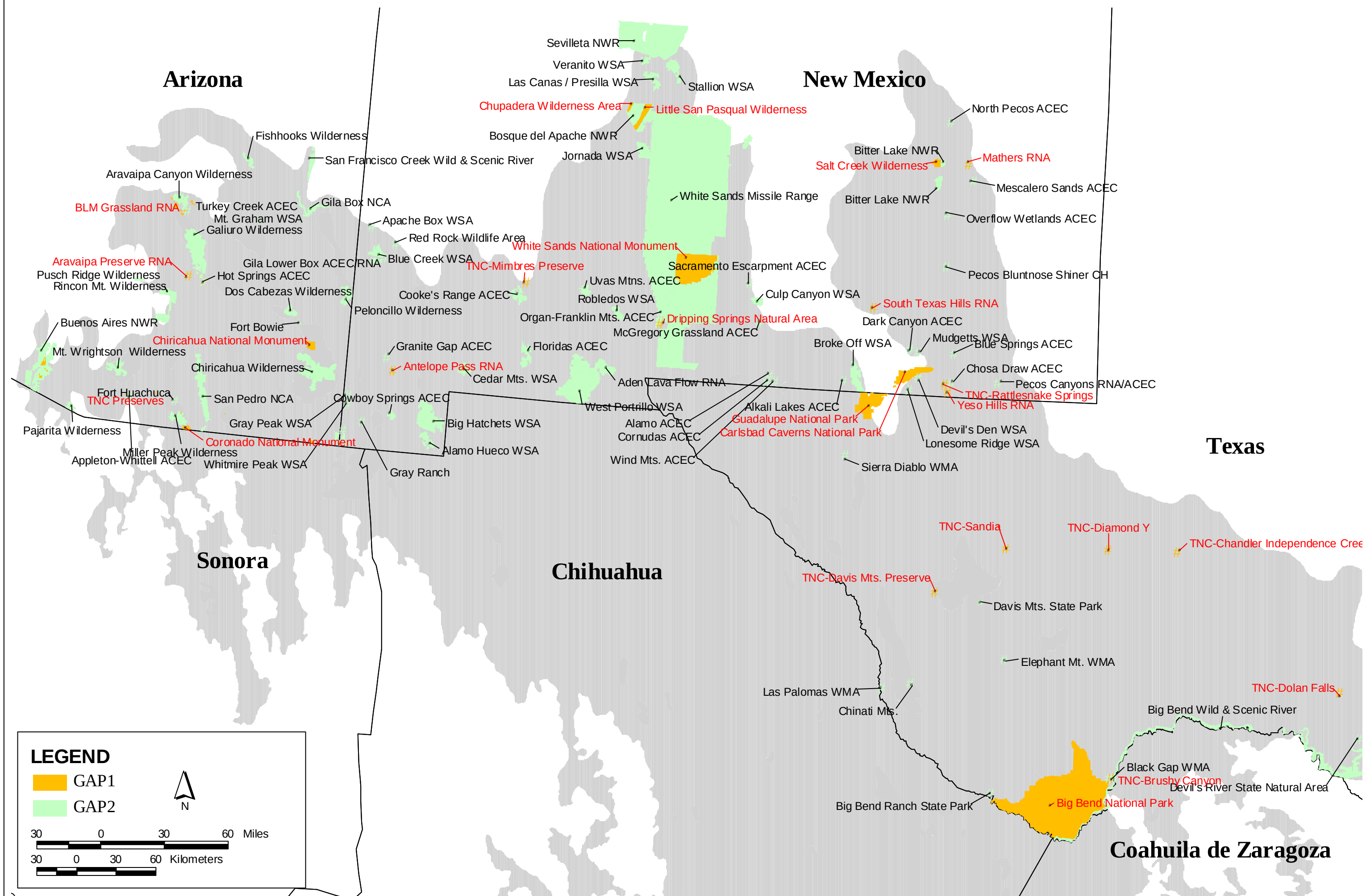
Natural Monument/Natural Landmark (3)
To protect and preserve nationally significant natural features because of their special interest or unique characteristics. These are relatively small areas focused on protection of specific features.

Managed Nature Reserve/Wildlife Sanctuary (4)
To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment where these may require specific human manipulation for their perpetuation. Controlled harvesting of some resources can be permitted.

Protected Landscapes and Seascapes (5)
To maintain nationally significant natural landscapes which are characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal life style and economic activity of these areas. These are mixed cultural/natural landscapes of high scenic value where traditional land uses are maintained.

Resource Reserve (6)
To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning. This is a `holding' category used until a permanent classification can be determined.

Anthropological Reserve/Natural Biotic Area (7)
To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology. This category is appropriate where resource extraction by indigenous people is conducted in a traditional manner.



AppE-1 GAP 1 and GAP2 locations

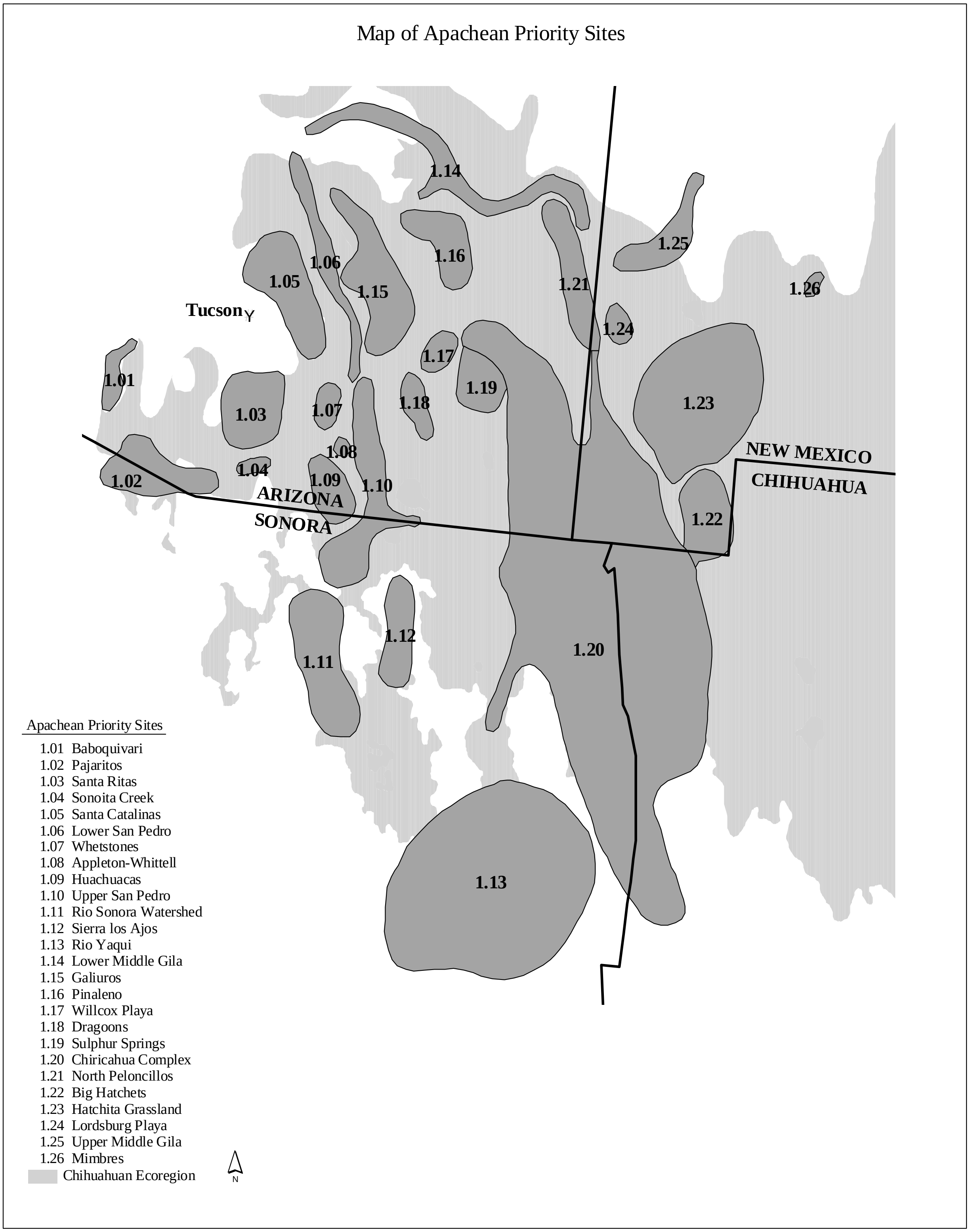
Appendix Figure E-1 GAP 1 and GAP2 locations

Appendix F : Description of Priority Sites

Priority site descriptions are arranged by sub-region, then numerically. Some freshwater priority site descriptions are included within associated terrestrial priority site descriptions.

Site#	Site Name
1.01	Baboquivari
1.02	Pajarita
1.03	Santa Ritas
1.04	Sonoita Creek
1.05	Santa Catalinas
1.06	Lower San Pedro
1.07	Whetstones
1.08	Appleton-Whittell
1.09	Huachucas
1.10	Upper San Pedro
1.11	Rio Sonora Watershed
1.12	Sierra Los Ajos
1.13	Rio Yaqui
1.14	Lower Middle Gila
1.15	Galiuros
1.16	Pinaleño
1.17	Willcox Playa
1.18	Dragoons
1.19	Sulphur Springs
1.20	Chiricahua Complex
1.21	North Peloncillos
1.22	Big Hatchets
1.23	Hatchita grassland
1.24	Lordsburg Playa
1.25	Upper Middle Gila
1.26	Mimbres
2.01	Sierra del Nido
2.02	Rio Grande-El Paso to Amistad
2.03	Rio Grande-Elephant Butte to El Paso
2.04	Guadalupe-Carlsbad
2.05	Davis-Chinatis Mts.

Site #	Site Name
2.06	Devil's River
2.07	Big Bend
2.08	Chihuahuan Grasslands
2.09	Tularosa
2.10	Pecos River
2.11	Alta Bavicora
2.12	La Perla
2.13	Mescalero Dunes
2.14	Samalayuca Dunes
2.15	Conchos River
2.16	Marathon Basin
2.17	Sierra Blanca
2.18	Rio Grande-Above Elephant Butte
3.01	Complejo Mapimí
3.02	Complejo de Sierras del Carmen
3.03	Cuatrociénegas
3.04	Sierra de la Paila
3.05	Sierra Santa Fe de Pino
3.06	Sierra de Menchaca
3.07	Sierra de la Gloria
3.08	Sierra de las Minas Viejas
4.01	Altiplano Mexicano Nordoriental
4.02	Huizache-Cerritos
4.03	Querétaro
4.04	Peco de Teyra
4.05	Órganos Malpais
4.06	Laguna de Santiaguillo
4.07	Río Nazas Basin
4.08	Saltillo-Monterrey
4.09	Sierra de Picacho



Appendix Figure F-1 Apachean priority sites

1.01
Name: Baboquivari
Location: 38 km northwest of Nogales, Arizona
Approximate Size: 291 km^2
Priority Rank: 3
Level of threat: medium

Ownership: Private, State of Arizona, U.S. Bureau of Land Management-Tucson District, U.S. Fish and Wildlife Service-Buenas Aires National Wildlife Refuge.

Description of the site: Bordering the western edge of the Chihuahuan Desert, and the Sonoran Desert, the Baboquivaris are a lower mountain range dominated by degraded semi-desert grasslands, and Madrean evergreen woodlands. Baboquivari Peak, a striking granite dome, reaches to 2,300 m. Emory oak (*Quercus emoryi*) and Arizona white oak (*Q. arizonica*) dominate the encinal (Brown 1994). Perennial and intermittent drainage support lowland riparian woodlands of Arizona sycamore (*Platanus wrightii*), netleaf hackberry (*Celtis reticulata*), and velvetleaf ash (*Fraxinus velutinus*). Mesquite (*Prosopis* sp.) thickets are found along the lowlands (Taylor 1995).

Outstanding biological features: A number of neo-tropical migratory birds nest within the intact riparian woodlands, a rapidly declining and keystone habitats type (Taylor 1995). Within the mountain range, an endemic ant have recently been described. A jaguar (*Panthera onca*) was trapped and radio-collared here in 1997.

Conservation status: The site is protected by the BLM Baboquivari Peak Wilderness Area and the Brown Canyon unit of Buena Aires National Wildlife Refuge. Cattle graze Arizona State trusts lands.

Description of threats: Overgrazing by livestock on state and private lands threaten the watershed condition. Loss of riparian vegetation is a continuing threat.

Reasons for selection as a priority site: Chihuahuan, Sierra Madre, and Sonoran habitat types are represented here. Endemic species also occur. This site is poorly studied and requires further biological inventory.

Active conservation groups: Wildlands Project and Sky Island Alliance, Sonoran Institute, Native Seed Search, The Nature Conservancy of Arizona, Tohono O'odham Nation.

Contributors: B. MacKay

1.02
Name: Pajarita-Atascosa Mountains
Location: 16 km west of Nogales, Arizona
Approximate Size: 1,110 km^2
Priority Rank: 3
Level of threat: medium

Ownership: The U.S. Forest Service-Coronado National Forest primarily controls The U.S. portion of these mountains. The Mexican portion is privately owned.

Description of the site: Here the influence of the Chihuahuan Desert interdigitates with Madrean evergreen woodland and riparian deciduous forest community types within these low (~2,000 m) mountain ranges (Brown 1994). The occurrence of the pine-oak woodland habitat is unusually low in elevation (Toolin *et al.* 1979).

Outstanding biological features: At least 200 species of butterfly are found here and the region is overall high in diptera and lepidoptera, including the viceroy butterfly (*Limenitis archippus obsoleta*)and the moth *Rothchildia*. Unusual invertebrate species include an endemic scorpion (*Diplocentrus spitzeri*) Subtropical vertebrate species, such as vine snake (*Oxybelus aeneus*), and Tarahumara frog (*Rana tarahumarae*), are at their northernmost extent. Intact lowland riparian woodlands provide important neo-tropical migratory bird breeding habitat. In Sycamore Canyon, species with widely divergent ecological affinities grow near one another such as the Utah serviceberry (*Amelanchier utahensis*) and the subtropical epiphyte, ball moss (*Tillandsia recurvata*). The flora includes 593 species of plants (Toolin *et al.* 1979).

Conservation status: A portion of the site is within the Pajarita Wilderness, managed by the Coronado National Forest. Remaining Forest Service lands are grazed by cattle and explored for minerals. Timber is not extracted here but fuelwood is collected (USDA Forest Service 1986).

Description of threats: Increasing urban populations in Tucson and Nogales utilize the mountains for recreation. Encroaching development in the lowlands will reduce migration and movement corridors for wildlife. Overgrazing on national forest and Mexican lands decreased watershed integrity. Hard-rock mining causes landscape fragmentation through road building and the creation of mine spoils. Fuelwood collection may cause disturbances to wildlife and may affect the oak woodland community composition.

Reasons for selection as a priority site: A priority site with high quality invertebrate, reptile, and bird assemblages representative of the Sierra Madre Occidental.

Freshwater Sites: Streams from these mountains feed Upper Santa Cruz River (5.04).

Active conservation groups: The Nature Conservancy of Arizona, Tohono O’odham Nation.

Contributors: G. Forbes

1.03
Name: Santa Rita Mountains
Location: 32 km south of Tucson, Arizona
Approximate Size: 1,095 km^2
Priority Rank: 3
Level of threat: high

Ownership: Private and U.S. Forest Service-Coronado National Forest

Description of the site: Amid the 1,500 m of elevation gain, the lower semi-desert grassland community is influenced in character by both Chihuahuan and Sonoran Desert habitat types including grama grassland, desert scrub, cactus scrub, and lowland riparian woodland. Rising in elevation, Madrean evergreen woodland and Rocky Mountain conifer forest community types are characterized by pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland habitat types (Muldavin and DeVelice 1987). Madera Canyon, draining the north edge of Mount Wrightson, contains riparian deciduous forests dominated by Arizona sycamore (*Platanus wrightii*). Degraded grasslands are now dominated by shrubs and low growing trees such as velvet mesquite (*Prosopis velutina*) and catclaw acacia (*Acacia greggii*) (McAuliffe and Burgess 1994). Low elevations with Sonoran affinities support Palo Verde (*Cercidium floridum*) and saguaro (*Carnegiea giganteus*) (Brown 1994).

Outstanding biological features: Regional floras document at least 628 species of plants occur in the Santa Ritas (McLaughlin 1994). Within the pine-oak woodlands and riparian woodlands, distinct Sierra Madre Occidental assemblages of birds, invertebrates, and herpetofauna are found. The U.S. federally threatened ridge-nosed rattlesnake (*Crotalus willardi*) occurs in pine-oak woodlands, as does the cat-eyed snake (*Leptodeira punctata*), Yarrow's spiny lizard (*Sceloporus jarrovi*), elegant trogon (*Trogon elegans*), and blue-throated hummingbird (*Lampornis clemenciae*). In montane communities, twin-spotted rattlesnake (*C. pricei*), golden-mantled ground squirrel (*Citellus lateralis*), and Arizona gray squirrel (*Scirus arizonicus*) are characteristic species. Grasslands and scrublands support such species as rufous-winged sparrow (*Aimophila carpalis*), two species of jackrabbit (*Lepus californicus* and *L. alleni*), desert cottontail (*Sylvilagus audubonii*), and javelina (*Dicotyles tajacu*).. Invertebrate surveys have uncovered at least six species of desert, termite possibly the highest richness in North American deserts. *Plusiotis beyeri* is an endemic beetle within the site, and the giant silk moth, *Antheria polyphemus* is also found here. Other rare invertebrates include a tiger beetle, *Amblychelia barroni*, the Atascosa gem grasshopper (*Aztecacris gloriosus*) the lichen grasshopper (*Leuronotina ritensis*) and the ant (*Acanthostichus arizonensis).*

Conservation status: The Coronado National Forest manages the Mount Wrightson Wilderness (10,220 ha). Public lands outside the wilderness designation are managed for multiple use. Livestock grazing, mining, fuelwood collection, and recreation are prevalent throughout the mountain range, however timber extraction does not occur (USDA Forest Service 1986).

Description of threats: Extremely popular for bird watching, the Santa Ritas are visited by recreationists regularly (Taylor 1995). Facilities encourage continual human use in some parts of the range in campsites, and on roads and hiking trails. Overgrazing, road building, and mineral exploration outside of the protected area are threats to vegetation and watershed function. The invasion of Lehman's lovegrass (*Eragrostis lehmanniana*) has diminished diversity in grasslands.

Reasons for selection as a priority site: Representation of species assemblages from Sierra Madre, Rocky Mountain, Chihuahuan, and Sonoran ecoregions. Some relatively intact habitats.

Freshwater Sites: This site drains into the Upper Santa Cruz (5.04).

Active conservation groups: The Wildlands Project-Sky Island Alliance, Friends of the Santa Cruz

Contributors: M. Hakkila, R. List, B. MacKay, R. Meyer, E. Muldavin

1.04
Name: Sonoita Creek
Location: 80 km southeast of Tucson, Arizona.
Approximate Size: 112 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private, State of Arizona, The Nature Conservancy of Arizona.

Description of the site: The site is a roughly 12 km corridor of riparian deciduous forest at an elevation of 1,200 m with alternating mesquite bosque and cottonwood-willow forest and *ciénega*, all under different management strategies. The Nature Conservancy of Arizona manages 3 km of the riparian habitat, including giant, mature Fremont cottonwoods (*Populus fremontii*) that dominate an understory of velvet-leaf ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), and Goodding's willow (*Salix gooddingii*) (Minckley and Brown 1994). TNC is also restoring wetlands invaded by Johnson grass (*Sorghum halapense*). Sonoita Creek flows from TNC land into a private working cattle and guest ranch. Livestock have opened up the formerly dense understory. The lower five kilometers of Sonoita Creek are a State Natural Area. The creek then flows into Patagonia Lake, a State Park.

Outstanding biological features: The river corridor is a good example of a riparian gallery forest. The older cottonwoods are at least 130 years old and effectively shade the banks and floodplains. Surrounded by highly degraded semi-desert grassland, the woodland is an oasis for birds throughout the year. A range of upland and riparian species mix in this grassland, including gray hawk (*Buteo nitidus*), northern-beardless tyrranulet (*Camptostoma imberbe*), brown-crested flycatcher (*Myiarchus tyrannulus*), common ground-dove (*Columbina passerina*), greater roadrunner (*Geococcyx californianus*), and gilded flicker (*Colaptes auratus*). The woodland is the northernmost breeding locality of the rose-throated becard (*Pachyramphus aglaiae*) and violet-crowned hummingbird (*Amazilia violiceps*). Dense thickets of Mexican elder (*Sambucus mexicana*), netleaf hackberry (*Celtis reticulata*), and downed cottonwood branches mask the activity of mountain lions (*Felis concolor*), white-tail deer (*Odoicoileus virginiana*), javelina (*Dicotyles tajacua*), coatimundi (*Nasua nasua*), and desert tortoise (*Gopherus agassizii*). The viceroy butterfly (*Limenitis archippus obsoleta*) also occurs here.

Conservation status: Cottonwood-willow communities are candidates for the most threatened habitat type in the North America. Arizona has lost 90% of its original gallery forests to human activities (Krueper 1992). Although once extensively farmed, Sonoita Creek retains its vegetation structure and species diversity that were present during pre-European settlement. In the semi-arid regions of the southwest U.S., 51% of all birds are dependent on riparian habitat. (Krueper 1992). Sonoita Creek is a thriving wintering and nesting ground for birds. Within the Sonoita State Natural Area are private lands and state trust lands. This 2,023 ha parcel was acquired in 1994. The state is completing its management plan. The Nature Conservancy of Arizona owns approximately 303 ha (TNC 1992).

Description of threats: Johnson grass, an exotic, displaces native species in the *ciénegas*. Another exotic, tree of heaven (*Ailanthus altissima*), has invaded the riparian woodland. Increased intensive flooding due to upland grazing shears stream banks and vegetation. Subdivision of surrounding ranches expands groundwater demands and restricts large mammal movement. Long-term fire suppression has increased the threat of a catastrophic fire within the woodland.

Reasons for selection as a priority site: Long known for its outstanding representation of bird species, Sonoita Creek is a conspicuous example of the importance of riparian communities in semi-arid regions.

Freshwater Sites: Sonoita Creek is a tributary to site Santa Cruz River (5.04).

Active conservation groups: Crossroads Forum, Phoenix Zoo, The Nature Conservancy of Arizona, Sonoita Valley Planning Partnership, Southern Arizona Grassland Trust, Tucson Audubon Society.

Contributors: J. Atchley, G. Forbes

1.05
Name: Santa Catalina Mountains
Location: 16 km northeast of Tucson, Arizona
Approximate Size: 1,428 km^2
Priority Rank: 2
Level of threat: medium

Ownership: U.S. Forest Service-Coronado National Forest, and U.S. National Park Service-Saguaro National Monument.

Description of the site: As one of the 'sky islands' of the Apachean sub-region, the Santa Catalina mountains represent a highly diverse transition zone between the Sierra Madre and Rocky Mountain cordilleran vegetation types. Along the western flank of the mountains, Sonoran Desert predominates yet the eastern flanks grade into the Rincon mountains which exhibit Chihuahuan Desert characteristics. The highest point in this site is 2770 m. All terrestrial montane chaparral and montane woodland habitat types are found within the greater Madrean evergreen woodland and Rocky Mountain conifer forest community types. These include the montane chaparral, pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland (Brown 1994). Additionally, lower elevation communities of semi-desert grassland and Plains and Great Basin grassland have affinities with Chihuahuan and Sonoran deserts communities such as grama grassland, desert scrub, and cactus scrub habitat types (McAuliffe and Burgess 1994).

Outstanding biological features: Montane forests support Engelmann spruce (*Picea engelmannii*), sub-alpine fir (*Abies lasiocarpa*), blue spruce (*Picea pungens*) and white fir (*Abies concolor*) (Muldavin and DeVelice 1987). Within these forests, olive warbler (*Peucedramus taeniatus*), mountain chickadee (*Parus gambeli*), red crossbills (*Loxia curvirostra*), Mexican spotted owl (*Strix occidentalis mexicanus*), and black bear (*Ursus americanus*) are typical higher elevation species. Within the pine-oak woodlands, Apache pine (*Pinus engelmannii*), Chihuahua pine (*P. leiophylla*), Emory oak (*Quercus emoryi*), silverleaf oak (*Q. hypoleucoides*), and netleaf oak (*Q. rugosa*) occur together with species such as Mexican jay (*Aphelocoma ultramrina*), acorn woodpecker (*Melanerpes formicivorus*), ridge-nosed rattlesnake (*Crotalus willardi*), and Coue's white-tailed deer (*Odocoileus virginianus crooki*). Grasslands and desert scrub of curly mesquitegrass (*Hilaria berlangeri*), sideoats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), catclaw acacia (*Acacia greggii*), Palmer agave (*Agave palmeri*), and velvet mesquite (*Prosopis velutina*) provide excellent reptile habitat for such species as gila monster (*Heloderma suspectum*). Rare species such as desert bighorn sheep (*Ovis canadensis mexicana*), Sanborn's long-nose bat (*Leptonycteris curasoae yerbabuenae*) and the ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) inhabit mid-elevation habitats (McLaughlin 1994).

Conservation status: Within the site are three wilderness areas: Rincon Mountain (15,614 ha), Pusch Ridge (23,035 ha), both managed by the U.S. Forest Service, and a portion of Saguaro National Monument, managed by the U.S. National Park Service. The balance of land area is managed for multiple use with an emphasis on recreation in the Coronado National Forest. Roads, recreational facilities, and timber harvest are sources of habitat fragmentation and habitat loss. Degradation to scrub and grassland communities as a result of livestock grazing is moderate (USDA-Forest Service 1986).

Description of threats: Tucson, a city of 700,000, sits at the base of this mountain range. Urban expansion in the foothills, increasing recreational pressures, and urban encroachment into corridors of habitat leading to the Santa Catalinas are the gravest threats to this site. Overgrazing, ORV use, and timber harvest in the National Forest, as well as air pollution, also threaten the habitat quality of this site.

Reasons for selection as a priority site: A wide representation of habitat types and species assemblages.

Freshwater Sites: The northeastern edge drains into San Pedro-Aravaipa (5.03).

Active conservation groups: The Wildlands Project-Sky Island Alliance, Tucson Audubon Society, Sierra Club-Grand Canyon Chapter, The Arizona Native Plant Society, Sonoran Institute, and Rincon Institute.

Contributors: M. Hakkila, R. List, R. Meyer, E. Muldavin

1.06
Name: Lower San Pedro River
Location: A 133 km stretch between Benson and Hayden, Arizona.
Approximate Size: 778 km^2
Priority Rank: 4
Level of threat: high

Ownership: Private, State of Arizona, The Nature Conservancy of Arizona, U.S. Bureau of Land Management.

Description of the site: The fragments of woodlands and wetlands along the Lower San Pedro corridor represent remnants of once extensive interior strands of lowland riparian woodland and *ciénega* habitats. Communities dominated by Goodding's willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), and velvet mesquite (*Prosopis velutina*) are maintained by periodic flooding and provide habitat for riparian dependent fauna (Brown *et al.* 1977). This broken ribbon of riparian vegetation is surrounded by elements of both Chihuahuan and Sonoran desert scrub, which influence the increasing amount of edge between fragments of woodland and *ciénega* (Hendrickson and Minckley 1984). Agricultural fields, primarily cotton and alfalfa, and pasture land have been planted in the wake of fuelwood and timber harvest along the river. This interspersion of human caused disturbance has greatly influenced the condition and make-up of the remaining tracts of native vegetation. Nevertheless, the Lower San Pedro riparian corridor continues to support a diverse array of flora and fauna. Most ciénega habitats are greatly altered, being either drained or inundated (Minckley and Brown 1994). However, many historic spring sources along parts of the river persist (Hendrickson and Minckley 1984).

Outstanding biological features: While fragmented, the riparian communities provide an extension of the recovering bosque habitat along site Upper San Pedro River (1.10). The intact strands support the northern extension of breeding streaked-back oriole (*Icterus pustulatus*), and ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*), as well as riparian dependent birds such as black hawk (*Buteogallus anthracinus*), zone-tailed hawk (*Buteo albonotatus*), yellow-billed cuckoo (*Coccyzus americanus*), and blue-throated hummingbird (*Lampornis clemenciae*). Riparian dependent bats, silver-haired bat (*Lasionycteris noctivagens*) and big brown bat (*Eptesicus fuscus*), roost in mature cottonwoods. Leopard frogs (*Rana* sp.) and toads (*Bufo* sp.) are found within the woodland galleries. Lower elevation mesquite bosques have a more open, grassy aspect and support tree lizard (*Urosaurus ornatus*), desert pocket-mouse (*Perognathus penicillatus*), white-winged dove (*Zenaida asiatica*), and other xeric species.

Historically, the San Pedro River contained 14 species of native fish, including the loach minnow (*Tiaroga cobitis*), spikedace (*Meda fulgida*), Gila chub (*Gila intermedia*), Gila topminnow (*Poeciliopsis occidentalis*), desert pupfish (*Cyprinodon macularius*), and razorback sucker (*Xyrauchen texanus*). Today, only two native species remain: the longfin dace (*Agosia chrysogaster*) and desert sucker (*Catostomus clarkii*) (Jeff Simms, personal communication).

Conservation status: The Lower San Pedro streambanks are nearly all privately owned. Some BLM lands touch the banks. Most of the immediate surrounding uplands are private or State of Arizona lands leased for livestock grazing. The Nature Conservancy of Arizona owns and manages 803 ha along the river and holds easements on 1,065 ha. The river does not have special status or management on this lower portion on public lands. Cottonwood-willow communities are one of the most threatened habitat types in North America. Arizona has lost 90% of its original gallery forests to human activities. The lower San Pedro is among those rivers that have lost an enormous amount of continuity, diversity, and flood dynamics since the mid-1800s. In the semi-arid regions of the southwest U.S., 51% of all birds are dependent on riparian habitat (Krueper 1992). Diminshed areas of major migratory and breeding habitat, that once occured on the San Pedro, reduces overall populations of neotropical migratory birds. The Lower San Pedro now contains more alien salt cedar and mesquite strands along its banks than native cottonwood-willow and *ciénega* communities that once dominated (Minckley and Brown 1994). This increasingly rare community type is in poor condition, but the river retains some original vegetation and physical characteristics that should be protected from continued degradation and treated as source pools for restoration

Description of threats: Water diversions for agricultural crops and pastures are the greatest source of continuing degradation. Upstream groundwater pumping for municipalities and agriculture also reduce year round flows in the Lower San Pedro. Salt cedar invasion appears to be uncontrolled. The cutting of mesquite for fuelwood is unregulated and is known to create more xeric conditions along the streambanks.

Reasons for selection as a priority site: Preservation of existing woodlands and *ciénegas* along the Lower San Pedro will provide a northern extension corridor for migratory birds, and mammals, such as the jaguar, connecting to similar habitats on the Gila River. These habitats will also serve as disjunct refugia from other riparian communities, and improve watershed function.

Freshwater sites: San Pedro River (5.03).

Active conservation groups: The Nature Conservancy of Arizona, Saguaro-Juniper Alliance, Cascabel Community Planning Group.

Contributors: D. Lightfoot, R. Meyer

1.07
Name: Whetstone Mountain
Location: 20 km north of Sierra Vista, Arizona
Approximate Size: 234 km^2
Priority Rank: 4
Level of threat: medium

Ownership: Private, State of Arizona, U.S. Bureau of Land Management-Safford District, U.S. Forest Service-Coronado National Forest.

Description of the site: A mid-elevation mountain range, up to 2,345 m, with the Madrean evergreen woodland community type. The dominant habitat types are pine-oak woodlands, desert scrub, and grama grasslands.

Outstanding biological features: This range plays a role in colonization and extinction dynamics across the northern Sierra Madre Occidental for montane mammals, reptiles and amphibians

Conservation status: Managed for multiple use by the Coronado National Forest, primarily fuelwood collection, recreation, and grazing. Arizona State Trust lands are also managed for livestock grazing.

Description of threats: Increased recreation and increased fragmentation from surrounding mountains are threats. Overgrazing by cattle on state and federal lands is also a threat. Damage to riparian areas from grazing.

Reasons for selection as a priority site: Linkage site for short and long-term movements of Madrean species.

Freshwater sites: The eastern flank drains into San Pedro (5.03).

Active conservation groups: None known

Contributors: R. List, B. MacKay

1.08
Name: Appleton-Whittell Research Ranch Sanctuary and Canelo Hills
Location: 60 km northeast of Nogales, Arizona
Approximate Size: 62 km^2
Priority Rank: 2
Level of threat: low

Ownership: Private, National Audubon Society, State of Arizona, The Nature Conservancy of Arizona (TNC), U.S. Bureau of Land Management-Safford District, U.S. Forest Service.

Description of the site: This landscape of rolling hills, at 1,500 m, is comprised of grama grasslands with scattered mesquite communities. Hillsides support a savanna of grasses and Emory oak (*Quercus emoryi*). The seasonally flooded bottomlands are dominated by big alkali sacaton (*Sporobolus wrightii*) (Brown 1994).

Outstanding biological features: Intact and recovering blue and hairy grama (*Bouteloua gracilis* and *B. hirsuta*) grasslands maintain important ecological processes such as rodent and invertebrate influences on soil development and community composition (McClaran and VanDevender 1995). This site hosts assemblages of species associated with this declining grassland habitat type. Typical wintering birds include Sprague's pipit (*Anthus spragueii*) and McCowan's longspur (*Calcarius mccownii*). Among the breeding birds are the state endangered grasshopper sparrow (*Ammodramus savannarum*), Cassin's and Botteri's sparrow (*Aimophila cassinii* and *A. botterii*), and Montezuma quail (*Cyrtonyx montezumae*)

(Taylor, 1995). *Ciénegas* along O'Donnell Creek within TNC property harbor the endangered Canelo Hills ladies tresses (*Spiranthes delitescens*), an orchid.

Conservation status: The Research Ranch (3,237 ha) was established to investigate the consequences of removing livestock from grassland ecosystems. The ranch is a combination of public and private lands. To its north is the TNC Canelo Hills Preserve (100 ha). BLM and State of Arizona lands, scattered within the site, are managed for livestock.

Description of threats: Grazing occurs outside the two preserves on private and public lands.

Reasons for selection as a priority site: The grasslands have been rested from grazing since 1969, which is unusual in the Chihuahuan Desert. The site has a good scientific database. It is critical for large-scale ecological processes and has a representative assemblage of grassland species.

Freshwater Sites: San Pedro-Aravaipa Watershed (5.03)

Active conservation groups: Crossroads Forum, National Audubon Society, The Nature Conservancy of Arizona, Sierra Club-Grande Canyon Chapter.

Contributors: J. Atchley, E. Fredrickson

1.09
Name: Huachuca Mountains
Location: 5 km west of Sierra Vista, Arizona
Approximate Size: 575 km^2
Priority Rank: 3
Level of threat: medium

Ownership: U.S. Forest Service-Coronado National Forest, U.S. Army-Fort Huachuca Military Reservation, private, The Nature Conservancy of Arizona.

Description of the site: The Huachuca Mountains represent a highly diverse transition zone between the Sierra Madre and Rocky Mountain cordilleran vegetation types. Habitat types of pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland are found in the higher-elevation Madrean evergreen woodland community type. Pine-oak woodlands typically contain Mexican blue oak (*Quercus oblongifolia*), Emory oak (*Q. emoryi*), sliverleaf oak (*Q. hypoleucoides*), Arizona white oak (*Q. arizonica*), Chihuahua pine (*Pinus leiophylla*), and Apache pine (*P. engelmanii*). Chaparral components including pointleaf manzanita (*Arctostaphylos pungens*) and silktassel (*Garrya wrightii*). Mexican pinyon (*P. cembroides*) and alligator juniper (*Juniperus deppeana*) are the typical pinyon-juniper dominants. The highest montane woodlands, a Rocky Mountain community type, are comprised of ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), limber pine (*P. flexilis*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*) (Brown 1994). The lower elevation community type, semi-desert grassland, is influenced in character by the Chihuahuan grama grassland, desert scrub, and lowland riparian woodland habitat types. Riparian woodlands of velvet-leaf ash (*Fraxinus velutinus*), desert willow (*Chilopsis linearis*), Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), Fremont cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*) occur in the well-watered canyons.

Outstanding biological features: At least 907 species of plants are distributed across this mountain range (Wallmo 1955). The desert and scrub communities at the lower elevations are home to such species as desert cottontail (*Sylvilagus audubonii*), pronghorn (*Antilocapra americana*), spotted skunk (*Spilogale putorius*), Sanborn's long-nose bat (*Leptonycteris curasoae yerbabuenae*), and loggerhead shrike (*Lanius ludovicianus*). Within the pinyon and oak woodlands are coatimundi (*Nasua narica*), Madrean alligator lizard (*Gerrhonotus kingii*), Gould's turkey (*Meleagris gallopavo mexicana*), Yarrow's spiny lizard (*Sceloporus jarrovi*), and Mexican jay (*Aphelocoma ultramrina*). The cooler, higher elevation habitats of pine and fir woodlands are habitat for Mexican spotted owl (*Strix occidentalis lucida*), yellow-eyed junco (*Junco phaeonotus*), black bear (*Ursus americanus*), band-tailed pigeon (*Columba fasciata*), greater pewee (*Contopus pertinax*), whip-poor-will (*Caprimulgus carolinensis*), twin-spotted rattlesnake (*Crotalus pricei*), and mule deer (*Odocoileus hemionus*). Riparian woodlands and springs are host to such rare species as the Huachuca tiger salamander (*Ambystoma tigrinum stebbensi*), Huachuca water-umbel (*Lilaeopsis schaffneriana recurva*), Huachuca leopard frog (*Rana huachucensis*), and the Ramsey Canyon leopard frog (*Rana subvocalis*), unique among leopard frogs in its skills at underwater communication (Van Pelt 1994). Fourteen species of hummingbird have been documented within the riparian corridor of Ramsey Canyon Preserve (Taylor 1995).

Conservation status: Miller Peak Wilderness Area (8,169 ha) is managed by the Coronado National Forest. Coronado National Memorial contains 1,922 ha (USDA-Forest Service 1986). The Nature Conservancy of Arizona owns Ramsey Canyon Preserve (154 ha) protecting riparian woodlands. Controlled burning is promoted by the National Forest.

Description of threats: Sierra Vista, as the base of the mountains, is a growing city of 40,000 inhabitants. Recreation demands throughout the National Forest and army base are high. Fuelwood collection is common on the west side of the range within the pinyon-juniper woodland. Livestock grazing affects riparian and spring communities.

Reasons for selection as a priority site: The Huachucas support a wide representation of habitat types and species assemblages from the Sierra Madre, Rocky Mountain, and Chihuahuan ecoregions. Additionally, they support critical ecological processes such as natural fire regimes and migration stopover sites.

Freshwater Sites: The range drains into San Pedro-Aravaipa (5.02).

Active conservation groups: Arizona Bird Conservancy, Sky Island Alliance, and The Nature Conservancy of Arizona, Center for Biolgical Diversity.

Contributors: M. Hakkila, R. List, R. Meyer, E. Muldavin

1.10
Name: Upper San Pedro River
Location: A 110 km stretch from Cananea, Sonora to Benson Arizona.
Approximate Size: 1,684 km^2
Priority Rank: 2
Level of threat: high

Ownership: U.S. private lands, U.S. Bureau of Land Management, Mexican private lands.

Description of the site: This riparian deciduous forest community type lies within an upland transition zone of semi-desert grassland with elements of Chihuahuan and Sonoran desert scrub habitats. Approximately 60% of the site is under the protection of the U.S. Congress, which designated the 50 km of the Upper San Pedro a National Conservation Area. The area is a mosaic of mesquite bosques, *ciénegas*, and cottonwood-willow woodland habitat types. The lowland riparian woodland and *ciénega* habitats are recovering from over 100 years of intensive livestock grazing and water diversion (Hendricskon and Minckley 1984). Communities dominated by Goodding's willow (*Salix goodingii*), Fremont cottonwood (*Populus fremontii*), and velvet mesquite (*Prosopis velutina*), maintained by periodic flooding, create broad age and structual classes of trees and shrubs which provide excellent habitat for riparian dependent fauna (Rich 1992).

Outstanding biological features: The thriving riparian community in the protected portion of the Upper San Pedro is recognized for its rich avifauna. Migratory, resident, and breeding birds utilize the multi-storied, diverse woodlands as a corridor for migration, cover, feeding and nesting. Cattails and bulrush once again flourish in recovering wetlands, which now support such species as American bittern (*Botaurus lentiginosus*) and black tern (*Chlidonias niger*). Sonoran box turtles (*Terrapene ornata luteola*) are common. Mexican garter snake (*Thamnophis eques*), dependent on marshy or aquatic habitats, Mojave green rattlesnake (*Crotalus scutulatus scutulatus*), found in sacaton grasslands, and Gila monster (*Heloderma suspectum*), a creature of desert scrub, are three rare reptiles that all occur within the protected area. More gray hawks (*Buteo nitidus*) live here than anywhere else in the U.S.. The riparian woodland is also home to the highest density in the western U.S. of yellow-billed cuckoos (*Coccyzus americanus*), a species that has suffered serious population declines in the west in the last two decades. Declining species of grassland birds, such as Botteri's and Cassin's sparrows (*Aimophila botterii* and *A. cassinii*) are found regularly in the sacaton bottomlands. The richness of vertebrate species within the protected area is among the highest of any one site in the U.S. with 379 species of birds, 80 species of mammals, and 40 species of amphibians and reptiles (TNC 1990). Historically, the San Pedro River contained 14 species of native fish, including the loach minnow (*Tiaroga cobitis*), spikedace (*Meda fulgida*), Gila chub (*Gila intermedia*), Gila topminnow (*Poeciliopsis occidentalis*), desert pupfish (*Cyprinodon macularius*), and razorback sucker (*Xyrauchen texanus*). Today, only two native species remain, the longfin dace (*Agosia chrysogaster*) and desert sucker (*Catostomus clarkii*).

Conservation status: As a Riparian National Conservation Area, the Upper San Pedro Management Area has had considerable management flexiblity within its 19,286 ha. A 15 year grazing moratorium, begun in 1988, has dramatically improved neotropical migratory bird breeding habitat. Occurences of western wood peewee (*Contopus sordidulus*) increased 400% after breeding habitat was restricted from livestock grazing for four years, and song sparrows (*Melospiza melodia*) increased by 50% (Rich 1992). Salt cedar (*Tamarix ramosissima*) remains a pervasive alien weed problem (Hendrickson and Brown 1994). However, the Upper San Pedro River is benefiting substantially from a heightened awareness of the value of riparian communities at the international level. In 1999, the Commission for Environmental Cooperation released a report, *Sustaining and Enhancing Riparian Migratory Bird Habitation on the Upper San Pedro River*, that details the hydrologic, biologic, and social context for improving the management of this globally important migratory bird corridor. The Nature Conservancy of Arizona also owns 37 ha within the site.

Description of threats: Ground water pumping for the growing city of Sierra Vista has caused a cone of depression within the aquifer, and this will eventually lower streamside water levels and inhibit establishment of riparian vegetation. Water diversions for agricultural crops and pastures in the unprotected areas exacerbate the problem. Mining operations in Cananea dam headwaters may pollute streamflow. The cutting of mesquite for fuelwood in Mexico creates more xeric conditions along the streambanks.

Reasons for selection as a priority site: Intact and recovering riparian communities are rare in the Chihuahuan Desert. This site harbors rare species and is the northern extension of many sub-tropical species and also supports high numbers of temperate species. The protected area serves as a genetic source for neighboring riparian communities with less habitat integrity. The riparian corridor is critical for large-scale ecological processes.

Active conservation groups: Centro Ecológico de Sonora, Friends of the San Pedro, IMADES, San Pedro Water Management Council, The Nature Conservancy, U.S. Agricultural Research Station (Southwest Watershed Research Center in Tucson), U.S. Bureau of Land Management-Tucson Field Office, Udall Center for Studies in Public Policy, District, Sonoran Institute, Center for Biological Diversity, SEMARNAP-Sierra de los Ajos Protected Area, Southeast Arizona Bird Observatory.

Freshwater Sites: San Pedro-Aravaipa watershed (5.03)

CONABIO Sites: The Mexican segment is entirely within site 20.

Contributors: R. Meyer, E. Muldavin

1.11 & 5.05
Name: Río Sonora Watershed (1.11)
Río Sonora Freshwater (5.05)
Location: Northern Sonora and northwest Chihuahua
Approximate Size: 1,704 km^2
Terrestrial priority rank: 4
Freshwater priority rank: 3
Terrestrial level of threat: medium
Freshwater level of threat: high

Ownership: Ejidos and private

Description of the site: Stronger evidence of Sonoran vegetation mixes with Chihuahuan Desert and Sierra Madre vegetation types along this extreme western edge of the Chihuahuan Desert Ecoregional Complex. Very little is known about this area. Small *ciénegas* persist along the Río Sonora.

Outstanding biological features: This portion of the Sierra Madre is probably critical as a corridor and a population source for species in the sky islands to the north. Several species of large mammal persist in the Sierra Madre Occidental- the mountains are a corridor for black bear (*Ursus americanus*), mountain lion (*Felis concolor*), and jaguar (*Panthera onca*).

The Río Sonora has not been detrimentally affected by exotic species of fish. Two endemic fish, the Opata sucker (*Catostomus wigginsi*) and the desert chub (*Gila eremica*), as well as Mexican stoneroller (*Campastoma ornatum*) occur in the river

Conservation status: None known.

Description of threats: Overgrazing, water diversions for livestock, illegal timber harvest.

Reasons for selection as a priority site: Although the terrestrial region requires inventory, the freshwater segments are known to contain representative species assemblages and relatively intact aquatic habitats.

CONABIO Sites: Terrestrial sites 20 and 21 and freshwater site 12.

Active conservation groups: IMADES, The Wildlands Project, Naturalia.

Contributors: D. Henrickson, A. Lafón, W. Minckley

1.12
Name: Sierra Los Ajos
Location: Northern Sonora and northwest Chihuahua
Approximate Size: 770 km^2
Priority Rank: 4
Level of threat: low

Ownership: private

Description of site: Mixed conifer forests, grasslands, and pine-oak woodlands of the Sierra Madre.

Outstanding biological features: Two endemic fish, the Opata sucker (*Catostomus wigginsi*) and the desert chub (*Gila eremica*), occur in tributries to the Río Sonora, which flows through this site. Mammal assemblages, while missing grizzly bear and wolf, consist of many species in decling in Mexico: badger (*Taxidea taxus*), black bear (*Ursus americanus*), mountain lion (*Puma concolor*), and javelina (*Tayassu tajacu*). Mexican spotted owl (*Strix occidentalis lucida*) has been documented in the conifer forests. It is thought that an endemic horned lizard and whiptail lizard may occur here.

Conservation status: Much of this site is occupied by the Sierra Los Ajos-Bavispe Área de Protección de Recursos Naturales (183,565 ha) which is managed by SEMARNAP. The watershed feeds several large cities downstream, including Hermosillo.

Description of threats: Unsustainable forestry practices, poaching of game, and fire mismanagement.

Reasons for selection as a priority site: Requires further study.

CONABIO sites: 20

Freshwater sites: Río Sonora (5.05) runs through the site.

Active conservation groups: Sky Island Alliance, Southeast Arizona Bird Obersvatory

Contributors: C. Lieb, R. List, B. MacKay

1.13
Name: Río Yaqui
Location: 140 km northeast of Hermosillo, Sonora
Approximate Size: 8,297 km^2
Priority Rank: 3
Level of threat: high

Ownership: Ejido, federal and private

Description of the site: This is the transition zone between the Chihuahuan and Sonoran Deserts where the range limits of many species overlap. Basin elevations of 1000 m support a strong Sonoran flora and fauna. The river flows through the Sierra Madre pine-oak woodlands and into lower elevation matorral. There are grasslands within the site.

Outstanding biological features: Nesting bald eagles (*Haliaeetus leucocephalus*) and resident black bear (*Ursus americanus*) have been documented in the forested regions. The river basin has historically supported populations of the imperiled Yaqui chub (*Gila purpurea*), roundtail chub (*Gila robusta*), and Yaqui sucker (*Catostomus bernardini*). Beaver (*Castor canadensis*) inhabit the river as well.

Conservation status: The area is within the Natural System of Protected Areas of the State of Sonora as an Area Subject to Ecological Conservation, Proposed by the State Government in 1994.

Description of threats: Agriculture, overgrazing, mining of gold, silver and copper are the primary threats.

Reasons for selection as a priority site: Species assemblages

Active conservation groups: SEMARNAP, IMADES, The Wildlands Project, Naturalia.

CONABIO Sites: Site 22 overlaps slightly on the northern boundary.

Freshwater Sites: Upper Yaqui (5.02).

Contributors: M. Hakkila, A. Lafón, E. Muldavin

1.14
Name: Lower Middle Gila River
Location: Virden, New Mexico to San Carlos Lake, Arizona
Approximate Size: 1,562 km^2
Priority Rank: 4
Level of threat: medium

Ownership: Private, State of Arizona trust lands, U.S. Army Corps of Engineers, U.S. Bureau of Land Management-Safford District.

Description of site: This site is a highly disturbed 150 km stretch of the Gila River. The upper third of this corridor lies within a matrix of Chihuahuan desert scrub while the lower two thirds flow through Sonoran desert scrub. At least half of this stretch of the Gila River is in agricultural production. Remnant riparian woodlands are infrequent and in poor condition. Introduced salt cedar (*Tamarix ramosissima*) is a dominant within most mesquite bosques (Minckley and Clark 1984). Portions of the river run through steep-walled, dramatic canyons. There are no dams upstream of this site.

Outstanding biological features: Remnants of subtropical mesquite bosques, including velvet and honey mesquite (*Prosopis velutina, P. glandulosa*), also support other shrub species such as wolfberry (*Lycium berlandieri*), netleaf hackberry (*Celtis reticulata*), blue paloverde (*Cercidium floridum*), and catclaw acacia (*Acacia greggii*). These bosques occur along floodplains. Isolated strands of cottonwood and willow woodland (*Populus fremontii-Salix goodinggii*) also persist. Ferruginous pygmy-owl (*Glaucidium brasilianum*), black-bellied whistling duck (*Dendrocygna autumnalis*), common black hawk (*Buteogallus anthracinus*), coatimundi (*Nasua nasua*), and Arizona mountain kingsnake (*Lampropeltis pyromelana pyromelana*) are all state-listed species found along the river. Black-chinned hummingbird (*Archilochus alexandri*), the most common hummingbird in the Chihuahuan Desert, is abundant here. This is also the most eastern extension of saguaro (*Carnegiea giganteus)* in Arizona.

Freshwater fish found in the lower Gila River include the longfin dace (*Agosia chrysogaster*) and Gila topminnow (*Poeciliopsis occidentalis occidentalis*), both of which can each be considered endemic to the Gila catchment, though their ranges extend southward into the Sonoran region (Minckley *et al.* 1985; Page and Burr 1991). The Gila chub (*Gila intermedia*), whose taxonomy is uncertain, persists in one location in the Gila catchment. Colorado squawfish (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*), endemic to the Colorado complex, may have once occurred in the Gila River, as did spikedace (*Meda fulgida*), and roundtail chub (*Gila robusta*) still occurs in three separate reaches of the river.

Conservation status: East of Safford, 40 km of the river is within the Gila Box Riparian National Conservation Area (8,807 ha, and 25 km of river), administered by the U.S. Bureau of Land Management-Safford District. This is the only protected reach within the site. However, this reach is under considerable agricultural pressure. The river is channelized near Safford, Arizona and irrigation ditches feed local crops. BLM and State of Arizona lands are managed for livestock use.

Description of threats: Current and historic clearing of bosques increases flooding intensity and frequency, causing a scoured and widened channel. Water diversion for agriculture (cotton and alfalfa) reduces water available for riparian vegetation. Floodplain woodlands and bosques are cleared for crops. Alien salt cedar encroaches in unaltered and altered strands. Fuelwood cutting eliminates the bosque overstory. Frequent off-road vehicle use in the river channel disrupts all aspects of the life cycles of fish.

Reasons for selection as a priority site: Vestiges of riparian bosque and springs should be preserved for future restoration efforts. If agricultural forces are altered and opportunities for restoration arise the few remaining bosques and woodlands could become seed sources. If restored, the Middle Gila could regain importance as an avian flyway.

Freshwater sites: Gila River (5.37) overlaps with the eastern third.

Active conservation groups: Gila Monster Watershed Group, Upper Gila Watershed Alliance.

Contributors: G. Forbes, R. Meyer

1.15
Name: Galiuro Mountains
Location: 48 km northwest of Willcox, Arizona
Approximate Size: 1,602 km^2
Priority Rank: 3
Level of threat: low

Ownership: U.S. Bureau of Land Management-Safford District, U.S. Forest Service-Coronado National Forest.

Description of the site: The Galiuro Mountains are a transition zone between the Sierra Madre and Rocky Mountain cordilleran vegetation types. Pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland habitat types are found in the higher elevation Rocky Mountain and Madrean evergreen woodland community types. Chaparral components include pointleaf manzanita (*Arctostaphylos pungens*) and silktassel (*Garrya wrightii*). Mexican pinyon (*Pinus cembroides*) and alligator juniper (*Juniperus deppeana*) are the typical pinyon-juniper dominants. The highest montane woodlands, up to 2,326 m, are comprised of ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), limber pine (*P. flexilis*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*) (Brown 1994). The lower elevations are influenced in character by the Chihuahuan grama grassland, desert scrub, and lowland riparian woodland habitat types. Riparian woodlands of velvet-leaf ash (*Fraxinus velutinus*), desert willow (*Chilopsis linearis*), Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), Fremont cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*) occur in the well-watered canyons (Brown 1994).

Outstanding biological features: Perennial streams support Gila chub (*Gila intermedia*), longfin dace (*Agosia chrysogaster*), and speckled dace (*Rhinichthys osculus*). Desert bighorn sheep (*Ovis canadensis mexicana*), coatimundi (*Nasua nasua*), and javelina (*Dicotyles tajacu*) are found in the pine-oak woodlands and chaparral. Ocelot (*Felis pardalis*) have been reported as well. Breeding pairs of gray hawk (*Buteo nitidus*), zone-tailed hawk (*Buteo albonotatus*), and common black hawk (*Buteogallus anthracinus*) nest within the riparian woodlands.

Conservation status: The Coronado National Forest manages the Galiuro Wilderness (30,878 ha). The National Forest also has entered into a coordinated management agreement (CMA) with the BLM-Safford District and The Nature Conservancy of Arizona, which manages the Muleshoe Ranch Preserve. The Redfield Canyon Wilderness Area (2,670 ha) is part of this management area. Within the CMA is the Swamp Springs-Hot Springs Canyon ACEC with 4386 ha of federal land (USDI-BLM 1998).

Description of threats: Livestock grazing on state and private lands.

Reasons for selection as a priority site: Assemblages of diverse, unfragmented habitats in the transition zone between Chihuahuan and Sonoran Deserts.

Freshwater Sites: The eastern flank drains into the San Pedro-Aravaipa watershed (5.03).

Active conservation groups: The Nature Conservancy of Arizona

Contributors: R. List, E. Muldavin

1.16
Name: Pinaleño Mountains
Location: 10 km south of Safford, Arizona.
Approximate Size: 831 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private, State of Arizona, U.S. Bureau of Land Management-Safford District, U.S. Forest Service-Coronado National Forest.

Description of the site: As one of the 'sky islands' of the Basin and Range Province, the Pinaleño Mountains represent a highly diverse transition zone between the Sierra Madre and Rocky Mountain cordilleran vegetation types. Mount Graham, the tallest peak in the U.S. sky islands, reaches 3,257 m in elevation. These upper slopes support unusual high elevation *ciénegas*. Typical habitats include grama grassland, desert scrub, cactus scrub, and lowland riparian woodland. Madrean evergreen woodland and Rocky Mountain conifer forest community types, pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland habitat types dominate the slopes. The lower elevations support semi-desert grasslands, with biotic influences of both the Chihuahuan and Sonoran deserts. (Brown 1994).

Outstanding biological features: Corkbark fir-Engelmann spruce forests (*Abies arizonica-Picea engelmannii*) are home to such montane vertebrate species as the Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*), Mexican spotted owl (*Strix occidentalis lucida*), black bear (*Ursus americanus*), long-tailed vole (*Microtus longicaudus leucophaeus*) and Clark's nutcracker (*Nucifraga columbiana*)(Carr 1992). Herpetofauna characteristic of the Sierra Madre Occidental include the ridge-nosed rattlesnake (*Crotalus willardi*), twin-spotted rattlesnake (*Crotalus pricei*), cat-eyed snake (*Leptodeira punctata*), Chiricahua leopard frog (*Rana chiricahuensis*), lowland leopard frog (*Rana yavapaiensis*), and canyon spotted whiptail (*Cnemidophorus burti*). A regional flora lists cite 786 species of plants (McLaughlin 1993).

Conservation status: The lands are US Forest Service controlled and managed for multiple use.

Description of threats: Timber harvest is permitted within the Coronado National Forest but is not currently practiced. The construction of the University of Arizona Mount Graham Observatory threatens the habitat of the endemic Mount Graham red squirrel. Roads fragment blocks of untimbered habitats.

Reasons for selection as a priority site: Representation of a montane habitat type.

Freshwater Sites: The western flank drains into the San Pedro-Aravaipa watershed (5.02).

Active conservation groups: The Wildlands Project-Sky Island Alliance

Contributors: M. Hakkila, R. List, D. Richman

1.17
Name: Willcox Playa
Location: 10 km south of Willcox, Arizona
Approximate Size: 284 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private, State of Arizona, and U.S. Bureau of Land Management-Safford District.

Description of the site: Nested within a degraded habitat of semi-desert grassland, Willcox Playa retains surface water following rainy seasons. The playa is alkaline and tufts of alkali sacaton (*Sporobolus airoides*) dot the flats. At an elevation of 1,500 m in the Sulphur Springs Valley, the site collects runoff from the surrounding Galiuro, Chiricahua, and Dragoon Mountains. *Ciénegas* are scattered along the perimeter of the playa (Hendrickson and Minckley 1984).

Outstanding biological features: The playa is home to the highest species diversity of tiger beetles (family *Cincindelidae*) in North America, as well as other saline adapted invertebrates such as harverster ants *Pogonomyrmex* sp. These ants build giant mounds in the playa and may be a unique, undescribed species. Migratory shorebirds and waterfowl utilize the playa during periods of inundation. At least 10,000 sandhill cranes (*Grus canadensis*) winter in the playa and feed along the agricultural fields nearby (Taylor 1995). Wintering McCown's longspurs (*Calcarius mccownii*), savanna sparrows (*Passerculus sandwichensis*), American pipits (*Anthus rubescens*), and lark buntings (*Calamospiza melanocorys*) utilize the playa, as do ferruginous (*Buteo regalis*) and rough-legged hawks (*B. lagopus*). Mountain plover (*Charadrius montanus*), a declining species, also occurs here during winter (Carr 1992).

Conservation status: The playa is closed to mineral entry and leasing, as well as off-highway vehicles, within the 1,488 ha BLM Area of Critical Environmental Concern. The playa is also a National Natural Landmark, a U.S. Park Service designation recognizing its geological value as a remnant Pleistocene lake (USDI-BLM 1990).

Description of threats: Groundwater pumping for agriculture reduces flows of *ciénegas* surrounding the playa.

Reasons for selection as a priority site: The site requires further inventory, but it is known to contain many saline adapted species. It is also critical for large-scale shorebird migratory processes and large-scale wintering grassland bird populations.

Freshwater Sites: This is a closed basin, but has been mapped within site Upper Yaqui (5.02).

Active conservation groups: The Wildlands Project-Sky Island Alliance

Contributors: D. Lightfoot, P. Mehlhop, R. Meyer, D. Richman

1.18
Name: Dragoon Mountains
Location: 20 km northeast of Tombstone, Arizona
Approximate Size: 8,297 km^2
Priority Rank: 4
Level of threat: low

Ownership: Private and U.S. Forest Service-Coronado National Forest

Description of site: The small mountain range is an isolated 'sky island' reaching 2,500 m. The Madrean evergreen woodland community type is represented by habitat types of pine-oak woodlands dominated by Emory and Mexican blue oak (*Quercus emoryi* and *Q. oblongifolia*) (Carr 1992).

Outstanding biological features: The madrean fauna of this site includes Mexican jays (*Aphelocoma ultramrina*), coatimundi (*Nasua nasua*), white-tailed and mule deer (*Odocoileus virginianus* and *O. hemionus*), bobcats (*Lynx rufus*), and ringtail cats (*Bassiriscus astutus*). Seasonal streams are bordered by Arizona sycamore (*Platanus wrightii*), Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), and Arizona cypress (*Cupressus arizonica*) (McClaran and VanDevender 1995).

Conservation status: The mountains are managed for multiple use and have no protected status. Currently there is no commercial timber harvest, although fuelwood collection occurs. Recreation, mineral exploration, and grazing are the primary uses.

Description of threats: Livestock grazing on public lands reduces on riparian vegetation and can destroy watershed conditions.

Reasons for selection as a priority site: Relatively intact habitat and its functional role as a stepping stone for species of the Sierra Madre Occidental of the south moving to larger mountains to the north.

Freshwater sites: The western flank drains into the Aravaipa Watershed (5.03), the eastern flank drains into the Upper Yaqui (5.02).

Active conservation groups: The Wildlands Project-Sky Island Alliance.

Contributors: D. Lightfoot

1.19
Name: Sulphur Springs Valley Grassland
Location: 30 km southeast of Benson, Arizona.
Approximate Size: 621 km^2
Priority Rank: 3
Level of threat: high

Ownership: Private and State of Arizona

Description of the site: Along and below the western bajadas of the Chiricahua Mountains, portions of this valley contain high quality semi-desert grasslands of various grama grasses (*Bouteloua* sp.) (Carr 1992). The western portion of the site is highly degraded semi-desert grassland along rolling foothills and arroyos at 1,500 m in elevation. The degraded areas are dominated by velvet mesquite (*Prosopis velutina*) and whitethorn acacia (*Acacia constricta*) (Hendrickson and Minkley 1984). Once dominated by yucca, grama grasses, and three-awns (*Aristida* sp.), this portion is now extremely altered and requires restoration.

Outstanding biological features: These grasslands once supported large prairie dog towns. Although many species and ecological processes are absent in this highly altered landscape (Hastings and Turner 1965), there is some restoration potential.

Conservation status: These lands are managed as grazing allotments by the State of Arizona (USDI-BLM, 1990).

Description of threats: Lehman's lovegrass (*Eragrostis lehmanniana*), an aggressive exotic, replaces native species in the area. Livestock grazing on state lands prevents active restoration of grasslands and natural fires. Soil erosion and compaction inhibit the site's ability to recover without human inputs. Sub-division of large ranches into small communities fragments grasslands and increases groundwater withdrawals. This site is experiencing a rapid increase in human settlement.

Reasons for selection as a priority site: This area can support critical grassland processes and species assemblages.

Freshwater Sites: Upper Yaqui (5.02).

Active conservation groups: Arizona Bird Observatory, The Nature Conservancy of Arizona.

Contributors: C. Curtin

1.20
Name: Chiricahua-Peloncillo-Sierra Madre Complex
Location: southeast Arizona, southwest New Mexico, and northeast Sonora
Approximate Size: 19,156 km^2
Priority Rank: 1
Level of threat: high

Ownership: Animas Foundation, ejidos, Phelps-Dodge Mining Company, private, State of Arizona, State of New Mexico, U.S. Bureau of Land Management-Safford and Las Cruces Districts, U.S. Fish and Wildlife Service-San Bernadino National Wildlife Refuge, U.S. Forest Service-Coronado National Forest, U.S. Park Service.

Description of site: The Chiricahua-Peloncillo-Sierra Madre Complex comprises an extensive landscape of sky island mountain ranges and intervening basins in a sparsely populated area. A broad range of Apachean vegetation communities exist: Rocky Mountain conifer forest, Madrean evergreen woodland, semi-desert grassland, plains and great basin grasslands, Chihuahuan desert scrub, and riparian deciduous forest. With adequate protection, this region can act as a corridor for many vertebrate species that migrate across the international boundary, repopulating the Sierra Madre Occidental, the Mogollon Plateau, and portions of the southern Rocky Mountains. Habitats for wide ranging carnivores and predators extirpated from this region, such as Mexican gray wolf (*Canis lupus baileyi*), grizzly bear (*Ursus horribilis*), ocelot (*Felis pardalis*), and jaguar (*Panthera onca*) still exist. Specific areas within the region are described below.

The Yaqui headwaters are located in the San Bernadino Valley at 1,130 m in elevation, and are surrounded by limestone hills. This area has been heavily degraded over the past 200 years. The basin once supported lush grasslands and *ciénegas* on which cattle and sheep grazed intensively during the 1800's. Now Chihuahuan desert scrub grows where grama (*Bouteloua* sp.) and curly mesquitegrass (*Hilaria belangeri*) once flourished. Marshland areas formed by seepage of surface artesian flows have been drained and plowed for farmland or pasture. Other marshes are now invaded by mesquite (*Prosopis glandulosa*) and snakeweed (*Gutierrezia* sp.) (USDI-USFWS 1995). A large tributary, Río Bavispe, drains northward from the Sierra Huachinera and remains undamned in this segment. It is dominated by Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), and sycamore (*Platanus wrightii*). Salt cedar (*Tamarix rammossisma*), is notably absent.

San Simon Valley is an area north of the Yaqui headwaters. Although contiguous topographically with the Yaqui, the San Simon Creek drains northward to the Gila River. This valley is regarded as one of the most seriously disturbed environments in the southwestern U.S.. Overstocking and channelization of San Simon Creek transformed a lush grassland into a highly eroded, gullied landscape of impoverished vegetation types. At least 10% of the area has extremely high sedimentation yields and 42% of the area has moderate to high rates of erosion. Most of the rangeland (91%) is in poor or fair condition. A steep-walled trench, caused by sediment-loaded flood waters, stands where a marshy, unchannelled stream once flowed. Perennial stream flows are now only intermittent. Mesquite, acacia (*Acacia* sp.) and creosote bush (*Larrea tridentata*) dominate the floodplains and alluvial fans that once supported grasslands (USDI-BLM 1990).

The Chiricahuas-Dos Cabezas is the most massive of the Sierra Madre sky islands. This range experiences cool temperatures and periodic snowfall, and subsequently supports a large expanse of montane forests. The range rises up to 3,000 meters to the west of the San Simon Valley. Most of the range is characterized by Madrean oak woodland. The higher elevations support pinyon-juniper woodland, pine-oak woodland, mixed-conifer forest, and montane deciduous woodland. The lower elevations are influenced in character by the Chihuahuan grama grassland, desert scrub, and lowland riparian woodland habitat types. Riparian woodlands of velvet-leaf ash (*Fraxinus velutinus*), desert willow (*Chilopsis lineraris*) Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), Fremont cottonwood, and Goodding's willow occur in the well-watered canyons. Pine-oak woodlands typically contain Mexican blue oak (*Quercus oblongifolia*), Emory oak (*Q. emoryi*), sliverleaf oak (*Q. hypoleucoides*), Arizona white oak (*Q. arizonica*), Chihuahua pine (*Pinus leiophylla*) and Apache pine (*P. engelmannii*). Chaparral components include pointleaf manzanita (*Arctostaphylos pungens*) and silktassel (*Garrya wrightii*). Mexican pinyon (*P. cembroides*) and alligator juniper (*Juniperus deppeana*) are the typical pinyon-juniper dominants. The highest montane woodlands are comprised of ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), limber pine (*P. flexilis*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*) (Pase and Brown 1994).

The Peloncillo Range, of the Peloncillo-Animas area, rises to the east of the San Simon Valley. The Animas Range lies to the east of the Peloncillo, and together they flank the Animas Valley. Both ranges are dominated by Madrean evergreen woodland. The most common community associations are dominated by alligator juniper, gray oak (*Q. grisea*), and Chihuahua pine. Within the montane woodlands, ponderosa pine, quaking aspen, and Douglas fir dominate community associations. The interior chaparral has primarily point-leaf manzanita and mountain mahogany (*Cercocarpus montanus*) associations. Along the lowest slopes, desert scrub associations of ocotillo (*Fouquieria splendens*) and mesquite are most common. The canyons with perennial water sources support riparian woodlands of Arizona sycamore (*Platanus wrightii*) and Fremont cottonwood associations (Bourgeron *et al.* 1995).

The Animas Mountains to the east and the Peloncillo Mountains to the west flank the Animas Valley-Chihuahua Grasslands. This high valley (1,533 m) contains a largely intact expanse of grassland. The most common vegetative associations in the valley are Plains grassland, dominated by blue grama (*Bouteloua gracilis*), and semi-desert grassland, typically black grama, tobosa grass, or big alkali sacaton (*Sporobolus wrightii*). The Animas valley is a closed basin but is coterminous with the Hatchita Grassland priority site to its northeast. Towards the south of Animas valley, the grasslands extend into Chihuahua, along the eastern face of the Sierra Madre Occidental. Several wetlands in this northern portion of Chihuahua are seasonally inundated. *Ciénegas* are also scattered through the Animas valley (Bourgeron *et al.* 1995).

Information is sparse for the Sierra San Luis, Sierra Huachinera, and Mesa de Guacamayas of the Mexican Sierra Madre. They are principally Sierra Madre encinal woodland, semi-desert grassland, pine-oak forests, and riparian woodlands. They support plant and animal species very similar to the Chiricahua Mountains, and may contain the largest expanse of old growth in the state of Sonora. The mountains range from 1000-2700 m in elevation and contain large, roadless areas. They are very isolated and difficult to access.

Outstanding biological features: Yaqui Headwaters: Despite its degraded condition, the Yaqui headwaters is still home to rare and endemic plants and animals. Pronghorn (*Antilocapra americana*), badger (*Taxidea taxus*), kit fox (*Vulpes macrotis*), white-tailed kite (*Elanus caeruleus*), and Lincoln sparrow (*Melospiza lincolni*) are among the grassland inhabitants. *Ciénegas* contain endangered riparian and aquatic herpetofauna, fishes, and invertebrates such as the Mexican garter snake (*Thamnophis eques*), Chiricahua leopard frog (*Rana chiricahuensis*), longfin dace (*Agosia chrysogaster*), Yaqui catfish (*Ictalurus pricei*), Yaqui chub (*Gila purpurea*), Yepomera springsnail (*Fontelicella* sp.), Yepomera tryonia (*Tryonia* sp.), and San Bernadino spring snail (*Fontelicella* sp.). Among the wetland bird species are Virginia rail (*Rallus limicola*) and green kingfisher (*Chloroceryle americana*). In the riparian woodlands are gray hawk (*Buteo nitidus*), blue grosbeak (*Guiraca caerulea*), and summer tanager (*Piranga rubra*). Other herpetofauna throughout the valley are lowland leopard frog (*Rana yavapaiensis*), massasauga (*Sistrurus catenatus*), Dixon's spotted whiptail (*Cnemidophorus dixoni*), canyon spotted whiptail (*Cnemidophorus burti*), and bunchgrass lizard (*Sceloporus scalaris*) (USDI-USFWS 1995). The Río Bavispe is an important corridor and breeding ground for migratory birds, including Common black hawk (*Buteogallus anthracinus*), Cassin's kingbird (*Tyrannus vociferan)*, violet-crowned hummingbird (*Amazilia violiceps*) and hepatic tanager *(Piranga flava*).

The degraded San Simon Valley contains remnants of grassland and wetland species assemblages such as the kit fox (*Vulpes macrotis*), Bendire's thrasher (*Toxostoma bendirei*), painted and varied buntings (*Passerina ciris* and *P. versicolor*), Bell's vireo (*Vireo bellii*), and black-tailed gnatcatcher (*Polioptila melanura*). The valley continues to serve as a corridor for the movement of grassland species such as pronghorn and Cassin's sparrow (*Aimophila cassinii*) McClaren and VanDevender 1995, USDI-BLM 1990).

While the Chiricahuas-Dos Cabezas mountains are renowned for their high richness of birds in the U.S., they also support a notable diveristy of other taxa. At least two endemic land snails have been described from the Chiricahuas, *Ashmunella chiricahuana* and *Holospira chiricahuana*. Several rare reptiles are found here, including ridge-nosed rattlesnake *(Crotalus willardi*) and twin-spotted rattlesnake (*Crotalus pricei*). These mountains could provide corridors of movement and prey for extirpated large predators such as jaguar (*Panthera onca*), Mexican gray wolf (*Canis lupus baileyi*) and grizzly bear (*Ursus horribilis*). Other mammals documented in these mountains are Sanborn's longnose bat (*Leptonycertis curasoae yerbabuenae*), Chiricahua fox squirrel (*Sciurus apache*), mountain lion (*Felis concolor*), black bear (*Ursus americanus*), and porcupine (*Erethizon dorsatum*). In addition to the occurrence of bird species with neo-tropical affinities such as the greater pewee (*Contopus pertinax*), elegant trogon (*Trogon elegans*), magnificent hummingbird (*Eugenes fulgens*), and buff-bellied flycatcher (*Empidonax fulvifrons*), montane species such as Mexican spotted owl (*Strix occidentalis lucida*) and Mexican chickadee (*Parus sclateri*) also occur at higher elevations. This range once supported thick-billed parrots (*Rhynchopsitta pachyrhyncha*) until 1938, although unsuccessful reintroduction attempts were made in 1986 and 1995. Riparian woodlands support zone-tailed hawks (*Buteo albonotatus*), as well as the Chiricahua leopard frog (*Rana chiricahuensis*). Montezuma quail (*Cyrtonyx montezumae*) and Strickland's woodpecker (*Picoides stricklandi*) are commonly found within the oak-pine woodlands (Taylor 1995).

The Peloncillo-Animas area still contains intact habitats which may provide corridors of movement for wide ranging mammals such as the Mexican gray wolf (*Canis lupus baileyi*). In 1997 a jaguar was photographed in the Peloncillo Mountains. Once locally extinct, desert bighorn *(Ovis canadensis mexicana*) have been reintroduced into the Peloncillo Mountains (USDI-BLM 1993). At least 638 species of plants occur in the Animas Mountains (Wagner 1977). The area is considered to have the highest diversity of cacti in the state of New Mexico. Pine-oak woodlands support endangered mountain snakes such as ridge-nosed rattlesnake (*Crotalus willardi*) and two endemic land snails, *Ashmunella animasensis* and *Sonorella animasensis*. The riparian woodlands are unusual for their escape from extensive salt cedar (*Tamarix ramosissima*) invasion, an introduced species, particularly in Guadalupe Canyon. The woodlands support the Chiricahua leopard frog, northern beardless tyrannulet (*Camptostoma imberbe*), and thick-billed kingbird (*Tyrannus crassirostris*). The desert scrub and pine-oak woodlands are also home to whiskered screech-owl (*Otus trichopsis)*, violet-crowned hummingbird (*Amazilia violiceps*), Lucifer hummingbird (*Calothorax lucifer*), Sanborn's longnose bat, and eight other species of bat.

The Animas Valley is home to the Gray Ranch, which is 129,877 ha of deeded land with a conservation easement. Within the ranch and its neighboring properties are large expanses of sacaton (*Sporobolus airoides*) and grama (*Bouteloua sp*.) grasslands. The grasslands provide a corridor for the movement for pronghorn (*Antilocapra americana*) and a herd of bison (*Bison bison*) of uncertain origin across the international border into Mexico. Dozens of species of wintering grassland birds are found here, including McCowan's longspur (*Calcarius mccownii*), Smith's longspur (*Calcarius pictus*), western and eastern meadowlarks (*Sturnella neglecta* and *S. manga*), and Baird's sparrow (*Ammodramus bairdii*). During breeding season, declining grassland birds such as Botteri's sparrow (*Aimophila botterii*) utilize the sacaton grasslands. Fire is used as a management tool in the area. The *ciénegas* on Gray Ranch and in surrounding areas support endangered or aquatic herpetofauna, including the declining Chiricahua leopard frog (*Rana chiricahuensis*). Antelope Pass, in the Animas Valley, has the highest lizard species diversity in the continental U.S. (USDI-BLM 1993). The grasslands in the Mexican state of Chihuahua are home to the largest remaining black-tailed prairie dog (*Cynomys ludovicianus*) town in North America. The black-tailed prairie dogs provide suitable wintering habitat for large numbers of ferruginous hawk (*Buteo regalis*) and mountain plover (*Charadrius montanus*). Year round residents associated with the prairie dog towns include kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), golden eagle (*Aquila chrysaetos*), and burrowing owl (*Athene cunicularia*). Prairie dog towns are found throughout the Chihuahuan grasslands, and were at one time coterminous with the Hatchita Grassland prairie dog towns that are now extirpated (McClaran and VanDevender 1995). This area may contain the highest diversity of graniverous mammals in the U.S.. Kangaroo rats (*Dipodomys sp*.) play a functional role in the maintenance of grasslands through seed caching, seed distribution, and soil movement. The grasslands once supported breeding populations of Aplomado Falcon (*Falco femoralis*), now endangered in the U.S. and Mexico, and possibly Worthen's sparrow (*Spizella Wortheni*).

Published biological information about the Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera) area is lacking. The region is extremely important, however, for landscape scale conservation. Thick-billed parrots (*Rhynchopsitta pachyrhyncha*) nest here, as do eared trogon (*Trogon neoxenus*) and golden eagle (*Aquila chrysaetos*). The old growth forests are important wintering areas for Williamson's sapsucker *(Sphyrapicus thyroideus*). Jaguar may use the area as a corridor. Invertebrate inventories on the Río Piedras Verdes, flowing eastward from the Sierra Huachinera, document intact riparian woodland containing viceroy butterfly (*Limenitis archippus obsoleta*), a very local metalmark crescent butterfly (*Apodemia phyciodoides*,) lampyrid beetles, and the rare bee, *Heteropogon divisus*. Another lepidoptera, Nokomi's fritallary (*Speyeria nokomis corulescensis*) is also dependent on this riparian zone. An undescribed Formica ant has been collected in this portion of the

Sierra Madre. The area is a probable corridor for predators with large ranges, such as the Mexican gray wolf, grizzly bear, and jaguar. A large population of of black bear persists.

Conservation status: Most of this region is intact, however, portions are degraded beyond restoration. 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 (Turner *et al.* 1994).

Yaqui Headwaters: 1,590 ha managed by the San Bernadino National Wildlife Refuge. The refuge has proposed an additional site as a protected area (working with private landowners and the USDI-BLM). Cattle were removed from the refuge in 1980, but degradation is considerable (USDI-USFWS 1995).

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 to be highly degraded by groundwater pumping, historic grazing practices, and conversion to farming (USDI-BLM 1990).

Chiricahua-Dos Cabezas: These mountain ranges have several special management designations. U.S. Forest Service manages the Dos Cabezas Wilderness Area (4,734 ha), and the Chiricahua Wilderness Area (35,483 ha). The National Park Service manages Fort Bowie National Historic Site (405 ha), and Chiricahua National Monument (4,849 ha). Dos Cabezas Area of Critical Environmental Concern (ACEC), designated by BLM, is only 10 ha. Scattered parcels of private land are a small segment of the total area. The area has experienced low levels of fragmentation through timber harvest and road building (USDA-Forest Service 1986).

Peloncillo-Animas: The land status through this area ranges from wilderness to private commercial livestock to mining companies. However, large portions of the ranges are protected through special management areas and conservation easements. Within the Peloncillos, the BLM-Safford District manages Guadalupe Canyon ACEC (874 ha), and Baker Canyon Wilderness Study Area (WSA) at 1,947 ha. The BLM Las Cruces District manages an adjacent Guadalupe Canyon ACEC in New Mexico (1,687 ha), the Granite Gap ACEC (708 ha), Central Peloncillo Mountains ACEC (31,505 ha), and the Gray Peak WSA (5,939 ha). The Coronado National Forest manages Bunk Robinson Wilderness Study Area (1,058 ha), and Whitmire Canyon Wilderness Study Area (850 ha). Scattered parcels of private land are managed under a range of strategies. The Malpais Borderlands group, comprised of ranchers in the Peloncillo and Animas mountains and the Animas Valley, manage livestock in a manner intended to improve the fire regime, provide grassbanks during times of poor forage production, and restore degraded lands. Many private land owners in the area do not participate in the Malpais group.

Animas Valley-Chihuahuan Grasslands: Gray Ranch (129,877 ha) supports the Malpais Borderlands Group with conservation easements. Cowboy Springs ACEC is 2,727 ha. Antelope Pass Research Natural Area (3,524 ha) was designated to protect the 19 known lizard species (USDI-BLM 1993).

Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera): No known formal protection, however, The Wildlands Project is fostering the purchase of ranches for conservation and ecotourism.

Description of threats: Yaqui Headwaters: The economy of the area at one time was based almost solely on smeltering operations from large copper mines in Bisbee, Arizona, which began to close in the early 1980s. Agua Prieta, Sonora, has 80,000 people and Douglas, Arizona has 19,000. An estimated 180,000 people live in the area. Auto emissions and ore processing continue in Mexico. Heavy grazing, downcutting of channels, water depletion through agriculture, and municipal and mining uses on the Mexico side of the border are issues. Within wetland and aquatic habitats, exotic bullfrogs (*Rana catesbeiana*) threaten native herp and fish populations (USDI-USFWS 1995). Depletion of spring flows from excessive groundwater pumping, stream diversion and streambank erosion are primary threats to native fish in the smaller tributaries. The introduction of nonnative fish species is also a serious threat to native species (Williams *et al.* 1985).

San Simon Valley: Continued livestock grazing, groundwater pumping, and subdivision of ranch lands into private home sites are the primary threats.

Chiricahua-Dos Cabezas: Timber harvest is an ongoing threat to the Chiricahua mountains. Biological supply companies threaten native herpetofauna and invertebrate populations through overcollection of rare species. Mismanaged fire policies for prescribed fire and fire suppression is a threat to the woodlands and grasslands.

Peloncillo-Animas: Overcollection of herpetofauna threatens local native populations. Grazing mismanagement continues to occur on private, state, and federal lands. Mining and mineral exploration also threatens to fragment this largely intact landscape.

Animas Valley-Chihuahuan Grasslands: Water diversions for agriculture disrupt *ciénega* 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 fragments the landscape in the Animas valley.

Mexican Sierra Madre (Sierra San Luis and Sierra Huachinera): Pesticides associated with agriculture in Casas Grandes and Colonia Juarez 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.

Reasons for selection as a priority site: This is a large, intact ecosystem with top carnivores, high plant and animal diversity, high endemism, contiguous, intact grassland habitats, intact shrub and montane systems with adequate corridors.

CONABIO Sites: Nearly half of the area is within Conabio sites 34 and 35.

Freshwater Sites: Upper Yaqui (5.02), San Pedro-Aravaipa (5.03) overlap to the northwest and Guzman Basin (5.13) and Bavispe (5.07) intersect in the southern regions of the site.

Active conservation groups: Animas Foundation, Desert Laboratory at the University of Arizona, Malpais Borderlands Group, IMADES, ITESM, Museum of Natural History Southwest Research Station, New Mexico Wilderness Alliance, PROFAUNA, The Nature Conservancy of Arizona, Universidad Nacional Autonoma Mexico, USDA Natural Resources Conservation Service, Wildlands Project-Sky Island Alliance.

Contributors: C. Curtin, G. Forbes, M. Hakkila, R. List, B. MacKay, D. Richman

1.21
Name: North Peloncillo Mountains
Location: 67 km east of Willcox, Arizona
Approximate Size: 982 km^2
Priority Rank: 2
Level of threat: low

Ownership: State of Arizona, U.S. Bureau of Land Management-Safford District,.

Description of the site: A lower 'sky island', the Northern Peloncillos reach only to 2,200 m at their highest elevation. The Madrean evergreen woodland community type characterizes the higher portions of habitat. However, 90% of the range is considered a transitional semi-desert grassland, containing elements of the Madrean encinal at the upper elevations, and Chihuahuan desert scrub at lower elevations (Brown 1994).

Outstanding biological features: Grassland, riparian, and woodland species assemblages are represented here. Among the vertebrate species documented in this range are the zone-tailed Hawk (*Buteo albonotatus*), Gila monster (*Heloderma suspectum*), Arizona mountain kingsnake (*Lampropeltis pyromelana pyromelana*), coatimundi (*Nasua narica*), javelina (*Dicotyles tajacua*), and bobcat (*Lynx rufus*).

Conservation status: BLM-Safford district manages a 7,865 ha wilderness area, the Peloncillo Mountain Wilderness. State of Arizona and BLM lands outside the wilderness are managed for livestock use, mineral exploration, and recreation. BLM-Las Cruces District manages a 307 ha Area of Critical Environmental Concern (USDI-BLM 1990, USDI-BLM 1993).

Description of threats: Ovegrazing and mineral exploration outside of the protected area are threats to vegetation and watershed function.

Reasons for selection as a priority site: Representation of habitat types, species assemblages, and ecosystem services. The range also provides a corridor between the Sierra Madre Occidental to the south and the Mogollon Plateau to the north.

Freshwater Sites: The mountains drain into Gila River (5.37).

Active conservation groups: New Mexico Wilderness Alliance, The Wildlands Project-Sky Island Alliance.

Contributors: M. Hakkila

1.22
Name: Big Hatchet-Alamo Hueco Mountains
Location: 80 km southeast of Lordsburg, New Mexico
Approximate Size: 1,022 km^2
Priority Rank: 2
Level of threat: medium

Ownership: U.S. Bureau of Land Management-Las Cruces District, State of New Mexico, and private.

Description of the site: Situated in the "bootheel" of New Mexico, the Alamo Hueco Mountains are a lower range, volcanic in origin, and dominated by community types of semi-desert grasslands grading into Madrean evergreen woodlands of oak and pine savannas at the higher elevations (1,700 m). Just north of the Alamo Huecos, the Big Hatchets, are a limestone range reaching 2,700 m, and high enough to support pinyon-juniper woodlands (Brown 1994). On both ranges, the lower elevations are primarily degraded grasslands of creosote bush (*Larrea tridentata*) and fluffgrass (*Dasyochloa pulchella*). Mid-elevations contain grama grasslands, mesquite shrublands, and bottoms of tobosa (*Hilaria mutica*). Higher elevations are primarily grama grasslands with beargrass (*Nolina microcarpa*), silktassel (*Garrya wrightii*), whitethorn acacia (*Acacia constricta*), Palmer agave (*Agave palmeri*) and many other species of grass, including Muhlenbergia (*Muhlenbergia* sp.), sprangletop (*Diplachne dubia*), and threeawn (*Aristida* sp.). Lower, ephemeral arroyos are dominated by apache plume (*Fallugia paradoxa*), characteristic of higher water tables. In the Alamo Huecos, along perennial reaches of stream, lowland riparian woodland species such as Arizona sycamore (*Platanus wrightii*), Fremont cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*) distinguish these mountains as eastern outlyers of the Sierra Madre flora (USDI-BLM 1993).

Outstanding biological features: Both mountain ranges support high quality grasslands and shrub/grass communities as well as intact riparian communities. The shrub/grassland communities are excellent habitat for desert bighorn sheep (*Ovis canadensis mexicana*). Desert bighorn sheep have been translocated to the site after many years of extirpation. Five species of state sensitive or rare plants are found; night-blooming cereus (*Peniocereus greggii*), Big Hatchet pincuchion cactus (*Coryphantha sneedii* var. *orcutti*), an endemic hedgehog cactus (*Echinocereus engelmannii*), scarlet-tube beardtongue (*Penstemon barbatus*), and Lemmon's rockdaisy (*Perityle lemmonii*). These mountains are the eastern range limit for several Apachean species, including Yarrow's spiny lizard (*Sceloporus jarrovi*), and Sonora mountain kingsnake (*Lampropeltus pyromelana*). Caves degraded by guano miners once supported Mexican free-tail bat (*Tadarida brasiliensis*) maternity colonies. The mountains also support populations of pronghorn (*Antilocapra americana*), and are potential jaguar (*Panthera onca*) habitat.

Conservation status: Within the Alamo Hueco Mountains, BLM manages 5,268 ha as an Area of Critical Environmental Concern (ACEC). Within the Big Hatchet Mountains, BLM manages 11,806 ha as an ACEC. Vehicle use is limited to existing roads, mineral leasing is closed, livestock grazing is closely monitored, and riparian resources are fenced. Natural fires are allowed to burn. Private and state lands comingling within the ACEC are not managed in cooperation with BLM. Lands outside the protected areas are managed for livestock use, recreation, and mineral exploration (USDI-BLM 1993).

Description of threats: Overgrazing throughout the mountain ranges alters grassland and woodland community composition and destroys riparian areas. Oil and gas exploration in the valleys may cause fragmentation of corridors.

Reasons for selection as a priority site: This site is critical for important large-scale grassland phenomena. It is a potential source pool for expansion of a potentially wild herd bison (*Bison bison*) and pronghorn (*Antilocapra americana*) into Mexico. Fires are allowed to burn within agency prescriptions. Species of limited distribution have persisted. Potential valuable bat habitats should be restored.

Active conservation groups: Malpais Bordland Group, New Mexico Wilderness Alliance, Sky Island Alliance.

Contributors: M. Hakkila, R. List, R. Worthington

1.23
Name: Hatchita Grasslands
Location: 20 km southeast of Lordsburg, New Mexico
Approximate Size: 3,754 km^2
Priority Rank: 4
Level of threat: medium

Ownership: Phelps-Dodge Mining Company and their subsidiary, Pacific Western Livestock Company, private, State of Arizona, U.S. Bureau of Land Management-Las Cruces District.

Description of site: The large open valleys of this site were once home to what may be the most celebrated prairie dog towns ever described. Vernon Bailey, chief naturalist for the U.S. Biological Survery from 1887 to 1924, estimated that these semi-desert grasslands averaged a density of ten black-tailed prairie dogs (*Cynomys ludovicianus*) per acre. The region as a whole may have supported 6.4 million individuals when he travelled through the area in 1908 (Parmenter and Van Devender 1995). While Bailey described the affects of this abundant herbivore as destructive toward livestock interests, research today indicates that prairie dogs played a critical role in the maintenance of grasslands by consuming shrub seedlings. Despite Bailey's description of a barren landscape, the prairie dog towns were established amid grasslands dominated by blue, black, sideoats, and hairy grama grasses (*Bouteloua gracilis, B. eriopoda, B. curtipendula*, and *B. hirsuta*). Shrub occurrence was varied but was primarily soaptree yucca (*Yucca elata*) and mesquite (*Prosopis glandulosa*), largely limited to patches of deeper soil (McClaran and VanDevender 1995). Today, much of this landscape has been highly degraded by livestock grazing to a Chihuahuan desert scrub favoring tarbush (*Flourensia cernua*), creosote bush (*Larrea tridentata*), snakeweed (*Guitierrezia* sp.), jointfir (*Ephedra* sp.), and walking stick cholla (*Opuntia imbricata*). Playas Lake, in Playas Valley, is also contained within this site. Long and narrow, 20 km by 2 km, it lies within private lands and has not been studied.

Outstanding biological features: This site is currently bereft of outstanding biological features, however, the landscape is capable of recovering and supporting the myriad species associated with functional, intact grasslands, including termites, ants, kangaroo rats (*Dipodomys* sp.), pronghorn (*Antilocapra americana*), black-tailed prairie dogs (*Cynomys ludovicianus*), and aplomado falcon (*Falco femoralis*).

Conservation status: This site requires extensive restoration. Currently, livestock grazing, mineral exploration, fire suppression, fences, roads, predator and rodent control, and public access, are all subject to regulation on federal and state lands. No special federal or state management has been designated for this area (USDI-BLM 1993).

Description of threats: Shrub encroachment caused by overgrazing, lack of keystone species, and fire suppression are the primary threats.

Reasons for selection as a priority site: Potential for restoration of ecological phenomena is high at this site. Grassland fires, prairie dog towns, predator-prey relationships, and large concentrations of wintering grassland birds and aplomado falcon habitat could be restored to this area.

Active conservation groups: Southwestern New Mexico Consolidated Sportsmen, Malpais Bordlands Group, New Mexico Wildlerness Alliance.

Contributors: M. Hakkila, A. Montoya

1.24
Name: Lordsburg Playa
Location: 11 km east of Lordsburg, New Mexico
Approximate Size: 209 km^2
Priority Rank: 3
Level of threat: medium

Ownership: Private, State of New Mexico, and U.S. Bureau of Land Management-Las Cruces District.

Description of the site: At the north end of a closed basin, a series of three seasonally inundated clay flats are sparsely vegetated with alkali sacaton (*Sporobolus airoides*) and several species of saltbush (*Atriplex* sp.). The flats lie within a degraded semi-desert grassland community type.

Outstanding biological features: Griffith's saltbush (*Atriplex torreyi griffithsii*) an endemic Chenopodaceae with an extremely limited range, occurs in patches on the playas. Migratory waterfowl and shorebirds utilize the playas seasonally (USDI-BLM 1993). Long-billed curlew (*Nemenius americanus*), American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), mallard (*Anas platyrhychos*), and sandhill crane (*Grus canadensis*) are among the species known to exploit the playas when inundated (MacCarter 1994). During spring migration, birds feed here on fairy and tadpole shrimp. Invertebrates of saline, ephemeral, and other aquatic habitats require futher inventory.

Conservation status: A BLM Research Natural Area comprises 87% of the site (1,825 ha). This area is managed to protect the endemic Griffith's saltbush and the runoff waters utilized by migratory birds. Off-road vehicle use and mining are prohibited (USDI-BLM 1993).

Description of threats: Livestock use and off road vehicle use are potential threats but currently are controlled. Private inholdings sold for housing will fragment this undeveloped landscape.

Reasons for selection as a priority site: This site is critical for large-scale migratory phenomena and represents a saline habitat type.

Active conservation groups: T&E, Inc., The Wildlands Project-Sky Island Alliance.

Contributors: P. Mehlhop, R. Meyer

1.25
Name: Upper Middle Gila River
Location: 37 km north of Lordsburg, New Mexico
Approximate Size: 785 km^2
Priority Rank: 2
Level of threat: high

Ownership: Private, State of New Mexico, and U.S. Bureau of Land Management-Las Cruces District.

Description of the site: Over half of this 40 km stretch of river runs through narrow, steep walled canyons. The shallow, sandy channel supports a recovering lowland riparian woodland dominated by Fremont cottonwood (*Populus fremontii*) and Arizona sycamore (*Platanus wrightii*). Floodplains that were formerly disturbed by agriculture are now covered by weedy exotic annuals. The uplands surrounding the riparian corridor are a highly degraded semi-desert grassland community type dominated by a creosote bush (*Larrea tridentata*) and desert scrub habitat type. Private lands interspersed between state and federal reaches support livestock grazing and consequently do not contain the density or quality of riparian species. Floodplains on private lands are also cleared for farming (USDI-BLM 1993).

Outstanding biological features: Undammed and free flowing, this portion of the Gila River is subject to frequent flooding. Cottonwood stands represent a variety of age classes, from sapling to over-mature. These woodlands support the richest riparian avifauna in New Mexico. Many state listed and federally threatened and endangered herpetofauna occur here including the Gila monster (*Heloderma suspectum*), Mexican garter snake (*Thamnophis eques*), and Chiricahua and lowland leopard frogs (*Rana chiricahuensis* and *R. yavapaiensis*). The U.S. federally endangered southwest willow flycatcher (*Empidonax trailii extimus*) nests here. Peregrine falcons (*Falco peregrinus*), once U.S. federally endangered, nest on the cliffs and prey upon the abundant cliff swallows (*Hirundo pyrrhonota*) and white-winged doves (*Zenaida asiatica*). Other declining riparian bird species such as least Bell's vireo (*Vireo bellii*), common black hawk (*Buteogallus anthracinus*) and yellow-billed cuckoo (*Coccyzus americanus*) also nest here.

Unusual or rare freshwater fish found in the Gila River include the spikedace (*Meda fulgida*) and the loach minnow (*Tiaroga cobitis*), both of which represent monotypic genera (though most ichthyologists now place the loach minnow in the genus *Rhinichthys*) (Robins *et al.* 1991). The Gila trout (*Oncorhyncus gilae*) was historically restricted to the headwaters of the Gila and San Fransisco Rivers in the Gila National Forest, but has been translocated elsewhere in the Gila catchment (Page and Burr 1991; Propst *et al.* 1992). The longfin dace (*Agosia chrysogaster*) and Gila topminnow (*Poeciliopsis occidentalis*) can each be considered endemic to the Gila catchment, though their ranges extend southward into the Sonoran region (Minckley *et al.* 1985; Page and Burr 1991). The Gila chub (*Gila intermedia*), whose taxonomy is uncertain, persists in one location in the ecoregion. Colorado squawfish (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*), endemic to the Colorado complex, may have once occurred in the Gila River, and roundtail chub (*Gila robusta*) still occurs in three separate reaches of the river.

Conservation status:. There are several protected areas within this site. Sixteen kilometers of this reach are managed as Wild and Scenic River Study Area, and as Areas of Critical Environmental Concern by the BLM. Thirteen kilometers of stream are protected from livestock grazing. Red Rock State Wildlife Area is a breeding facility for desert bighorn sheep (*Ovis canadensis mexicana*) as well as a Watchable Wildlife location. The site also includes Apache Box, Blue Creek, and Gila Lower Box Wilderness Study Areas. Unprotected BLM and State of New Mexico lands are managed for multiple use and livestock (USDI-BLM 1993).

Description of threats: Within the site, the greatest direct threats are continuous livestock grazing along the river on private lands and the conversion of floodplain into cropland for corn, cotton, and alfalfa. Levees and irrigation diversions restrict channel movement. Introduced salt cedar (*Tamarix ramosissima*) continuously invades disturbed sites. Brown-headed cowbirds (*Molothrus ater*), a brood parasite, concentrate at feeding sites such as dairies, barns, and livestock water sources surrounding the site. Their aggressive mode of reproduction reduces the number of fledged neotropical migratory birds dependent on the riparian habitat. Surrounding the site, upland livestock grazing on BLM and Gila National Forest has altered water infiltration rates and increased the frequency and intensity of flooding in the river corridor.

The native freshwater fish fauna of the Gila River is relatively intact, yet land and water use practices and introduced species pose substantial threats to all native species persistence. The upper Gila River in New Mexico still provides important habitat for the federally threatened spikedace and loach minnow, which have been extirpated from much of their former habitat elsewhere in the basin (Minckley 1973; Propst *et al.* 1986; Propst *et al.* 1988). These species are primarily threatened by habitat modification in the form of channelization, dam construction, removal of riparian vegetation, exotic species, and stream dessication by water diversion. Nonnative trout (rainbow, *Oncorhynchus mykiss*, and brown, *Salmo trutta*) pose perhaps the greatest threat to the federally endangered Gila trout, through competition, predation, and hybridization (Propst *et al.* 1992). This species, which now inhabits twelve sites due to intense recovery efforts, is also threatened by livestock grazing, illegal angling, and stochastic natural events. Black bullhead (*Ameiurus melas*), smallmouth bass (*Micropterus dolomieu*), and other exotics are responsible for the elimination of spikedace and loach minnow from much of their ranges; both native species are listed as federally threatened. The roundtail chub, listed in New Mexico as endangered, has suffered from the establishment of exotic fishes as well as from habitat loss. The Gila topminnow has been extirpated from New Mexico, and the Gila chub may or may not persist in one location. The reduction in ranges of all native fishes in the Gila River in the past 50 to 75 years has been well.

Reasons for selection as a priority site: Intact and recovering riparian communities are rare in the Chihuahuan Desert. The woodlands rested from livestock grazing in this priority site maintain important riparian ecological processes and represent examples of declining riparian dependent species assemblages, and habitat types. The Gila River is unusual in that there are no flow-controlling dams on it, and flow regimes in the basin are natural.

Freshwater Sites: Upper Gila River (5.37)

Active conservation groups: New Mexico Wilderness Alliance
Contributors: J. Atchley, M. Hakkila, E. Muldavin

1.26
Name: Mimbres River Terrestrial
Mimbres River Freshwater (5.12)
Location: 24 km east of Silver City, New Mexico
Approximate Size: 80 km^2
Terrestrial priority rank: 3
Freshwater priority rank: 3
Terrestrial level of threat: high
Freshwater level of threat: high

Ownership: Private, State of New Mexico State Land Office, New Mexico Department of Game and Fish, The Nature Conservancy of New Mexico, Western Pacific Livestock Company, U.S. Forest Service-Gila National Forest.

Description of the site: This is a 20 kilometer stretch of river that is an important example of lowland riparian woodland. The riparian deciduous forest community type is highly fragmented, interspersed with livestock pastures. Floodplains have been cleared of woodland, seeded with pasture grass, and flood-irrigated with river water. However, approximately 1480 ha owned by TNC includes Fremont and narrow-leaf cottonwood (*Populus fremontii* and *P. angustifolia*), and (*Alnus firmifolia*) strands with primarily older trees. Stretches under the management of TNC are recovering native assemblages of plants and animals. The corridor lies within a pinyon-juniper woodland along the northernmost edge of the Chihuahuan Desert at 1,800m.

Outstanding biological features: Riparian dependent species have persisted in this drastically altered habitat. Chiricahua leopard frog (*Rana chiricahuensis*) breeds in stretches within TNC property, as does the common black hawk (*Buteogallus anthracinus*). The river also serves as a migration corridor for neotropical birds. In addition, this is the only extant location of the U.S. federally threatened Chihuahua chub (*Gila nigrescens*). Other native species include Rio Grande sucker (*Pantosteus plebeius*) and transplanted poulations of Gila trout (*Oncorhynchus gilae*) upstream in McKnight Creek. Beautiful shiner (*Cyprinella formosa*) has been extirpated from the river. An unnamed springsnail of the genus *Pyrgulopsis* also occurs in the Mimbres River. This river is undammed and flooding occurs regularly, a rare condition for a stream in the U.S..

Conservation status: The Nature Conservancy of New Mexico (TNC) is purchasing properties, establishing perserves, and encouraging the purchase of conservation easements (Sullivan 1996). TNC has protected 40 km of river, and at least 30,000 ha of surrounding watershed through purchasing base properties associated with U.S. Forest Service grazing allotments. Conservation easements have been established on 2,124 ha in the watershed.

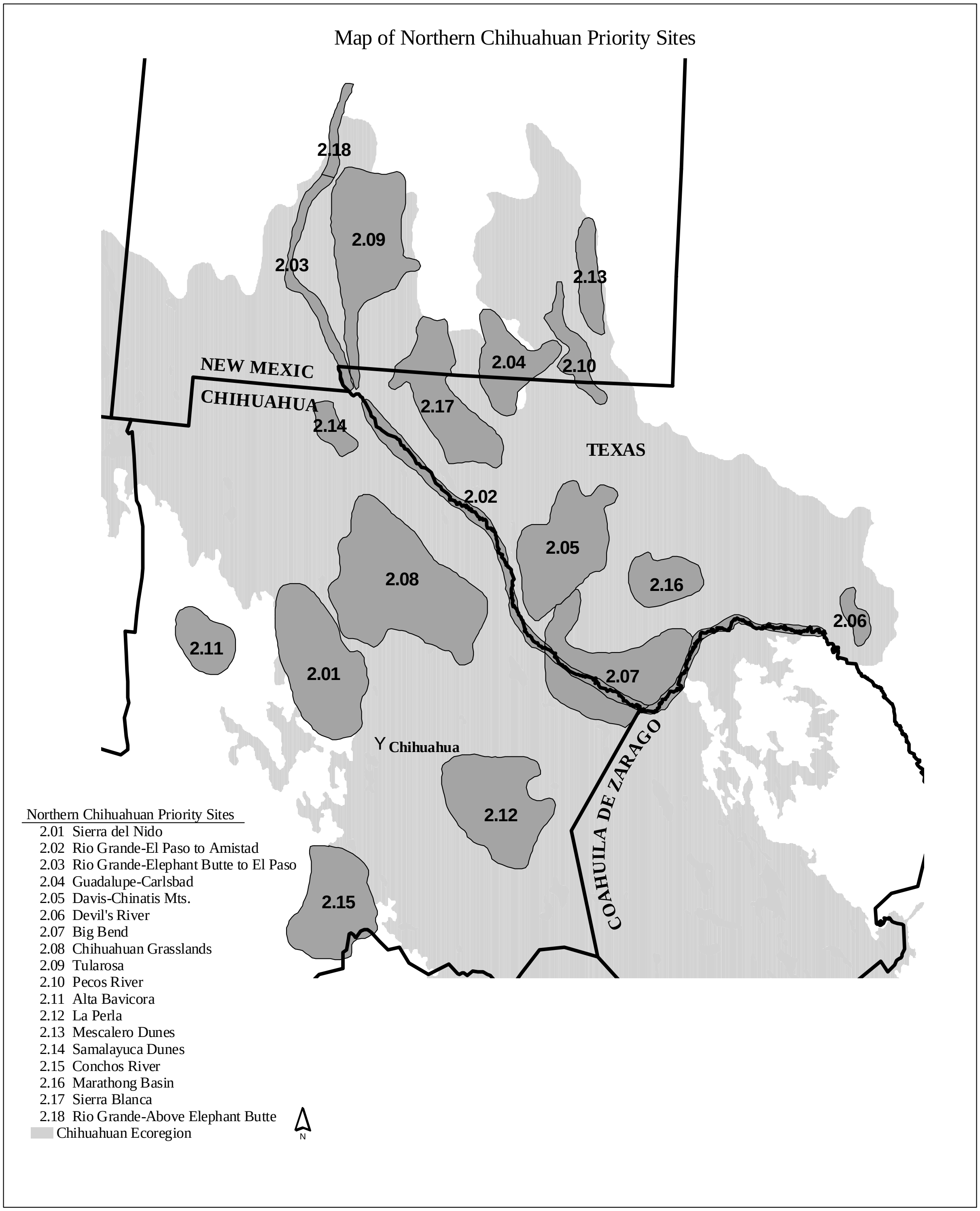
Description of threats: Many forces around and along the river threaten water availability and habitat structure. Overgrazing, agricultural conversion of the floodplain, groundwater pumping and diversions from the channel for irrigation, and channelization, affect the river directly. Timber harvest and sand and gravel removal threaten the integrity of the watershed. This area is also rapidly developing as a vacation and retirement community.

Reasons for selection as a priority site: Recovering riparian communities are rare in the Chihuahuan Desert. The woodlands rested from livestock grazing in this priority site maintain important riparian ecological processes and represent examples of declining riparian dependent species assemblages, and habitat types. Flooding, a critical ecological process, occurs on this undammed river.

Freshwater Sites: Mimbres River (5.12) overlaps on the northern edge.

Active conservation groups: The Nature Conservancy of New Mexico

Contributors: J. Atchley, E. Fredrickson, P. Mehlhop, D. Propst



Appendix Figure F-2 Northern Chihuahuan Priority Sites

2.01
Name: Sierra del Nido
Location: 30 km northwest of Ciudad Chihuahua
Area: 9,827 km^2
Priority rank: 1
Level of threat: high

Ownership: Ejidos, La Campana Research Station, Majalca National Park, private lands, and a large, private hunting preserve.

Description of the site: This is a relatively undisturbed and isolated mountain range, supporting grama grasslands and desert scrub in lower elevations, and mixed conifer forest and pine-oak woodlands in higher elevations up to 2,380 m. The Madrean evergreen woodland community type comprises about 50% of the site and Plains and Great Basin grassland community types comprise about 40% of the site. The remaining community type is Rocky Mountain conifer forest in the highest elevations.

Outstanding biological features: Relatively intact freshwaters support aquatic insects and a native trout. An endemic ant species has been documented. In addition, montane and woodland species such as black bear (*Ursus americanus*), elegant trogon (*Trogon elegans*), thick-billed parrot (*Rhynchopsitta pachyrhyncha*), and nesting golden eagle (*Aquila chrysaetos*) have been recorded. Intact grasslands with two undescribed species of Muhlenbergia are found at mid and higher elevations. An endemic ant (*Trachymyrmex carinatus*) occurs here. This was the last known vestige of grizzly bear (*Ursus horribilus*) habitat in Mexico.

Conservation status: Cumbres de Majalca Parque Nacional (781 ha) is protected but funding for staffing fluctuates greatly each year. Private lands are well managed but are not protected.

Description of threats: Timber regulations are poorly enforced. Human-caused fires have increased. Overgrazing, particularly on ejido lands, damages grass communities and riparian areas. Deer and black bear are hunted illegally.

Reasons for selection as a priority site: Representation of Sierra Madre and Chihuahuan desert species assemblages, and intact habitats.

CONABIO sites: Number 39

Freshwater sites: The northern range drains into the closed Guzmán Basin (5.13). The eastern portion drains into Sauz Basin (5.29). The western portion drains into Laguna Bustillos (5.14).

Active conservation groups: Mexican Wolf Recovery Program, PROFAUNA, Ballenas Ranches

Contributors: R. Corral, D. Conde, G. Forbes, A. Lafón, C. Lieb

2.02 & 5.10
Name: Rio Grande-El Paso to Amistad Terrestrial (2.02)
Rio Grande/Río Conchos Freshwater (5.10)
Location: El Paso, Texas to Amistad Reservoir, near Villa Acuña, Coahuila
Approximate Size: 6,546 km^2
Terrestrial priority rank: 1
Freshwater priority rank: 2
Terrestrial level of threat: high
Freshwater level of threat: high

Ownership: The Rio Grande forms the international boundary between Mexico and the U.S. along this segment. State governments (Texas, Chihuahua, and Coahuila), and municipal entities influence water management. El Paso, Ciudad Juárez, Fort Hancock, Presidio, Ojinaga, Big Bend National Park, Villa Acuña, and Del Rio are the largest towns and cities. U.S. Bureau of Reclamation, International Boundary and Water Commission (IBWC), Comisión Internacional de Aguas y Límites (CILA), private, ejido, and various irrigation districts own water rights and land beyond the floodplain. The floodplain itself is controlled by IBWC.

Description of the site: This reach is 835 km in length, coursing through Chihuahuan desert scrub, surrounded by mesas, buttes, broad valleys, low terraces, deep canyons, and agricultural lands. The Rio Grande riparian zone was once an important ecosystem for herpetofauna, mammals, invertebrates, and birds, however, the woodlands, scrublands, and wetlands are now reduced to a very small fraction of their previous extent. Upland scrub habitat types are variable by slope, soil, aspect, elevation, and grazing history. Creosote bush (*Larrea tridentata*), lechuguilla (*Agave lechuguilla*), sotol (*Dasylerion wheeleri*), and mesquite (*Prosopis glandulosa*) scrublands predominate. Yucca woodlands are scattered throughout the region. Human activities upstream of this region have detrimentally affected the amount and quality of water as well as the shape of the channel. Riparian vegetation can extend a few feet to up to two kilometers. Salt cedar, an exotic, dominates both tree and shrub canopies. Riparian lowland woodlands may contain native species, including Fremont cottonwood (*Populus fremontii*), seepwillow (*Baccharis* sp.), mesquite, Goodding's willow (*Salix gooddingii*), and coyote willow (*Salix exigua*), however, these stands are typically depauperate and contain large numbers of salt cedar (*Tamarix ramosissima*). Other native bosque and shrub species along the river include screwbean mesquite (*Prosopis pubescens*), catclaw acacia (*Acacia greggii*), desert willow (*Chilopsis linearis*), and the introduced tree tobacco (*Nicotiana glauca*). Bermuda grass (*Cynodon dactylon*), another exotic, dominates in scoured areas.

El Paso to Fort Hancock: The river has experienced water depletion throughout this century. Its ability to meander and flood was curtailed in the 1960's when the channel was straightened and deepened, then lined with concrete, to settle international boundary disputes between the cities of El Paso, Texas, and Ciudad Juárez, Chihuahua (CoRio 1997). The river is nearly dry by the time it reaches Fort Hancock. Water is diverted through the American Canal to the El Paso County Water Improvement District #1, and the El Paso Water Utility for agricultural and municipal uses. Water is diverted to Ciudad Juárez for agriculture fields. In the U.S. and Mexico, crops of alfalfa, cotton, and chile are the primary uses of the agricultural water. Remnant cottonwoods are scattered along the floodplain in Mexico. Strands of screwbean mesquite or coyote willow are present but uncommon.

Ft. Hancock to Río Conchos: Below Fort Hancock, the valley narrows and the ground water surfaces to occasionally to form a highly saline stream. Additional water is added to the stream by small salt laden springs and fresh tributary creeks. However, these flow increases are commonly exceeded by losses. Drastic increases in flow periodically follow intense desert rains. The river flow above the Río Conchos confluence consists mostly of sporadic storm runoff, treated and untreated municipal wastewater, and irrigation return flow. Some stretches are seasonally intermittent, reflecting the affects of dams, flood control, channelization, and water diversion. Mesquite bosques, stands of willow, cottonwoods, wetlands, all once abundant, now remnants within salt cedar dominated riparian communities. Exotic salt cedar forms a nearly continuous bosque in this stretch. Freshwater biodiversity has been severely impoverished at this site.

Río Conchos Confluence to Amistad Reservoir: Sister cities Ojinaga, Chihuahua, and Presidio, Texas flank the Rio Grande 10 km below the Río Conchos River confluence. The Conchos River drains the Sierra Madre Occidental. Historically, the Río Conchos River had a sizable flow, more than five times the amount of water coming down the Rio Grande itself. That contribution is now affected by expanding Mexican agriculture, mining, and timber harvesting, as well as urban and industrial development. A 16 km segment at the Conchos confluence has been channelized. Between this segment and Amistad Reservoir, the river still remains relatively intact.

Outstanding biological features: El Paso to Fort Hancock: Near El Paso in 1597, a member of the Oñate Expedition noted that the river "seemed a calm and placid lake with scarcely a ripple to disturb its peaceful surface. Its bountiful waters teemed with many fish, and we easily caught a great number. The hunters then shot a large number of ducks and geese." Today, the river in this stretch is a conveyance channel and a boundary. It has none of the qualities described in 1597. However, old oxbows and springs still contain water, and in 1982, the bluntnose shiner (*Notropis simus*) was documented in this stretch. Potential for habitat restoration is good.

Fort Hancock to Río Conchos Confluence: No outstanding features documented.

Río Conchos Confluence to Amistad Reservoir: Freshwater biodiversity values in this segment are high; an assemblage of native fishes persists including the blue sucker (*Cycleptus elongatus*), channel catfish (*Ictalurus punctatus*), Chihuahua shiner (*Notropis chihuahuaensis*), Mexican stoneroller (*Campostoma ornatum*), Big Bend gambusia (*Gambusia gaigei*), Gray redhorse (*Scartomyzon congestus*), Rio Grande shiner (*Notropis jemezanus*), Conchos pupfish (*Cyprinodon eximius*), gray redhorse (*Moxostoma congesta*) and the Rio Grande darter (*Etheostoma grahami*) (Hubbs *et al.* 1977). An aquatic reptile, Big Bend slider (*Trachemys gaigeae*) occupies sloughs, poinds, and rivers with muddy bottoms. Neotropical migratory birds breed here including the painted bunting (*Passerina ciris*), blue grosbeak (*Guiraca caerulea*), varied bunting (*Passerina versicolor*), and dusky and gray flycatchers (*Empidonax oberholseri* and *E. wrightii*, respectively). Beaver (*Castor canadensis*) are found in the few locations with extant cottonwoods. Several riparian dependent species breed within Big Bend National Park, including orchard oriole (*Icterus spurius*), yellow-breasted chat (*Icteria virens*), Bell's vireo (*Vireo bellii*), and yellow warbler (*Dendroica petechia*) (Wauer 1977).

Conservation status: The floodplain in this segment is managed by the International Boundary and Water Commission (IBWC) under the jurisdiction of the U.S. State Department. Until 1998, the IBWC has not typically included the public in its management decision making process, nor has it managed the river to benefit preservation of biodiversity. However, this approach appears to be changing with the formation of a citizen focus group in 1999. The river is flanked for 232 km by a stretch of protected areas: Big Bend National Park, Big Bend Ranch State Park, and Black Gap Wildlife Management Area in the U.S., and Maderas del Carmen and Santa Elena preserves, in Mexico. The river flows as a U.S. Wild and Scenic River, downstream of the protected areas, through privately owned ranchland for approximately 136 km.

Description of threats: Agriculture extracts 80% of all instream flow along the course of the river. Agriculture contributes sediments, agrochemicals, salts, and nitrogen to the river. Diversions for irrigation of crops causes water loss through evaporation and transpiration. Irrigation begins as far north as the San Luis Valley, Colorado. Erosion from overgrazing and other sources contributes sediments throughout the length of New Mexico. Aggradation of the river channel between the levies has further removed native cottonwoods and willows from the water table. Pesticide levels are high near the confluence with the Río Conchos. Impoundments in New Mexico and Texas on the Rio Grande, and on the Río Conchos in Chihuahua, cause high evaporation losses and the drowning of previous riparian habitat. Dams and diversions also regulate flows, preventing historic flood patterns. Municipal uses constitute 6% of all uses. Municipal needs include hydroelectric power, sewage disposal, drinking water, industry, and recreation. Currently, El Paso and Ciudad Juárez account for 1.5 million people. Both cities rely on two aquifers, the Hueco Bolson and the Mesilla Bolson. Mining of these aquifers is expected to affect channel flows of the Rio Grande. A water shortage is projected to occur in 30 years. While the surface waters of the river are allocated by treaties, there is no agreement between the U.S. and Mexico concerning shared groundwater (Project del Rio 1997). Exotic species invasion, primarily salt cedar, has displaced most of the native riparian vegetation from Fort Quitman, TX all the way to Big Bend National Park , a distance of approximately 320 km. The river once harbored a fish fauna adapted to survive and reproduce in ephemeral pools and dry river beds during low water periods. Changes to the flow regimes have seriously altered conditions for this unique and highly endangered fauna.

Reasons for selection as a priority site: This site was selected for the representation of riparian species assemblages and the representation of riverine ecological and evolutionary phenomena. The salt cedar and cottonwood communities continue to serve as a green corridor during hot dry periods, particularly in spring and fall, when birds are migrating. The freshwater segments were selected because of the unusual adaptations of the fauna to widely fluctuating water levels, and for the potential for restoration.

Active conservation groups: Amigos Bravos, Big Bend Regional Sierra Club, Border Environment Cooperation Commission (Ciudad Juárez), Center for Environmental Resource Management (CERM) at University of Texas at El Paso, Consortium of the Rio Grande (CoRio), Keystone Park, Rio Grande Alliance, Río Grande/Río Bravo Basin Coalition, Rio Grande Restoration, Southwest Center for Environmental Research and Policy (SCERP), Texas Organization for Endangered Species, Texas Center for Policy Studies (Austin, Texas), Texas Natural Resource Conservation Commission (TNRCC-Austin), Texas Water Resources Institute (TWRI), Southwest Environmental Center, Trans-Pecos Audubon Society, USGS-Biological Resources Division (Austin).

CONABIO Sites: Site 40 overlaps from Ciudad Juárez to Ojinaga and site 41 overlaps with the remaining downstream portions. Freshwater site 41, Cuenca baja del Río Conchos overlaps as well.

Contributors: C. Lieb, R. Meyer

2.03 & 5.11
Name: Rio Grande-Elephant Butte to El Paso Terrestrial (2.03)
Rio Grande-Southern New Mexico Freshwater (5.11)
Location: Truth or Consequences, New Mexico to El Paso, Texas
Approximate Size: 2,299 km^2
Terrestrial Priority Rank: 3
Freshwater Priority Rank: 3
Level of threat: high

Ownership: The State of New Mexico, the Texas-New Mexico Interstate Water Commission, Bureau of Reclamation (BOR), and International Boundary and Water Commission regulate flows in this stretch. The river water is stored in Elephant Butte & Caballo Dams. Private and municipal entities retain water rights. IBWC and BOR manage the releases from the reservoir complex; IBWC guarantees delivery to Mexico and provides flood control. BOR manages releases from the dam to ensure delivery to members of the Rio Grande Compact (farmers and cities) and to generate hydroelectric power. Elephant Butte Irrigation District manages the water in the channel in this stretch for irrigation, and it owns the irrigation delivery infrastructure. The floodplain outside of the levees is a mix of federal, state, municipal, and private lands. The lands within the levee are owned by IBWC.

Description of the site: This 200 km segment of the Rio Grande is a degraded riparian woodland amidst agricultural fields, cities and towns, and desert scrub. Woodlands, or bosques, that once lined the meandering channel are reduced to a fraction of their former extent. Shrub thickets and *ciénegas* are virtually absent, with the exception of a few areas invaded by salt cedar. Pecan orchards, chile, cotton, onion, and alfalfa fields are planted adjacent to the levees that constrict the channel and are irrigated with river water. Cottonwood stands persist along the banks of the river immediately below Elephant Butte Dam for approximately three km, near Percha Dam for two km, and in Selden Canyon for three km. Freshwater habitats include wetlands at San Marcial, low gradient ephemeral from Percha Dam to El Paso, and low gradient perennial streams from Socorro to Elephant Butte. The floodplain adjacent to the channel, within the levees, is mowed annually.

Outstanding biological features: The river currently supports limited amounts of riparian herpetofauna. Mammals of the area include beaver (*Castor canadensis*), and gray fox (*Urocyon cineargentus*). Wintering waterfowl, such as Clark's and Western grebe (*Aechmophorus clarkii* and *A. occidentalis*), neotropical cormorant (*Phalcrocorax olivaceus*), and eared grebe (*Podiceps migicollis*) are found on impoundments. Neotropical migratory birds such as common yellowthroat (*Geothlypis trichas*), yellow warbler (*Dendroica petechia*), and olive-sided flycatcher (*Contopus borealis*) migrate along the remaining bosque corridor (Leal *et al.* 1995). Western kingbirds (*Tyrannus verticalis*) are extremely common. The U.S. federally endangered southwest willow flycatcher (*Empidonax trailli*) nests in salt cedar and cottonwood strands in Selden Canyon. Freshwater species assemblages are depauperate and the Rio Grande silvery minnow (*Hybognathus amarus*), a U.S. federally endangered and state (NM) endangered species, is declining rapidly. Rio Grande shiner (*Notropis jemezanus*), and speckled chub (*Macrhybopsis aestivalis*) have both beend extirpated from this stretch of river.

Conservation status: Within this segment, the river is transformed into a water conveyance channel. The result of a federal project intended for agriculture, the future of this river relies on restoration, achieved through federal programs and the U.S. National Environmental Protection Act. Several state parks straddle the river- Caballo, Percha, Elephant Butte, Leasburg, and Fort Selden, and provide recreation and limited amounts of habitat.

Description of threats: Channelization and dams prevent natural flooding and meandering. Salt cedar (*Tamarix ramosissima*) invasion has reduced native willow and cottonwood abundance substantially. Water diversions, and reservoirs and dams, leave the channel virtually empty during winter months. Poor water quality, which is exacerbated by low flows, threatens freshwater species. Overgrazing in the uplands upstream of Las Cruces increases silt loads. Urban development in El Paso, Texas and Las Cruces, New Mexico increases runoff and non-source point pollution.

Reasons for selection as a priority site: Restoration potential of critical riparian habitats, rare and threatened freshwater assemblages, important site for migratory birds.

Active conservation groups: Forest Guardians, Mesilla Valley Audubon Society, Southwest Environmental Center, Rio Grande Restoration, Rio Grande/Rio Bravo Basin Coalition, Alliance for Rio Grande Heritage, USDA-Natural Resources Conservation Service: Jornada Conservation District, University of Texas-El Paso.

Contributors: K. Bixby, M. Hakkila, C. Lieb, D. Propst

2.04
Name: Guadalupe Mountains-Carlsbad Escarpment
Location: 48 km southwest of Carlsbad, New Mexico.
Approximate Size: 4,549 km^2
Priority Rank: 1
Level of threat: low

Ownership: Private ranches and farms, The Nature Conservancy of New Mexico, U.S. Bureau of Land Management-Roswell District, U.S. National Forest-Lincoln National Forest, and the U.S. Park Service-Guadalupe Mountains National Park and Carlsbad Caverns National Park.

Description of the site: Steep cliffs and exposed ledges define Guadalupe Peak at 2,660 m. The dramatically eroded escarpment is a limestone and granite uplift. Rocky Mountain conifer forests and evergreen Madrean woodlands are in the upper elevations and are dominated by ponderosa pine (*Pinus ponderosa*), limber pine (*P. flexilis*), quaking aspen (*Populus tremuloides*), big-tooth maple (*Acer grandidentatum*), and Douglas fir (*Psuedotsuga menziesii*) (Brown 1994). Mid-elevations contain the southernmost extension of Great Basin conifer woodland, which is primarily pinyon-juniper woodlands of pinyon (*Pinus edulis*), Mexican pinyon (*Pinus cembroides*), alligator juniper (*Juniperus deppeana*), and mountain mahogany (*Cercocarpus montanus*). Descending in elevation, a narrow band of interior chaparral is found on the east slope, where silktassel (*Garrya wrightii*), apache plume (*Fallugia paradoxa*), and beargrass *(Nolina texana*) predominate. The lowest elevations in the site are grasslands, primarily a grama grass matrix with patches of desert scrub associations, including prickly pear (*Opuntia sp*.), algerita (*Berberis haematocarpa*), sotol (*Dasylerion wheerleri*), Torrey yucca (*Yucca torreyi*), catclaw mimosa (*Acacia mimosa*), and creosote bush (*Larrea tridentata*). Dense thickets of Texas madrone (*Arbutus xalapensis*), big-tooth maple, Arizona walnut (*Juglans major*), black cherry (*Prunus serotina*), and mescal bean (*Sophora secundiflora*) exist along perennial springs. Playas and gypsum dunes are present in the western basin, along with plants characteristic of the saline mineral soils, including pickleweed (*Allenrolfea occidentalis*), fourwing saltbush (*Atriplex canescens*), and alkali sacaton (*Sporobolus airoides*) (Warnock 1974).

Outstanding biological features: Playas harbor an extremely high diversity of tiger beetles as well as Tinkham's desert grasshopper and an undescribed *Trimerotropis*. Within the mountain habitats, herpetofauna diversity is high and includes the barking frog (*Eleutherodactylus augusti latrans*), gray-banded kingsnake (*Lampropeltis alterna*), and Trans-Pecos rat snake (*Elaphe subocularis*). Black bear *(Ursus americanus*), Mexican spotted owl (*Strix occidentalis lucida*), mountain chickadee (*Parus gambeli*) and other montane adapted taxa are represented in the higher elevations. The gray-footed chipmunk *(Eutamias canipes*), a species of limited distribution, and the U.S. spotted bat (*Euderma maculata*) are also found in montane forests. Gypsum soils in the escarpment support the gypsum mescal bean (*Sophora gypsophila*) in the mountains, and on the alkali flats, gypsum scalebroom (*Lepidospartum burgessi*), a plant extremely limted in distribution. Endemic gypsophiles occur throughout the site, including gypsum moonpod (*Selinocarpus lanceolatus*). Two species of endemic cactus, Lee's pincushion cactus (*Coryphantha sneedii var. leeii*) and Guadalupe pincushion cactus (*Escobaria guadalupensis*), occur on limestone soils. The largest colony of cave swallows (*Hirundo fulva*) in the U.S. nests in Carlsbad Caverns National Park along with a large colony of Mexican free-tailed bats (*Tadarida brasiliensis*). There are up to 350,000 adult and young bats in the fall.

Conservation status: Guadalupe Mountains National Park is comprised of 34,964 ha, of which 54% is managed as Guadalupe Mountains Wilderness. The park contains desert habitat to the west but this is currently grazed. The park also intends to acquire 91 ha of gypsum dune habitat currently owned by The Nature Conservancy of Texas (Karges 1998). Carlsbad Cavern National Park is 18,922 ha in area, of which 13,402 ha are managed as the Carlsbad Caverns Wilderness. BLM lands contain the Lonesome Ridge, McKittrick Canyon, Mudgetts, and Devil's Den Wilderness Study Areas. Private landowners and the Lincoln National Forest manage the balance of land in the site. The National Forest lands are managed for multiple use, however this area is unsuitable for timber harvest. Livestock grazing, mineral extraction, fuelwood, and recreation are the primary uses on the national forest. This section of the national forest contains several protected areas. North McKittrick Canyon Research Natural Area is protected from grazing, South Guadalupe Escarpment Wilderness Area has been withdrawn from mining, andWest Guadalupe Wildlife Management has multiple uses but is managed to benefit wildlife. Dark Canyon (599 ha) is managed to benefit riparian values and has limited mineral extraction. The Central Guadalupe area is managed with stipulations on oil and gas leasing.

Description of threats: Recreational trails and roads, plus off-road vehicle use, cause fragmentation and degradation in this intact landscape. Groundwater pumping for irrigation of alfalfa in the western basin may destroy native plant communities. Overgrazing in the national forest causes riparian areas and upland sites increased erosion, alters vegetative species composition, and reduces cover for grassland dependent species. Oil and gas exploration in unprotected areas cause fragmentation of the landscape.

Reasons for selection as a priority site: The intact and broad representation of Rocky Mountain, Sierra Madre, Great Basin, and Chihuahuan habitat types creates high species richness. The site also contains an important species assemblage that represents the continuum from desert dunes to the desert scrub upwards to the pine-fire forest.

Active conservation groups: Chihuahuan Desert Conservation Alliance, New Mexico Wilderness Alliance, The Nature Conservancy of New Mexico, The Nature Conservancy of Texas.

Contributors: C. Curtin, G. Forbes, M. Hakkila, R. Wauer, R. Worthington

2.05
Name: Davis-Chinati Mountains Complex
Location: The Davis Mountains are 29 km northwest of Alpine, Texas. The Chinati Mountains are 82 km southwest of Alpine.
Approximate Size: 8,643 km^2
Priority Rank: 1
Level of threat: medium

Ownership: Bureau of Reclamation, private land with conservation easements, Reeves County Irrigation District, State of Texas, and The Nature Conservancy of Texas.

Description of the site: The Davis Mountains reach to 2,300 m and Chinati Mountains reach 2,100 m. These two mountain ranges support habitat types characteristic of the Sierra Madre Oriental and the Rocky Mountains. Community types are semi-desert grasslands and Plains and Great Basin grasslands in the lower elevations. Madrean evergreen woodlands and a very small representation of Rocky Mountain conifer forests occur in the higher elevations. Mixed-conifer forests, pine-oak woodlands of Emory oak (*Quercus emoryi*), Arizona gray oak (*Quercus arizonicus*), and pinyon-juniper woodlands, with Mexican pinyon (*Pinus cembroides*) and one-seed juniper (*Juniperus monosperma*), grama grasslands, and desert scrub are all represented in this site. Connecting the two mountain ranges is a broad grama grassland dotted with yucca and mesquite. Along the northern base of the Davis Mountains is San Solomon Spring, a former *ciénega* that now supports irrigation and a public swimming pool. A small portion of the *ciénega* has been restored.

Outstanding biological features: San Solomon Spring is one of two known location of the Comanche springs pupfish (*Cyprinodon elegans*), and the rare Pecos gambusia (*Gambusia nobilis*). Both fish are U.S. federally endangered species. Intact woodland habitats support a raptor migration corridor, as well as a wide distribution of bird species more typical of habitats to the south in Mexico, e.g. white-eared and berryline hummingbirds (*Hylocharis leucotis* and *Amazilia yucatanensis*). Painted redstart (*Myioborus pictus*), Grace's warbler (*Dendroica graciae*), Montezuma quail (*Cyrtonyx montezumae*), lesser goldfinch (*Carduelis psaltria*)and pinyon jay (*Gymnorhinus cyanocephalus*) are among the varied montane, woodland, and desert species represented. Several species of endemic plant, including Livermore sandwort (*Arenaria livermorensis*), and several species of undescribed invertebrates contribute to the localized richness. The Chinatis have the highest documented bat richness in the U.S. with 16 species. Three species of undescribed ant have been collected in the Davis Mountains, two of the genus *Leptothorax* and one of the genus *Camponotus*. Other rare invertebrate species include the butterfly *Fixsenia polingi*, and the beetle *Plusiotus woodii*. Fireflies, uncommon in the west, have been documented here, as has an extremely rare harvestman. The mammal distribution is noted for the presence of isolated populations of eastern cottontail (*Sylvilagus floridanus*), Texas antelope squirrel (*Ammospermophilus interpres*), possibly gray-footed chipmunk (*Tamias canipes*), northern rock mouse (*Peromyscus nasutus*), and hoary bat (*Lasiurus cinereus*).

Conservation status: The Texas Parks and Wildlife Department manages the Chinati Mountains State Park (15,327 ha). This granite range contains many uninventoried springs. The Davis Mountains host a 1,096-ha state park. The Nature Conservancy's Davis Mountains and Middle Madera Preserves total 8,180 ha, with additional conservation easements and management agreements with surrounding private landowners. The Nature Conservancy also owns 97 ha, Sandia Preserve, near Balmorhea State Park.

Description of threats: Overgrazing in the intervening valleys threatens grassland bird and plant species. Fire suppression has resulted in an increase in shrubs and juniper. Air pollution has impaired visibility across the area. Illegal hunting and collection of reptiles has reduced populations. Subdivision of large ranches into homesites has fragmented the expanses of woodland and grasslands. Groundwater pumping depletes spring habitats and the amount and subsurface area of groundwater is unknown.

Reasons for selection as a priority site: This site was selected for its representation of habitat types and species assemblages, and the intact biota.

Freshwater Sites: Balmorhea and Phantom Springs, on the north edge of Davis Mountains, are within Pecos River watershed (5.15).

Active conservation groups: Texas Parks and Wildlife Department, The Nature Conservancy of Texas, Big Bend Regional Sierra Club.

Contributors: K. Bryan, C. Curtin, G. Forbes, J. Karges, R. Worthington

2.06 & 5.09
Name: Devil's River Terrestrial (2.06)
Devil's River Freshwater (5.09)
Location: 34 km northwest of Del Rio, Texas
Approximate Size: 980 km^2
Terrestrial priority rank: 3
Freshwater priority rank: 1
Terrestrial level of threat: medium
Freshwater level of threat: medium

Ownership: Private, Texas Parks and Wildlife Department, and The Nature Conservancy of Texas.

Description of the site: The clear waters of this river are spring-fed, rising from rolling limestone hills along the edge of the Edwards Plateau. The Tamaulipan and Chihuahuan Desert ecoregions join the Edwards Plateau ecoregion along this undammed drainage. Sycamore and willow (Platanus-Salix) associations dominate the lowland riparian woodland. The surrounding upland communities are oak woodlands and desert scrub. The river terminates at Amistad Reservoir behind a dam on the Rio Grande.

Outstanding biological features: A rich amalgamation of flora and fauna representing three ecoregions occurs here. The uplands show the influence of the central Texas Edwards Plateau, and are primarily dominated by curlymesquite (*Hilaria belangeri*) grasslands or juniper (*Juniperus ashei* and *J. pinchottii*) shrublands. The Tamaulipan thronscrub of south Texas and northeastern Mexio is evidenced by the presence of purple sage (*Leucophyllum frutescens*) or guajillo (*Acacia berlandieri*) shrublands. The Chihuahuan Desert component of the site is usually found on hot, dry slopes, and is represented by the lechuguilla (*Agave lechuguilla*)-sotol (*Dasylirion texanum*) shrubland. The riparian corridor varies according to water availability, from the intermittently flooded Apache Plume (*Fallugia paradoxa*) shrubland to the streamside woodand dominated by sycamores *(Platanus occidentalis*). The bird assemblage is unusual and includes eastern and western species such as black-capped vireo (U.S. federally endangered), gray, white-eyed, red-eyed, Bell's, and yellow-throated vireos *(Vireo atricapillus, V. vicinior, V. griseus, V.olivaceus, V. bellii,* and *V. flavifrons*). The largest known population of the rare and U.S. federally endangered Texas snowbells (*Styrax texanus*) grows here (Connally 1994). The woodland corridor hosts the only occurrence of Mexican white oak (*Quercus polymorpha*) in the U.S.. A jaguarundi (*Felis yagouaroundi*) was documented within the woodlands in 1957, where the species possibly reached its northern limits (Gehlbach 1981). Monarch butterflies (*Danaus plexipus*) migrate south along the riparian corridor. At least 16 native species of fish are found in the Devil's River. Rio Grande darter (*Etheostoma grahami*), Devil's River minnow (*Dionda diaboli*), Conchos pupfish (*Cyprinodon eximius*) and longnose gar (*Lepisotus osseus*), proserprine shiner (*Cyprinella proserpina),* and headwater catfish (*Ictalurus lupus)* are among the extremely rich assemblage of native species here.

Conservation status: Devil's River State Natural Area (8,087 ha) is managed for primitive recreational camping and river running. The Nature Conservancy of Texas owns 5,471 ha of the site at Dolan Falls Preserve. Surrounding private lands are typically used for cattle and angora goat grazing and appear to be heavily overgrazed.

Description of threats: Groundwater pumping reduces flows reaching the channel. Loss of topsoil from overgrazing of goats decreases water quality. Subdivision of ranches for housing fragments upland desert scrub and the riparian forest. Exotic salt cedar (*Tamarix ramosissima*) invasion overtakes native species.

Reasons for selection as a priority site: This site was selected because of its species assemblages, representative of Chihuahuan, Tamaulipan, and Edward's Plateau ecoregions, and because it is critical for important ecological riverine processes.

Active conservation groups: Texas Parks and Wildlife Department, The Nature Conservancy of Texas

Contributors: K. Bryan, J. Karges, D. Hendrickson, J. Poole

2.07
Name: Big Bend
Location: Presidio, Texas west 145 km to the east edge of Black Gap Wildlife Management Area
Approximate Size: 9,448 km^2
Priority Rak: 1
Level of threat: medium

Ownership: Cañon Santa Elena Protected Area, private, State of Texas Parks and Wildlife Department (Big Bend Ranch State Natural Area, and Black Gap Wildlife Management Area), U.S. National Park Service-Big Bend National Park, State of Texas General Land Office (Christmas Mountains and other lands), The Nature Conservancy of Texas (TNC), and ejidos and municipal lands in Mexico.

Description of the site: This site encompasses rugged, remote terrain with jagged landscape of limestone cliffs, steep and rocky canyons, jumbled talus slopes, limestone mountains, and extinct volcanoes. The area has many scrub dominants, among them whitethorn acacia (*Acacia constricta*), mesquite (*Prosopis glandulosa*), tarbush (*Flourensia cernua*), giant dagger yucca (*Yucca carnerosana*), lechuguilla (*Agave lechuguilla*), sotol (*Dasylirion leiophyllum*), and chino grass (*Bouteloua ramosa*). The lowest elevations in the Chihuahuan Desert, approximately 457 m, are found in the canyons between Big Bend and Del Rio, Texas. Emory Peak, in the Chisos Mountains of Big Bend National Park, rises to 2,300 m. In the higher elevations, mixed-conifer forests of Douglas fir (*Psuedotsuga menziesii*), Arizona cypress (*Cupressus arizonica*), big-tooth maple (*Acer grandidentatum*) and other montane species are found (Brown 1994).

Outstanding biological features: The Big Bend area is renowned as a large, wild land of unfragmented desert communities and populations of large vertebrate species including pronghorn *(Antilocapra americana*), mule deer (*Odocoileus hemionus*) coyote (*Canis latrans*), mountain lion (*Felis concolor*), black bear (*Ursus americanus*) and javelina (*Percari angulatus*). Several species are habitat specialists, including zone-tailed hawk (*Buteo albonotatus*), Colima warbler (*Vermivora crissalis*), black-capped vireo (*Vireo atricapillus*), and the Chinati checkerspot butterfly (*Thessalia chinatiensis*). The canyons host a large nesting concentration of peregrine falcons (*Falco peregrinus*). An endemic scorpion (*Vaejovis chisos*), a katydid (*Serradigitus* sp.), a local scorpion *Paruroctonus williamsi*, and the metalmark butterfly *Apodemia chisosensis* are among the rare and endemic vertebrate fauna known from the Chisos Mountains. Bighorn sheep (*Ovis canadensis mexicana*) have been reintroduced to several mountain ranges. Sierra del Carmen white-tailed deer (*Odocoileus virginia carminis*) are found only in this and the Sierra del Carmen site to the south. Outstanding examples of desert adapted reptiles occur here, including Big Bend slider (*Trachemys gaigeae*), Chihuahuan mud turtle (*Kinosternon hirtipes*), and the endemic reticulated gecko (*Coleonyx reticulatus*) (Karges 1998). Endemic plant species include the Terlingua Creek cat's-eye (*Cryptantha crassipes*), Chisos Mountain hedgehog cactus (*Echinocereus chisoensis chisoensis*), which are both on the U.S. threatened and endangered species list. Additional species include Chisos oak (*Quercus graciliformis*), silver cholla (*Opuntia imbricata* var. *argentea*), Chisos pin-weed (*Lechea mensalis*), golden-spine prickly-pear (*Opuntia aureispina*), Jackie's bluet

(*Hedyotis pooleana*), and stairstep two-bristle rock-daisy (*Perityle bisetosa* var. *scalaris*). Big Bend Ranch is home to a large population of Hinkley oak (*Q. hinkleyi*).

Conservation status: Most of this site is protected through state and federal ownership. Big Bend Ranch contains 113,401 ha of TXPWD land. Primitive recreation is permitted here. Black Gap Wildlife Management area is 42,769 ha and is also managed by TXPWD. Big Bend National Park manages and protects 324,150 ha. The Texas General Land Office has a special management area in the Christmas Mountains, contiguous with Big Bend National Park. Big Brushy Canyon (3,959 ha), owned by TNC, connects Black Gap with the National Park. The U.S. National Park Service manages the Rio Grande River corridor as a Wild and Scenic River for 308 km. Lands within the Cañon Santa Elena are private and ejido.

Description of threats: Subdivision on private lands within the site will fragment intact habitats and migration corridors. Facilities that support recreationists fragment the landscape. Fire suppression increases juniper and shrub populations. Illegal collection of reptiles, plants, and hunting of game depletes populations, particularly in Mexico. Overgrazing on state lands increases erosion and changes grassland community structure. Pollution from Mexico power plants degrades the air quality.

Reasons for selection as a priority site: Large block of relatively intact desert communities, large vertebrate populations.

CONABIO Sites: Site 41, Cañon Santa Elena, lies within the Mexico portion

Freshwater Sites: Rio Grande-Río Conchos (5.10) runs the length of this site.

Active conservation groups: Big Bend Natural History Association, Big Bend Regional Sierra Club, Texas Policy Center, The Nature Conservancy of Texas.

Contributors: D. Aguirre, J. Karges, D. Lazcano, C. Lieb, D. Lightfoot, J. Poole, D. Riskind, R. Wauer

2.08
Name: North-central Chihuahuan Grasslands
Location: El Sueco, Chihuahua south and southeast to Coyame, Chihuahua
Approximate Size: 15,889 km^2
Priority Rank: 1
Level of threat: medium

Ownership: Private landowners and Ejidos Esperanza and Sueco.

Description of the site: Semi-desert grasslands and Chihuahuan desert scrub are the dominant community types of these high basins of northern Chihuahua. An extension of Plains and Great Basin grasslands occurs in the northern portion of the site. Expansive grama grasslands, with swales of tobosa

(*Hilaria mutica*) and sacaton (*Sporobolus airoides*) grasslands, intersperse with desert scrub and low limestone ranges. Playas occur within several basins.

Outstanding biological features: These intact habitats are of unusually high quality for the Chihuahuan Desert. Expansive plains with tall, lightly grazed grasses are the wintering grounds for high numbers of sparrows (*Aimophila sp., Aimphispiza bilineata, Passerculus sandwhichensis, Poocetes gramineus*, and *Ammodramus sp*.), Sprague's pipit (*Anthus spragueii*), McCowan's and chestnut-collared longspurs (*Calcarius mccownii* and *C. ornatus*). This site also supports a breeding population of aplomado falcons (*Falco femoralis*) a federally endangered species in both the U.S. and Mexico (Montoya and Zwenk 1997). Pronghorn (*Antilocapra americana*), white-sided jackrabbit (*Lepus callotis*), and kit fox (*Vulpes macrotis*) utilize these grasslands year-round. Chihuahuan raven (*Corvus caurinus*) and Swainson's hawk (*Buteo swainsoni*) commonly breed in the area. The playas support migratory waterfowl, shorebirds, sandhill cranes (*Grus canadensis*), and raptors. An additional landscape feature, gypsum outcrops west of Ojinaga, Chihuahua, support rare species of gypsum mescal bean (*Sophora gypsophila*), a gypsum blanketflower (*Gaillardia pinnatifida* var. *turneri*), and a gypsum prickly poppy (*Argemone turneri*).

Conservation status: Wildlife populations are protected under Mexican law. In general, the private lands in this site are lightly grazed, while ejido lands are heavily grazed every year creating deteriorated rangeland conditions. Fragmentation is low and grassland conversion is limited.

Description of threats: Threats include illegal hunting of deer and antelope, overgrazing, and degradation of riparian vegetation from farming and ranching practices. Feral pigs and sheep compete for forage with native ungulates as well.

Reasons for selection as a priority site: This site was selected for its intact habitat, presence of larger vertebrate populations, and role as critical habitat for migratory birds.

Active conservation groups: Universidad Autonoma de Chihuahua, T&E, Inc.

Contributors: R. Meyer, A. Montoya

2.09 & 5.18
Name: Tularosa Basin Terrestrial (2.09)
Tularosa Basin Freshwater (5.18)
Location: El Paso, Texas, north 225 km to Carrizozo, New Mexico
Approximate Size: 10,101 km^2
Terrestrial priority rank: 1
Freshwater priority rank: 1
Terrestrial level of threat: medium
Freshwater level of threat: medium

Ownership: State of New Mexico, State of Texas-Franklin Mountains State Park, U.S. Air Force-Holloman Air Force Base, U.S. Army (Fort Bliss and White Sands Missile Range, U.S. Bureau of Land

Management-Las Cruces District (BLM), U.S. Fish and Wildlife Service-San Andres National Wildlife Refuge, and U.S. National Park Service-White Sands National Monument.

Description of the site: An excellent example of a basin and range landscape with functioning, large-scale ecological processes.

Franklin Mountains: A north-south trending ridge, 37 km in length, of sedimentary limestone. The highest elevation in the Franklins is 2,192 m. Alluvial fans, piedmonts, and ridges support desert scrub and grama grassland habitat types. Creosote bush (*Larrea tridentata*), viscid acacia (*Acacia neovernicosa*), honey mesquite (*Prosopis glandulosa*), and tarbush (*Flourensia cernua*) associations are common, as well as ocotillo (*Fouquieria splendens*) and lechuguilla (*Agave lechuguilla*). Grasslands are dominated by black grama (*Bouteloua eriopoda*), fluffgrass (*Dasyochloa pulchella*), and bush muhly (*Muhlenbergia porteri*). Fremont cottonwood (*Populus fremontii*) and hardstem bulrush (*Scripus acutus*) are found in the few springs along the range (Worthington 1996).

Organ Mountains: North of the Franklin Mountains, this volcanic range with granite-derived soils rises to 2,743 m and is 29 km in length. The scrublands of the lower elevations are similar to the Franklin Mountains but lack lechuguilla. Rising in elevation, grama grasslands intersperse with Rocky Mountain montane chaparral, characterized by mountain mahogany (*Cercocarpus montanus*) in xeric sites and Gambel oak (*Quercus gambelii*) in mesic sites. At the highest elevations, pine-oak woodlands of the Great Basin woodland community type consist of pinyon pine (*Pinus edulis*), alligator juniper (*Juniperus deppeana*), gray oak (*Q. grisea*), and Arizona white oak (*Q. arizonica*). These sites transition into montane forests of Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) (Muldavin *et al.* 1997, Brown 1994).

San Andres and Oscura Mountains: Sedimentary limestone fault blocks, rising to 2,733 m at Salinas Peak support primarily semi-desert grassland and Great Basin woodland community types. The alluvial fans and foothills are typical desert scrub habitat types of creosote bush, viscid acacia, and tarbush. Grama grasslands, blue, black, hairy, and sideoats (*B. gracilis, B. eriopoda, B. hirsuta,* and *B. curtipendula*), are interspersed with patches of Torrey, soaptree, and banana yuccas (*Yucca torreyi, Y. elata, Y. bacata*), as well as sotol (*Dasylirion wheeleri*). Mid and upper elevations support pinyon-juniper woodlands, pinyon and alligator juniper, as well as evergreen oaks such as gray oak and live oak. Montane scrub is dominated by mountain mahogany. At the highest elevations, ponderosa pine forests and Gambel oak woodlands occur with montane grasslands. Arroyos, channels which carry seasonal rainfall, are typically dominated by netleaf hackberry (*Celtis reticulata*), apache plume (*Fallugia paradoxa*), desert willow (*Chilopsis lineraris*), and three-leaf sumac (*Rhus trilobata*) (Muldavin *et al.* 1997). Along the western edge of the San Andres, a playa lake, known as Isaack's lake, holds water seasonally.

Tularosa Basin: The minimum elevation in this valley to the east of the San Andres, Organ, and Franklin Mountains is 1,175 m. It is home to the gypsum dunes of White Sands National Monument, as well as seasonally inundated playas, alkali flats, coppice dune fields, and gypsum lake deposits. At its north end lies a basalt flow called the Carrizozo Malpais. The basin floor supports extensive Chihuahuan desert scrub; honey mesquite, tarbush, broom snakeweed (*Guterriezia* sp.), bush muhly, and creosote bush dot the landscape. Lowland grasslands of mesa dropseed (*Sporobulus flexuosus*), big alkali sacaton (*Sporobolus wrightii*), tobosa (*Hilaria mutica*), and grama grasses are interspersed with the scrublands.

Several gypsophilous species occupy the gypsum outcrops, including gypgrass (*Sporobolus nealleyi*), gyp grama (*Bouteloua breviseta*), and hairy coldenia (*Tiquilia hispidissima*). Springs and streams are dominated by the exotic salt cedar, however, Fremont cottonwood, seepwillow (*Baccharis glutinosa*), pickleweed (*Allenrolfea occidentalis*), and big alkali sacaton are often associated with these invaded sites. Thermal springs, streams, and extensive *ciénegas* are home to the endemic White Sands pupfish (*Cyprinodon tularosa*).

Northern Jornada: High quality semi-desert grasslands persist along this basin to the west of the San Andres Mountains. The minimum elevation is 1,495 m and the dominant community type is semi-desert grassland. The fire regime appears to be unaltered and maintains blue and black grama and sacaton grasslands. Black, hairy, and sideoats gramas, as well as New Mexico needlegrass (Stipa neomexicana) variously dominate other grasslands. Banana yucca and soaptree yucca are common and conspicuous. Basin floors also support desert scrublands dominated by fourwing saltbush and sandsage (*Artemisia filifolia*) (Muldavin *et al.* 1997).

Outstanding biological features: Franklin Mountains: Endemic and rare cacti are found within the high quality desert scrub communities, including the federally endangered Sneed's pincushion cactus (*Coryphantha sneedii sneedii*), and state sensitive sand prickly pear (*Opuntia arenaria*). Plant species diversity is high, with 684 catalogued species of vascular plant (Worthington 1996). Ringtail cat (*Bassariscus astutus*), javelina (*Pecari angulatus*), rock squirrel (*Citellus variegatus*), verdin (*Auriparus flaviceps*), ash-throated flycatcher (*Myiarchus cinerascens*), sage sparrow (*Amphispiza belli*), crissal thrasher (*Toxostoma crissale*), and cactus wren (*Campylorhynchus brunneicapillus*) are typical vertebrate species of this low range rising above the city of El Paso. Invertebrate endemism is found here as well, with the land snail *Sonorella metcalfi*.

Organ Mountains: This mountain range is rich in habitats, species diversity, and is largely intact. The mesic microhabitats of the high elevations in the Organ Mountains harbor four endemic species of plant, smooth figwort (*Scrophularia laevis*), nodding rock-daisy (*Peritlye cernua*), Organ Mountain evening primrose (*Oenothera organensis*), and Sneed's pincushion cactus, several species of endemic landsnail, *Ashmunella todseni*, *A. auriculata*, *A. organensis*, and *Holospira pyrgonasta*, and an endemic subspecies of chipmunk (*Eutamias quadravittatus* var. *australis*). Montane forests, chaparral, and riparian habitats are relatively intact. Peregrine falcons, once extirpated from the region, again nest in the steep granite spires. Montane bird species, such as band-tailed pigeon (*Columba fasciata*) and whip-poor-will (*Caprimulgus vociferus*), nest in the higher elevation forests. Six species of hummingbird have been documented here. Reptile diversity is rich throughout the range - the 33 species represent 11% of U.S. reptile diversity (Atchley 1996). At least 600 species of invertebrates have been identified, including an undescribed scorpion *Vaejovis* sp., several undescribed jumping spiders and a firefly, an undescribed oonopid spider, and an endemic camel cricket *Centhophilus* sp.. The Organ Mts. is one of few known sites of the butterfly *Fixenia polingi*.

Tularosa Basin: This basin has been free of cattle and goat grazing for 50 years. Desert scrub and grassland communities are robust, supporting kit fox (*Vulpes macrotis*), black-tailed prairie dog (*Cynomys ludovicianus*), desert massasauga (*Sistrurus catenatus*), western box turtle (*Terrapene ornata*), plains spadefoot toad (*Scaphiopus bombifrons*), Cassin's sparrow (*Aimophila cassinii*), and other species associated with largely intact ecosystems. The seasonally inundated playas are migratory stopovers for birds species such as snowy plover (*Charadrius alexandrinus*), Baird's sandpiper (*Calidris* *bairdi*), greater yellowlegs (*Tinga melanoleuca*), white-faced ibis (*Plegadis chihi*), and Franklin's gull (*Larus pipixcan*). Bat species documented in the basin include western small-footed myotis (*Myotis subulatus*) and pallid bat (*Antrozous pallidus*) (Johnson *et al.* 1997). Melanistic forms of reptiles and mammals are found in the lava malpais, while lighter forms of insects, mammals, and reptiles occur in the gypsum dunes (MacCarter 1994). The endemic White Sands pupfish (*Cyprinodon tularosa*) is the only fish species occupying the freshwater habitats of the basin. There are several endemic invertebrates in the gypsum dunes; a camel cricket, *Dahineodes inruale*, a grasshopper, *Cibolacris samalayucae*, and a fly, *Apiocera bilineata*. There are gypsum sand specialists, including Tinkham's desert grasshopper (*Anconia hebardii*) and an undescribed *Trimerotropis*.

San Andres and Oscura Mountains: Within these mountains are the last remaining individuals of desert bighorn (*Ovis canadensis mexicana*) native to the northern Chihuahuan Desert. Two endemic plants, Sandberg's pincushion cactus (*Escobaria sandbergi*) is restricted to the San Andres, and Todsen's pennyroyal (*Hedeoma todsenii*), is found in the San Andres and the Sacramento Mountains. Two endemic land snails occur here, *Sonorella orientis* and *Ashmunella paonis*. Both ranges contain intact habitats that have not been grazed by livestock for 50 years. In Isaack's Lake, several important invertebrate species have been documented, including the rare grasshopper *Shotwellia isleta*, an undescribed asilid fly, *Psilocurus* sp., and a very rare asilid fly, *Efferia ordwayae*. Isaack's Lake supports high concentrations of raptors which feed on the millions of toads emerging after summer rains.

Northern Jornada: Also ungrazed for 50 years, this broad basin supports a relatively natural fire regime within the blue grama and sacaton grasslands. Additionally, high-quality, intact black grama grasslands dominate the bajadas. Annually, 10 million migrating Mexican free-tail bats (*Tadarida brasiliensis*) inhabit the Jornada Bat Caves.

Conservation status: Franklin Mountains: Although the southern third of the range is flanked by the city of El Paso, Texas, the mountains themselves are well protected. Franklin Mountains State Park (9,810 ha), covers approximately 80% of the range in Texas. Private and City of El Paso lands in the southern lower elevations are not protected. A portion of the range extends north into New Mexico. U.S. Army-Fort Bliss, controls the northeastern half in New Mexico and the BLM controls the northwestern half in New Mexico. The BLM portions lie within the Organ/Franklin Mountains Area of Critical Environmental Concern (USDI-BLM 1993).

Organ Mountains: The U.S. Army-Fort Bliss manages 60% of the mountain range and 33% of the range is BLM land. All BLM land is managed as an Area of Critical Environmental Concern as the Organ/Franklin Mountains ACEC (22,667 ha). The ACEC limits vehicle access, minerals are withdrawn from further public entry, and rights-of-way are limited. Within the ACEC boundary are three Wilderness Study Areas, the Organ Mountains, Organ Needle and Peña Blanca, totaling 7,822 ha. Additionally, Dripping Springs Natural Area (1,133 ha) is excluded from livestock grazing. There are 2,517 ha of private land and 24 ha of state trust land which is managed for livestock (USDI-BLM 1993).

Tularosa Basin: This subarea is entirely within federal ownership: U.S. Army-White Sands Missile Range, U.S. Air Force-Holloman Air Force Base, and the U.S. National Park Service-White Sands National Monument. The three agencies manage within federal land use policy. The Department of Defense demonstrates an ongoing commitment to conservation of resources and implementation of ecosystem management. White Sands National Monument preserves and protects its resources.

San Andres and Oscura Mountains: San Andres National Wildlife Refuge (23,149 ha) manages approximately one third of the San Andres Mountains. The refuge was originally established to protect desert bighorn populations. White Sands Missile Range manages the Oscura Mountains within federal land use policy guidelines.

Northern Jornada: The land is under control of White Sands Missile Range.

Description of threats: Franklins Mountains: Collection of herpetofauna and cacti depletes local populations of rare and sensitive species. Sand and gravel mining, on private inholdings in Texas, fragments blocks of desert scrub habitat. Urban encroachment by the city of El Paso and agriculture along the southern and western boundaries restricts migration patterns and distribution of native desert biota.

Organ Mountains: Overgrazing in riparian and desert scrub communities by livestock on BLM land is an ongoing problem. Artillery use in the grasslands may ignite more frequent fires than historically occurred. A four-lane highway at the northern edge restricts big horn sheep migration. Urban and agricultural uses in the Mesilla Valley to the west of the range impairs migration corridors and species distribution patterns.

Tularosa Basin: Overgrazing on springs by wild horses is a threat, although the horses are scheduled for adoption in 1999. Overgrazing by an unchecked and growing exotic oryx population has not been studied, but is thought to be a future concern. African Rue (*Peganum harmala*), an exotic weed, is increasing in aerial extent each year. Road building and maintenance on White Sands Missile Range fragments corridors and increases erosion. Alien salt cedar invasion of springs and watercourses proceeds unchecked and displaces native riparian vegetation such as willow and cottonwood. Infrastructure development, such as roads, buildings, landing strips and towers, in remote or pristine areas may have a cumulative affect on wildlife populations. Freshwater sites are threatened by groundwater withdrawal along the Sacramento escarpment to the east, reduction of springs for military purposes, and introduction of exotic fish. The pupfish is the only fish occupying its habitat, and introduced species such as large-mouth bass, (*Micropterus salmoides*) goldfish (*Carrasius auratus*) and mosquitoe fish (*Gambusia affinis*), pose a critical threat.

San Andres and Oscura Mountains: Road building and maintenance fragments corridors and causes erosion. Fire suppression has led to an increase in pinyon and juniper in former grasslands. Buildings, towers, and roads in isolated, remote areas can disrupt wildlife populations.

Northern Jornada: Herds of exotic oryx are increasing on the Jornada and their presence may affect native populations of pronghorn.

Reasons for selection as a priority site: This is a vast complex of mountains and valleys that are largely federally owned and managed. Migration corridors within the site exist and fragmentation is relatively low. Public access is limited. Mining, mineral exploration, and fuelwood cutting are not permitted. Large-scale ecosystem processes such as fire, flooding, and migration, are in place. Additionally, the area is extremely rich biologically, with representative elements of the Chihuahuan, Rocky Mountain, and Sierra Madre provinces. It also contains a high incidence of plant and invertebrate endemism.

Active conservation groups: Mesilla Valley Audubon Society, Southwestern Consolidated Sportsman, Southwestern Environmental Center, The Nature Conservancy of New Mexico.

Contributors: J. Atchley, R. Corral, G. Forbes, D. Lightfoot, B. MacKay, E. Muldavin, J. Pittenger, D. Propst, D. Richman, R. Worthington

2.10
Name: Pecos River Corridor
Location: 30 miles south of Roswell, NM to Red Bluff Reservoir along TX-NM border.
Approximate Size: 2,242 km^2
Priority Rank: 3
Level of threat: medium

Ownership: Private agricultural and ranching interests, New Mexico Department of Game and Fish, New Mexico Parks and Recreation Division, U.S. Bureau of Reclamation, U.S. Bureau of Land Management-Carlsbad Field Office, Carlsbad Irrigation District, potash mining companies. Water allocation between New Mexico and Texas is managed under the Pecos River Compact Commission.

Description of the site: This is a complex of lowland riparian grassland and wetlands, limestone canyons, gypsum soils, playas, and spring sites at lower elevations (1,300 m). Baseflows of the Pecos are sustained by the Roswell Artesian aquifer. Black River, Delaware River, and Salt Creek are spring-fed tributaries contributing to flow. The vegetation patterns in the riparian zone of the Pecos River have been altered and largely influenced by human activities, primarily from diversions, large dams, and the introduction of salt cedar (*Tamarix* sp.) (Duncan *et al.* 1993). Uplands surrounding the river are typical Chihuahuan desert scrub and semi-desert grasslands with creosote bush (*Larrea tridentata*), soaptree yucca (*Yucca elata*), desert holly (*Acourtia nana*) and fluffgrass (*Dasyochloa pulchella*). Channel gradients are less than 0.5% and confinement by the valley is moderate. Travertine and bedrock riffles separate deep and long pools (~2m x >100m). Except for very large floods, deposition from the river occurs exclusively within the river channel and reservoir deltas, and floodplains are non-existent. Riparian vegetation consists of open fields of alkali sacaton (*Sporobolus airoides*) and saltgrass (*Distychlis* sp.), scattered stands of Fremont cottonwood (*Populus fremontii*) and Goodding willow (*Salix gooddingii*), Arizona walnut (*Juglans major*), and netleaf hackberry (*Celtis reticulata*), as well as bulrushes (*Eleocharis* sp.) and cattails (*Typha domingensis*). But the dominant species throughout the river is the exotic salt cedar. Four dams have been erected on the Pecos. Furthest upstream is Santa Rosa Dam, completed in 1980, then near Fort Sumner is Sumner Dam, completed in 1937. Upstream of Carlsbad is Brantley Dam, which replaced McMillan Dam in 1989, and finally the oldest, Avalon Dam, completed in 1891.

Outstanding biological features: Although degraded, the riparian communities site support assemblages of riparian and aquatic herpetofauna such as the blotched watersnake (*Nerodia erythrogaster*), arid land ribbon snakes (*Thamnophis proximus*), and the river cooter (*Pseudemys* *concinna*). Both eastern and western species of migratory birds such as the blue jay (*Cyanocitta cristata*), the white-eyed vireo (*V. griseus*), and orchard oriole (*Icterus spurius*) frequent the site. The playas, wetlands and shorelines are an important migratory stopover for snowy plover (*Charadrius alexandrinus*) and interior least tern (*Sterna antillarum*), both U.S. federally endangered, as well as other shorebirds, waterfowl, and cranes. Several species of plants endemic to gypsum occur here, including gypsum buckwheat (*Eriogonum gypsophilum*), a U.S. federally threatened species. Another U.S. federally endangered species, the southwest willow flycatcher (*Empidonax traillii*), formally inhabited riparian vegetation here but is rarely sighted now.

Conservation status: This stretch is a non-functional riparian system. Flood control and diversion dams, overgrazing along its banks, oil and gas exploration and extraction, the absence of beavers and reduced riparian vegetative diversity all have negative affects on the function of the river. BLM Carlsbad Resource Area has two special management areas on the river: Bluntnose Shiner Habitat Management Area (81 ha and approximately 1 km of river), and the Pecos River/Canyons Complex Area of Critical Environmental Concern and Research Natural Area (3,039 ha). The BLM has also established special management areas for the Black River Buckwheat Population, Chosa Draw, Yeso Hills, and Blue Springs (USDI-BLM 1997a). The state of New Mexico manages three waterfowl hunting sites, Huey, Brantley, and Seven Rivers Wildlife Management Areas, as well as Brantley Lake State Park.

Description of threats: Modification of the flow regime by dams and depletion of groundwater discharge changed the hydrologic nature of the Pecos River corridor, allowing salt cedar to invade the historic floodplain. Natural floods and base flows are crucial to nutrient cycling both in the floodplain and river channel. The destructive affects of salt cedar invasion along the banks of the Pecos River can not be overstated. Where *ciénegas* once lined the river corridor, salt cedar now dominates. Species that once depended upon these habitats are greatly reduced in number. The high water use by salt cedar is estimated to have the ability to completely dry up the Pecos River by 2010 (Duncan *et al*. 1993). Irrigation, and non-point source pollution from the oil and gas industry, and agriculture compromise water quality and quantity. Agriculture diversions for the Carlsbad Irrigation District are made at Avalon Dam. Brine by-products from potash mines pollute playas and contaminate migratory birds.

Reasons for selection as a priority site: The site was selected for representation of gypsum, limestone, and riparian habitats and species, and because it is critical for important riverine ecological processes such as flooding and the creation of wetlands.

Freshwater Sites: Pecos River (5.15), which includes disjunct spring sites in the region

Active conservation groups: Chihuahuan Desert Conservation Alliance, New Mexico Riparian Council, Pecos River Native Riparian Restoration Organization, New Mexico Audubon Society-Southeast Chapter.

Contributors: K. Bryan, J. Karges, M. Hakkila, C. Lieb, R. Meyer, J. Poole

2.11 & 5.16
Name: Alta Bavicora Terrestrial (2.11)
Bavicora Freshwater (5.16)
Location: 160 km northwest of Ciudad, Chihuahua
Area: 2,990 km^2
Terrestrial priority rank: 2
Freshwater priroity rank: 3
Terrestrial level of threat: 1
Freshwater level of threat: 1

Ownership: Private, ejidos, State of Chihuahua, 13 towns, four municipios, and colonias.

Description of the site: Alta Bavicora is an ephemeral lake and wetland complex. Community types are primarily Plains and Great Basin grasslands with some Madrean evergreen woodland and Rocky Mountain conifer forests. Within the basin, saltgrass (*Distichlis* sp.) and alkali sacaton (*Sporobolus airoides*) dominate the more saline soils. Agricultural fields surround the lake basin. Rising along the bajadas, grasslands dominated by blue grama (*Bouteloua gracilis*) grades into live oak (*Quercus turbinella*) dominated shrubland. Higher elevation sites are primarily pine-oak, Apache pine (*Pinus engelmanii*), Mexican pinyon (*P. cembroides*), and ponderosa pine (*P. ponderosa*) woodlands, typical associations of the Madrean evergreen woodland community type.

Outstanding biological features: Waterfowl, cranes, and shorebirds utilize the site as a wintering area or migratory stopover. Bald eagles (*Haliaeetus leucocephalus*) winter in the basin. Native fish include endemic *Gila*, *Notropis*, *Catostomus*, and *Cyprinodon* species, and a yet to be described trout. No introduced fish species have been documented.

Conservation status: Several agencies (state, federal, and municipal) have completed a management plan for the entire watershed. This plan contains a strong environmental education component that has already been implemented. Community members, U.S. and Mexico agency personnel, and university staff contributed to the plan (Facultad Zootecnia-UACH 1998).

Description of threats: Diversions of both surface and groundwater for agriculture decrease water availability for wildlife. Timber harvest and overgrazing in surrounding uplands increases sediment loads. Overgrazing in seasonally dry wetlands decreases cover and species diversity. Municipal and agricultural wastes pollute the water. Illegal hunting occurs.

Reasons for selection as a priority site: This site was selected because of the representation of wetland species assemblages. Further biological inventories are necessary.

CONABIO Sites: Freshwater site 34, Lago Babicora.

Active conservation groups: Ducks Unlimited de Mexico (DUMAC), Iowa State University, North American Wetlands Conservation Council, PROFAUNA, Texas Tech University, Turner Foundation, Universidad Autonoma de Chihuahua, Universidad Autonoma de Nuevo Léon, U.S. Fish and Wildlife Service, SEMARNAP.

Contributors: D. Propst, A. Lafón

2.12
Name: La Perla
Location: 100 km east of Ciudad Camargo, Chihuahua
Approximate Size: 9,069 km^2
Priority Rank: 3
Level of threat: high

Ownership: Private and ejido lands.

Description of site: An expanse of semi-desert grasslands, including grama, tobosa, and sacaton habitats. The grasslands intersperse with Yucca woodlands and Chihuahuan desert scrub.

Outstanding biological features: High populations of declining grassland birds winter here, such as golden eagle (*Aquila chrysaetos*), Sprague's pipit (*Anthus spraguii*), McGowan's longspur (*Calcarius mccownii*), and Baird's sparrow (*Ammodramus bairdii*). Pronghorn (*Antilocapra americana*), white-sided jackrabbit (*Lepus callotis*), and swift fox (*Vulpes macrotis*), grassland dependent species, also occur. The intact grasslands support high grass diversity. An endemic forb, *Euphorbia henricksonii*, has been documented here, as well as an endemic genus, *Raphanorhyncha crassa*, known only from this location. Migratory shorebirds utilize seasonally inundated playas within the site.

Conservation status: La Perla Mining Company has made an effort to promote environmental education in the area. There is also an Unidad de Manejo Administracion de Vida Sylvestre or UMA associated with the site. The UMA is officially recognized by SERMARNAP as a hunting area. It must have a management plan that limits hunter take and creates a sustainable harvest.

Description of threats: Threats are illegal hunting and overgrazing. A reduction in grazing, as well as enforcement of current hunting laws and environmental education, can relieve many of the immediate threats.

Reason selected as a priority site: Relatively intact grassland habitats and migratory bird stopover site.

CONABIO sites: Terrestrial site 47.

Active conservation groups: La Perla Mining Company, PROFAUNA, SEMARNAP, Unidos la Conservación.

Contributors: F. Chávez-Ramirez, J. Henrickson, D. Conde, A. Lafón, J. Valdés-Reyna.

2.13
Name: Mescalero Sands
Location: 58 km east of Roswell, New Mexico
Approximate Size: 2,291 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private, oil and gas companies, U.S. Bureau of Land Management-Roswell District.

Description of the site: Spanning the edges of two distinct ecoregions, Mescalero Dunes is a semi-desert grassland with a strong Plains floral component. Large dunes support shrubby shinnery oak (*Quercus havardii*), sand bluestem (*Andropogon hallii*) and little bluestem (*Schizachyrium scoparium*) and mesquite (*Prosopis glandulosa*), both contributing important cover within the grassland.

Outstanding biological features: The declining lesser prairie-chicken (*Tympanuchus pallidicinctus*), proposed for U.S. federal listing as an endangered species, extends into grassy openings within the shinnery oak. Massassauga (*Sistrurus catenatus*), scaled quail (*Callipepla squamata*), pronghorn (*Antelocapra americana*) and mule deer (*Odocoileus hemionus*) are typical vertebrates species of the area. The sand dune lizard (*Sceloporus graciosus arenicolous*), adapted to sandy soils and shinnery oak, is restricted to this priority site (Degenhardt *et al*. 1996, MacCarter 1994). The invertebrate fauna is highly endemic; two crickets, *Ammobamentes mescalero* and *Stenopelmatus mescalero* and the katydid *Plagiostiera mescalero*, have adapted to the dune and shinnery oak habitats.

Conservation status: The BLM manages the Mescalero Sands Area of Critical Environmental Concern (3,191 ha) and Mathers Research Natural Area (98 ha). A portion of the dunes is a designated off-highway vehicle recreation area.

Description of threats: Removal of shinnery oak to improve the sands for cattle disrupts plant communities and sand dune lizard populations. Off-highway vehicle use in designated and non-designated areas degrades oak and grass communities. Roads created for oil and gas extraction fragment the landscape, compact sands, and alter dune movement. Livestock grazing reduces grass cover required by the lesser prairie-chicken.

Reasons for selection as a priority site: This site was selected for the representation of habitat types and species assemblages associated with dunes, and the presence of larger vertebrate populations.

Active conservation groups: Audubon Society-New Mexico Chapter, Chihuahuan Desert Conservation Alliance, Sierra Club-Southern New Mexico Group, Southwest Consolidated Sportsmen, Forest Guardians, The Nature Conservancy of New Mexico.

Contributors: D. Lightfoot

2.14
Name: Samalayuca Dunes

Location: 20 km south of Ciudad Juárez, Chihuahua
Approximate Size: 1,322 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private and ejido lands, two federally owned kerosene fueled power plants.

Description of the site: This site has extensive, tall quartz dune fields sparsely vegetated with soatptree yucca (*Yucca elata*), giant dropseed (*Sporobolis giganteus*), hoary rosemary mint (*Poliomintha incana*), and false buffalograss (*Munroa squarrosa*). The community type is considered to be Chihuahuan desert scrub.

Outstanding biological features: The site supports dune adapted cactaceae such as *Coryphantha scheeri* var. *pallida*, and at least twenty other plants associated with deep sandy soils, including the sand reverchonia, (*Reverchonia arenaria*) an annual in a monotypic genus of the Euphorbiaceae, Plains penstemon (*Penstemon ambiguus*), bindweed heliotrope (*Heliotropium convolvulaceum*), Parry euphorbia (*Euphorbia parryi*), another euphorb (*Euphorbia carunculata*) and broom groundsel (*Senecio reidellii*). The endemic *Echinocactus parryi* and the rare sand prickly pear (*Opuntia arenaria*) occur in areas adjacent to the dunes. Kangaroo rat (*Dipodomys* sp.), kit fox (*Vulpes macrotis*), bobcat (*Lynx rufa*), and white-tailed deer (*Oidocoilus viriginianus*) utilize the dunes. There are also several dune associated beetles and flies. Harverster ants in the area construct large mounds, a phenomena found only here and near Willcox Playa (1.17). The grasshopper, *Cibolacris samalayucae*, occurs here, as do several species of apiocerid flys, including *Apioceria rockefelleri*, a regional sand dune endemic. They blister beetle *Lytta mirifica* is endemic to the dunes.

Conservation status: The dunes are not protected.

Description of threats: Operation of a cement plant located in the immediate vicinity may impact the dune fields. This plant is mining the limestone in adjacent mountains. The construction industry in the region may lead to excessive extraction of sand from these dunes which could disrupt plant communities. Urban encroachment threatens to stabilize portions of the dunes. A railroad, a four-lane highway, and power line run though the dunes.

Reasons for selection as a priority site: This site was selected because of its representation of habitat types.

CONABIO Sites: Terrestrial site 37, Médanos de Samalayuca

Active conservation groups:

Contributors: R. Corral, B. MacKay,

2.15 & 5.35
Name: Conchos Headwaters Terrestrial (2.15)
Upper Conchos Freshwater (5.35)
Location: 50 km west of Hidalgo Parral
Approximate Size: 7,436 km^2
Terrestrial priority rank: 2
Freshwater priority rank: 1
Terrestrial level of threat: high
Freshwater level of threat: high

Ownership: Private and ejidos

Description of the site: The Conchos River headwaters flows through a pine-oak forest, then flows into a cottonwood dominated lowland riparian woodland.

Outstanding biological features: The cottonwood-sycamore (*Populus-Plantanus*) deciduous riparian woodland community type supports river otter (*Lutra canadensis*) and beaver (*Castor canadensis*) populations. The river supports several endemic fish species, including Chihuahua Shiner (*Notropis chihuahua*), Ornate Shiner (*Codoma ornata*), Blotched gambusia (*Gambusia senilis*), Guayacón de Hacienda Dolores (*G. hurtadoi*), Guayacón de San Gregorio (*G. alvarezi*), Conchos pupfish, (*Cyprinodon eximius*), Bighead pupfish (*C. pachycephalus*), and largescale pupfish (*C. macrolepis*) plus a *Dionda* sp. and a *Cyprinella* sp.. All of these fish species are considered endangered.

Conservation status: The area is not protected. Private ranches appear to be more intact while ejidos appear to be depleting resources.

Description of threats: Overgrazing is the greatest threat to the site. In addition, while regulations exist for proper timber extraction, enforcement of the regulations is weak. A limited amount of mining occurs. Deforestation, overexploitation of groundwater, contamination from agrochemical and urban/industrial wastewater, and introduced gamefish also pose substantial threats.

Reasons for selection as a priority site: Representative and rare habitat types, and a highly endemic fish fauna.

CONABIO Sites: Site 46 overlaps on the western half and freshwater site 39, Cuenca alta del Río Concho is upstream.

Active conservation groups: Bosque Modelo, Universidad Autonoma de Chihuahua

Contributors: A. Lafón

2.16
Name: Marathon Basin
Location: Marathon, Texas
Approximate Size: 3,130 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private

Description of the site: Intact and degraded semi-desert grasslands characterize this limestone basin. The Glass Mountains, a segment of the world's largest fossil reef, supports Madrean evergreen woodlands. An unusual mineral outcrop, Caballos Noviculite, supports a wide cacti assemblage.

Outstanding biological features: This basin and northwestern limestone range not only harbor extremely rare cacti, but also support grasslands with outstanding assemblages of wintering birds and a black-tailed prairie dog (*Cynomys ludovicianus*) town. The area is also within the former range of the aplomado falcon (*Falco femoralis*). Burrowing owl (*Athene cunicularia*), savanna sparrow (*Passerculus sandwichensis*), and prairie falcon (*Falco mexicanus*) are also associated with the grasslands. Rare and endemic plants include glass mountain rockdaisy (*Perityle vitreomontana*), Nellie cory cactus (*Coryphantha minima*), old blue pennyroyal (*Hedeoma pilosum*), and the Davis green pitaya (*Echinocereus davisii*).

Conservation status: The basin is entirely in private ownership.

Description of threats: Threats are groundwater pumping for irrigation, overgrazing of cattle, development and ranch subdivision, and air pollution.

Reasons for selection as a priority site: This site was selected for the representation of evolutionary phenomena, endemism, and for the representation of grassland species assemblages

Active conservation groups: Texas Parks and Wildlife Department, The Nature Conservancy of Texas

Contributors: J. Poole, R. Wauer

2.17
Name: Sierra Blanca
Location: From Sierra Blanca, Texas north 115 km into New Mexico
Approximate Size: 7,418 km^2
Priority Rank: 2
Level of threat: medium

Ownership: Private, State of New Mexico State Land Office lands, Texas General Land Office lands,Texas Parks and Wildlife Department-Hueco Tanks State Historic Park and Sierra Diablo

Wildlife Management Area, University of Texas-El Paso Indio Mountain Research Station, U.S. Army-Fort Bliss, and U.S. Bureau of Land Management- Las Cruces District.

Description of the site: This is a large expanse of low elevation rolling hills (from 1,500 m to 2,294 m) with sporadic occurrences of sedimentary and volcanic outcrops. This semi-desert grassland contains many associations but is primarily blue, black, and side-oats grama (*Bouteloua gracilis, B. eriopoda, B. curtipendula*). Soaptree yucca (*Yucca elata*), cholla (*Opuntia imbricata*), mesquite (*Prosopis glandulosa*), and creosote bush (*Larrea tridentata*) occur as sparse elements of the grasslands or in dense patches signifying range degradation. Curly mesquitegrass (*Hilaria berlangeri*), tobosa (*H. mutica*), and various three-awns (*Aristida* sp.) are a signifcant part of the grassland matrix as well (Brown 1994). Several endemic but undescribed invertebrates occur here; two *Leptothorax* ant, a honey pot ant, *Myrmecocystems* and, an isopod.

Outstanding biological features: From Otero Mesa in the north, to the private lands of Texas in the south, this site is an excellent example of the vast black grama grasslands that once dominated the basins of the Chihuahuan Desert. In the winter, these grasslands are critical for migratory sparrows, longspurs (*Calcarius* sp.), pipits (*Anthus* sp.), and raptors such as ferruginous hawk (*Buteo regalis*). The U.S. federally endangered aplomado falcon (*Falco femoralis*) formerly bred in this region. Along the limestone escarpments dotting the landscape, are endemic plants, such as the Hueco Mountain rockdaisy (*Perityle huecoensis*). Freshwater shrimp are evident in puddles at Hueco tanks.

Conservation status: Hueco Tanks State Park (348 ha) was established for archaeological interpretation. Cornudas Mountain, Wind Mountain, and Alamo Mountain are newly established BLM-Areas of Critical Environmental Concern, totaling 2,447 ha (USDI-BLM 1997). The Fort Bliss portion of this site is known as McGregor Range, a training site primarily utilized for launching missiles. Sierra Diablo Wildlife Management Area (4,703 ha) is also in Texas and was established to re-introduce desert bighorn sheep (*Ovis canadensis mexicana*).

Description of threats: . The site is within 50 km of El Paso, Texas; subdivision of private lands in the future could fragment habitat. Fire suppression has led to increases in cholla and shrubs. Overgrazing has reduced grass cover and increased cholla, creosote bush, and mesquite. Recreation in state and federally managed lands disrupts wildlife and rare plant populations. Grazing on public lands has been poorly managed; heavy livestock utilization levels have decreased vertical structure in grasses and caused increases in shrub species and densities. Within Fort Bliss, fire frequency may have increased on grasslands where missiles are launched or exploded. The German Air Force, stationed at Holloman Air Force Base in the Tularosa Basin, plans to establish a bombing range within Otero Mesa. A private ranch north of Sierra Blanca has been a repository for New York City sludge since 1993. Texas Tech University studies the environmental impacts of spreading about three tons per acre per year to 7,284 ha (El Paso Times, February 16, 1996).

Reasons for selection as a priority site: This site was selected for its intact habitats and because it is critical for large-scale ecological phenomena in grasslands such as a migratory stopover or wintering ground for birds.

Active conservation groups: Sierra Club-Southern New Mexico Section, Consolidated Sportsmen of Southern New Mexico, Sierra Blanca Defense Fund.

Contributors: R. Corral, C. Lieb, B. MacKay, R. Meyer

2.18
Name: Rio Grande-Above Elephant Butte Reservoir
Location: Bernardo, New Mexico to Elephant Butte Reservoir, New Mexico
Area: 932 km^2
Priority rank: 2
Level of threat: high

Ownership: U.S. Bureau of Reclamation, Middle Rio Grande Conservancy District, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service Sevilleta National Wildlife Refuge and Bosque del Apache Wildlife Refuge, New Mexico Department of Game and Fish - La Joya State Game Refuge.

Description of the site: This 115 km stretch of the Rio Grande has been altered from its natural condition by humans. The stretch once supported open stands of Rio Grande and Fremont cottonwood (*Populus deltoides wislizenii* and *P. fremontii*) and Goodding's willow (*Salix gooddingii*) interspersed with *ciénegas* and wetlands of bulrushes (*Scirpus* sp.), cattails (*Typha* sp.), sedges (*Carex* sp.), and saltgrass (*Distichlis spicata*). The channel meandered greatly and was highly braided. Flooding was frequent, with a maximum flow in 1943 of 12,000 cubic feet per second (cfs). The channel is now heavily modified by levee confinement, upstream flood and water storage controls, and water diversion. It consists of a shifting sand bed with mixtures of silt or clay with a very low gradient, about 0.1%. At a diversion dam near San Acacia, the channel is dry when flows are less than 300 cfs by complete diversion to the low flow conveyance channel. The wetlands, maintained by flooding, meandering, and groundwater discharge, have been drastically reduced in area and number through groundwater pumping and water diversion for agriculture. Vegetation along the banks of the river has been invaded by dense stands of salt cedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*). While cottonwood continues to dominate the canopy layer, hydrologic changes have dramatically reduced its regeneration. The river carries a high sediment load in this segment and is aggrading (Durkin *et al.* 1995).

Outstanding biological features: The Rio Grande is the fifth largest watershed in North America and flows 3,200 km from San Juan, Colorado, to the Gulf of Mexico. This segment of the river is more prone to flooding than other segments due to inputs by the Rio Salado, an undammed tributary. Occasional flooding maintains the remnant bosques, recharges wetlands, and provides fluctuating conditions for its unusual fish fauna. Migratory waterfowl such as mallard (*Anas platyrhynchos*), lesser scaup (*Aythya affinis*), gadwall (*Anas strepera*), and Canada goose (*Branta canadensis*) are found within created and natural marshes and ponds, that also support wading birds like sora (*Porzana carolina*), Virginia rail (*Rallus limicola*), green-backed heron (*Butorides striatus*), and least bittern (*Ixobrychus exilis*. Bosques, while degraded, are still vital habitat for the federally endangered southwest willow flycatcher (*Empidonax traillii*), and a species of concern, the western yellow-billed cuckoo (*Coccyzus americanus*). Beaver (*Castor canadensis*) are found in this area and the marshes are habitat for the New Mexico jumping mouse (*Zapus hudsonius luteus*), a species with a drastically decreased range. The federally endangered Rio Grande silvery minnow (*Hybognathus amarus*) is restricted to this segment of the Rio Grande.

Conservation status: Federal and state laws and an international treaty control the allocation of Rio Grande water to Colorado, New Mexico, Texas and the Republic of Mexico. Within the valley, the river is managed mainly by the Middle Rio Grande Conservancy District, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers. Water rights are held by individuals, municipalities, pueblos, and wildlife refuges. Flood control, ground-water drainage, and irrigation are under the jurisdiction of the Middle Rio Grande Conservancy District, and other agencies. A plan has been developed for management of this segment. The plan designates an active, representative council of managers and concerned citizens. Communication and coordination are spearheaded by the Middle Rio Grande Bosque Coordinator, currently associated with the U.S. Fish and Wildlife Service. The plan is intended to coordinate water management activities to support and improve the bosque's riverine and terrestrial habitats, with special emphasis placed on mimicking typical natural hydrographs, benefiting aquatic and terrestrial resources (Crawford *et al*. 1993).

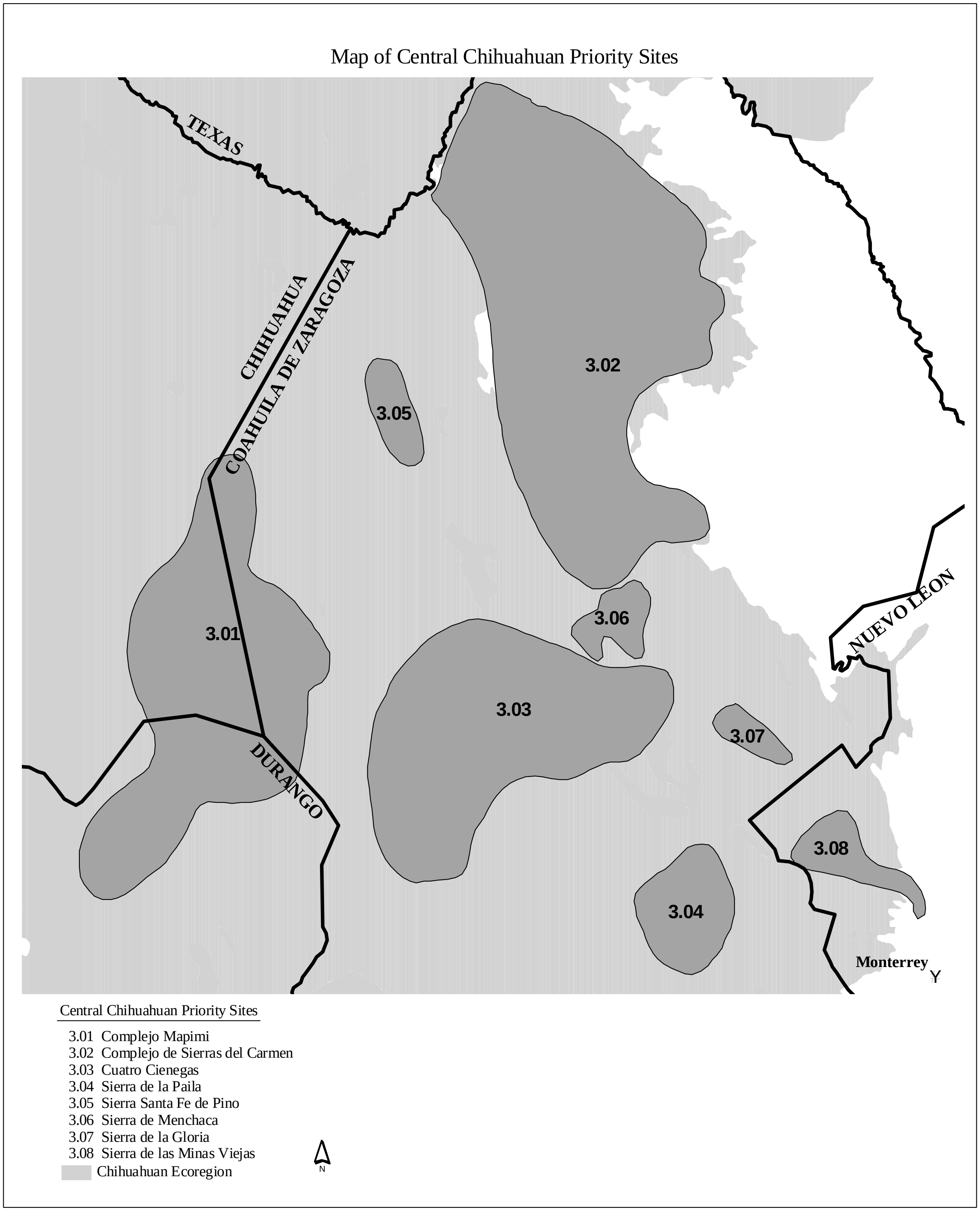
Description of threats: Water storage, diversion, and delivery projects such as irrigation ditches and return drains have drastically altered the hydrology of the Rio Grande. Hydrologic changes, particularly the regulated summer flows for agriculture, decrease the ability of cottonwoods to regenerate and encourage the establishment of exotics such as salt cedar and Russian olive. High groundwater levels, from irrigation, and poor return of irrigation water leaches salt into the floodplain, which favors the establishment of salt cedar over cottonwood. This exotic is now the typical co-dominant in the riparian communities. Levees were built in the 1920's and 1930's to reduce the affect of flooding, which restricted the river's ability to meander. Groundwater pumping in Albuquerque decreases groundwater discharge to the river. Bosques are cleared for farming, and by livestock. House mice, cats, dogs, starlings, brown-headed cowbirds (*Molothrus ater*), and pill bugs are exotic species that detrimentally affect ecological processes on the bosque and floodplain. Removal of wetlands has had a pronounced affect on amphibians and reptiles. Fragmentation of the riparian zone by residential development, roads, bridges, and power lines reduces density, biomass and productivity of riparian plant and animal communities. Lack of flooding contributes to leaf litter buildup which then contributes to an increase in fire frequency (Durkin *et al.* 1995). Municipal, industrial, and agricultural discharges impair water quality in the river, and introduced freshwater species threaten natives, including through hybridization.

Reasons for selection as a priority site: The site was selected for its restoration potential and because it is critical for supporting large-scale ecological phenomena such as flooding and migration.

Freshwater sites: Rio Grande-Southern New Mexico (5.11).

Active conservation groups: 1000 Friends of New Mexico, Amigos Bravos, Defenders of Wildlife, Ducks Unlimited, Forest Guardians, Hawks Aloft, Hawkwatch, New Mexico Audubon Society, Middle Rio Grande Biological Interagency Team, Rio Grande/Rio Bravo Basin Coalition , Sierra Club-Rio Grande Chapter, Southwest Environmental Center.

Contributors: R. Meyer



Appendix Figure F-3 Central Chihuahuan Priority Sites

3.01
Name: Complejo Mapimi
Location: Located at the intersection of the states of Coahuila, Chihuahua and Durango.
Approximate Size: 13,261 km^2
Priority Rank: 1
Level of threat: high

Ownership: 70% ejido and communal lands, 30% privately-owned property.

Description of the site: A complex terrain with a wide variety of community types, ranging from Chihuahuan desert scrub, riparian woodlands, and semi-desert grasslands, to mixed conifer forests of pine and juniper savannas. Playas and gypsum soils are also. The western foothills range from juniper savanna to chaparral, with butterfly-bush (*Buddleia marrobiifolia*), viscid acacia (*Acaia vernicosa*), creosote (*Larrea tridentata*), mesquite (*Prosopis glandulosa*), mariola (*Parthenium argentatum* and *P. incanum*, saltbush (*Atriplex* sp.), and althorn (*Koeberlinia spinosa*), and cordia (*Cordia parviflora*) (Gentry 1957). The southeast portion of the site overlaps with the Mapimi Biosphere Reserve. Geographic areas within the site include Sierra del Diablo, Sierra Mojado, Laguna del Rey, Laguna de Jaco.

Outstanding biological features: An unusually large number of endemic species can be found at Complejo Mapimí, including An endemic tarantula, and an endemic centipede have also been described. Two endemic reptiles are the bolson turtle (*Gopherus flavomarginatus*) and the sand lizard (*Uma paraphygas*). Plant species richness is estimated to be about 350 species, and cacti species richness is also very high. Several endemic plant species have been identified, such as *Atriplex reptans*, and *Suaeda jacoensis*. Halophytic plants and those associated with gypsum are abundant in the valleys. There are also low gypsum/saline dunes, including an endemic dropseed, *Sporobolus regis*. Sparrows and raptors use the grasslands for wintering grounds. More than 270 vertebrate species occur in this site, including more than 35 reptile, 25 mammal, and 220 bird species. The Nelson kangaroo rat (*Dipodomys nelsoni*) a grassland resident, kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), desert shrew (*Notiosorex crawfordi*), Nelson's pocket mouse (*Chaetodipus nelsoni*), and golden eagle (*Aquila chrysaetos*) all occur in this region. Goldman's woodrat (*Neotoma goldmani*), and Nelson's spiny pocket mouse (*Perognathus nelsoni*) occupy rockier habitats. At least six species of bats have been reported in this site including big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), long-tongued bat (*Leptonycteris* sp.), Mexican long-nosed bat (*Leptonycteris nivalis)* (pollen and nectar feeders), and spotted bat (*Euderma maculata).* Mountain lion, or puma, (*Felis concolor*) have also been reported in this area, and are in danger of local extinctions.

Conservation status: A portion of the area -181,257 ha - is a Man in the Biosphere Reserve. No other protection exists in the site.

Description of threats: Feral donkeys and high numbers of cattle and goats have severely degraded both the reserve and the surrounding lands. Traditional grazing methods have not been updated with more current grazing systems. Poaching and illegal trade of cacti is common. Unregulated recreational activities affect the stability of the ecosystem.

Reasons for selection as a priority site: The diverse assemblages represent the full range of Chihuahuan Desert biota. There is a high level of endemism.

CONABIO sites: Sites 57, 58, and 81 overlap.

Active conservation groups: Instituto Ecología A.C., State of Durango, Universidad Autonoma de Chapingo, Universidad de Juarez, Biodesert, A.C., Universidad Autonoma Agraria Antonio Narro-Laguan Unit, Universidad Autonoma Nuevo Leon.

Contributors: T. Wendt, J. Henrickson, J. Nocedal, G. Aguirre, C. Lieb, D. Lazcano, D. Lightfoot,

3.02
Name: Complejo de Sierras del Carmen y Santa Rosa
Location: Southeast of Boquillas del Carmen, Coahuila
Approximate Size: 21,172 km^2
Priority rank: 1
Level of threat: medium

Ownership: Mostly ejido land and small privately owned properties, SEMARNAP, Universidad Autonoma Agraria Antonio Narro-Las Norias Experimental Station.

Description of the site: This is a stunning complex of remote, rugged, arid, limestone mountain ranges and associated valleys including the Rincon de María, Sierra del Burro, Sierra La Encantada, Sierras del Carmen (which contains some igneous parent material) and the Sierra de Santa Rosa. The most frequent habitat types are mattoral desertico microfilo (*Larrea* sp., *Flourensia* sp., *Acacia*, sp.,) and matorral espinoso (mesquite scrubland) in the lower elevations, and pine-oak woodlands in the mid-elevations. In the higher elevations, mixed-conifer forests (bosque de Oyamel) are common, including true firs (*Abies* sp.) and Douglas fir (*Pseudotsuga menziesii*). The mountains are perforated by subterranean systems of large caverns containing important groundwater deposits. The highest peak reaches an altitude of 2,731 m.

Outstanding biological features: Important habitats with critical large-scale phenomena are found in this area, including several cordillera that are corridors for spring migrating birds on their way north, while other cordilleras serve as corridors for autumn migrating birds on their way south. Black-capped vireo (*Vireo atricapillus*), Audubon's oriole (*Icterus graduacauda*), white-tipped dove (*Leptotila verreauxi*), rufous-capped warbler (*Basileuterus rufifrons*), and tropical parula (*Parula pitiayumi*) nest in woodland, grassland, and desert scrub. Montane communities support northern goshawk (*Accipiter gentilis*), northern saw-whet owl (*Aegolius acadicus*), olive warbler (*Peucedramus taeniatus*), peregrine falcon (*Falco peregrinus*), painted redstart (*Myioborus pictus*), and northern pygmy-owl (*Glaucidium gnoma*). Pinyon-juniper communities support Colima warbler (*Vermivora crissalis*), Montezuma quail (*Cyrtonyx montezumae*), and elf owl (*Micrathene whitneyi*). The site is an important migration corridor for bats, including, California myotis (*Myotis californicus*), long-eared myotis (*M. evotis*), cave myotis (*M. velifer*), long-legged myotis (*M. volans*), big brown bat (*Epsicus fuscus*), red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), and western big-eared bat (*Plecotus townsendi*) (SEMARNAP 1997). The site also shelters mammals with larger habitat requirements such as the mountain lion (*Felis concolor*), black bear (*Ursus americanus*), and two subspecies of white-tail deer (*Odocoileus virginianus carminis* and *O. v. miquihuanensis*). Abert's squirrel (*Sciurus aberti*), beaver (*Castor canadensis*), and badger (*Taxidea taxus*) have all been documented in these mountains. A monotypic genus of the extremely rare plant, *Fryxellia*, occurs in the Sierra Santa Rosa. Other endemic plant species are leaf-flower (*Phyllanthus ericoides*),Sierra snowbell (*Stryax youngae*),*and* Shinner's tickle-tongue (*Zanthoxylum parvum*), *Euphorbia chaetocalyx,* bedstraw (*Galium caremnicola*), *Tidestromia gemmata,* and milkwort (*Polygala maravillasensis*) (SEMARNAP 1997). Endemic gastropods are thought to occur in the Rincon de María, in relict fir (*Abies concolor*) forests. While the species assemblages are unusual, the mosaic or pattern of community types and habitats, is also noteworthy.

Conservation status: A portion of the site, 208,332 ha, is managed as an Área de Protección de Flora y Fauna- Maderas del Carmen Protected Area.

Description of threats: Grazing animals, especially goats, horses and cattle, stress native plants and plant communities. Illegal hunting of deer is reducing populations. In addition, birds and reptiles are harvested and sold. Exploitation of several native plant species, including lechuguilla and candelilla, is moderate and important for the local economies. Mining of feldspar, fluorite, and silver fragments habitats through road building. At least 157,641 ha of the protected area have mining (SEMARNAP 1997).

Reasons for selection as a priority site: Portions of these mountain ranges contain large relatively intact habitats. The areas are considered as critical for large-scale ecological phenomena, as in the case of migrating birds and bats. Additionally, there are many relict species and at least one monotypic plant genus.

CONABIO sites: Site 49, the Maderas del Carmen Protected Area, and 50, and 51.

Active conservation groups: Profauna A.C., SEMARNAP, Museo de Maderas del Carmen, ANGADI, A.C. (Associacion Nacional Ganaderia Diversificada), Universidad Autonoma Nuevo Leon, Universidad Autonoma Agraria Antonio Narro, The Nature Conservancy, Pronatura Noreste, CEMEX.

Contributors: R. Wauer, K. Bryan, J. Valdés-Reyna, D. Riskind, E. Muldavin, D. Lightfoot

3.03
Name: Cuatrociénegas Complejo
Location: Coahuila
Approximate Size: 11,591 km^2
Priority rank: 1
Level of threat: high

Land ownership: Land ownership is varied and includes ejido and communal lands, small private properties, federal and municipal areas, as well as other types of land tenure.

Description of the site: Complejo Cuatrociénegas is a rare and wonderful place. Steep limestone mountains, up to 3,000 m, enclose numerous broad valleys rich in wetlands (vegetacion subacuatica de tierra bajo), and desert alluvial fans. The valleys, at an average elevation of 830 m, were naturally closed and internally drained until the 20th century, when man diverted streams away from the valleys. These valleys are characterized by Chihuahuan desert scrub and semi-desert grasslands that have long been isolated from other such complexes in the Chihuahuan Desert. Thickets of glittering organillo cactus (*Opuntia bradtiana*) emerge from the creosotebush dominated alluvial fans. The nearly invisible living rock cactus (*Ariocarpus fissuratus*), prostrate to the desert floor, gives away its location with brilliant pink flowers. Sky blue pools (*pozas*) stud the alkali grasslands, and cattails and reeds obscure hundreds of *ciénegas* and streams. Stark gypsum dunes undulate across the *bolsón*, punctuated by lone yuccas and sotol.

There are five subareas within this complex. The Sierra de la Madera is a high mountain range with chaparral, pine-oak woodland, and mixed conifer forest. The Sierra de la Fragua is a lower range but also supports oak woodlands and mixed conifer forests. There are three valleys-Valle de Sobaco, Valle Humidido, and the Valle de Cuatrociénegas. Sobaco and Humidido are rich in desert scrub and alkali communities while Cuatrociénegas is noted for its gypsum dunes, gypsum grasslands, and halophytic grasslands.

Outstanding biological features: The long isolation of the area, climatic stability, and complex terrain and have contributed to a diverse desert biota with an unusually high number of endemic species. Mountain habitats throughout this complex sustain communities of black bears (*Ursus americanus*), bats, small mammals, an endemic katydid species, and a diverse assemblage of other undescribed invertebrates. At least 25 endemic plant species have been identified in the valleys and there at least 50 species of cacti in the priority site. Endemic species of scorpions have also been found between the dunes and the sandy valleys.

Valle Cuatrociénegas: This valley supports numerous endemic aquatic invertebrate, reptile, and fish species. Locally endemic plants, particularly cacti, are notable for their extremely limited distributions. A number of endemic gypsophilous plant species occur only on the valley's gypsum dunes. Two endemic scorpions have also been described, *Vaejovis minckley* and *Serradigitus calidus*. An endemic aquatic box turtle (*Terrapene coahuila*) and black softshell turtle (*Apalone ater*) are restricted to the valley's pozas. Dominant grassland species are alkali scacaton (*Sporobolus airoides*) and big alkali sacaton (*S. wrightii*), scratch muhly (*Muhlenbergia asperifolia*), saltgrass (*Distichlis stricta*), and salt-mat grass (*Monanthochloe littoralis*). Aplomado falcon (*Falco femoralis*) are thought to use the grasslands. One halophyte found of the region is pickleweed (*Salicornia virginica*). Common aquatic plants in pozas and along lakeshores are water-lily (*Nymphaea ampla*), bladderwort (*Utricularia obtusa*), water-nymph (*Najas marina*), widgeon-grass (*Ruppia maritima*), and pondweed (*Potamogeton nodosus*). Sedge borders and marsh species include *Fuirena simplex* and *Schoenus nigricans*. Bajadas of the valley are primarily Chihuahuan desert scrub, commonly dominated by mesquite (*Prosopis glandulosa*), condalia (*Condalia warnockii*), seepweed (*Suaeda palmeri*), lechuguilla (*Agave lechuguilla*), *Opuntia bradtiana*, and mariola (*Parthenium incanum*).

Sierra de La Madera: These mountains support diverse communities along elevational gradients ranging from deserts to temperate conifer forests. At least ten endemic plants species have been recorded in its canyons and bajadas. The range is considered critical for groundwater accumulation and fresh water supply. Peregrine falcon (*Falco peregrinus*) are known to nest here. Dominant montane tree species are Arizona pine (*Pinus* arizonica), southwestern white pine (P. *strobiliformis*), Douglas fir (*Psuedostuga menziesii*), Choahuila fir or guayame blanco (*Abies durangensis coahuilensis*), and Arizona cypress (*Cupressus arizonica*). Chaparral communities contain *Quercus laceyi*, at the northern edge of its more sub-tropical range, and the more common Mexican pinyon (*Pinus cembroides*). A rare katydid, *Pediodectes* sp., also occurs in this range.

Sierra de la Fragua - Valle de Sobaco – Valle Humidido: This area contains a large number of endemic species in relatively intact communities on gypsum outcrops. Within the valley gypsum dunes are stabilized by mesquite, catclaw acacia (*Acacia greggii*), Spanish dagger (*Yucca treculeana*), and *Varilla mexicana*. Dune endemic plants include *Machaeranthera restiformis,* blanketflower (*Gaillardia gypsophila*), and *Dyssodia gypsophila*. Other uncommon communities, such as weeping pinyon (*Pinus pinceana*) forests occur at higher elevation. This site is thought to have been a Pleistocene desert refugia. A Larrea specialist grasshopper (*Boutettix joerni*), a gypsum associated grasshopper (*Trimerotropis* sp.), and a rare salt-flat grasshopper (*Anconia hebardi*) have been documented in the Valle de Sobaco. An unusual community of *Pinus pinceana-flourensia retinophylla* dominates sandstone outcrop at Puerto Colorado. *Marshalljohnstonia gypsophila*, an endemic genus of the Asteraceae family, occupies gypsum soils.

Conservation status: Although the former lake has now been greatly reduced, this is a relatively well-preserved area, currently considered as protected through its inclusion in the National System of Protected Areas operating under the conservation programs established by the SEMARNAP. However, the valley, and not the mountains, are protected. The Area de Protecion de Flora y Fauna Cuatrociénegas covers 84,327 ha.

Description of threats: One of the most important threats is the extraction of ground water in the neighboring valleys outside of Cuatrociénegas and diversion of surface water for agricultural purposes. A number of exotic plants are present, particularly salt cedar (*Tamarix rammossissima*) and giant cane (*Arundo donax*). Persistent grazing on alluvial and rocky slopes has greatly reduced the grass element of the desert scrub throughout the basin, and has changed the composition and structure of the scrub, as well as damaging rare plant populations.

Other problems include those associated with poaching and legal and illegal extraction of plant and animal specimens for trade. These practices are the result of both recreational hunting and the subsistence needs of the local population and are directly leading to a reduction in the populations of mammals, reptiles, invertebrates, and other species. Cacti and reptiles are particularly of concern because of the limited distribution and small populations of many rare species.

Reasons for selection as a priority site: A diverse and endemic desert biota, outstanding at global and continental scales. Relatively intact habitats present. This site requires further inventory of the mammalian fauna.

CONABIO sites: Sites 54, 55 and 56 are included in this area.

Active conservation groups: Instituto Nacional Ecología (SERMARNAP), Bioconservaccion, Desert Fishes Council, PROFAUNA, Universidad Autonoma Agraria Antonio Narro, Universidad Autonoma Nuevo León, Desuvalle A.C., North American Wetland Conservation Council, The Nature Conservancy-Northeast Mexico, PRONATURA, A.C., Guardianas de Valle, A.C., Universidad Autonoma Coahuila, University of Texas-Austin.

Contributors: S. Contreras-Balderas

3.04
Sierra de La Paila
Location: Northwest of the city of Saltillo, Coahuila.
Approximate Size: 2,270 km^2
Priority rank: 2
Level of threat: medium

Ownership: Mostly ejido land and small private properties.

Description of site: The site is a small, mountainous limestone cordillera with an elevation up to 2,370 m. Its primary habitats are composed of xerophylous scrub, pine and oak forests, grasslands, and mountain chaparral.

Outstanding biological features: Little is known about the local fauna, although the vegetation is well documented. Tree species of the evergreen woodland include Grave's oak (*Quercus gravesii*), weeping juniper (*Juniperus flaccida*), and Texas madrone (*Arbutus xalapensis*). Among the understory and chaparral species documented are mountain sage (*Salvia regla*), and eggleaf silktassel (*Garrya ovata*). Grassland communities are dominated by blue grama (*Bouteloua gracilis*), bush muhly (*Munhelnbergia porteri*) and needlegrass (*Stipa tenuissima*). Chihuahuan Desert endemic species identified in this area include *Randia pringlei*, emorybush (*Emorya suaveolens*), and *Hemichaena spinulosa.* Rare species of the region are (*Echinocereus delaetii*), *Flourensia retinophylla*, birthwort (*Aristolochia writghtii*), *Bernardia myricifolia*, and rosewood (*Vauquelinia corymbosa* var. *heterodon*). In addition, the site supports high numbers of migratory monarch butterflies (*Danaus plexipus*).

Conservation status: There are no known protected areas here.

Description of threats: Regional cattle ranching practices are a serious threat. Furthermore, while Mexican law limits timber extraction, the law is allows for fuelwood collection and logging after fires. This has led to the intentional lighting of forest fires aimed at increasing wood exploitation. These actions affect the soil stability and degrade the vegetation growth. Forest fires set intentionally alter the natural fire regimes of different vegetation types. This results in the fragmentation and loss of wildlife habitats in the ecosystem. Coupled with the problem of overgrazing, the integrity of the ecosystem is threatened. Illegal hunting and the extraction of natural plant resources such as candelilla and lechuguilla constitute the major exploitation threats and inefficient management of resources.

Reasons for selection as a priority site: Representative assemblages of intact plant and animal habitats. Inventories and studies are necessary to further understand the site.

Active conservation groups: CONABIO, Universidad Autonoma Antonio Narro, Fondo Méxicano Conservación de la Naturaleza, industrial corridor companies.

Contributors: D. Lazcano, D. Lightfoot, J. Henrickson, J. Valdés-Reyna.

3.05
Name: Sierra Santa Fe del Pino
Location: 100 km northeast of Ocampo, Coahuila.
Approximate Size: 967 km^2
Priority rank: 2
Level of threat: medium

Ownership: Both ejido and small private properties.

Description of the site: The site is a small mountain cordillera with mixed temperate forest community types, including pine parklands and montane chaparral.

Outstanding biological features: This is an important corridor for the wildlife of the northeast, including bats, monarch butterflies (*Danaus plexipus*), and large mammals such as the black bear (*Ursus americanus*). It is also considered a relict site for populations of small mammals and other species.

Conservation status: There are no known protected areas in this site.

Description of threats: As in other areas of Coahuila, cattle ranching practices are becoming widespread in these natural habitats. It is therefore pressing to establish regulatory measures to avoid overgrazing and to diminish the increasing pressures on the survival of wildlife. New roads and unregulated recreational activities are among the major threats that cause habitat loss and require monitoring in the future.

Reasons for selection as a priority site: Existence of well-preserved wildlife habitats and a high richness of species. The site is poorly documented and requires further research and inventory.

Active conservation groups: Universidad Autonoma Nuevo León, Universidad Autonoma Antonio Narro.

Contributors: D. Riskind

3.06
Name: Sierra de Menchaca
Location: Located northeast of Cuatrociénegas, Coahuila.
Approximate Size: 965 km^2
Priority rank: 3
Level of threat: medium

Ownership: Mostly ejido land and small private properties.

Description of the site: A limestone mountain range, reaching 2,818 m in elevation.

Outstanding biological features: This small sierra is located northeast of the Cuatrociénegas region and has several species of endemic fauna, as well as populations of large mammals and monarch butterflies (*Danaus plexipus*).

Conservation status: The site has no known protected areas.

Description of threats: While Mexican law limits timber extraction, the law is allows for fuelwood collection and logging after fires. This has led to the intentional lighting of forest fires aimed at increasing wood exploitation. These actions affect the soil stability and degrade the vegetation growth. Forest fires set intentionally alter the natural fire regimes of different vegetation types. This results in the fragmentation and loss of wildlife habitats in the ecosystem. Coupled with the problem of overgrazing, the integrity of the ecosystem is threatened. Additionally, mining activities have occured, mainly for the extraction of gypsum and other minerals used in the construction industry. There are reports concerning the negative affect of unregulated recreational activities, in addition to poaching in the area.

Reasons for selection as a priority site: This site was selected due to the lack of research conducted on its biological and ecological features and the urgency to carry out such studies. It also believed to contain intact habitats.

Active conservation groups: Universidad Autonoma Nuevo León, BIOCONSERVACIÓN, A.C.

Contributors: D. Lazcano

3.07
Name: Sierra de la Gloria
Location: 10 km southeast of Monclova, Coahuila.
Approximate Size: 570 km^2
Priority rank: 3
Level of threat: high

Ownership: Information not available.

Description of the site: The interesting floristic composition of this small cordillera results from the combination of Tamaulipan, Chihuahuan, and Sierra Madre Oriental vegetation.

Outstanding biological features: While the lower reaches serve as habitat for important communities of desert scrub, higher communities support pine and oak forests, montane chaparral, mixed coniferous communities of fir, pine, and palm trees, and a high diversity of cacti throughout. Peregrine falcons (*Falco peregrinus*) nest within this unusual mosaic of woodlands and forests.

Conservation status: The site has no known protected areas.

Description of threats: Gypsum extraction, among other types of mining, greatly contributes to soil depletion. This activity, coupled with the continuous extraction of timber, leads to the loss of the protective vegetation cover and exerts pressure on wildlife. This scenario is further exacerbated through the construction of new roads for urban and housing developments. Mining activities and the use of pesticides and weed-killers in agriculture, have led to the pollution of the soil and groundwater in this area. Although mining and agriculture practices are controlled through federal regulations, increased monitoring is necessary to ensure compliance with the regulations. Poaching and illegal extraction of plants such as cacti, lechuguilla, and candelilla, are considered serious threats to the integrity of the ecosystem.

Reasons for selection as a priority site: Presence of representative, intact habitats.

Active conservation groups: None known

Contributors: D. Riskind

3.08
Name: Sierra de las Minas Viejas
Location Between the municipalities of Mina and Hidalgo in Nuevo León.
Approximate Size: 1,254 km^2
Priority rank: 3
Level of threat: medium

Ownership: Both ejido and small private properties.

Description of the site: This is a lowland desert complex with desert scrub vegetation and elements of rosetofilo, or yucca woodlands, and crasicaule, or cactus scrub. Chaparral is found in higher areas. Gypsophilous and halophytic vegetation, possibly including several endemic species, occur in valleys.

Outstanding biological features: Composition of community types is uncommon.

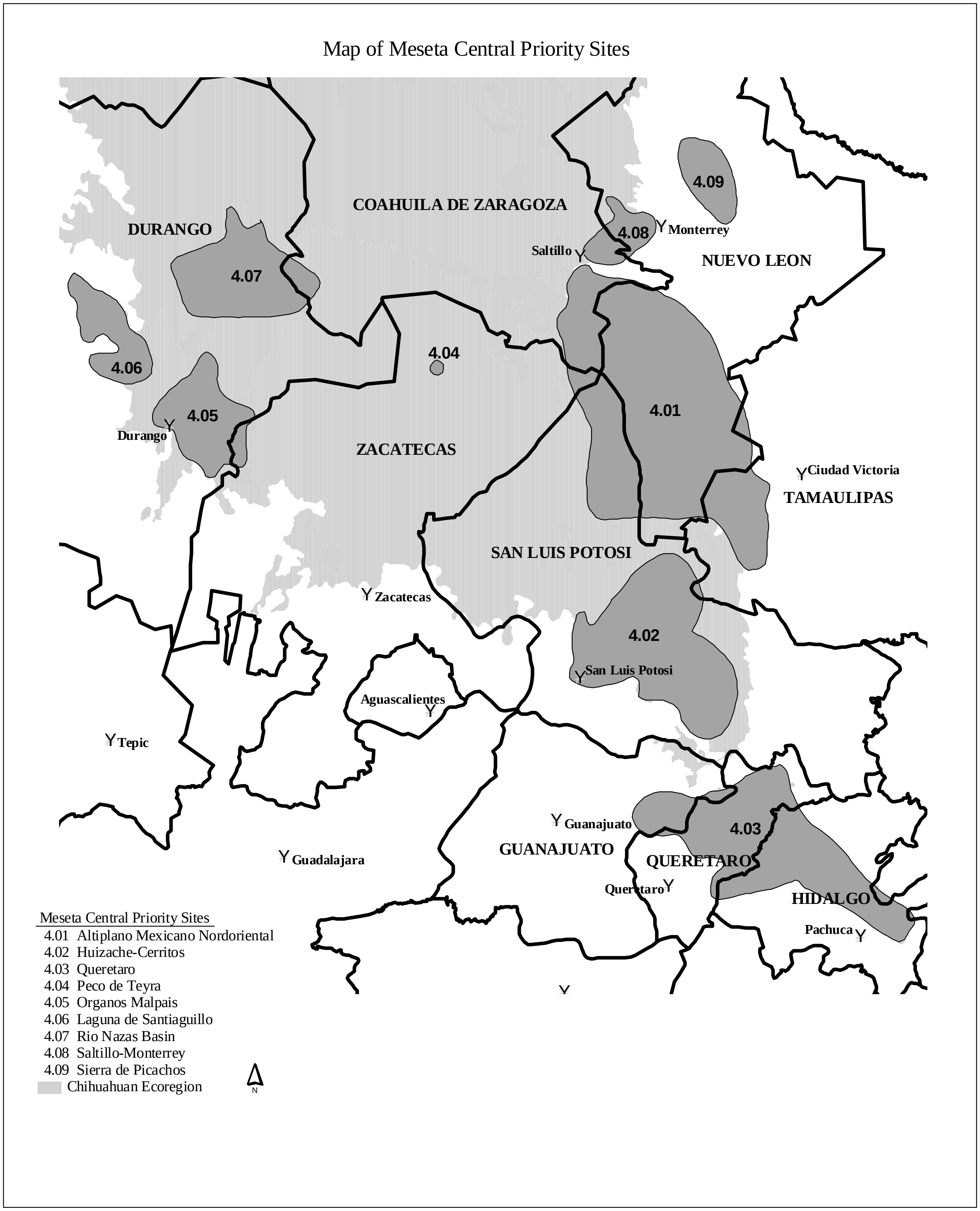
Conservation status: The site is relatively well-preserved, partly because its arid climate has prevented excessive exploitation.

Description of threat: The area is not adequate for seasonal agriculture. However, extensive goat herding has led to overgrazing and the alteration and degradation of native habitats. Exploitation of candelilla for wax occurs. Hunting of animals, water usage, and firewood collection are associated with this industry. In order to promote its sustainable exploitation and prevent its disappearance, candelilla extraction has been recently regulated. The site suffers constant and repetitive poaching. Due to the existing richness of cacti and animal species, there is continuous extraction for illegal markets.

Reasons for selection as a priority site: This site requires further inventory, particularly of cactus species.

Active conservation groups: Universidad Autonoma Nuevo León.

Contributors: G. Alanis



Appendix Figure F-4 Meseta Central priority sites

4.01
Name: Altiplano Méxicano Nordoriental
Location: Southeastern Coahuila, southwestern Nuevo León, northern San Luis Potosí and southwest Tamaulipas
Approximate Size: 60,000 km^2
Priority rank: 1
Level of threat: high

Ownership: Mostly ejido ownership. However, after the modifications to Article 27 of the Mexican Constitution, many parcels have become private property. Currently, certain ejido land properties are rented for potato, bean, alfalfa, and other crop cultivation.

Description of Site: A diverse habitat complex, ranging in elevation from 400-2700 m, with many community types including halophytic and gypsophytic grasslands, gypsophytic matorral, cactus shrublands, yucca woodlands, and izotal.

Western Valleys: These valleys include the regions of Galeana, Doctor Arroyo, Matehuala, El Tokio, Sandia, Cedral, Real Catorce and Los Angeles. These areas are dominated by gypsum grasslands, mainly *Bouteloua* spp. , *Buchloe dactyloides*, and *Aristida divaricata, A. wrightii*, and *A. barbata*. The climate is semiarid, with 90% of the rain falling in the summer months. Desert scrub (mattoral rosetófilo) communities are common also, and are dominated by creosote *(Larrea tridentata*), and contain lesser amounts of smooth sumac (*Rhus virens)*, little-leaf sumac (*R. microphylla*), guajillo (*Acacia berlandieri*), sotol (*Dasylirion* sp.), sangre de draco (*Jatropha dioica*), lechuguilla (*Agave lechuguilla*), and prickly pear (*Opuntia* spp). Transition areas in the higher elevations are characterized by the shrubby *Quercus potosina*, Emory oak (*Q. emoryi*), manzanita (*Arctostaphylos pungens*), azure ceanothus (*Ceanothus coeruleus*), and sotol (*Dasilyrion berlandieri*). Yucca woodlands (*Yucca carnerosana*) occur along the bajadas of grasslands. In the vicinity of Doctor Arroyo, microphyll desert scrub and submontane shrub intermix with species such as mesquite (*Prosopis glandulosa*), afinador (*Mortonia greggii*), guayule (*Parthenium argentatum*), mescal bean (*Sophora secundiflora*), prickly pear cacti (*Opuntia engelmannii and O. cantabrigiensis*), allthorn (*Koeberlinia spinosa)*, and rock-trumpet (*Macrosiphonia macrosiphon*).

Sierra Madre Oriental: This geographic area includes the communities of Miquihuana, Pena Nevada, Cerro Potosi, Arteaga, Zaragosa, Aramberri. The region is characterized by pine-oak woodlands, pinyon-juniper woodlands. The mountains are considered subtropical with summer rainstorms accounting for nearly 90% of the precipitation. However, the highest peaks, at 3,000 m, receive up to 20% of total precipitation in the winter, some of it in the form of snow and hail.

Eastern Valley: This area includes the Valle Jaumave and ranges from 400 –1500 m. Mesquite (*Prosopis laevigata*), palo verde, (*Cercidium floridum*), yucca (*Yucca treculeana*), cenizo (*Leucophyllum frutescens*), allthorn, Christmas cholla (*Opuntia leptocaulis*), sangre de draco, lechuguilla, and hopbush (*Dodonaea viscosa*). Commonly distributed cacti include barrel cactus (*Ferocactus echidne*), *Mamillaria roseoalba*, *Opuntia kleiniae, O. stenopetala*, and *Thelocactus conothelos*.

Outstanding biological features:
Western Valleys: Extensive towns of Mexican prairie dog (*Cynomys mexicanus*), an endangered species, are highly fragmented. Species associated with the towns include mountain plover (*Charadrius montanus*), ferruginous hawk (*Buteo regalis*), burrowing owl (*Athene cunicularia*), long-billed curlew (*Numenius americanus*), Worthen's sparrow (*Spizella wortheni*), savanna sparrow (*Passerculus sandwichensis*), Botteri's sparrow (*Aimophila botterii*), swift fox (*Vulpes macrotis*), and badger (*Taxidea taxus*). Grasslands contain over 140 plant species and more than 80 species of vertebrates, and near Galeana are several endemic grasses. The region is noted for a great variety of cacti, 72 species, of which 8% are endemic. In the Matehuala area, six species of undescribed Leptothorax ant and an endemic katydid (*Eremopedes)* are among the rich invertebrate diversity. An undescribed grasshopper may exist in gypsum areas.

Sierra Madre Oriental: Canyons south of Nuevo León are good habitat for jaguars (*Panthera onca*) and black bear (*Ursus americanus*).

Eastern Valley- These valleys are famous for their endemic cacti which have extremely restricted ranges. Chaute (*Ariocarpus retusus*) occurs only in the Miquihuana area. Among the narrow endemics of the Valle de Juamave, are sand dollar cactus (*Astrophytum asterias*), and the living rock (*Ariocarpus agavoides*).

Conservation status: There are no protected areas in this priority sites.

Description of threats:
Western Valleys: As agricultural production increases, the native vegetation has been displaced by the introduction of different crops that gradually reduce and fragment native habitats. Potatoes are the main crop planted in the once productive grasslands. Prairie dogs are killed by poison or discing by tractors establishing crops.

Sierra Madre Oriental: Logging is not well regulated in the mountains. The trees are very large and many forested ejidos depend on the harvest of these trees for income.

Eastern Valleys: Extensive cattle ranching causes overgrazing and hinders plant regeneration. Collection of cactus is prevalent and a serious concern.

Reasons for selection as a priority site: High concentrations of endemic cacti and other taxa, presence of intact halophytic and gypsophytic grasslands, representation of important species assemblages dependent on prairie dog towns, potential restoration sites for prairie dog habitats.

CONABIO sites: This area overlaps with sites 61, 62, 63, 64, and 69.

Active conservation groups: CACT, A.C. (Comision Associacion de Cactus Tamaulipas), CONABIO, SEMARNAP, Universidad Autonoma de Tamaulipas, Direccion General de Ecologia de estado Tamaulipas, State of Nuevo Leon, Universidad Autonoma Agronomia Antonio Narro, Universidad Nacional Autonoma Mexico-Instituto Biologia, Instituto Tecnilogico de Ciudad Victoria, Municipios-Jaumave y Tula, Instituto Investigaciones de Zonas Aridas de Universidad Autonoma de San Luis Potosi, Conservaccion Humana, A.C..

Contributors: V. Treviño, F. González-Medrano, T. Wendt, F. Chávez-Ramirez, R. Wauer, K. Bryan, C. Lieb, E. Juardo, B. MacKay, C. Gómez-Hinostrosa.

4.02
Name: Huizache - Cerritos
Location: 120 km northeast of San Luis Potosí, in the direction of Río Verde.
Approximate Size: 12,838 km^2
Priority rank: 1
Level of threat: high

Ownership: Mainly ejido land devoted to farming and cattle breeding.

Description of Site: Chihuahuan desert scrub as well as pine and oak forests, found mainly in Guadalcazar and Cerritos.

Outstanding biological features: This is one of the richest cacti areas in México (Hernandez and Barcenas 1996). In addition, a large number of endemic cactus species have been reported. Plants characteristic of gypsum plains and salt marshes, and intact mesquite communities are found in the Río Verde area. Within the Sierra de Guadlacazar, endemic species are found in submontane matorral and pine-oak woodlands. An undescribed Leptothorax ant may be endemic.

Conservation status: Several well-preserved sites within this area can be found. However, these sites require ongoing monitoring to prevent the activities that threaten local wildlife

Description of threat: Agricultural expansion, clearing of forests for urban growth and housing developments are threats. Exploitation of uplands through excessive goat browsing prevents regeneration of vegetation and causes soil compression. Mining activities permanently alter the soil structure and vegetative composition. Poaching and trade of both plants and animals are common practices in this area. Trapping of small mammals and birds to be sold to both foreign and domestic markets is common.

Reasons for selection as a priority site: Presence of characteristic habitats, high diversity and richness in species composition and the presence of large numbers of endemic species.

CONABIO sites: Sites 65, 93, and 94.

Active conservation groups: CONABIO, CONACYT.

Contributors: C. Gómez-Hinostrosa, F. González-Medrano, T. Wendt

4.03 & 5.17 & 5.34
Name: Chihuahua Querétaro Desert Terrestrial (4.03)
Panuco Freshwater (5.17)
Extorax Freshwater (5.34)
Location: Vast region located in the intersection of the states of Guanajuato, Querétaro, Hidalgo, and Veracruz. Approximate Size: 20,000 km^2
Terrestrial priority rank: 1
Freshwater Panuco priority rank: 2
Freshwater Extorax priority rank: 2
Terrestrial level of threat: high
Freshwater Panuco level of threat: high
Freshwater Extorax level of theat: medium

Ownership: Most of the land is part of ejido regimes; however, some of these ejidos are in the process of selling the land to private owners.

Description of the site: This site is one of the southernmost representations of the Chihuahuan Desert biota, even though it is disjunct. Vegetation types include lowland microphyte and *rosetofilo xerophylous* scrublands, with a wide variety of cactus species. Deep canyons and gorges present a complex terrain.

Outstanding biological features: A variety of reptiles representative of Veracruz and central Mexico inhabit the interior of the site, including several species associated with subtropical transition zones. Endemic subspecies of herpetofauna associated with matorral occur. In addition, the Panuco and Extorax freshwater sites are home to a rich variety of aquatic and invertebrate species. Both the Panuco and Extorax harbor endemic fish and are the southern limit of the Cyprinids. They support flatjaw minnow (*D. mandibularis*), bicolor minnow (*D. dichroma*), *D. rasconis*, *D. erymizonops*, *D. catostomops*, and *D. ipni*. These rivers are considered the radiation focie for the fish genus *Xiphophorus.* Documented species are *X. variatus*, Montezuma swordtail (*X. montezumae*), pygmy play (*X. pygmaeus*), *X. nigrensis*, *X multilineatus*, *X. cortezi*, relict splitfin (*X. nezahualcoyotl)*, and *X. continens*. Other fish are gooidae: bluetail gooid (*Ataeniobius toweri*), dusky goodea (*Goodea gracilis*), and *Xenoophorus* sp.,. Media luna killie (*Cualac tessellatus*), and *Gambusia atrora* have also been documented. Cichlids of the rivers include Meida luna cichlid (*Cichlasoma bartoni*), *C. labridens*, *C. cyanostictum*, and probably 3 more undescribed Cichlasoma. Other general Panuco endemics are undescribed *Astyanax* (1-3 forms). Different tributaries have different species of fish complexes. The site also contains very high concentrations or rare and endemic cacti.

Conservation status: The site does not contain protected areas.

Description of threat: Farming and cattle ranching have largely converted the landscape. This has triggered strong hydrologic and wind erosive processes in certain areas, to the point of exposing bedrock and deep soil crevices. Extensive cattle ranching has led to overgrazing and the reduction of community diversity. Wherever timber exploitation is possible, illegal extraction has led to the loss of vegetation, the exposure of soil to erosion, and habitat fragmentation. Pesticides and insecticides used in agriculture have caused soil and groundwater contamination in several areas and water pollution in Extorax. Industrial wastes are dumped into the Extorax. Non-native fish species have been introduced into the

Extorax. Due to its rich and diverse variety of reptile and cactus species, the site is a frequent target of poachers. Additionally, illegal hunting of small mammals and mountain lion (*Felis concolor*), black bear (*Ursus americanus*), and white-tailed deer (*Odocoileus virginianus*) is common in the area.

Reasons for selection as a priority site: Representation of species assemblages, including a wide variety of reptiles and cacti, representation of important evolutionary and ecological processes, *e.g.* a radiating nucleus of the fish genus *Xiphophorus*, and the potential existence of progenitors of crop plants. The freshwater sites, Panuco and Extorax, are also rich in species assemblages with some endemism.

CONABIO sites: The area overlaps with CONABIO sites 102, 103 and 105, and CONABIO freshwater 75.

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma de Nuevo León working in Extorax.

Contributors: F. González-Medrano, C. Lieb, E. Jurado, S. Contreras-Balderas

4.04
Name: Pico de Teyra
Location: 70 km east of the city of Concepción del Oro, Zacatecas
Approximate Size: 108 km^2
Priority rank: 3
Level of threat: medium

Ownership: Information not available.

Description of the site: The site is an immense granite peak relatively isolated from its surroundings, both physically and biologically. Its slope transitions from desert scrub in the low areas to pine and oak forests in the higher areas.

Outstanding biological features: The peak supports a diverse, but largely undescribed, flora with many endemics. Among the few rare or endemic species that have been described are *Thalictrum henricksonii* (Family Ranunculaceae)and *Mancoa henricksonii*, (Family Brassicaceae).

Conservation status: Due to its relative isolation and difficult accessability, Pico de Teyra is relatively well preserved, however, it is not protected.

Description of threats: The most important threat results from the possibility of land conversion for agriculture, especially in the lower parts of the mountain where social and economic pressures lead local communities to become involved in seasonal agricultural activities. The higher parts of the peak are especially threatened by cattle grazing, and by wood and firewood collection.

Reasons for selection as a priority site: Potential for locally endemic biota, this site requires further biological inventory.

Active conservation groups: None known

4.05 & 5.22
Name: Órganos Malpais Terrestrial (4.05)
La Concha Freshwater (5.22)
Location: Southeast of Durango, near Guadalupe Victoria, in Zacatecas and Durango.
Approximate Size: 5,024 km^2
Terrestrial priority rank: 3
Freshwater priority rank: 2
Terrestrial level of threat: medium
Freshwater priority rank: medium

Ownership: Mostly ejido and communal lands

Description of site: The site is an elevated lava deposit at 2,100 m with small peaks reaching up to 2,900 m. This area is composed of pine and oak forest communities, as well as juniper forests and grasslands. La Concha is a large thermal spring at the northeast edge of this site.

Outstanding biological features: The habitat harbors diverse communities of bats and rodents. Known mammal species include Mexican long-tongued bat (*Leptonycterus curazace*), white-throated woodrat (*Neotoma albigula*), spotted groundsquirrel (*Citellus spilosoma*), black-tailed jackrabbit (*Lepus californicus*), a kangaroo rat (*Dipodomys phillipsi*), brush mouse (*Peromyseus boylei*), and California myotis (*Myotis californicus*). La Concha spring contains Río Nazas derived fish, including two local endemics and five basin endemic fish. *Etheostoma* sp., *Cyprinella alvarezdelvillari*, and it is believed the Nazas pupfish (*Cyprinodon nazas)* have been documented here. An *Astyanax* sp. is also found here, as is the exotic tilapia.

Conservation status: The site has no formal protection.

Description of threats: Land conversion and increasing human activities and settlement continue to alter native habitats and reduce species populatons. Timber mills, roads, and intentional forest fires have led to a loss of habitats and alteration of the natural fire regime. The degraded condition of the site has been exacerbated by the excessive use of insecticides and pesticides, frequent clearing through fire, the introduction of exotic species and damage to the landscape caused by off-road vehicles. Illegal hunting and trading of species occurs. The site is also used as an unregulated recreational facility.

Reasons for selection as a priority site: Presence of intact biota with endemic species of fish. It is also an important corridor for the seasonal movements of bats.

CONABIO sites: Overlaps with site 87 and freshwater priority site 40, Río Nazas.

Active conservation groups: CONABIO, Intstituto de Ecología, A.C., Fondo de la Conservación de la Naturaleza, CIIDIR-IPN.

Contributors: L. Fierro, R. Alvarez-Martinez

4.06 & 5.20 & 5.21
Name: Laguna de Santiaguillo Terrestrial (4.06)
Laguna de Santiaguillo Freshwater (5.20)
Río Mezquital Freshwater (5.21)
Location: Located in Nuevo Ideal, northern central Durango.
Approximate Size: 3,364 km^2
Terrestrial priority rank: 1
Freshwater priority ranks: 3
Terrestrial level of threat: high
Freshwater levels of threat: high

Ownership: Mostly ejido land, with some communal properties used by several families, in addition to small extensions of privately owned land.

Description of the site: This is a closed river basin that at one time was part of the Mezquital and the Río Nazas basin. Aquatic biotas occur in two large lakes, and the Río Mezquital that flows to the Pacific Ocean.

Outstanding biological features: Many endemic fish species are apparently derived from the Río Bravo. Three endemic fish species have been located at this site, along with rare *Cyprinodon* and *Gila* species. The area is an important wintering site for remarkably high populations of aquatic birds and a seasonal resting site for migrating shorebirds. Wintering and migratory populations of American white pelican (*Pelecanus erthythrorhynchos*) have been identified. Western and Clark's grebe (*Aechmorphorus occidentalis* and *A. clarkii*), snow goose (*Chen caerulescens*), greater white-fronted goose (*Anser albifrons*), sora (*Porzana carolina*) and Virginia rail (*Rallus limicola*) winter here. Migratory species include longspurs (*Calcarius sp*.) and long-billed curlew (*Numenius americanus*). The fish fauna of the Río Mezquital, a Pacific bound river, is unusual in that it was originally derived from the Rio Grande fauna. This river supports seven endemic species, including *Ictalurus* sp., *Moxostoma* sp., and *Chirostoma mezquital*.

Conservation status: There are no protected areas within the site.

Description of threat: Expansion of agricultural activities on beaches of the lagoon, where natural vegetation is commonly replaced by mostly seasonal crops, degrades water resources. Increasing diversion of water resources is occuring. The water level is currently reduced, and this decreases the presence and number of birds in the area. Insecticide and pesticide pollution is also increasing. The arrival of wintering birds attracts a large number of poachers. A thriving illegal trade in animal and plants also occurs. Several exotic fish species, including a carp, have been introduced for human consumption.

Reasons for selection as a priority site: Representation of species assemblages, unusual biogeographic history of fish fauna, important for migratory birds.

CONABIO sites: This site overlaps with CONABIO site 88 and freshwater site 40, Río Nazas.

Active conservation groups: Intstituo Nacional de Ecología (SEMARNAP), Instituto Silvícolas (Universidad de Juárez) CIIDIR IPN, Universidad Autonoma de Chihuahua, Universidead de Juárez, BIOCONSERVACIÓN, A.C., Universidad Autonoma de Nuevo León.

Contributors: J. Nocedal, S. Contreras-Balderas

4.07 & 5.19
Name: Río Nazas Basin Terrestrial (4.07)
Upper Nazas Freshwater (5.19)
Location: North-central Durango.
Approximate Size: 7, 252 km^2
Terrestrial priority rank: 1
Freshwater priority rank: 1
Terrestrial level of threat: high
Freshwater level of threat: high

Ownership: Mostly ejido and communal lands, in addition to small private properties. Increased riverside population growth has been reported, mostly of irregular human settlements.

Description of the site: The Río Nazas drains limestone mountain ranges. A variety of communities ranging from desert rosetofilo woodlands, yucca woodlands, to montane chaparral are distributed throughout the area. The upper half (from the Francisco Zarco Dam to the Durango toll-free foad) is less disturbed then the portions de-watered in the Torreon metropolitan area. Montezuma Bald Cypress (*Taxodium mucronatum*) is the dominant riparian tree. Recent dendrocronology sudies have found trees of 1000-1500 years of age in this part of the Nazas. There are a number of minor dams that allow water to be present year round. T his part of the river is remarkable as it comprises Cypress-Cottonwood-Willow gallery forest, Mezquite-Huizache stands and typical xerophite vegetation in the hills on both sides of the Nazas (Francisco Valdés-Perezgasga, personal communication).

Outstanding biological features: Rare and endemic species can be found throughout the entire length of the Río Nazas river. A shiner, *Cyprinella alvarezdelvillari* is found in Ojo La Concha. The many rare fish include: An endemic Nazas chub (*Gila conspersa*), *Codoma* sp., a shiner *Cyprinella garmani*, a *Notropis* sp., stumptooth minnow (*Stypodon signifer*), a darter, *Etheostoma* sp., a sucker, *Pantosteus guzmaniensis* (not reassigned yet, up to now included in *P*. *plebeius*), and an *Astyanax* sp. that is under description. Unusual higher plant taxa include *Setchylonthus*, possibly a new family, and other long disjunct taxa including the genera *Henricksonia (*Family Asteraceae*)*, *Siphonoglossa* and *Justicia* (Family Acanthaceae). *Thamnosma stanfordii* (Family Rutaceae) and *Cnidoscolus shrevei* (Family Euphorbiaceae) are distinctive endemic plants of this area. There are large stands of *Agave victoria-reginae* in the surrounding mountains. Adjacent arid canyons have not been studied but stands of rare Queen of the Night cacti (*Peniocereus greggii*) have been recorded in the area. More than two hundred and thirty species of birds have been recorded in this portion of the Nazas River, including Wood duck (*Aix sponsa* Birds not reported by the literature (Howell and Webb 1995) as residents or migrants of the Chihuahuah Desert have been recorded in the Nazas River, between the Francisco Zarco Dam and the San Fernando Dam just outside the Torreon-Gómez Palacio-Lerdo metropolitan area (Francisco Valdés-Perezgasga , personal communication). These records include the summer sighting (including young birds in some instances) of Gray Hawk (*Buteo nitidus*), Peregrine Falcon (*Falco peregrinus*), Common Ground-Dove (*Columbina passerina*), Northern Beardless-Tyrannulet (*Camptostoma imberbe*), Greater Pewee (*Contopus pertinax*) and White-collared Seedeater (*Sporophila torqueola*). Winter records also include many species of bird undocumented in this part of the desert. (Francisco Valdés-Perezgasga, personal communication).

Conservation status: This is a large river basin located between two large artificial bodies of water, the El Palmito dam and the Francisco Zarco dam. The basin has retained many of its original characteristics.

Description of threats: The lower half of this section of the Nazas (from the toll-free Durango highway to the San Fernando Dam) has suffered extensive vegetation loss due a number of factors that include the severe drought that started in 1994, the intensive cultivation of alfalfa, over grazing, the construction of a large thermoelectric power station in the late 1980s, the introduction of exotic plants such as eucalyptus and salt cedar (*Tamarix* spp.) and fires started intentionally for agriculture practices or accidentally. A noticeable exception is a 17-hectare plot known as la Isla, outside the village of Villa Juárez, that has been set apart as a reserve by its owner, Felipe Gaytán. La Isla maintains the flora and fauna of this part of the Nazas as it was fifteen years ago. The gallery forest and its fauna are subjected to illegal hunting and fishing, fires and overgrazing (Francisco Valdés-Perezgasga, personal communication).

Reasons for selection as a priority site: Unusual higher plant taxa, representation of species assemblages.

CONABIO sites: The Upper Nazas freshwater site overlaps with CONABIO freshwater site 40.

Active conservation groups: Instituto Nacional de Ecología (SEMARNAP), IISM, CIIDIR, IPN, Universidad Autonoma de Chihuahua, Universidad Ciudad Juarez, Instituto Politecnico Nacional.

Contributors: J. Henrickson

4.08
Name: Saltillo-Monterrey Corridor
Location: Areas in the valleys of the mountainous region separating the cities of Monterrey, Nuevo León and Saltillo, Coahuila.
Approximate Size: 2,000 km^2
Priority rank: 3
Level of threat: high

Ownership: Ejido land in the process of becoming private property.

Description of the site: Intermontane valleys of montane desert scrub. Pinyon woodlands dominate the upper bajadas.

Outstanding biological features: Two known species of endemic plant occur here, *Agave victoria-reginae* and *Mirandea huastecensis*.

Conservation status: No formal protection occurs in this site.

Description of threats: These areas have undergone excessive deforestation for commercial purposes. Additionally, strong pressure for urban development, including maquiladoras, and the use of land for pasture contribute to environmental degradation. It is expected that these factors will affect 25% of the area within 20 years. Mining activities are carried out in the area, mainly for the extraction of materials for the construction industry, including gypsum, gravel, and other soil components. Urban growth is constant and water resources are strained as a result of the construction of dams and underground pumping. In addition, the area is used for seasonal agriculture and extensive cattle grazing. Constant pressure from off-road vehicles leads to the erosion and degradation of the soil. Finally, the site is affected by excessive, unregulated recreational activities. Although on a moderate scale, poaching and natural resource extraction contribute to the deterioration of the site.

Reasons for selection as a priority site: Uncommon habitats and some endemic invertebrates.

CONABIO sites: Number 61, Sierra de Arteaga.

Active conservation groups: Mining companies, State Governments of Coahuila and Nuevo León.

Contributors: G. Alanís, E. Jurado.

4.09
Name: Sierra de Picachos
Location: Sabinas Hidalgo municipality, northeast of Monterrey, Nuevo León
Approximate Size: 51,000 km^2
Priority rank: 2
Level of threat: high

Ownership: Land ownership is distributed among ejidos, small private owners, and federal property. There is also a community in the area, and a large expanse of which the property status is not clear.

Description of the site: Sierra de Picachos is a massif located northeast of the city of Monterrey. It rises in an area dominated by the sub-province Coahuilan Sierras of the Plains of the Sierra Madre Oriental province. The peaks of Sierra de Picachos rise to 1,550 m elevation. Sierra de Picachos supports a wide variety of vegetation, including pine and oak forests, desert scrub, montane chaparral, Tamaulipan thorny woodland, as well as grasslands, both natural and pasture land. Montane chaparral is the predominant vegetation type, which covers approximately 67% of the site. Pine forests cover the remaining area.

Outstanding biological features: Due to its relative geographic isolation, this range has preserved populations of the black bear (*Ursus americanus*), white-tail deer (*Odocoileus virginianus*), and mountain lion (*Felis concolor*). The west slope is characterized by a mixture of Chihuahuan herpetofauna while the east side is primarily populated by Tamaulipan herpetofauna. Scrub communities on limestone soils are noteworthy. High numbers of monarch butterfly (*Danaus plexipus*) migrate through the conifer communities.

Conservation status: Partly due to the relative isolation of this range, the proposed site is presently well preserved. Another factor that has favored the conservation of the site is the interest in conservation shown by many of the landowners of the area interested, in part, by the possibility of regulated hunting. Sierra de Picachos has been proposed as part of the National System of Protected Natural Areas. The Department of Forest Sciences of the University of Nuevo León has conducted a series of ecological studies in this region.

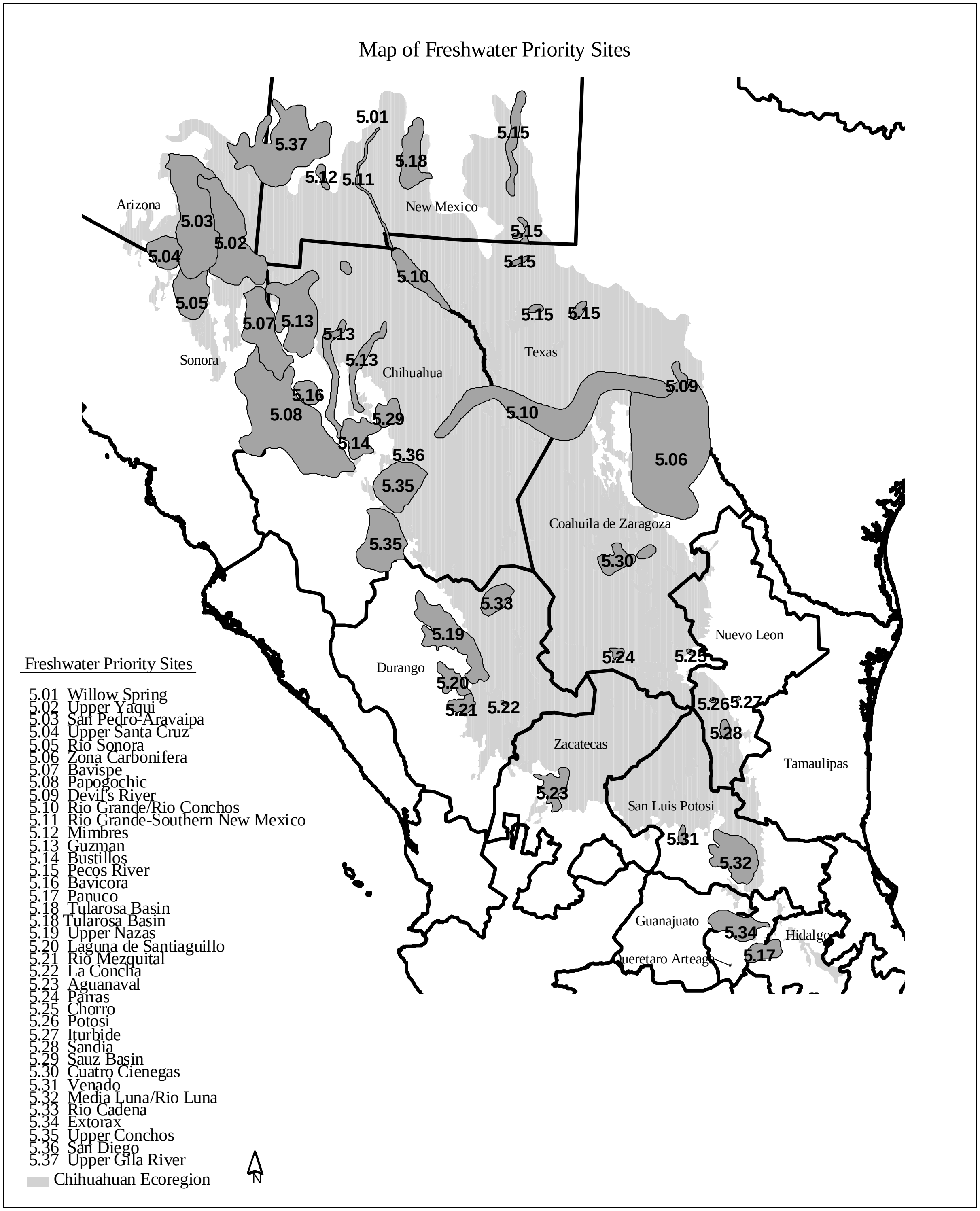
Description of threats: Land conversion to farming has increased throughout the state and has encroached onto the Sierra de Picachos. Currently, several private cattle ranches plant exotic pastures in place of the original vegetation. Illegal wood-cutting has been reported, altering the pine forests, and disturbing the habitat of black bear and associated species. Poaching and illegal wildlife trade are common throughout the state of Nuevo León.

Reasons for selection as a priority site: Presence of large vertebrate populations, relatively intact habitats, biotic transition zone.

CONABIO sites: Site 60 overlaps.

Active conservation groups: Private land-owners, Universidad Autonmoa de Nuvo León, Asociación de Ecología Sierra Madre.

Contributors: D. Lazcano, F. González-Medrano



Appendix Figure F-5 Freshwater Priority Sites

5.01
Name: Willow Spring
Location: 24 km southeast of Socorro, New Mexico, at the base of the Chupadera Mountains.
Priority Rank: 3
Level of threat: high

Ownership: Private land.

Description of site: This highly altered *ciénega*, within a rolling hill of semi desert grassland community type at around 1,600 m., lies at the northern edge of the Chihuahuan Desert.

Outstanding biological features: This is the only known location of the endemic Chupadera spring snail (*Pyrgulopsis chupadera*).

Conservation status: This spring is used as a livestock watering area by the landowner.

Description of threats: Water diversion for livestock and trampling by livestock.

Reasons for selection as a priority site: Although degraded, this is the only known habitat for its endemic springsnail.

Active conservation groups: The Nature Conservancy of New Mexico.

Contributors: P. Mehlhop.

5.02
Name: Upper Yaqui
Location: Southeastern Arizona, northeastern Sonora
Priority Rank: 1
Level of threat: high

Ownership: Private, State of Arizona General Land Office, U.S. Bureau of Land Management- Safford District , U.S. Fish and Wildlife Service-San Bernadino and Leslie Creek National Wildlife Refuges (USFWS).

Description of site: This riverine system lies in a valley at 1,130 m elevation, surrounded by limestone hills. This basin once supported lush grasslands and *ciénegas* on which cattle and sheep grazed extensively during the 1800's. Artesian wells that once had 12 feet of lift now have only have four. Chihuahuan desert scrub grows where grama and curly mesquitegrass once flourished. Marshland areas formed by surface artesian flows were drained and plowed for farmland or pasture. Other marshes are now invaded by mesquite and snakeweed (USDI-USFWS 1990).

Outstanding biological features: Six endemic fishes are found in *ciénegas* and streams of the Upper Yaqui watershed. These are the Yaqui chub (*Gila purpurea*), Yaqui topminnow (*Peociliopsis* *occidentalis sonoriensis*), Yaqui catfish, (*Ictalurus pricei*), Yaqui sucker (*Catostomus bernardini*), beautiful shiner (*Cyprinella formosa*) and Mexican stoneroller (*Campostoma ornatum*). The Ornate shiner (*Codoma ornata*) represents a monotypic genus and is found in the upper Yaqui as well as the upper Rio Mezquital, Rio Nazas, upper and lower Rio Conchos, and upper Rio Fuerte. The Yaqui chub, Yaqui catfish, and beautiful shiner are recognized as threatened and endangered by the U.S. federal government. Roundtail chub (*Gila robusta*) and longfin dace (*Agosia chrysogaster*) are two declining species that occur here (Hendrickson and Minckley 1980). *Ciénegas* also support the San Bernadino springsnail (*Fontelicella* sp.), and the southernmost population of Chiricahua leopard frog (*Rana chiricahuensis*).

Conservation status: San Bernadino National Wildlife Refuge manages 934 ha of the Yaqui headwaters. Cattle were removed from the refuge in 1980. Although the USFWS is working to protect freshwater communities, demands on groundwater for agriculture, mining, and municipal purposes will increase as the populations of Douglas, Arizona and Agua Prieta, Sonora increase.

Description of threats: Heavy grazing outside of the wildlife refuge limits water infiltration through soil compaction, destabilizes streambanks, and denudes riparian zones of vegetation. Downcutting of channels is caused by excessive erosion, a result of road-building and fire-suppression activities, as well as grazing. Water depletion through agricultural, municipal and mining uses alters natural flow regimes and in severe cases dewaters channels. Species movements are impeded by small dams, which are effective barriers to upstream migration (Galat and Robertson 1992). Within wetland and aquatic habitats, exotic bullfrogs (*Bufo* sp.) and other introduced species threaten native reptile, amphibian, and fish populations (Rinne and Minckley 1991).

Reasons for selection as a priority site: This is a critical area for fish conservation in the U.S.. The presence of six species of endemic fish, as well as an overall intact assemblage of fish, is an exceptional situation in the southwest U.S.. A monotypic genus (*Codoma*), represented by the ornate shiner, occurs here as well.

CONABIO sites: Terrestrial site 34 and freshwater site 16.

Terrestrial sites: Galiuro Mountains (1.15), Pinaleño Mountains (1.16), Willcox Playa (1.17), Sulphur Springs (1.19), and Chiricahua-Peloncillo-Sierra Madre Complex (1.20).

Active conservation groups: The Malpai Borderlands Group, IMADES, The Wildlands Project-Sky Island Alliance,

Contributors: D. Hendrickson, W. Minckley.

5.03
Name: San Pedro-Aravaipa
Location: Cananea, Sonora, north 140 km to San Manuel, Arizona
Priority Rank: 1
Level of threat: high

Ownership: Private and ejido lands, State of Arizona General Land Office, The Nature Conservancy of Arizona , and U.S. Bureau of Land Management-Safford and Tucson Districts.

Description of site: The waters of San Pedro River and Aravaipa Creek run through a desert valley hemmed in by the northern outlier 'sky islands' of the Sierra Madre Occidental. Within this large basin, four subareas are critical for freshwater taxa: San Pedro Headwaters, Aravaipa Creek, Redfield Canyon, and Babacomari creek.

San Pedro: Portions of this lowland riparian woodland and *ciénega* habitats are recovering from over 100 years of intensive livestock grazing and water diversion. Periodic flooding maintains plant communities dominated by Goodding's willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), and velvet mesquite (*Prosopis velutina*). Broad age and structural classes of trees and shrubs provide excellent habitat for riparian dependent terrestrial and freshwater fauna (Rinne and Minckley 1991). This riparian zone lies within an upland transition zone of Chihuahuan and Sonoran desert scrub.

Aravaipa Creek: The creek begins as a gravelly channel near Klondyke, Arizona, in a broad valley of highly disturbed desert scrub and semi-desert grassland. The stream enters a steep-walled canyon in the north end of the Galiuro Range. In the canyon, cottonwood and willow woodlands are present, and alternate with bosques of mesquite (Barber and Minckley 1966).

Redfield Canyon: Flows south and west out of the Galiuro Mountains, and drains into the San Pedro river south of Mammoth, Arizona. Madrean woodland, pinyon-juniper woodland, and pine-oak woodland feed the headwaters. The creek then runs into Chihuahuan grama grassland and desert scrub as it descends the mountains (Brown 1994).

Babacomari Creek: This creek drains the Canelo Hills (1.08) and flows into the San Pedro River north of Sierra Vista, Arizona. The surrounding landscape of semi-desert grasslands is heavily grazed. The creek was once slow moving and grass-choked through a grass and marsh landscape. It is now incised and characterized by a disturbance community of cottonwood and willow. Despite this condition, there is still a *ciénega* along the creek (Hastings and Turner 1965).

Outstanding biological features: San Pedro: Historically, this river had 13 native fish species: Colorado squawfish (*Ptychocheilus lucius*), flannelmouth sucker (*Catastomus latipinnas*), razorback sucker (*Xyrauchen texanus*) (reported to be sold commercially in Tombstone!), roundtail chub (*Gila robusta*), Gila chub (intermedia , spikedace (*Meda fulgida)*, loachminnow (*Tiaroga cobitis*), desert pupfish (*Cyprinodon macularius*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), speckled dace (*Rhinichthys osculus*), longfin dace (*Agosia chrysogaster)*, desert sucker (*Catostomus clarki*), and Sonora sucker (*Catostomus insignis*). Today, only three species survive: Desert sucker, longfin dace, and Sonora sucker (Jeff Simms, personal communication).

Aravaipa Creek: The creek shelters the best remaining assemblage of desert fishes in Arizona, including the loach minnow, spikedace, roundtail chub, speckled chub (*Macrhybopsis aestivalis*), Sonora sucker, desert sucker and longfin dace.

Redfield Canyon: The fish assemblage is entirely native with the exception of one exotic, green sunfish (*Lepomis cyanellus*) . Gila chub, speckled dace, longfin dace, and Sonora sucker are found here.

Babacomari Creek: A sizeable population of Gila chub (*Gila intermedia*) persists in the upper reaches.

Conservation status: As a National Conservation Area, the Upper San Pedro has had considerable management flexibility. A 15-year grazing moratorium starting in 1988 has dramatically increased the disturbance vegetation communities of cottonwood and willow. The banks of this portion of the San Pedro were once marshland. Salt cedar (*Tamarix ramosissima*) remains a pervasive weed. Three km of the Upper San Pedro have been designated Wild and Scenic River status. The Upper San Pedro in Mexico, approximately 30 km, is proposed as a Federal Protected Area (CEC 1999).

BLM-Safford District manages Aravaipa Canyon Wilderness Area (7,853 ha) which surrounds the canyon. The Nature Conservancy owns 2,832 ha and controls a grazing allotment surrounding Aravaipa Creek. A portion of Aravaipa Creek (16 km) has been designated Wild and Scenic River status (USDI-BLM 1996).

Redfield Canyon: The headwaters are managed as a 2,670 ha Wilderness Area by the BLM-Safford District. The Nature Conservancy of Arizona manages Aravaipa Ranch Preserve, adjacent to the Wilderness Area. Redfield Canyon is included in a Coordinated Management Agreement between TNC and BLM. The lower elevations of Redfield Canyon are State of Arizona Land Office leases for livestock grazing (USDI-BLM 1996).

Babacomari Creek: While primarily private lands, protection has been proposed for the region as the Las Cienegas National Conservation Area. This proposal includes the creek.

Description of threats: San Pedro: Groundwater pumping in Sierra Vista poses a long term threat to the riparian woodlands, as does water diversion for agriculture. Mining along the headwaters, overgrazing in uplands, exotic fish species such as bluegill (*Lepomis macrochirus*) and bullhead catfish (*Ameiurus sp.*), and the alien shrub salt cedar also contribute to stream degradation.

Aravaipa: Abandoned mines in the headwaters leach into the stream during and after rains. Heavy metals are probably a serious problem. State lands in the upper watershed have been degraded by heavy livestock grazing, and contribute extremely high sediment loads into the stream. The subsequent siltation of the river limits habitat diversity for fish.

Redfield Canyon: Livestock grazing within the creek and on streambanks is the primary threat.

Babocomari Creek: The creek is heavily contaminated by non-native fish mosquitoefish (*Gambusia affinis*) and crayfish. If the creek were free of non-natives, it would be an excellent candidate as a reintroduction site for topminnow and pupfish. Sonora or desert sucker. In addition, groundwater pumping by Fort Huachuca and Sierra Vista have severely reduced the water levels in the creek.

Reasons for selection as a priority site: Intact fish assemblages on Aravaipa Creek and in Redfield Canyon.

CONABIO sites: Terrestrial 20 and 34, freshwater 12 and 13.

Terrestrial sites: Santa Catalina Mountains (1.05), Lower San Pedro River (1.06), Whetstone Mountains (1.07), Appleton-Whittell Research Ranch (1.08), Huachuca Mountains (1.09), Upper San Pedro River (1.10), and Dragoon Mountains (1.18).
Active conservation groups: The Nature Conservancy of Arizona, Sonoran Institute, Sky Island Alliance, IMADES, SEMARNAP, Center for Biological Diversity, USDA-Agricultural Research Service, US Environmental Protection Agency, Udall Center-University of Arizona, Rocky Mountain Forest and Range Experiment Station, Friends of the San Pedro.

Contributors: W. Minckley.

5.04
Name: Upper Santa Cruz
Location: 35 km southeast of Nogales, Sonora and the San Rafael Valley, Arizona.
Priority Rank: 2
Level of threat: high

Ownership: Private and State of Arizona Land Office.

Description of site: The Upper Santa Cruz flows through highly altered grassland, foothills, desert scrub, and agricultural lands. The river still supports cool springs, *ciénegas*, and riparian woodland. The river became dry in 1945 from water diversion in the upper watershed, which resulted in the death of mesquite bosques. Today, for most of the year, the channel is dry and sandy. In the summer rainy season the channel fills to produce a highly irregular flow regime. In a section of this river downstream near Tucson, banks that are now 22 m across were once a mere 2 m wide (Hastings and Turner 1965). The river once ran through marshes of sacaton, untrenched, with multiple channels. Small remnants of *ciénegas* persist 10 km north of Nogales in an area that once abounded with marsh grasses and common reed (Hendrickson and Minckley 1984). Kino Springs and Drive-in Theater ponds are among the few extant *ciénegas*.

Outstanding biological features: Despite the extreme degradation of this system, remnant habitats support the Gila topminnow (*Poeciliopsis occidentalis occidentalis*), and speckled dace (*Rhinichthys osculus*). Gila chub (*Gila intermedia*), has been extirpated from the river but probably persists in springs. Desert sucker (*Catostomus clarkii*). is found in Sonoita Creek, a tributary to the Santa Cruz. Huachuca water-umbel Water-umbel, Huachuca (*Lilaeopsis schaffneriana recurva*) and the Huachuaca tiger salamander (*Ambystoma tigrinum stebbensii*) also occur here. Monkey Springs Pupfish, and undescribed *Cyprinodon*, once occurred in this drainage but succumbed to fluctuating water levels and exotic species, and to date is the only documented species extinction in the state of Arizona.

Conservation status: This river has no special management designations but a National Conservation Area, Las Cienegas, has been proposed for a large portion of the watershed. Private lands have been put into conservation easeemnts.

Description of threats: Groundwater pumping within the watershed has reduced the flow. Effluent leaving Nogales, Sonora has increased the water level of the river but water quality is poor (R. Ohmart, personal communication). Urban and agricultural development along the river degrades its streambanks, which in turn reduces instream flow, favors the establishment of the exotic salt cedar (*Tamarix ramosissima*), and increases erosion and damage during flood events. Pesticide runoff and livestock overgrazing are also threats along the river. Monkey Spring still supports the Gila topminnow but the ranch where it occurs is being subdivided. Subdivision for housing severely threatens the headwaters of this system, in Rio Rico Patagonia, and the San Rafael Valley. Degredation of water quality and quantity are expected with groundwater pumping for these developments. Groundwater extraction and surface water diversions have greatly reduced the flow and changes to the watershed and channel make it subject to dramatic floods.

Reasons for selection as a priority site: Rarity of habitat type.

CONABIO sites: Terrestrial site 22 overlaps slightly on the northern boundary.

Terrestrial sites: Pajarita-Atasca Mountains (1.02), Santa Rita Mountains (1.03), and Huachuca Mountains (1.09).

Active conservation groups: Sonoran Institute, Departmento de Investigaciones Cientificas y Tecnologicas of the Universidad de Sonora, Friends of the Santa Cruz, University of Arizona-Udall Center.
Contributors: W. Minckley

5.05
Name: Río Sonora (5.05) See terrestrial description for Río Sonora Watershed (1.11).

5.06
Name: Zona Carbonifera
Location: Del Rio, Texas south 300 km to Melchar Muzquiz, Cohuila
Priority Rank: 1

Ownership: private, ejidos

Description of site: A subterranean aquifer with associated caves and springs, as well as the rivers draining the eastern edge of the Chihuahuan Desert: Upper Rio Salado de Sabinas-Muzquiz and Celemania.

Outstanding biological features: Devil's river minnow (*Dionda diaboli*) and marbled swordtail (*Xiphophorus meyeri*) are strict local endemics. Sand shiner (*Notropis stramineus*) has also been documented in the Rio Salado. Rare isopods and amphipods are also present. Mexican blindcat, (*Prietella phreatophila*), and associated but unstudied aquatic crustacea inhabit the aquifer. In Clemania, an endemic darter, (*Etheostoma segrex*), may occur.

Conservation status: This aquifer is under intense pressure and is without protection.

Description of threats: Pumping of the aquifer for industry and agriculture is a major threat. The water quality of the aquifer is contaminated by industrial runoff.

CONABIO sites: Terrestrial site 61 and freshwater site 43, Río Bravo-Piedras Negras

Terrestrial sites: Devil's River (2.06), and Sierras del Carmen and Santa Rosa Complex (3.02).

Reasons for selection as a priority site: Several local endemic fish species.

Active conservation groups: No groups are known to be working on this aquifer.

Contributors: D. Hendrickson.

5.07
Name: Bavispe
Location: This river flows north along the Chihuahua-Sonora border, flowing out of the Sierra Huachinera, and joins the Río Yaqui.
Priority Rank: 1
Level of Threat: medium

Ownership: Private and Ejido

Description of site: The river and its tributaries drain the northwestern flank of the Sierra Madre Occidental.

Outstanding biological features: Río Bavispe harbors a diverse and relatively intact assemblage of fish species that reflect pristine conditions. Species present include the Yaqui catfish (*Ictalurus pricei*), Bavispe sucker (*Catostomus leopoldi*), beautiful shiner (*Cyprinella formosa*), Mexican stoneroller (*Campostoma ornatum*), a trout (*Oncorhynchus* sp.), roundtail chub (*Gila robusta*), and Yaqui sucker (*Catastomus bernardini*). Neotropical otter (*Lutra longicaudis*) have been seen here as well.

Conservation status: The headwaters of this river lie within the Sierra Los Ajos-Bavispe Área de Protección de Recursos Naturales, managed by SEMARNAP. The protected area is 183,565 ha.

Description of threats: Livestock grazing and timber harvest in the upper watersheds are poorly regulated. Damming of streams reduces available riverine habitat and blocks species movements. The potential introduction of non-native species is a grave threat.

Reasons for selection as a priority site: The river supports a rare intact fish assemblage. Further investigation of the biota is required.

CONABIO sites: Terrestrial site 35 and freshwater site 16, Río Yaqui.

Terrestrial sites: Chiricahua-Peloncillo-Sierra Madre complex (1.20)

Active conservation groups: The Wildlands Project-Sky Island Alliance, Naturalia, U.S. National Park Service, SEMARNAP.

Contributors: W. Minckley

5.08
Name: Papigochic
Location: Headwaters of Río Papigochic, Río Aros, and Río Sirupa.
Priority Rank: 1
Level of Threat: high

Ownership:Ejidos and private lands.

Description of site: The river flows through unique barranca habitats of the Sierra Madre Occidental. A critical area is Ojo de Yepomera. This watershed drains into the ecoregion but is situated west of the Chihuahuan Desert proper.

Outstanding biological features: The site supports a number of characteristic Chihuahuan freshwater fish, some threatened, including the beautiful shiner (*Cyprinella formosa*), Mexican stoneroller (*Campostuma ornatum*), a trout (*Oncorhynchus* sp.), roundtail chub (*Gila robusta*), Yaqui sucker (*Catasotoma bernardini*), and Yaqui catfish (*Ictalurus pricei*). In addition, otter (*Lutra canadensis*), have been reported in this unusual river.

Conservation status: No protected areas occur in this site.

Description of threats: Grazing, clear-cutting in upper watershed, damming, potential introduction of non-native species.

CONABIO sites:Terrestrial sites 26, 28, 26, 42 and freshwater site 16, Río Yaqui.

Terrestrial sites: Upper Yaqui (1.13)

Reasons for selection as a priority site: The river supports an intact fish assemblage.

Active conservation groups: Information not available.

Contributors: D. Hendrickson

5.09
Name: **Devil's River, see terrestrial site description for Devil's River (2.06).**

5.10
Name: Rio Grande/Río Conchos, see terrestrial description for Rio Grande-El Paso to Amistad (2.02).

5.11
Name: Rio Grande-Southern New Mexico see terrestrial description for Rio Grande-Elephant Butte to El Paso (2.03).

5.12
Name: Mimbres River see terrestrial description for Lower Mimbres River (1.26).

5.13
Name: Guzman Basin
Location: Northwestern Chihuahua, north and east of Nuevo Casas Grandes.
Priority Rank: 2
Level of Threat: high

Ownership: Private, ejido.

Description of site: The streams and springs flow through basins at around 1,800 m. Throughout the watershed, the uplands of Chihuahuan desert scrub are highly degraded by livestock grazing. Lowland riparian woodlands of Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*) are patchy in quality with some stretches of river containing multiple age class stands, while along others, lines of snags attest to lowered water tables and channel diversions. The Río Casas Grandes, which drains the eastern front of the Sierra Madre, empties into this basin. Other rivers which terminate here are the Río Santa María and the Río Santa Clara. Several springs arise along rivers and in basins.

Outstanding biological features: Within Ojo Apache two endemic fish and one endemic isopod species occur. The Río Santa María contains an undescribed whitefin pupfish. Ojo de Los Reyes, near Galeana, Chihuahua, is a spring refuge for endemic species associated with the Río Santa María. Ojo Solo, which is actually two springs, contains largemouth shiner (*Notropis bocagrande*) and a pupfish, *Cyprinodon carbonaria*. Río Santa Clara and Río Casas Grandes share the Chihuahua chub (*Gila nigrescens*), Rio Grande sucker (*Pantosteus plebeius*), beautiful shiner (*Cyprinella formosa*), and the Mexican stoneroller (*Campostoma ornatum*). Río Casas Grandes also contains flathead minnow (*Pimephales promelas*), and three undescribed *Cyprinodon* species. Several undescribed species have been reported, including an *Oncorhynchus*, a *Catatomus* and an *Ictalurus*.

Conservation status: No protected areas occur in this site.

Description of threats: Agricultural diversions of water negatively impact the aquatic systems of the Guzman Basin. Flood irrigation of alfalfa, oats, squash, and apple crops depletes instream flows.). Non-native fish species such as bullhead minnow (*Pimephales vigilax*), western mosquitofish (*Gambusia affinis*) compete with natives. Groundwater pumping for the city of Ciudad Juárez may have consequences on the water availability and the depth of rivers.

Reasons for selection as a priority site: Representative of habitat type and high degree of endemism for freshwater taxa.

CONABIO sites: 33 & 35 freshwater sites**.**

Terrestrial sites: Chiricahua-Peloncillo-Sierra Madre complex (1.20), Sierra del (2.01)Nidos

Active conservation groups: None known.

Contributors: D. Propst, W. Minckley, S. Contreras-Balderas

5.14
Name: Bustillos
Location: approximately 50 km to the west of the city of Chihuahua, Mexico
Size: 3303 km^2
Priority Rank: 4
Level of Threat: medium

Ownership:Private

Description of site: Bustillos is a lake situated in a watershed draining the west edge of the Sierra del Nido (2.01). Laguna Bustillo sits at approximately 1800 meters within a landscape of desert scrub, grasslands, and agriculture.

Outstanding biological features: Chihuahua chub (*Gila nigrescens*), beautiful shiner (*Cyprinella formosa*), and a pupfish (*Cyprinodon* sp.), and fathead minnow (*Pimephales promelas*) are found in this drainage.

Conservation status: There are no protected areas within this site.

Description of threats: Groundwater pumping, livestock grazing, deforestation, agricultural and urban runoff and wastewater, and introduced species.

Reasons for selection as a priority site: Relatively intact fish species assemblages and habitat.

Active conservation groups: None known.

CONABIO sites: Freshwater site 37.

Terrestrial sites: Sierra del Nido drains into this basin (2.01).

Contributors: D. Propst, W. Minckley

5.15
Name: Pecos River
Location: Fort Sumner to Carlsbad, New Mexico. Spring sites are south of Carlsbad in New Mexico and Texas.
Priority Rank: 1
Level of threat: high

Ownership: Irrigation districts, agricultural interests, Reeves County Irrigation District, State of Texas-Parks and Wildlife Department, The Nature Conservancy of Texas and New Mexico, U.S. Army Corps of Engineers, U.S. Bureau of Land Management-Roswell and Carlsbad Field Offices, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service- Bitter Lake National Wildlife Refuge and Dexter National Fish Hatchery.

Description of site: This is a complex of lowland riparian grassland and wetlands, limestone canyons, gypsum soils, and spring sites at lower elevations (1,300 m). Baseflows of the Pecos are sustained by the Roswell Artesian aquifer. Black River, Delaware River, and Salt Creek are spring-fed tributaries contributing to flow. The vegetation patterns in the riparian zone of the Pecos River have been altered and largely influenced by human activities, primarily from diversions, large dams, and the introduction of salt cedar (*Tamarix ramosissima*.) (Duncan *et al.* 1993). Uplands surrounding the river are agricultural fields and typical Chihuahuan desert scrub and semi-desert grasslands with creosote bush (*Larrea tridentata*), soaptree yucca (*Yucca elata*), desert holly (*Acourtia nana*) and fluffgrass (*Dasyochloa pulchella*). Channel gradients are less than 0.5% and confinement by the valley is moderate. Travertine and bedrock riffles separate deep and long pools (~2m x >100m). Except for verly large floods, deposition from the river occurs exclusively within the river channel and reservoir deltas, and floodplains are non-existent. Four dams have been erected on the Pecos. Furthest upstream is Santa Rosa Dam, completed in 1980, then near Fort Sumner is Sumner Dam, completed in 1937. Upstream of Carlsbad is Brantley Dam, which replaced McMillan Dam in 1989, and finally the oldest, Avalon Dam, completed in 1891.

Blue Spring: This is a three-mile long spring-fed stream that flows into the Black River, a tributary to the Pecos. Livestock graze portions of the riparian and wetland areas. Native species are protected from invasion by exotic fish in the Black River by a waterfall at the stream’s confluence with the river.

Rattlesnake Spring: Thirteen springs give rise to this desert oasis, owned by The Nature Conservancy of New Mexico. Tall Fremont cottonwood and a dense understory of Russian olive (Elaeagnus angustifolia), salt cedar, and soapberry (Sapindus saponaria) dominate it.

Salt Creek: The spring source for this creek is an alkali flat and spring complex. The spring and wetlands are heavily degraded by erosion. This, along with salt cedar invasion, is causing the upper reaches of extensive marsh to dry up. The low gradient stream is extremely salty. Salt cedar and netleaf hackberries (Celtis reticulata) are the dominant trees in the riparian zone.

Diamond Y Spring: This preserve of The Nature Conservancy of Texas is 608 ha and is 20 km northwest of Fort Stockton, Texas. Located within desert scrublands, the spring supports a *ciénega*.

Balmorhea: Historically, this was an extensive *ciénega*, created by the outflow of 20 million gallons of water a day. The spring sits within a 45-acre state park. Since the early 1900's, the water has been diverted for agriculture through cement lined canals. Today, a 3.5 million gallon public swimming pool sits on top of the spring. Approximately four ha of wetland have been restored. Fish live in the pool and canals of the irrigation system. Nearby Phantom Spring is also used for agriculture.

Chandler/Independence Creek: The Nature Conservancy of Texas owns this 549-ha preserve. The creek is springfed and surrounded by a pinyon-juniper woodland

Bitter Lake National Wildlife Refuge (BLNWR): BLNWR contains the most biologically significant wetlands in the Pecos watershed, protecting a huge number of species. Within its 9,927 ha is an imprssive sinkhole, wetland and pool system, as well as open shrub and grassland. Typical species are alkali sacation, mesquite (*Prosopis glandulosa*) and four-wing saltbush (*Atriplex canescens*). Areas adjacent to watercourses contain coyote willow (*Salix exigua*), seepwillow (*Baccharis* sp.), and salt cedar. The waters are naturally saline.

Outstanding biological features:
Pecos Mainstem: Fish species include the gray redhorse (*Moxostoma congestum*), blue sucker (*Cycleptus elongatus*), bigscale logperch (*Percina macrolepida*), Rio Grande shiner (*Notropis jemezanus*), possibly headwater catfish (*Ictalurus lupus*), bluntnose shiner, and speckled chub (*Machrybopsis aestivalis*), which may be genetically distinct from other subspecies in other drainages (Hatch *et al.* 1985). The Texas horneshell mussel (*Popenaias popeii*) was once abundant but is now extremely rare and found only in Black River. This mussel is a Federal Species of Concern. Microfauna such as the mussel and several other species found in the following subsites are at the very basic level of the food chain, as primary consumers and decomposers of plant material. Providing vital ecosystem functions in terms of energy flow and nutrient cycling, as well as a soruce of food for animals higher on the food chain, these species are critical to any conservation plan (Arritt 1998).

Blue Spring: Greethroat darter (*Etheostoma lepidum*) a state endangered species in New Mexico, Pecos gambusia (*Gambusia nobilis*), a U.S. federally endangered species, Mexican tetra (*Astyanzax mexicanus*), roundnose minnow (*Dionda episcopa*), and the Pecos springsnail (*Pyrgulopsis pecosensis*) are found in the upper two miles of stream (NMNHP 1997).

Rattlesnake Springs: The oasis serves as a migration stopover, and over 250 species of birds have been documented. Within its waters, greenthroat darter and round-nosed minnow have been reintroduced. Ten species of aquatic snails have been documented (TNC 1995).

Salt Creek: This is an important refuge for a pure strain of the Pecos pupfish (*Cyprinodon pecosensis*), which has not hybridized with congeners found in the mainstem of the Pecos. The importance of Salt Creek to Pecos pupfish cannot be understated.

Diamond Y: The world's only known population of Leon spring pupfish (*Cyprinodon bovinus*), as well as the Pecos gambusia and three endemic snails, occur here. Three spring snails inhabit the waters; *Tryonia adamantina, Tryonia stocktonensis, and Gammarus pecosensis*. The wetlands also support the proposed U.S. federally endangered puzzle sunflower (*Helianthus paradoxus*).

Balmorhea Spring: Comanche springs pupfish (*Cyprinodon elegans*), Pecos gambusia and headwaters catfish live in this altered habitat. Comanche springs pupfish and Pecos gambusia are both U.S. federally endangered species, and in addition to Balmorhea, there is a small population in nearby Phantom Spring.

Chandler/Independence Creek: Prosperine shiner (*Cyprinella proserpina*), Mexican tetra, Rio Grande darter (*Etheostoma grahami*), roundnose minnow (*Dionda epsicopa*), Tamaulipan shiner (*Notropis braytoni*), Rio Grande cichlid (*Cichlasoma cyanoguttatum*), Texas shiner (*Notropis amabilis*), and gray redhorse all occur here. The upland vegetation supports the U.S. federally endangered black-capped Vireo (*Vireo atricapillus*).

Bitter Lake: A spectacular array of species and processes are found in this well-managed wetlands complex. Within the tributaries to the Pecos mainstem, native fish find refuge. The assemblage of rare and declining species contains Pecos gambusia, Pecos pupfish, greenthroat darter, Mexican tetra, and roundnose minnow. The refuge supports some of the best available habitat for the puzzle sunflower. Migratory birds number 352 species, and range from passerines such as the common Townsend's warbler (*Dendroica townsendi*), to rare seabirds such as the pomarine jaeger (*Stercorarius pomarinus*), to abundant waterfowl and shorebirds. High numbers of American widgeon (*Anas americana*), snow goose (*Chen caerulescens*), black-necked stilt (*Himantopus mexicanus*), snowy plover (*Charadrius alexandrinus*), and western sandpiper (*Calidris mauri*) forage in the wetland and shoreline enviroments winter, spring, and fall. The number of mammal species documented on the refuge number 57. Spotted ground squirrel (*Spermophilus spilosoma*), plains pocket gopher (*Geomys bursarius*), beaver (*Castor canadensis*), and hispid cotton rat (*Chaetodipus hispidus*) are among the abundant rodent assemblage. Perhaps the most extraordinary feature of Bitter Lake is its invertebrate diversity. BLNWR appears to host the highest dragonfly (Odonata) diversity in the Western Hemisphere with over 54 species identified. Among the dragonflys are the world's largest, *Anax walsinghami*, the world's largest damselfly, *Archilestes grandis*, and the world's smallest damselfly, *Ischnura hastata*. Velvet ant (Mutilid) diversity is inexplicably high as well, with at least 39 species of this wingless wasp documented. Lastly, the snail representation is exceptional. *Assiminea pecos*, *Tryonia adamantina*, *Tyronia kosteri*, *Pyrgulopsis roswellensis*, *Prygulopsis pecosensis*, and Noel's amphipod (*Gamarus desperatus*) persist in aquatic refugia. These springsnails indicate the health of the springs and aquifers (Arritt 1998, USDI 1998).

Conservation status: The Pecos River and associated tributaries and spring sources are protected in some areas and heavily exploited in others. The U.S. Bureau of Reclamation is a primary controller of water and diversions.

Pecos Mainstem: Flood control and diversion dams, overgrazing along the streambank, oil and gas exploration and extraction, the absence of beavers, and reduced riparian vegetative diversity all have negatively affected the function of the river. BLM Carlsbad Resource Area has two special management areas on the river: 1) Bluntnose Shiner Habitat Management Area (81 ha), and 2) Pecos River Canyon Complex Area of Critical Environmental Concern and Research Natural Area (3,039 ha). BLM Roswell Resource Area manages three special management areas: 1) Pecos River Research Natural Area, 2) Overflow Wetlands Area of Critical Environmental Concern, in which 1,209 ha of floodplain is closed to fluid minerals leasing for protection of the Pecos gambusia and Pecos bluntnose shiner, and 3) the North Pecos River Area of Critical Environmental Concern (1,359 ha) (USDI-BLM 1977a, USDI-BLM 1977b). Critical Habitat has been designated for the Pecos bluntnose shiner along this stretch of the river. Bitter Lake National Wildlife Refuge straddles approximately 10 miles of the mainstem, four of which are Wilderness Area. New Mexico Game and Fish Department manages two waterfowl hunting areas, the Huey Wildlife Management Area near Artesia, NM, and the Brantley Wildlife Management Area, upstream of Brantley Lake.

Blue Spring: This site is within private land but the State of New Mexico has acquired some of the water rights associated with it.

Diamond Y Spring, Chandler/Independence Creek, and Rattlesnake Spring, owned in part by The Nature Conservancy.

Salt Creek is privately owned and there are also parcels of Texas General Land Office land. It has no protection or special management.

Balmorhea and Phantom Spring: Neither has protection although the Bureau of Reclamation owns Phantom Spring.

Bitter Lake National Wildlife Refuge contains the Salt Creek Wilderness (3,893 ha) and several Research Natural Areas. The refuge has considerable protection under the USDI National Wildlife Refuge System.

Description of threats: Water diversions for irrigation, groundwater pumping for irrigation and municipal uses, natural gas and oil exploration and exploitation, channelization, exotic fish, urban development, and habitat alteration (e.g., alien salt cedar) are all major threats (Duncan *et al.* 1993, USDI-BLM 1997b).

Reasons for selection as a priority site: Critical for ecological processes supporting species assemblages of fish, springsnails, and other invertebrates within gypsum spring, riverine, and wetland habitats.

Active conservation groups: Pecos River Native Riparian Restoration Organization, New Mexico Riparian Council, The Nature Conservancy of Texas and New Mexico, Chihuahuan Desert Conservation Alliance, Forest Guardians, Southwest Environmental Center, Rio Grande/Rio Bravo Basin Coalition.

Terrestrial sites: Site Pecos River (2.10) overlaps at the southern edge of this site.

Contributors: D. Hendrickson, P. Mehlhop, D. Propst.

5.16
Name: Bavicora, see terrestrial description for Alta Bavicora (2.11).

5.17
Name: Panuco, see terrestrial site description for Chihuahua Querétaro Desert (4.03).

5.18
Name: Tularosa Basin, see terrestrial description for Tularosa Basin (2.09).

5.19
Name: Upper Nazas, see terrestrial description for Rio Nazas Basin (4.07).

5.20
Name: Laguna de Santiaguillo Freshwater, see terrestrial description for Laguna de Santiaguillo (4.06)

5.21
Name: Mezquital, see terrestrial description for Laguna de Santiaguillo (4.06).

5.22
Name: La Concha, see terrestrial description for Órganos-Malpais (4.05)

5.23
Name: Upper Aguanaval
Location: Approximately 20 km northwest of the city of Fresnillo, Zacatecas.
Priority rank: 2
Level of threat: high

Ownership: Private, communal, and ejido land properties.

Description of site: An endorheic (closed) basin, associated with the Río Nazas.

Outstanding biological features: This is a riverine environment that includes seven fish species endemic to the Río Nazas and five species that are shared with the Río Grande. This site can be considered a sanctuary for several species, including several endemics, such as various species of cyprinid. The local *Gila* is not *G. conspersa*. It is not known if the other fish are the same or differentiated from the Nazas forms: Mexican darter (*Etheostoma pottsi*), *Pantosteus* sp., Cyprinodon "nazas", and possibly a new *Astyanax* sp.

Conservation status: There are no protected areas in this site.

Description of threats: The consequences of land conversion to agricultural use have been the loss of native vegetation, lack of soil retention, and reduction in water quality and availability, and an altered flood regime. Damming, channelization, and surface and groundwater extraction have reduced quality riparian habitat and altered natural freshwater habitats. The water is also polluted by pesticides, fertilizers, and insecticides to the point of being rendered uninhabitable for native species, including several endemics.   The construction of a dam on the Río Aguanaval has led to the establishment of exotic fish species.

Reasons for selection as a priority site: Composition of representative species of the Nazas basin, relatively intact habitat in some areas, relict habitats.

Active conservation groups: Ejidos, private land owners, SEMARNAP, Secretaría de Agricultura Deserrollo Rural, Secretaría Desarrollo Social.

Contributors: S. Contreras-Balderas

5.24
Name: Parras
Location: Coahuila
Size: A relatively small river basin, associated to the Nazas-Aguanaval system.
Priority rank: 4
Level of threat: high

Ownership: Private and ejido lands.

Description of site: The site is a springfed desert valley oasis, with formerly high quality abundant springs. The site corresponds to a small closed-system basin that is a satellite of the Nazas River.

Outstanding biological features: Due to relative isolation, the fauna has differentiated to a large degree, resulting in numerous endemic species. The fauna was documented in 1964, although the first reports date from 1903 (Miller 1964). Species endemic to the Parras Basin are the stumptooth minnow (*Stypodon signifer*), of a monotypic genus, the Parras pupfish (*Cyprinodon latifasciatus*), and a distinct form of Chihuahua Chub (*Gila nigrescens)*. A goodeid, *Characodon lateralis*, which is endemic to the region, was also found in the basin. Of the seven native species originally reported, six have presumably disappeared. Only Chihuahua Chub has survived, in addition to an endemic freshwater shrimp whose present status is unknown, but probably currently endangered

Conservation status: The site is not protected.

Description of threats: The reduction of water and degradation of the water quality has been caused by excessive groundwater extraction and channeling for agriculture. Most of the endemic species have disappeared. The hydrographic regime of the river basin has been modified through irrigation works. These modifications have led to the disappearance of endemic species and have produced conditions favorable to the introduction of several exotic species, including two carp, Common carp (C*yprinus carpio*) and Japanese carp (*Carassius auratus*_. Fish species from other parts of the Chihuahuan, such as *Gambusia speciosa* and Fancy guppy (*Poecilia reticulata*), have also become established.

Reasons for selection as a priority site: A concentration for endemic fish and potential for endemic invertebrates.

Active conservation groups: BIOCONSERVACIÓN, Universidad Autonoma Nuevo León.

Contributors: S. Contreras-Balderas

5.25
Name: Chorro
Location: Southeast of the city of Saltillo, Coahuila.
Size: A stream associated with a series of springs that run approximately 5 km in length.
Priority rank: 4
Level of threat: high

Ownership: Mostly small, private-property parcels.

Description of site: Also known as El Chorro de Arteaga due to its proximity to the capital of a municipality that bears this name, located 15 km to the southeast of this city on the Mexico City - Saltillo Federal Highway 85. The site is formed by a group of springs and a stream that was formerly part of the Río San Juan.

Outstanding biological features: This is the last refuge for carpita de Saltillo (*Gila modesta*), an endemic species of fish first described in 1963 by researchers from the University of Tulane and the Universidad de Nuevo León. The site was remodeled and conditioned as a partially protected recreational area. This resulted in the introduction of the Japanese carp (*Carassius auratus*), an exotic species that competes with the native *Gila modesta*. Although this species is not in imminent danger of extinction, it currently survives under unfavorable conditions with a population totaling approximately 4,000 individuals. A hydroboid snail also occurs here.

Conservation status: The site is managed as a protected natural area. It has been designated as a National Park and as such has partial protection and is managed by local and state authorities. Its conservation status can be considered good. The area recently underwent modifications for its use as a recreational facility, modifying the habitat mainly through the construction of small dams and channels as well as the introduction of the Japanese carp.

Description of threats: Some areas of the site have suffered deforestation, resulting in diminished water infiltration. Furthermore, there have been unregulated recreational activities. The introduction of the Japanese carp is a major threat to the native *Gila modesta*.

Reasons for selection as a priority site: Endemic species, representative biota.

Terrestrial sites: This freshwater site is located entirely within the Monterrey-Saltillo Corridor (4.08).

Active conservation groups: BIOCONSERVACIÓN, Universidad Autonoma Nuevo León.

Contributors: S. Contreras-Balderas

5.26
Name: Potosí
Location: Catarino Rodríguez Ejido, 110 km west of the city of Linares, Nuevo León.
Size: A medium-sized spring that has almost disappeared.
Priority rank: 4
Level of threat: high

Ownership: The land is located entirely inside the Ejido Catarino Rodríguez.

Description of site: The site is a spring that has been drastically reduced in size as a result of water extraction for cattle and surrounding habitat destruction, which have resulted in a lowered water table and pool dessication. The spring now occupies three small pools with a diameter of no more than a meter (Arriaga *et al.* 1998). The original size of the spring is unknown, but from 1968 to 1983 it covered 10,000 m^2, its size most likely enlarged by construction of a dam many years earlier (Contreras and Lozano 1996).

Outstanding biological features: The spring was once inhabited by the catarina pupfish (*Megupsilon aporus*), whose genus is endemic to the region, and by Potosí pupfish (*Cyprinodon alvarezi*). An endemic shrimp species and a crayfish, *Cambarellus alvarezi*, were also found here. This site hosts a bladderwort, *Utricularia* sp. (Family Lentibulariaceae), usually found in acid bogs but uncharacteristically surviving in this hypersaline environment. An orchid has been reported as well. In 1974, specimens of the alien and predatory black bass, *Micropterus salmoides*, were collected at the site. The two endemic fish species are now apparently extinct and the spring water is almost depleted.

Conservation status: The endemic fish and crayfish are considered endangered species, although they may be already extinct in the wild.

Description of threats: The exploitation of the spring water, contained and diverted for irrigation, is among the most serious threats to the site. Agricultural activity has been increasing in this particular ejido. The introduction of the predatory black bass has been a factor in the extinctions of native species.

Reasons for selection as a priority site: This site has educational value as an example of practices with tragic consequences for native species, and of the presence of significant ecological and evolutionary phenomena, including extinction of species. With restoration of the habitat, species now held only in captivity could possibly be reintroduced.

CONABIO sites: This site overlaps with CONABIO site 62.

Terrestrial site: Altiplano Méxicano Nordoriental (4.01).

Active conservation groups: Universidad Autonoma de Nuevo León, BIOCONSERVACIÓN, A.C.

Contributors: S. Contreras-Balderas

5.27
Name: Iturbide
Location: Town and municipality of Iturbide, 100 km south of the city of Monterrey, Nuevo León.
Size: A brook less than 1 km long in a basin measuring approximately 300 km^2.
Priority rank: 4
Level of threat: medium

Ownership: The brook, which runs through a town, is considered public property.

Description of site: This is a permanent brook amid urban development.

Outstanding biological features: An endemic species of fish of the genus *Gila* has been found here. The species has not yet been described and this brook is its only known habitat.

Conservation status: The site contains no protection.

Description of threats: In the midst of urban developments, the brook suffers serious contamination problems and its water is over-exploited for irrigation and other applications. Agricultural expansion and the growing use of insecticides and pesticides have led to the pollution of this water course, threatening to drive the endemic species to extinction before being formally described. Unregulated use of water for agriculture through diversion and excessive pumping for irrigation are among the main factors affecting water quality.

Reasons for selection as a priority site: This area requires further biological inventory.

Terrestrial sites: Altiplano Méxicano Nordoriental (4.01).

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma Nuevo León.

Contributors: S. Contreras-Balderas

5.28
Name: Sandía
Location: Community of Llanos de Salas, Nuevo León.
Size: Closed basin of 1,800 km^2
Priority rank: 4
Level of threat: high

Ownership: Ejido land in its entirety.

Description of site: Sandía is a valley with a closed, relatively large basin in its interior, a dry terminal lagoon, and numerous marginal springs, most of which are dry. The fauna of two springs could be restored through restoration with captive stock. The spring occurs along the eastern face of the Sierra Madre Oriental.

Outstanding biological features: Patterns of endemism in the springs reflect micro-geographic speciation, as each unit sustains its own species. Four endemic species of fish and three shrimp are now extinct. Extant fish species include *Cyprinodon veronicae*, *C. ceciliae*, *C. inmemoriam*, and *C. longidorsalis (*Lozano-Vilano and Contreras-Balderas 1993). Eight endemic species of snails of two monophyletic genera occur here. Two of these species are *Valvata beltrani*, and *V. brisenoi* . Three endemic crayfish of the genus *Cambarellus* have also been described.

Conservation status: Several species are already extinct and the situation is critical. Restoration of the original springs is needed for the survival of extant species

Description of threats: Land conversion for agricultural use has brought increasing exploitation of the groundwater in the area. As a result, the springs have dried and the local fauna has disappeared.

Reasons for selection as a priority site: Site of extreme local endemism, harbors several endemic fish and invertebrates.

Terrestrial sites: The area is included entirely within (4.01).

Active conservation groups: BIOCONSERVACIÓN A.C., Universidad Autonoma de Nuevo León.

Contributors: S. Contreras-Balderas

5.29
Name: Sauz Basin
Location: North of the city of Chihuahua.
Size: Closed basin of approximately 2,700 km^2.
Priority rank: 3
Level of threat: high

Ownership: Land tenure at this site is varied and complex; part of the land operates under ejido regimes, part is divided into small privately-owned properties, and part is communal, probably owned by the municipality.

Description of site: The site is a senescent, closed river basin within a desert scrub, semi-desert grassland community type. The basin contains numerous springs and marginal streams, most of which are dry. Laguna de Encinillas is the only remaining aquatic refuge in the area.

Outstanding biological features: The fish community was first described in 1903 by Meek, who described four species. In 1964, three species were found, and in 1968 a new, rare species of the *Gila* genus was added. Other fish include a pupfish (*Cyprinodon* sp.), a local form of *Notropis lutrensis*, and a *Gambusia* species. The endemic subspecies of *Notropis lutrensis* is an intermediate series between similar subspecies of the Santa Catarina and Conchos rivers that limit the basin to the northwest and southeast, respectively. *Cyprinella* "lutrensis", *Pantosteus plebeius*, *Cyprinodon* "eximius", and *Gambusia* "*affinis*" are thought to have all occurred here.

Conservation status: The entire area is considered under high threat due to the current land use. The endemic fish species are reported as endangered. The long-term persistence of these aquatic habitats is uncertain due to the intensive use of the basin for agricultural purposes, including the construction of irrigation canals and various small dams along tributaries to the basin floor.

Description of threats: The hydrographic regime has been altered through the diversion of water flows with small dams and irrigation ditches for agriculture, resulting in lower and insufficient water levels to support native fish. Farming practices also include the occasional introduction of exotic species for aquacultural production.

Reasons for selection as a priority site: Endemic species and subspecies of fish.

CONABIO sites: The site overlaps with CONABIO site 39.

Terrestrial sites: The site intersects terrestrial site Sierra del Nido (2.01).

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma de Nuevo León.

Contributors: S. Contreras-Balderas

5.30
Name: Cuatrociénegas
Location: A basin 65 km west of the city of Monclova, Coahuila
Size: 11, 600 km^2
Priority rank: 1
Level of threat: medium

Ownership: Mostly ejido land and small private properties.

Description of site: This inter-mountain basin contains many endemic species, especially of fish and molluscs. It is an arid, gypsum-rich region with numerous springs, which local inhabitants call *pozas*. Pozas may be isolated or connected, thermal or cold. Connections between pozas presently are natural streams or man-made canals. Before significant water diversions, the basin supported a very large lake and marsh complex.

Outstanding biological features: Cuatrociénegas has been described as the freshwater Galápagos Islands of North America. The extraordinary adaptive radiation and micro-evolution of bony fishes, aquatic/semi-aquatic reptiles, hydrobiid molluscs, and crustaceans in the basin represents a globally outstanding evolutionary phenomena.

Endemic fish species include Cuatrociénegas killifish (*Lucania interioris*), a platyfish (*Xiphophorus gordoni*), a darter, *Etheostoma lugoi*, Cuatrociénegas gambusia (*Gambusia longispinis*), and one *Notropis* species, two *Cyprinodon* species, and two *Cichlasoma* species. The Cuatrociénegas cichlid (*Herichthys minckleyi*) has two highly distinct morphs, one with sharp rasping teeth to scrape algae and the other with broad molarlike teeth to crush snails.

Half of the 12 crustacean species and 23 of the 34 species of freshwater molluscs, including nine species of snails, are endemic. Some species of snail are restricted to a single small pool. Preliminary surveys suggest that there may be a specialized subterranean fauna in the interconnecting channels. Aquatic and semi-aquatic reptiles inhabiting the pozas include the endemic black softshell turtle (*Apalone ater*), the aquatic box turtle (*Terrapene coahuila*), pond slider (*Trachemys scripta taylor*), and plain-bellied water snake (*Nerodia erythrogaster*) (Conant 1974, Mccoy 1984). This concentration of endemic species is unrivaled in any other xeric freshwater ecoregion and the degree of beta diversity is virtually unrivalled globally.

The extensive wetlands that once covered much of the basin have been largely drained. Vast numbers of migratory waterfowl and shorebirds once relied on the basin as a stopover and wintering area. Restoration of native freshwater systems can help the basin regain this important ecological function.

Conservation status: The wetland and pool complex once covered a much larger area of the basin, but water diversions have greatly reduced its extent to scattered streams and pools. There are currently no documented extinctions in the Cuatrociénegas area, although the loss of vast areas of wetlands and numerous pools, coupled with the apparent extreme local endemism in snails and other invertebrates, suggests some species may already have been lost before being described or documented. Although the freshwater habitats are under threat, the site has maintained more of its ecological integrity than many others in the Chihuahuan Desert. The Mexican government has decreed 84,327 ha as an Area for the Protection of Flora and Fauna.

Description of threats: Pozas and stream waters are diverted for agriculture and domestic use. Consequently, water tables have been substantially lowered and surface waters are reduced in area and depth. Most of the remaining pozas are now inter-connected by subterranean seepage and overland channels, both natural and man-made. Channelization of streams is widespread. The extraction of groundwater beyond its regenerative capacity leads to the depletion of springs. Urban development represents another potential threat. One of the consequences of agricultural expansion is the increasing use of pesticides and insecticides. The effects on the native freshwater biota are unstudied but are potentially devestating based on patterns seen elsewhere. The collection of rare endemic fish and reptiles may pose a significant threat in the future if illicit markets are developed. As elsewhere in the Chihuahuan Desert, introduced fish, plants, and freshwater invertebrates represent an extreme threat. Several exotic species of fish have been introduced, including the Rio Grande cichlid (*Cichlasoma cyanoguttatus pavonaceus*) and largemouth bass (*Micropterus salmoides*). Several new introduced fish species were found in the last year alone. The alien water hyacinth has been established at a few sites and should be regarded as a potent threat to all freshwater systems.

Reasons for selection as a priority site: The spatial and evolutionary complexity of freshwater biodiversity patterns is virtually unrivaled in the world. Numerous endemic species in a range of taxa, as well as highly unusual adaptations (e.g., aquatic box turtles) and evolutionary patterns make this site a global conservation priority.

CONABIO Sites: Freshwater site 48 and terrestrial site 55.

Terrestrial sites: The site coincides with terrestrial site Cuatrociénegas (3.03).

Active conservation groups: Instituto Nacional de Ecología, Desert Fishes Council, PROFAUNA, Universidad Autonoma Antonio Narro, Universidad Autonoma de Nuevo León, Desuvalle A.C., Ducks Unlimited Mexico, North American Wetland Conservation Council, The Nature Conservancy, Northeast Mexico Program.

Contributors: W. Minckley, S. Contreras-Balderas.

5.31
Name: Venado
Location: North of the city of San Luis Potosí.
Size: A surface of approximately 3,000 km^2.
Priority rank: 3
Level of threat: medium

Ownership: Land ownership distribution is varied and complex, including ejido, communal, and small private properties. It has not been determined if part of the land is federal, state, or municipal property.

Description of site: The site is a group of springs remaining from a historic river for which no terminal lagoon has been identified. It is a mostly flat, low relief valley where the existing water can be considered a remainder of larger, historic water bodies. The impact on the surface water has reached levels of 98% for the general basin and around 60% for the spring.

Outstanding biological features: There are two endemic, highly endangered fish species, belonging to the Goodea group, in addition to a very rare fresh water shrimp. One form of the complex of goodeids *Xenoophorus* sp., composed of three nominal species and five populations, is present, however there are no recent revisions for this group. The shrimp, *Procambarus* sp., is undescribed, and rare.

Conservation status: Due to the near-extinction of the aquatic species in the area, the preservation status is considered highly sensitive, notwithstanding the generally good conservation level of the terrestrial site.

Description of threats: Unregulated groundwater extraction is causing the depletion of the area's water resources and freshwater habitats. Habitat fragmentation caused by water diversion is exerting strong pressure on the survival of native fish and shrimp populations. Additionally, the springs are exploited as recreational facilities without regulations or control.

Reasons for selection as a priority site: Endemic species, representation of species assemblage, and the need for further biological inventory.

Terrestrial sites: Huizache-Cerritos (4.02).

CONABIO Sites: This site is downstream from freshwater site 54, Venado.

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma de Nuevo León.

Contributors: S. Contreras-Balderas

5.32
Name: Media Luna/Río Verde
Location: Río Verde, east of San Luis Potosí.
Size: This site is an immense freshwater spring with numerous, smaller and semi-independent springs located in the vicinity, extending over a surface of approximately 10,000 km^2.
Priority rank: 1
Level of threat: high

Ownership: Mostly ejido and communal lands with small private properties.

Description of site: The Laguna Media Luna area is formed by a great spring where several endemic fish species and crustaceans occur. The main lagoon is in the shape of a half-moon and is up to 50 m deep. The water is clear, warm, sulfurish, and contains submerged and floating plants. The course of the Río Verde passes through a portion of the Rio Panuco basin, which delimits the Salado region to the south. The area is located in a region with abundant hot springs in limestone.

Outstanding biological features: The ichthyofauna of the Río Verde Headwaters is comprised of 11 species, nine of which are endemic. Among these are the rare flatjaw minnow (*Dionda mandibularis*), known from only two springfed locations, and the bicolor minnow (*D. dichroma*), also restricted to springfed headwater habitats. Within La Medialuna are the Medialuna killie (*Cualac tessellatus*) and the striped goodeid (*Ataeniobius toweri*), both of which represent monotypic genera. La Medialuna is also home to the Mojarra aracolera (*Cichlasoma bartoni*) and the yellow mojarra (*Cichlasoma.* sp.), the La Medialuna shrimp (*Palaemonetes lindsayi*), the La Medialuna crayfish (*Procambarus roberti*), and the crayfish's obligatory parasite, the La Medialuna ostracod (*Ankylocythere barbouri*). The crayfish is a highly disjunct member of its subgenus and may represent a relict crayfish stock that migrated southward into Mexico during the Pliocene. While the animal endemism and richness are remarkable, the presence of the bald cypress tree (*Taxodium tares*) is as well. This tree is commonly associated with sub-tropical habitats.

Conservation status: There are no apparent legal or administrative ordinances for the site's conservation. However, the site is generally well conserved with a relatively low degree of alteration and disturbance. Outdoor tourism occurs in the area. The Río Verde area is reportedly 80% disturbed and is therefore considered threatened with regard to local species.

Description of threats: The conversion of land from natural habitat into seasonal agricultural parcels is the major problem in the area. Additionally, there has been a recent increase in housing developments in the area that has led to the increasing extraction of water from the lagoon. Water use for irrigation and human consumption will continue to effect native habitats and species if unchecked. In addition, unregulated tourism and recreational activities have led to pollution, poaching, and illegal harvest of cacti in terrestrial habitats.

Reasons for selection as a priority site: Cluster of endemic species, representation of species assemblages, and a need for further biological inventories.

CONABIO sites: The site partially overlaps with 93 and completely overlaps site 94.

Terrestrial sites: Huizache-Cerritos (4.02).

Active conservation groups: State of San Luis Potosí

Contributors: S. Contreras-Balderas.

5.33
Name: Río Cadena
Location: Southeast of the city of Chihuahua and southwest of the Mapimí region, Durango.
Size: The extension of an interior river basin and a lagoon that cover approximately 18,000 km^2.
Priority rank: 2
Level of threat: high

Ownership: The area is mostly privately owned.

Description of the site: The site is formed by an interior (closed) basin, formerly part of the Río Grande basin. It is mostly flat with few, small hills, a seasonal terminal lagoon, and several remaining springs.

Outstanding biological features: The river is home to four endemic Chihuahuan Desert fish species currently considered to be relict populations of species derived from the Rio Grande basin: Mexican stoneroller (*Campostoma ornatum*), Ornate shiner (*Codoma ornata*), a chub (*Gila* sp.), and a shiner *Cyprinella garmani*. At least one fish is soon to be described.

Conservation status: Although the site is more intact than many other Chihuahuan freshwater habitats, the fish species are threatened from destructive agricultural practices.

Description of threats: The area has registered a sharp increase in agricultural activities. Water diversion and groundwater extraction threaten native species and habitats. The use of water for agriculture poses risks of groundwater contamination due to the use of pesticides, insecticides, fertilizers, and other chemicals employed in crop production. Additionally, irrigation canals and diversions reduce and fragment the habitat of native species.

Reasons for selection as a priority site: Representative and endemic species assemblages.

CONABIO sites: Number 81

Terrestrial sites: Mapimi complex (3.01).

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma de Nuevo León.

Contributors: S. Contreras-Balderas

5.34
Name: Extorax, see terrestrial site description for Chihuahua Querétaro Desert (4.03).

5.35
Name: Upper Conchos, see terrestrial description for Conchos River Headwaters (2.15).

5.36
Name: San Diego (5.36)
Location: San Diego de Alcalá, Chihuahua.
Size: San Diego de Alcalá is a hot spring area covering approximately 100 ha.
Priority rank: 2
Level of threat: high

Ownership: Private lands.

Description of site: A high-temperature spring in a semi-desert grassland. The hot spring is located on and at the sides of a small hilltop located in a wide valley of the Conchos River basin.

Outstanding biological features: This hot spring is habitat for several endemic fish species such as *Cyprinidon pachycephalus* and an undescribed *Gambusia* species, which survive in water temperatures as high as 43º to 44º C, the highest known temperatures inhabited by freshwater fish in the world. It also harbors a sphaeromatied isopod and two hydroboiid snails. In the neighboring Río Chuviscas, a unionid clam and fish characteristic of the Río Conchos are present.

Conservation status: Although not yet critical, native habitats and species continue to be threatened by overgrazing and groundwater extraction.

Description of threats: Land conversion associated with agricultural expansion and extensive goat browsing are the most significant threats to the site. These problems are compounded by the development of relatively close urban centers that extend highways and housing into the area. Molluscs and other invertebrates that inhabit the area are threatened by unregulated bathing. Irrigation canals and ditches alter river flows and cause habitat fragmentation and loss.

Reasons for selection as a priority site: Unique adaptations of freshwater species to high temperatures, some endemic species, relatively intact habitats.

Active conservation groups: BIOCONSERVACIÓN, A.C., and Universidad Autonoma de Nuevo León.

Contributors: S. Contreras-Balderas

5.37
Name: Upper Gila
Location: SW New Mexico
Priority Rank: 1
Level of threat: medium

Ownership: US Forest Service-Gila National Forest and Apache-Sitgreaves National Forest, private, Phelps-Dodge Mining Company, The Nature Conservancy of Arizona, San Carlos Indian Reservation

Description of site: In the upper watershed, tributaries begin as high-gradient cold water streams and in lower elevations become moderate gradient warm water rivers (Sublette *et al.* 1990).

Gila Headwaters: The headwaters begin in Rocky Mountain conifer forest community types then flow through Madrean evergreen woodland, and finally Great Basin conifer woodlands. Riparian zones of Fremont and Narrowleaf Cottonwoods (*Populus fremontii* and *P. angustifolia*), Arizona sycamore (*Platanus wrightii*), Arizona Walnut (*Juglans major*), and Arizona Alder (*Alnus firmifolia*).

Gila Forks to Bird Area: The area in between the forks of the Gila river and the "bird area", is characterized by Great Basin conifer woodland and semi-desert grassland community types. The river is lined by a riparian gallery forests of Arizona sycamore and Fremont cottonwood.

San Francisco and Blue Rivers to Morenci: These rivers run through rugged deep canyons, surrounded by Madrean evergreen woodland, Great Basin conifer woodlands, and Rocky Mountain conifer forest communities. The riparian zones consist of Fremont cottonwood, Goodding's willow (*Salix gooddingii*), Arizona sycamore, Arizona walnut, and mesquite.

Harden Cienega: This wetland lies in a narrow canyon within the Great Basin conifer woodland community type of pinyon and juniper.

Eagle Creek: The creek runs through Madrean evergreen woodland in its headwaters downstream into a semi-desert grassland as it nears Morenci.

Bonito Creek: The terrain surrounding the length of the creek ranges from plains and Great Basin grasslands, semi-desert grassland, and Sonoran desert scrub.

Outstanding biological features:
Gila Headwaters: The native fish species are speckled dace (*Rhinichthys osculus*) and Gila trout (*Oncorhynchus gilae*). Two rare springsnails, Hot springs snail (*Pyrgulopsis thermalis*), and Gila spring snail (*Pyrgulopsis gilae*) inhabit springs and the mainstem. Otter (*Lutra canadensis sonora*), were last reported in the region in the 1930's.

Gila Forks to Bird Area: Native fish species are spikedace (*Meda fulgida),* loach minnow (*Tiaroga cobitis),* roundtail chub (*Gila robusta*), and *Gila nigra*, a newly described species by Minckley.

San Francisco and Blue Rivers: Its three native fish species are loach minnow, speckled dace, and Gila trout.

Harden Cienega: Gila chub (*Gila intermedia*) once occupied portions of the upper Gila basin but is now found only in Harden Cienega.

Eagle Creek: Several species of native desert fishes occur here: Spikedace, loach minnow, speckled dace, roundtail chub, longfin dace (*Agosia chrysogaster*), desert sucker (*Catostomus clarkii*), and Sonora sucker (*Catostomus insignis*). The creek may have had Gila trout and Gila chub historically. Razorback suckers (*Xyrauchen texanus*) were re-introduced in the 80s but they have not survived.

Bonita Creek: Razorback suckers were re-introduced in 1991. Gila chub, longfin dace, speckled dace, Sonora sucker, and desert sucker all occur here. Only the lower 5 km are contaminated with exotics from Gila River; the upper 16 km are virtually exotic free.

Conservation status:
Gila Headwaters to Forks: The headwaters flow through Gila Wilderness Area. Livestock grazing has been removed from up to 120 km of the river.

Forks to Bird Area: This area is a mix off U.S. Forest Service and and few private lands until the Cliff-Gila Valley, where up to 80% of the lands are private. The Bird Area was once managed intensively by the Gila National Forest as a Mexican black duck area. Despite the lack of special management status, the area is managed seperately from surrounding lands, including fencing and bank stabilization projects.

San Francisco and Blue River to Morenci: The Apache-Sitgreaves National Forest has proposed wilderness in Arizona, in addition to its existing Blue Wilderness Area. The San Francisco has been proposed as a Wild and Scenic River.

Harden Ciénega: There is no protection for this area.

Eagle Creek- This site does not have protection and flows primarily through private lands.

Bonito Creek: A 24-km portion of this creek is included in the Gila Box Riparian National Conservation Area and has been proposed for Wild and Scenic River status.

Description of threats: Overgrazing in uplands impacts entire watershed through erosion, soil compaction, and riparian vegetation degradation. Channelization and water diversions are a continuing threat. In Eagle Creek, exotic fish and exotic vegetation have degraded fish habitat. In addition, water is pumped out of Eagle Creek by Phelps Dodge for their mining operations on the Black River. Future exotic fish introduction is expected with increases in recreational fishing on U.S. Forest Service lands. Off-road vehicle use throughout the headwaters increases erosion and alters in-stream habitat.

Reasons for selection as a priority site: Representation of species assemblages and intact riverine habitats.

Active conservation groups: The Nature Conservancy of New Mexico and TNC Arizona, Center for Biological Diversity, The Wildlands Project-Sky Island Alliance.

Freshwater sites: Gila River Lower and Middle Box (1.25), and Lower Gila River (1.14)

Contributors: P. Mehlhop, D. Propst

Appendix G : Species List of Plants and Animals of the Workshop

Common Name	Scientific Name
Fish Species by Family	
Gar-Lepisosteidae	
Gar, longnose	*Lepisotus osseus*
Minnows & Carps-Cyprinidae	
Carpita de Saltillo	*Gila modesta*
Carp, common	*Cyprinus carpio*
Carp, Japanese	*Carassius auratus*
Carpsucker, river	*Carpiodes carpio*
Chub	*Gila nigra*
Chub, Chihuahua	*Gila nigrescens*
Chub, desert	*Gila eremica*
Chub, gila	*Gila intermedia*
Chub, Nazas	*Gila conspersa*
Chub, roundtail	*Gila robusta*
Chub, speckled	*Macrhybopsis aestivalis*
Chub, Yaqui	*Gila purpurea*
Dace, longfin	*Agosia chrysogaster*
Dace, speckled	*Rhinichthys osculus*
Dace, spike	*Meda fulgida*
Minnow (Panuco/Extorax)	*Dionda catostompops*
Minnow (Panuco/Extorax)	*Dionda erymizonops*
Minnow (Panuco/Extorax)	*Dionda ipni*
Minnow (Panuco/Extorax)	*Dionda rasconis*
Minnow, bicolor	*Dionda dichroma*
Minnow, bullhead	*Pimephales promelas*
Minnow, Devil's river	*Dionda diaboli*
Minnow, flathead	*Pimephales promelas*
Minnow, flatjaw	*Dionda mandibularis*
Minnow, loach	*Tiaroga cobitis*
Minnow, manantial round-nosed	*Dionda argentosa*
Minnow, round-nosed	*Dionda epsicopa*
Minnow, Rio Grande silvery	*Hybognathus amarus*
Minnow, stumptooth	*Stypodon signifer*
Shiner (La Concha)	*Cyprinella alvarezdelvillari*
Shiner (Río Cadena)	*Cyprinella garmani*
Shiner, beautiful	*Cyprinella formosa*
Shiner, blacktail	*Cyprinella venusta*
Shiner, Chihuahua	*Notropis chihuahua*
Shiner, largemouth	*Notropis bocagrande*
Shiner, ornate	*Codoma ornata*
Shiner, Pecos bluntnose	*Notropis simus peocsensis*
Shiner, phantom	*Notropis orca*

Common Name	Scientific Name
Shiner, proserpine	*Cyprinella proserpina*
Shiner, red	*Notropis lutrensis*
Shiner, Rio Grande	*Notropis jemzanus*
Shiner, Rio Grande bluntnose	*Notropis simus simus*
Shiner, sand	*Notropis ludibundus*
Shiner, Tamaulipan	*Notropis braytoni*
Shiner, Texas	*Notropis amabilis*
Squawfish, Colorado	*Ptychocheilus lucius*
Stoneroller, Mexican	*Campostoma ornatum*
Suckers-Catostomidae	
Sucker (Río Nazas)	*Pantosteus guzmaniensis*
Sucker, Bavispe	*Catostomus leopoldi*
Sucker, blue	*Cycleptus elongatus*
Sucker, desert	*Catostomus clarki*
Sucker, flannelmouth	*Catastomus latipinnas*
Sucker, Opata	*Catostomus wigginsi*
Sucker, razorback	*Xyrauchen texanus*
Sucker, Rio Grande	*Pantosteus plebeius*
Sucker, Sonora	*Catostomus insignis*
Sucker, Yaqui	*Catostomus bernardini*
Redhorse, Gray	*Moxostoma congestum*
Characidae	
Tetra, Mexican	*Astyanax mexicanus*
Bullhead Catfish-Ictaluridae	
Blindcat, Mexican	*Prietella phreatophila*
Bullhead, Black	*Ameiurus melas*
Catfish, bullhead	*Ameiurus sp.*
Catfish, channel	*Ictalurus punctatus*
Catfish, flathead	*Pylodictis olivaris*
Catfish, headwater	*Ictalurus lupus*
Catfish, Yaqui	*Ictalurus pricei*
Trout-Salmonidae	
Trout, Apache	*Oncorhynchus apache*
Trout, Brown	*Salmo trutta*
Trout, Gila	*Oncorhynchus gilae*
Trout, rainbow	*Oncorhynchus mykiss*
Topminnows-Fundulidae	
Killifish, Cuatrociénegas	*Lucania interioris*
Live-bearers-Poeciliidae	
Gambusia (Panuco/Extorax)	*Gambusia atrora*
Gambusia (Parras)	*Gambusia speciosa*
Gambusia, Big Bend	*Gambusia gaigei*
Gambusia, bighead	*Gambusia pacycephalus*
Gambusia, blotched	*Gambusia senilis*
Gambusia, Cuatrociénegas	*Gambusia longispinus*
Gambusia, Pecos	*Gambusia nobilis*
Gambusia, robust	*Gambusia marshi*

Common Name	Scientific Name
Guayacón de Hacienda Dolores	*Gambusia hurtadoi*
Guayacón de San Gregorio	*Gambusia alvarezi*
Guppy, fancy	*Poecilia reticulata*
Mosquitofish	*Gambusia affinis*
Platyfish, Cuatrociénegas	*Xiphophorus gordoni*
Platyfish (Panuco/Extorax)	*Xiphophorus contines*
Platyfish (Panuco/Extorax)	*Xiphophorus cortezi*
Platyfish (Panuco/Extorax)	*Xiphophorus multilineatus*
Platyfish (Panuco/Extorax)	*Xiphophorus nigrensis*
Platyfish, pygmy	*Xiphophorus pygmaeus*
Topminnow, Gila	*Poeciliopsis occidentalis occidentalis*
Topminnow, Sonora	*Poeciliopsis occidentalis*
Topminnow, Yaqui	*Poeciliopsis o. sonoriensis*
Swordtail Montezuma	*Xiphophorus montezumae*
Swordtail (Panuco/Extorax)	*Xiphophorus variatus*
Splitfin, relict	*Xiphophorus nezahualcoyotl*
Swordtail, marbled	*Xiphophorus meyeri*
Silversides-Atherinidae	
Chirostoma	*Chirostoma mezquital*
Splitfins-Gooidae	
Characodon, Rainbow	*Characodon lateralis*
Goodea, dusky	*Goodea gracilis*
Splitfin, bluetail	*Ataeniobius toweri*
Cyprinodontidae	
Killie, Media Luna	*Cualac tessellatus*
Pupfish (Sandía)	*Cyprinodon ceciliae*
Pupfish (Sandía)	*Cyprinodon inmemoriam*
Pupfish (Sandía)	*Cyprinodon longidorsalis*
Pupfish (Sandía)	*Cyprinodon veronicae*
Pupfish (Guzman)	*Cyprinodon carbonaria*
Pupfish, Bighead	*Cyprinodon pachycephalus*
Pupfish, Catarina	*Megupsilon aporus*
Pupfish, Comanche Springs	*Cyprinodon elegans*
Pupfish, Conchos	*Cyprinodon eximius*
Pupfish, Desert	*Cyprinodon macularius*
Pupfish, largescale	*Cyrpinodon macrolepis*
Pupfish, Leon Springs	*Cyprinodon bovinus*
Pupfish, Nazas	*Cyprinodon nazas*
Pupfish, Parras	*Cyprinodon latifasciatus*
Pupfish, Pecos	*Cyprinodon pecosensis*
Pupfish, Potosí	*Cyrpinodon alvarezi*
Pupfish, White Sands	*Cyprinodon tularosa*
Sunfish & Bass-Centrarchidae	
Bass, black or large-mouth	*Micropterus salmoides*
Bass, small-mouth	*Micropterus dolomieu*
Bluegill	*Lepomis macrochirus*
Sunfish, longear	*Lepomis megalotis*

Common Name	Scientific Name
Sunfish, redbreast	*Lepomis auritus*
Darters-Percidae	
Darter (Cuatrociénegas)	*Etheostoma lugoi*
Darter (Zona Carbonifera)	*Etheostoma segrex*
Darter, greenthroat	*Etheostoma lepidum*
Darter, Mexica	*Etheostoma pottsi*
Darter, Rio Grande	*Etheostoma grahami*
Logperch, big scale	*Percina macrolepida*
Cichlids-Cichlidae	
Cichlid (Panuco/Extorax)	*Cichlasoma labridens*
Cichlid (Panuco/Extorax)	*Cichlasoma cyanostictum*
Cichlid, Cuatrociénagas	*Cichlasoma minckleyi*
Chichlid, Medialuna	*Cichlasoma bartoni*
Cichlid, Rio Grande	*Cichlasoma cyanoguttatum pavonaceus*
Mojarra, aracolera	*Cichlasoma bartoni*
Amphibians & Reptiles by Family	
Barking Frog-Leptodactylidae	
Frog, Eastern Barking	*Eleutherodactylus augusti latrans*
True Frogs-Ranidae	
Bullfrog	*Rana catesbeiana*
Frog, Chiricahua leopard	*Rana chiricahuensis*
Frog, Lowland leopard	*Rana yavapaiensis*
Frog, Huachuca leopard	*Rana huachucensis*
Frog, Ramsey Canyon leopard	*Rana subvocalis*
Frog, Tarahumara	*Rana tarahumarae*
Salamander-Ambystomatidae	
Salamander, Huachuca tiger	*Ambystoma tigrinum stebbinsi*
Spadefoot Toad-Pelobatidae	
Toad, Plains spadefoot	*Scaphiopus bombifrons*
True Toad-Bufonidae	
Toad, Woodhouse	*Bufo woodhousei*
Mud Turtle-Kinosternidae	
Turtle, Chihuahuan mud	*Kinosternon hirtipes*
Turtle, black softshell	*Apalone ater*
Turtle, spiny softshell	*Apalone spiniferus*
Box Turtles-Emydidae	
Cooter, river	*Pseudemys concinna*
Slider, Big Bend	*Trachemys gaigeae*
Slider, pond	*Trachemys scripta taylor*
Turtle, box	*Terrapene ornata*
Turtle, aquatic box	*Terrapene coahuila*
Turtle, Sonoran box	*Terrapene ornata var. luteola*
Land Tortoises-Testudinidae	
Tortoise, bolsón	*Gopherus flavomarginatus*
Tortoise, Desert	*Gopherus agassizii*
Geckos-Gekkonidae	
Gecko, reticulated	*Coleonyx reticulatus*

Common Name	Scientific Name
Gecko, Texas banded	*Coleonyx brevis*
Lizards-Iguanidae	
Lizard, bunchrass	*Sceloporus scalaris*
Lizard, sand dune	*Sceloporus graciosus arenicolous*
Lizard, tree	*Urosaurus ornatus*
Lizard, Yarrow'spiny	*Sceloporus jarrovii*
Skink-Scinicidae	
Skink, ground	*Sincella lateralis*
Whiptails-Teiidae	
Whiptail, canyon spotted	*Cnemidophorus burti*
Whiptail, checkered	*Cnemicdophorus grahami*
Whiptail, Dixon's spotted	*Cnemidophorus dixoni*
Whiptail, marbled	*Cnemidophorus tigris marmoratus*
Whiptail, New Mexico	*Cnemidophorus neomexicana*
Alligator Lizard-Anguidae	
Alligator lizard, Madrean	*Gerrhonotus kingii*
Venomous Lizards-Helodermatidae	
Monster, gila	*Heloderma suspectum*
Snakes-Colubridae	
Gartersnake, Mexican	*Thamnophis eques*
Kingsnake, gray-banded	*Lampropeltis alterna*
Kingsnake, Arizona mountain	*Lampropeltis pyromelana pyromelana*
Kingsnake, Sonoran mountain	*Lampropeltis pyromelana*
Rat snake, Trans-Pecos	*Elaphe subocularis*
Ribbonsnake, arid land	*Thamnophis proximus*
Watersnake, blotched	*Nerodia erythrogaster*
Watersnake, plain-bellied	*Nerodia rhombifera*
Snake, vine	*Oxybelus aeneus*
Snake, cat-eyed	*Leptodeira punctata*
Vipers-Viperidae	
Massasaugas, desert	*Sistrurus catenatus*
Ratsnake, Trans-Pecos	*Bogertrophis subocularis*
Rattlenake, Mojave green	*Crotalus scutulatus scutulatus*
Rattlesnake, ridge-nosed	*Crotalus willardi*
Rattlesnake, twin-spot	*Crotalus pricei*
Invertebrates- by Phylum	
Mollusks-Phylum Mollusca	
Helicacea	
Land snail (Animas Mts.)	*Sonorella animasensis*
Land snail (San Andres Mts.)	*Sonorella socorroensis*
Land snail (San Andres/Organ)	*Sonorella orientis*
Orthalicacea	
Land snail (Organ Mts.)	*Holospira pyrgonasta*
Land snail (Chiricahuas)	*Holospira chiricahuana*
Polygyridae	
Land snail (Animas Mts.)	*Ashmunella animasensis*
Land snail (Chiricahuas)	*Ashmunella chiricahuana*

Common Name	Scientific Name
Land snail (Organ Mts.)	*Ashmunella auriculata*
Land snail (Organ Mts.)	*Ashmunella organensis*
Land snail (Organ Mts.)	*Ashmunella todseni*
Land snail (San Andres)	*Ashmunella paeonis*
Rissoacea	
Spring snail (Pecos River)	*Assiminea pecos*
Spring snail, chupadera	*Pyrgulopsis chupadera*
Spring snail, Hot	*Pyrgulopsis thermalis*
Spring snail, Gila	*Pyrgulopsis gilae*
Spring snail, Pecos	*Pyrgulopsis pecosensis*
Spring snail, Rosewell	*Pyrgolopsis roswellensis*
Spring snail (DiamondY)	*Tryonia stocktonensis*
Spring snail (Pecos River)	*Tryonia adamantina*
Spring snail (Pecos River)	*Tryonia kosteri*
Spring snail, San Bernadino	*Fontelicella sp.*
Spring snail, Yepomera	*Fontelicella sp.*
Tryonia, Yepomera	*Tryonia sp.*
Unionoidea	
Mussell, Texas hornshell	*Popenaias popeii*
Valvatacea	
Spring snail (Sandía)	*Valvata beltrani*
Spring snail (Sandía)	*Valvata briesenoi*
Arthropods-Phylum Arthropoda	
Crustaceans-Class Crustaceae	
Order Amphipoda	
Amphipod, Noel's	*Gammarus desperatus*
Amphipod, hadzioid	*Mexiweckelia colei*
Amphipod, hadzioid	*Paramexiweckelia particeps*
Order Anostraca	
Shrimp, fairy	*Streptocephalus texanus*
Order Cladocera	
Waterflea	*Moina wierejskii*
Order Decapoda	
Crayfish (Potosí)	*Cambarellus alvarezi*
Crayfish, Media Luna	*Procambarus roberti*
Shrimp, medialuna	*Palaemonetes lindsayi*
Order Diplostraca	
Shrimp, clam	*Eulimnadia texana*
Order Isopoda	
Isopod, cirolanid	*Speocirolana thermydronis*
Isopod, cirolanid	*Sphaerolana affinis*
Isopod, cirolanid	*Sphaerolana interstitialis*
Isopod, stenasellid	*Mexistenasellus coahuila*
Order Maxillopoda	
Ostracod, medialuna	*Ankylocythere barbouri*
Insects-Class Insecta	
Odonta-Dragon and Damselflies	

Common Name	Scientific Name
Dragonfly (Bitter Lake)	*Anax walsinghami*
Damselfly (Bitter Lake)	*Archilestes grandis*
Damselfly (Bitter Lake)	*Ischnura hastata*
Ants-Formicidae	
Ant, carpenter	*Camponotus sp.*
Ant	*Leptothorax sp.*
Ant	*Trachymyrmex carinatus*
Ant, harvester	*Pogonomyrmex sp.*
Ant, honey pot	*Myrmecocystus sp.*
Scarabaeidae	
Beetle	*Plusiotus woodii*
Beetle	*Plusiotus beyeri*
Meloidae	
Beetle, Anthony blister	*Lytta mirifica*
Cicindeliaea	
Beetle, Tiger	*Amblychila barroni*
Beetle, Tiger	*Amblychila cylindriformis*
Fireflies-Lampyridae	
Firefly	
Gossamer Wing Butterflies-Lycaenidae	
Hairstreak, Poling’s	*Fixenia polingi*
Metalmark (Chisos Mts.)	*Apodemia nais chisosensis*
Metalmark, crescent	*Apodemia phyciodoides*
Nymphalidae	
Butterfly, viceroy	*Limenitis archippus obsoleta*
Butterfly, Monarch	*Danaus plexippus*
Checkerspot, Chinati	*Thessalia chinatiensis*
Fritallary, Nokomis	*Speyeria nokomis corulescensis*
Saturniidae	
Moth	*Rothchildia sp.*
Moth, polyphemus	*Antheraea polyphemus*
Prodoxidae	
Moth, yucca	*Tegeticula yuccasella*
Camel Crickets-Gryllacirdadeae	
Cricket, camel (Mescalero)	*Ammobamentes mescalero*
Cricket, camel (White Sands)	*Dahineodes inurale*
Cricket, camel (Organ Mts.)	*Centhophilus sp.*
Cricket, Jerusalem	*Stemopelmatus mescalero*
Shorthorn Grasshoppers-Acridieae	
Grasshopper, Tinkham’s desert	*Anconia hebardi*
Grasshopper,	*Shotwellia isleta*
Grasshopper (White Sands)	*Cibolacris samalayucae*
Grasshopper, bandwing	*Trimerotropis sp.*
Grasshopper, Lichen	*Leuronotina ritensis*
Saltatoria-Katydid	
Mescalero katydid	*Plagiostiera mescalero*
Arachnida-Spiders and Scorpions	

Common Name	Scientific Name
Scorpion	*Vaejovis minckley*
Scorpion	*Serradigitus calidus*
Scorpion	*Paruroctonus willimasi*
Plants by Major Form	
Grasses-	
Bermuda grass	*Cynodon dactylon*
Bluestem, sand	*Andropogon halli*
Bluestem, little	*Schizachryrium scoparium*
Buffalo-grass, false	*Munroa squarrosa*
Burrograss	*Scleropogon brevifolius*
Cane, giant	*Arundo donax*
Chino grass	*Bouteloua ramosa*
Dropseed, giant	*Sporobolus giganteus*
Dropseed, mesa	*Sporobolus flexuosus*
Fluffgrass	*Dasyochloa pulchella*
Gypgrass	*Sporobolus nealleyi*
Grama, black	*Bouteloua eriopoda*
Grama, blue	*Bouteloua gracilis*
Grama, gyp	*Bouteloua breviseta*
Grama, hairy	*Bouteloua hirsuta*
Grama, sideoats	*Bouteloua curtipendula*
Johnson grass	*Sorghum halapense*
Lovegrass, Lehmann	*Eragrostis lehmanniana*
Mesquitegrass, curly	*Hilaria berlangeri*
Muhly, bush	*Muhlenbergia porteri*
Muhly, scratch	*Muhlenbergia asperifolia*
Needlegrass	*Stipa tennuissima*
Needlegrass, New Mexico	*Stipa neomexicana*
Sacaton, alkali	*Sporobolus airoides*
Sacaton, big alkali	*Sporobolus wrightii*
Saltgrass	*Distichlis sp.*
Salt-mat grass	*Monanthochloe littoralis*
Sprangletop	*Diplachne dubia*
Three-awn	*Aristida divaricata*
Three-awn	*Aristida wrightii*
Three-awn	*Aristida barbata*
Tobosa	*Hilaria mutica*
Aquatic Plants	
Bladderwort	*Utricularia sp.*
Bladderwort	*Utricularia gibba*
Bulrush	*Scirpus sp.*
Bulrush, hardstem	*Scirpus acutus*
Cattails	*Typha domingensis*
Fuirena	*Fuirena simplex*
Pondweed	*Potamogeton nodosus*
Reed, common	*Phragmites communis*
Schoenus	*Schoenus nigricans*

Common Name	Scientific Name
Water-lily	*Nymphaea ampla*
Water-nymph	*Najas marina*
Widgeon-grass	*Ruppia maritima*
Cacti	
Barrelcactus	*Ferocactus echidne*
Cactus (Samalayuca)	*Echinocactus parryi*
Cereus, night blooming	*Peniocereus greggii*
Chaute	*Ariocarpus retusus*
Cholla, Christmas	*Opuntia leptocaulis*
Cholla, Klein's (tasajillo)	*Opuntia kleinae*
Cholla, organillo	*Opuntia brandtiana*
Cholla, walking stick	*Opuntia spinosior*
Cholla, silver	*Opuntia imbricata var. argentea*
Cory cactus, Nellie	*Coryphantha minima*
Hedgehog Chisos Mt.	*Echinocereus chisoensis*
Hedgehog	*Echinocereus delaetii*
Hedgehog	*Echinocereus engelmannii*
Living rock	*Ariocarpus agavoides*
Living rock	*Ariocarpus fissuratus*
Pincushion, Big Hatchet	*Coryphantha sneedii var. orcutti*
Pincushion, Guadalupe	*Coryphantha sneedii var. guadalupensis*
Pincushion, Lee's	*Coryphantha sneedii var. leei*
Pincushion, Scheer's	*Coryphantha scheeri var. scheeri*
Pincushion, Sneed's	*Coryphantha sneedii var. sneedii*
Pincushion, Sandberg's	*Escobaria sandbergii*
Pitaya, Davis green	*Echinocereus davisi*
Prickly pear	*Opuntia cantabrigiensis*
Prickly pear (nopal lasaron)	*Opuntia stenopetala*
Prickly pear, Engelmann	*Opuntia engelmannii*
Prickly pear, golden-spine	*Opuntia aureispina*
Prickly pear, purple	*Opuntia phaeacantha*
Prickly pear, sand	*Opuntia arenaria*
Prickly poppy (gypsum)	*Argemone turneri*
Saguaro	*Carnegiea giganteus*
Sand dollar cactus	*Astrophytum asterias*
Thelocactus	*Thelocactus conthelos*
Forbs	
Ballmoss	*Tillandsia recurvata*
Beardtongue, scarlet-tube	*Penstemon barbatus*
Bedstraw	*Gallium carmenicola*
Blanketflower	*Gaillardia comosa var. gypsophila*
Blanketflower	*Gaillardia pinnatifida var. turneri*
Bluet, Jackie's	*Hedyotis pooleana*
Buckwheat, gypsum	*Eriogonum gypsophyllum*
Cat's-eye's, Terlingua Creek	*Cryptantha crassipes*
Coldenia, hairy	*Tiquilia hispidissima*
Eurphorbia	*Euphorbia carunculata*

Common Name	Scientific Name
Euphorbia, Parry	*Euphorbia parryi*
Euphorbia, Henrickson	*Euphorbia henricksonii*
Evening primrose, Organ Mt.	*Oenothera organensis*
Fryxellia	*Fryxellia pygmaea*
Groundsel, broom	*Senecio riddellii*
Heliotrope, bindweed	*Heliotropium convolvulaceum*
Holly, desert	*Acourtia nana*
Ladie's tresses, Canelo Hills	*Sprianthes delitescens*
Leaf-flower	*Phyllanthus ericoides*
Machaeranthera	*Machaeranthera restiformis*
Mancoa	*Mancoa henricksonii*
Meadow-rue	*Thalictrum henricksonii*
Milkwort	*Polygala maravillasensis*
Moonpod, gypsum	*Selinocarpus lanceolatus*
Pennyroyal, old blue	*Hedeoma pilosum*
Pennyroyal, Todsen's	*Hedeoma todseni*
Penstemon, Plains	*Penstemon ambiguus*
Pickleweed	*Salicornia virginica*
Pin-weed, Chisos	*Lechea mensalis*
Raphanorhyncha	*Raphanorhynca crassa*
Reverchonia, sand	*Reverchonia arenaria*
Rock-daisy, Glass Mts.	*Perityle vitreomontana*
Rock-daisy, Hueco	*Perityle huecoensis*
Rock-daisy, Lemmon's	*Perityle lemmonii*
Rock-daisy, nodding	*Perityle cernua*
Rock-daisy, stairstep two bristle	*Perityle bisetosa var. scalaris*
Rock-trumpet	*Macrosiphonia macrosiphon*
Rue, African	*Peganum harmala*
Sandwort, Livermore	*Arenaria livermorensis*
Seepweed	*Suaeda jacoensis*
Siphonoglossa	*Siphonoglossa durangensis*
Tickle-tongue, Shinner's	*Euphorbia chaetocalyx*
Tidestromia	*Tidestromia gemmata*
Water-umbel, Huachuca	*Lilaeopsis schaffneriana recurva*
Zanthoxylum	*Zanthosylum parvum*
Shrubs & Agave & Yucca	
Acacia, catclaw	*Acacia greggii*
Acacia, viscid	*Acacia neovernicosa*
Acacia, whitethorn	*Acacia constricta*
Agave, Parry's	*Agave parryi*
Agave, Palmer's	*Agave palmeri*
Agave, noha	*Agave victoria-reginae*
Afinador	*Mortonia greggii*
Algerita	*Berberis haematocarpa*
Allthorn	*Koeberlinia spinosa*
Apache-plume	*Fallugia paradoxa*
Beargrass	*Nolina microcarpa*
Beargrass	*Nolina texana*

Common Name	Scientific Name
Birthwort	*Aristochloa wrightii*
Ceanothus, azure	*Ceanothus coeruleus*
Condalia	*Condalia warnockii*
Cordia	*Cordia parviflora*
Creosote bush	*Larrea tridentata*
Desertwillow	*Chilopsis linearis*
Dyssodia	*Dyssodia gypsophila*
Dutchman's Britches	*Thamnomsa stanfordii*
Emorybush	*Emorya suaveolens*
Genistidium	*Genistidium dumosum*
Guajillo	*Acacia berlandeieri*
Guayule	*Parthenium argentatum*
Hemichaena	*Hemichaena spinulosa*
Henricksonia	*Henricksonia mexicana*
Hopbush (chapolixtle)	*Dodonaea viscosa*
Huisache	*Acacia farnesiana*
Justicia	*Justicia sp.*
Lechugilla	*Agave lechuguilla*
Manzanita, pointleaf	*Arctostaphylos pungens*
Mariola	*Parthenium incanum*
Mala mujer	*Cnidoscolus shrevei*
Marshalljohnstonia	*Marshalljohnstonia gypsophila*
Mescal bean	*Sophora secundiflora*
Mescal bean	*Sophora gypsophila*
Mesquite	*Prosopis laevigata*
Mesquite, honey	*Prosopis glandulosa*
Mesquite, screwbean	*Prosopis pubescens*
Mesquite, velvet	*Prosopis velutina*
Mimosa, catclaw	*Mimosa aculeaticarpa var. biuncifera*
Mint, hoary rosemary	*Poliomintha incana*
Mirandea	*Mirandea huastecensis.*
Mountain mahogany	*Cercocarpus montanus*
Oak	*Quercus potosina*
Oak, shinnery	*Quercus harvardii*
Ocotillo	*Fouquieria splendens*
Oreja de raton	*Bernardia myricifolia*
Palo verde	*Cercidium floridum*
Pickleweed	*Allenrolfea occidentalis*
Randia	*Randia pringlei*
Rosewood-guauyul	*Vaquelinia corymbosa var. heterodon*
Sage, mountain	*Salvia regla*
Sage, sand	*Artemisia filifolia*
Sage, purple (cenizo)	*Leucophyllum frutescens*
Saltbush, Four-wing	*Atriplex canescens*
Saltbush, Griffith's	*Atriplex torreyi var. griffithsii*
Saltbush	*Atriplex reptans*
Salt cedar	*Tamarix ramosissima*
Sangre de draco	*Jatropha dioica*

Common Name	Scientific Name
Scalebroom, gypsum	*Lepidospartum burgessi*
Seepweed	*Suaeda palmeri*
Seepwillow	*Baccharis glutinosa*
Serviceberry, Utah	*Amelanchier utahensis*
Setchellanthus	*Setchellanthus caeruleus*
Silktassel	*Garrya wrightii*
Silktassel, eggleaf	*Garrya ovata*
Snakeweed	*Gutierrezia sp.*
Snowbells, Texas	*Styrax texanus*
Sotol	*Dasylirion leiophyllum*
Sotol	*Dasylirion wheeleri*
Sumac, three-leaf	*Rhus trilobata*
Tarbush	*Flourensia cernua*
Tree tobacco	*Nicotiana glauca*
Varilla	*Varilla mexicana*
Wolfberry	*Lycium berlandieri*
Yerba de Mula	*Flourensia retinophylla*
Yucca, banana	*Yucca baccata*
Yucca, giant dagger	*Yucca carnerosana*
Yucca, Schott's	*Yucca schottii*
Yucca, soaptree	*Yucca elata*
Yucca, Spanish dagger	*Yucca treculeana*
Yucca, Torrey	*Yucca torreyi*
Trees	
Alder, Arizona	*Alnus oblongifolia*
Ash, Velvet-leaf	*Fraxinus velutina*
Aspen, quaking	*Populus tremuloides*
Boxelder	*Acer negundo*
Cherry, black	*Prunus serotina*
Cottonwood, Fremont's	*Populus fremontii*
Cottonwood, narrowleaf	*Populus angustifolia*
Cypress, Arizona	*Cupressus arizonica*
Montezuma bald cypress	*Taxodium mucronatum*
Elder, Mexican	*Sambucus mexicana*
Fir, Coahuila- guyame blanco	*Abies durangensis var. coahuilensis*
Fir, corkbark	*Abies arizonica*
Fir, Douglas	*Pseudotsuga menziesii*
Fir, subalpine	*Abies lasiocarpa*
Fir, white	*Abies concolor*
Hackberry, netleaf	*Celtis reticulata*
Juniper, alligator	*Juniperus deppeana*
Juniper, one-seed	*Juniperus monosperma*
Juniper, Mexican	*Juniperus asheii*
Juniper, red-berry	*Juniperus pinchotii*
Juniper, weeping	*Juniperus flaccida*
Madrono, Texas	*Arbutus xalapensis*
Maple, big-tooth	*Acer grandidentatum*
Oak	*Quercus laceyi*

Common Name	Scientific Name
Oak, Mexican blue	*Quercus oblongifolia*
Oak, chinkapin	*Quercus muhlenbergia*
Oak, Chisos	*Quercus graciliformis*
Oak, Emory	*Quercus emoryi*
Oak, Gambel	*Quercus gambelii*
Oak, Arizona gray oak	*Quercus grisea*
Oak, Hinckley	*Quercus hinckleyi*
Oak, live	*Quercus turbinella*
Oak, Mohr	*Quercus mohriana*
Oak, netleaf	*Quercus rugosa*
Oak, silverleaf	*Quercus hypoleucoides*
Oak, Arizona white	*Quercus arizonica*
Palo Verde, blue	*Cercidium floridum*
Pine, Apache	*Pinus engelmanni*
Pine, Arizona	*Pinus arizonica*
Pine, Chihuahua	*Pinus leiophylla chihuahuana*
Pine, limber	*Pinus flexilis*
Pine, ponderosa	*Pinus ponderosa*
Pine, southwestern white	*Pinus strobiformis*
Pinyon	*Pinus edulis*
Pinyon , Mexican	*Pinus cembroides*
Pinyon, weeping	*Pinus pinceana*
Spruce, Blue	*Picea pungens*
Spruce, Engelmann	*Picea engelmanni*
Sycamore	*Platanus occidentalis*
Sycamore, Arizona	*Platanus wrightii*
Tree of Heaven	*Ailanthus altissima*
Walnut, Arizona	*Juglans major*
Walnut, New Mexico	*Juglans microcarpa*
Willow, Goodding's	*Salix gooddingii*
Willow, sandbar or coyote	*Salix exigua*
Birds by Family	
Grebes-Podicipedidae	
Grebe, Clark's	*Aechmophorus clarkii*
Grebe, Eared	*Podiceps nigricollis*
Grebe, Western	*Aechmophorus occidentalis*
Pelicans-Pelicanidae	
Pelican, American White	*Pelecanus erthythrorhynchos*
Comorants-Phalacrocoracidae	
Cormorant, Neotropical	*Phalcrocorax olivaceus*
Bitterns & Herons-Ardeidae	
Bittern, Least	*Ixobrychus exilis*
Bittern, American	*Botaurus lentiginosus*
Heron, Green-backed	*Butorides striatus*
Ibis-Threskiornithidae	
Ibis, White-faced	*Plegadis chihi*
Ducks & Geese-Anatidae	

Common Name	Scientific Name
Duck, Back-bellied Whistling	*Dendrocygna autumnalis*
Duck, Wood	*Aix sponsa*
Gadwall	*Anas strepera*
Goose, Canada	*Branta canadensis*
Goose, Greater White-fronted	*Anser albifrons*
Goose, Snow	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Scaup, Lesser	*Aythya affinis*
Widgeon, American	*Anas american*
Hawks & Eagles-Accipitridae	
Eagle, Bald	*Haliaeetus leucocephalus*
Eagle, golden	*Aquila chrysaetos*
Goshawk, Northern	*Accipiter gentilis*
Hawk, Common Black-	*Buteogallus anthracinus*
Hawk, Ferruginous	*Buteo regalis*
Hawk, Gray	*Buteo nitidus*
Hawk, Rough-legged	*Buteo lagopus*
Hawk, Swainson’s	*Buteo swainsoni*
Hawk, Zone-tailed	*Buteo albonotatus*
Kite, White-tailed	*Elanus caeruleus*
Falcons-Falconidae	
Falcon, Aplomado	*Falco femoralis*
Falcon, Peregrine	*Falco peregrinus*
Falcon, Prairie	*Falco mexicanus*
Quail, Grouse & Turkey-Phasianidae	
Prairie-Chicken, Lesser	*Tympanuchus pallidicinctus*
Quail, Montezuma	*Cyrtonyx montezumae*
Quail, scaled	*Callipepla squamata*
Turkey, Gould’s	*Meleagris gallopavo mexicana*
Rails-Rallidae	
Rail, Virginia	*Rallus limicola*
Sora	*Porzana carolina*
Cranes-Gruidae	
Crane, Sandhill	*Grus canadensis*
Crane, Whooping	*Grus americana*
Plovers-Charadriidae	
Plover, Mountain	*Charadrius montanus*
Plover, Snowy	*Charadrius alexandrinus*
Stilts & Avocets- Recurvirostridae	
Avocet, American	*Recurvirostra americana*
Stilt, Black-necked	*Himantopus mexicanus*
Sandpipers-Scolopacidae	
Curlew, Long-billed	*Numenius americanus*
Sandpiper, Baird’s	*Calidris bairdi*
Sandpiper, western	*Calidris mauri*
Yellowlegs, Greater	*Tinga melanoleuca*
Gulls, Jaegers, Terns-Laridae	

Common Name	Scientific Name
Jaeger, pomarine	*Stercorarius pomarinus*
Gull, Franklin's	*Larus pipixcan*
Tern, Black	*Chlidonias niger*
Tern, Interior Least	*Sterna antillarum*
Doves & Pigeons-Columbidae	
Pigeon, Band-tailed	*Columba fasciata*
Dove, Common Ground-	*Columbina passerina*
Dove, White-tipped	*Leptotila verreauxi*
Dove, White-winged	*Zenaida asiatica*
Parrots-Psittacidae	
Parrot, Thick-billed	*Rhynchopsitta pachyrhyncha*
Roadrunner & Cuckoo-Cuculidae	
Cuckoo, Yellow-billed	*Coccyzus americanus*
Roadrunner, greater	*Geococcyx californianus*
Owls-Tytonidae	
Owl, Burrowing	*Athene cunicularia*
Owl, Elf	*Micrathene whitneyi*
Owl, great-horned	*Bubo virginianus*
Owl, Ferruginous Pygmy	*Glaucidium brasilianum cactorum*
Owl, Northern Pygmy	*Glaucidium gnoma*
Owl, Northern Saw-whet	*Aegolius acadicus*
Owl, Whiskered screech	*Otus trichopsis*
Owl, Mexican spotted	*Strix occidentalis lucida*
Nightjars-Caprimulgidae	
Whip-poor-will	*Caprimulgus vociferus*
Hummingbirds-Trochilidae	
Hummingbird, Berryline	*Amazilia yucatanensis*
Hummingbird, Black-chinned	*Archilochus alexandri*
Hummingbird, Blue-throated	*Amazilia violiceps*
Hummiingbird, Lucifer	*Calothorax lucifer*
Hummingbird, Magnificent	*Eugenes fulgens*
Hummingbird, Violet-crowned	*Amazilia violiceps*
Hummingbird, White-eared	*Hylocharis leucotis*
Trogons-Trogonidae	
Trogon, Elegant	*Trogon elegans*
Kingfishers-Alcedinidae	
Kingfisher, Green	*Chloroceryle americana*
Woodpeckers-Picidae	
Flicker, Gilded	*Colaptes auratus*
Sapsucker, Williamson's	*Sphyrapicus thyroideus*
Woodpecker, Acorn	*Melanerpes formicivorus*
Woodpecker, Strickland's	*Picoides stricklandi*
Tyrant Flycatchers-Tryannidae	
Becard, Rose-throated	*Pachyramphus aglaiae*
Flycatcher, Ash-throated	*Myiarchus cinerascens*
Flycatcher, Brown-crested	*Myiarchus tyrannulus*
Flycatcher, Buff-bellied	*Empidonax fulvifrons*

Common Name	Scientific Name
Flycatcher, Dusky	*Empidonax oberholseri*
Flycatcher, Gray	*Empidonax wrightii*
Flycatcher, Olive sided	*Dendroica petechia*
Flycatcher, Sulphur-bellied	*Myiodynastes luteiventris*
Flycatcher, Willow	*Empidonax traillii*
Kingbird, Thick-billed	*Tyrannus crassirostris*
Kingbird, Cassin’s	*Tyrannus vociferan’s*
Kingbird, Western	*Trannus verticalis*
Pewee, Greater	*Contopus pertinax*
Tyrannulet, Northern-beardless	*Camptostoma imberbe*
Swallows-Hirundinidae	
Swallow, Cave	*Hirundo fulva*
Swallow, Cliff	*Hirundo pyrrhonota*
Jays & Crows-Corvidae	
Jay, Blue	*Cyanocitta cristata*
Jay, Mexican	*Aphelocoma ultramarina*
Jay, Pinyon	*Gymnorhinus cyanocephalus*
Nutcracker, Clark’s	*Nucifraga columbiana*
Raven, Chihuahuan	*Corvus cryptoleucus*
Chickadees-Paridae	
Chickadee, Mountain	*Parus gambeli*
Chickadee, Mexican	*Parus sclateri*
Verdin-Remizidae	
Verdin	*Auriparus flaviceps*
Wren-Troglodytidae	
Wren, Cactus	*Campylorhynchus brunneicapillus*
Old World Warblers -Muscicapdae	
Gnatcatcher, Black-tailed	*Polioptila melanura*
Thrashers- Mimidae	
Thrasher, Bendire’s	*Toxostoma bendirei*
Thrasher, Crissal	*Toxostoma crissale*
Thrasher, Curve-billed	*Toxostoma curvirostre*
Pipits-Motacillidae	
Pipit, American	*Anthus rubescens*
Pipt, Sprague’s	*Anthus spragueii*
Shrike-Laniidae	
Shrike, Loggerhead	*Lanius ludovicianus*
Vireo-Vireoniidae	
Vireo, Bell’s	*Vireo bellii*
Vireo, Black-capped	*Vireo atricapillus*
Vireo, Gray	*Vireo vicinor*
Vireo, Red-eyed	*Vireo olivaceus*
Vireo, White-eyed	*Vireo griseus*
Vireo, Yellow-throated	*Vireo flavifrons*
Passerines-Emberizidae	
Chat, Yellow-breasted	*Icteria virens*
Cowbird, Brown-headed	*Molothrus ater*

Common Name	Scientific Name
Crossbill, Red	*Loxia curvirostra*
Bunting, Lark	*Calamospiza melanocorys*
Bunting, Painted	*Passerina ciris*
Bunting, Varied	*Passerina versicolor*
Goldfinch, lesser	*Carduelis psaltria*
Grosbeak, blue	*Guiraca caerulea*
Junco, Yellow-eyed	*Junco phaeonotus*
Longspur, Chestnut-collared	*Calcarius ornatus*
Longspur, McCowan's	*Calcarius mccownii*
Longspur, Smith's	*Calcarius pictus*
Meadowlark, Eastern	*Sturnella magna*
Meadowlark, Western	*Sturnella neglecta*
Oriole, Audubon's	*Icterus graduacauda*
Oriole, Orchard	*Icterus spurius*
Oriole, Streak-backed	*Icterus pustulatus*
Parula, Northern	*Parula americana*
Parula, Tropical	*Parula pitiayumi*
Redstart, painted	*Myioborus pictus*
Sparrow, Baird's	*Ammodramus bairdii*
Sparrow, Botteri's	*Aimophila botterii*
Sparrow, Cassin's	*Aimophila cassinii*
Sparrow, Grasshopper	*Ammodramus savannarum*
Sparrow, Lincoln's	*Melospiza lincolni*
Sparrow, Rufous-winged	*Aimophila carpalis*
Sparrow, Sage	*Amphispiza belli*
Sparrow, Savannah	*Passerculus sandwichensis*
Sparrow, Worthen's	*Spizella wortheni*
Towhee, Green-tailed	*Pipilo chlorurus*
Tanager, Hepatic	*Piranga flava*
Tanager, Summer	*Piranga rubra*
Warbler, Colima	*Vermivora crissalis*
Warbler, Grace's	*Dendroica graciae*
Warbler, Olive	*Peucedramus taeniatus*
Warbler, Rufous-capped	*Basileuterus rufifrons*
Warbler, Townsend's	*Dendroica townsendi*
Warbler, Yellow	*Dendroica petechia*
Yellowthroat, Common	*Geothlypis trichas*
Mammals by Family	
Shrews-Soricidae	
Shrew, desert	*Notiosorex crawfordii*
Leafnose Bats-Phyllostomidae	
Bat, lesser long-nosed (Sanborn's)	*Leptonycteris curasoae yerbabuenae*
Bat, Mexican long-nosed	*Leptonycteris nivalis*
Bat, Mexican long-tongued	*Leptonycterus curazace*
Bat, western big-eared	*Plecotus townsendi*
Plainnose Bats-Vespertilionidae	
Bat, big brown	*Eptesicus fuscus*

Common Name	Scientific Name
Bat, hoary	*Lasiurus cinereus*
Bat, pallid	*Antrozous pallidus*
Bat, red	*Lasiurus borealis*
Bat, silver-haired	*Lasionycteris noctivagens*
Bat, spotted	*Euderma maculata*
Myotis, California	*Myotis californicus*
Myotis, cave	*Myotis velifer*
Myotis, long-eared	*Myotis evotis*
Myotis, long-legged	*Myotis volans*
Myotis, western small-footed	*Myotis subulatus*
Freetail Bats-Molossidae	
Bat, Mexican free-tailed	*Tadarida brasiliensis*
Bat, western mastiff	*Eumops perotis*
Bears-Ursidae	
Bear, black	*Ursus americanus*
Bear, grizzly	*Ursus horribilis*
Racoons & Coatis-Procyonidae	
Coatimundi	*Nasua narica*
Ringtail cat	*Bassariscus astutus*
Skunk, Badger & Otter-Mustelidae	
Badger	*Taxidea taxus*
Otter, neotropical	*Lutra longicaudis*
Otter, river	*Lutra canadensis*
Skunk, spotted	*Spilogale putorius*
Dogs & Wolves-Canidae	
Coyote	*Canis latrans*
Fox, gray	*Urocyon cineargentus*
Fox, kit	*Vulpes macrotis*
Wolf, Mexican gray	*Canis lupus baileyi*
Cats-Felidae	
Bobcat	*Lynx rufus*
Jaguar	*Panthera onca*
Lion, mountain	*Felis concolor*
Ocelot	*Felis pardalis*
Squirrels-Sciuridae	
Antelope groundsquirrel	*Ammospermophilus interpes*
Chipmunk, gray-footed	*Eutamias canipes*
Chipmunk, Organ Mountain	*Eutamias quadrivittatus australis*
Groundsquirrel, spotted	*Citellus spilosoma*
Prairie dog, black-tailed	*Cynomys ludovicianus*
Prairie dog, Mexican	*Cynomys mexicana*
Squirrel, Chiricahua fox	*Sciurus apache*
Squirrel, golden-mantled ground	*Citellus lateralis*
Squirrel, Arizona gray	*Sciurus arizonensis*
Squirrel, Mount Graham red	*Tamiasciurus hudsonicus var. grahamensis*
Squirrel, rock	*Citellus variegatus*
Squirrel, spotted ground	*Citellus spilosoma*

Common Name	Scientific Name
Pocket Gophers-Geomyidae	
Pocket gopher, plains	*Geomys bursarius*
Pocket Mice & Kangaroo Rats-Heteromyidae	
Kangaroo rat, Merriam's	*Dipodomys merriami*
Kangaroo rat, Nelson's	*Dipodomys nelsoni*
Kangaroo rat, Ord's	*Dipodomys ordii*
Kangaroo rat, Phillip's	*Dipodomys phillipsii*
Pocketmouse, Desert	*Perognathus pencilliatus*
Pocketmouse, Nelson's spiny	*Chaetodipus nelsoni*
Beaver-Castoridae	
Beaver	*Castor canadensis*
Mice, Voles-Cricetidae	
Cottonrat, hispid	*Chaetodipus hispidus*
Cottontail, desert	*Sylvilagus audubonii*
Cottonrat, yellownose	*Sigmodon ochrognathus*
Mouse, brush	*Peromyscus boylei*
Mouse, northern rock	*Peromyscus nasutus*
Vole, Mexican	*Microtus mexicanus*
Vole, long-tailed	*Microtus longicaudus leucophaeus*
Woodrat, Goldman's	*Neotoma goldmani*
Woodrat, white-throated	*Neotoma albigula*
Jumping Mice-Zapodidae	
Mouse, New Mexican jumping	*Zapus hudsonius luteus*
Porcupine-Erthizontidae	
Porcupine	*Erethizon dorsatum*
Peccaries-Tayassuidae	
Javelina	*Dicotyles tajacua*
Deer-Cervidae	
Deer, mule	*Odocoileus hemionus*
Deer, Coue's white-tailed	*Odocoileus virginianus crooki*
Deer, white-tailed	*Odocoileus virginianus*
Deer, Sierra del Carmen	*Odocoileus virginianus carminis*
Rabbits-Lagomorpha	
Cottontail, eastern	*Sylvilagus floridanus*
Jackrabbit, antelope	*Lepus alleni*
Jackrabbit , black-tailed	*Lepus californicus*
Jackrabbit, white-sided	*Lepus callotis*
Pronghorn-Antilocapridae	
Pronghorn	*Antilocapra americana*
Bison & Sheep-Bovidae	
Bighorn sheep, desert	*Ovis canadensis mexicana*
Bison	*Bison bison*
Oryx	*Oryx gazella*

Appendix H : A Conservation Audit of the Chihuahuan Biological Assessment and Biodiversity Vision

The challenge of ERBC is that it forces us to plan and act on larger spatial and temporal scales than those at which we normally operate. A major concern of ERBC is that unless we ask the right questions at the outset, we run the risk of spending a large amount of scarce resources on an approach that may be little more than business-as-usual.

One way to evaluate the rigor of a biological assessment and a biodiversity vision is to compare the elements it seeks to conserve with biological criteria identified by independent experts. Here we apply criteria developed by Dr. Gordon Orians, a leading thinker on ERBC (and a WWF-US Board member) to the Chihuahuan Desert analysis.
Overall, the approach followed in this report and the results of the assessment and vision address many of the questions raised by Dr. Orians. We encourage other groups undertaking ERBC to arrange an independent peer review of draft biological assessments and biodiversity visions by a group of scientists who did not participate in the ERBC workshop.

Toward a Checklist for Ecoregion Planning

Prepared by Dr. Gordon Orians

Note: This checklist focuses solely on biological issues and is not constructed in any particular order of priority. The italicized sections under each issue are the editor's interpretation of how effectively we have addressed each of these points through the Chihuahuan workshop process and subsequent analyses.

I. What are the most spatially intensive processes?

   A. Migrations - latitudinal migrations, altitudinal migrations, seasonal habitat shifts (are there any lost or degraded migratory patterns?)

   We have attempted to identify critical sites for migratory phenomena, particularly for birds, bats, and butterflies. Conservation of terrestrial vertebrate migrations and movements can be addressed through conserving sufficiently large natural areas (conservation landscapes) and adequate linkage or corridor habitat between larger core conservation areas.

   B. Species that require large areas to maintain viable populations

   We have attempted to address this target by having taxonomic experts identify core populations of various species, including those requiring large areas, and by emphasizing the need to identify areas that still support intact biotas, including larger vertebrates that need lots of space. In analyses following this initial priority-setting, we would recommend that the specific design of reserves within priority areas consider the needs of such species, as well as the location and design of linkage zones, buffers, and corridors (see Box 9.1 and Figure 9.1).

   C. Large-scale disturbance regimes

   Only in extensive landscapes of natural habitats will large-scale disturbance regimes operate within natural ranges of variation. We would hope to be able to conserve such regimes, and their associated ecological effects, by preserving larger intact habitats (one of the four targets of the strategy) in sizable core reserves. We also recommend that land use in matrix habitats *surrounding core reserves and linkage areas promote the persistence of relatively natural disturbance patterns and processes.*

II. What are the most critically sensitive areas?

A. Key migratory stopover areas

Priority areas could be identified as important because of their critical role in maintaining large-scale ecological phenomena such as long-distance bird migrations.

B. Critical areas at "down-times" - key watering areas, dry season water areas, areas that are important during unusual weather extremes for shelter or other resources

One of the four conservation targets espoused in this approach is keystone habitats, phenomena, and species. We advocate that such critical habitats, such as springs, caves, riparian habitats, and healthy native grasslands, are important to conserve wherever they occur, and, most importantly, within core reserves.

C. Local sites (e.g., caves, springs, etc.) of high biodiversity or endemism, and centers of endemism, in general

The taxon specialists identified several priority taxon sites based on these criteria. Priority sites may be selected because their entire biota is particularly rich or endemic. Such areas within the Chihuahuan Desert can be considered areas of high distinctiveness, another primary target.

D. Source-sink relationships - areas that are likely sinks for a number of species

Although this issue was not directly addressed in our approach, the identification of effective linkage areas in following analyses should consider sink habitats and landscapes for sensitive species. Moreover, by estimating minimum habitat sizes for viable populations of target species in the persistence analyses, one can eliminate certain habitat blocks (priority or not) as sinks for certain species.

III. Inter-ecoregion issues

A. Which species or processes require integration with neighboring or other ecoregions to remain viable?

(*see IIIB, below*)

B. Are sites or processes in the ecoregion important for viability of species in other ecoregions?

The process of identifying critical sites for long-distance migrants (a primary target) as well as important elevational gradients in Chihuahuan transition areas as priority sites addresses both of these issues, in part.

C. Locations of watersheds - which ones are and are not entirely within the ecoregion?

The freshwater analysis identified a series of priority sites and watersheds independent from the terrestrial analysis. Some of the priority watersheds extend beyond the terrestrial boundaries of the Chihuahuan Desert ecoregion complex.

IV. Size and connectivity issues in conservation planning

A. Which movement corridors are most important? For which organisms?

1. What is known about current use of corridors by various species?

2. Do opportunities exist for experimental corridor design and monitoring?

An important next step in developing a biodiversity vision is to identify linkage or corridor habitats that connect core reserves across large distances. Considerations of corridor width, habitat conditions, and path across landscapes are particularly critical for designing conservation landscapes (Chapter 9). Reserve designs within priority areas should also address such issues on more local scales.

B. Edge issues

1. Which elements are negatively affected by edges?
2. Which elements are positively affected by edges?
3. Is location of different edges & edge types important?
4. Is the concept of "zones of use" i.e. core undisturbed area, intermediate use, more intensive use?.

Because of the scale of this analysis, an entire ecoregion complex, and its goal of identifying core conservation areas, the issue of edge effects was not particularly pertinent. When specific habitat blocks are evaluated for reserve designs, some edge effects, such as high risk areas from hunting, should be considered. In desert habitats, some other relevant edge effects might include the proximity to populations of alien species or human-caused fires.

C. Which elements are most sensitive to which kinds of use?

Regional experts were asked to identify habitats and species that were particularly sensitive or threatened, as well as the type and severity of threats. A synthesis of the priority site descriptions provides a broad perspective on such sensitive elements, such as riparian habitats, springs and other freshwater systems, larger vertebrates, and cacti and other trade species.

V. Creating and managing disturbances

A. Fire

B. Grazing and browsing

C. Role of ICDPs in ecoregion planning

D. Where is restoration needed? Location of degraded habitats

E. Resource harvesting--logging, extraction of other resources (e.g. hunting, gathering)

All of these critical issues should be addressed when developing conservation strategies for particular priority sites. The workshop attempted to look at significant threats to biodiversity which were widespread and pervasive throughout the ecoregion complex. Experts also identified specific threats at focal sites. A synthesis of these site descriptions reveals alterations of natural disturbance regimes that are common throughout the region. The workshop resulted in some recommendations on how to rectify these problems for particular sites and the ecoregion complex, as a whole.

VI. Managing for "supersaturation" (maintaining more species than would otherwise persist in the area)

A. Is it likely to be needed, i.e. are species losses anticipated without it?

B. Which processes especially need to be manipulated? Immigration rates? Allele infusion?

Such issues are most relevant during the design of conservation areas within priority sites and connecting habitats. They were not addressed at the workshop.

VII. Identifying keystone species and processes

A. Keystone species - influence on biodiversity

1. Are any already identified?
2. Can likely keystone species be predicted?
3. What research on keystone species is needed?

B. Keystone species - influences on ecosystem processes

1. Functional groups "in relation to such processes as primary production and nutrient cycling"

2. Redundancy in functional groups - "which processes are dependent on just a few species?"

One of the primary targets of the approach employed here is to conserve keystone species, habitats, and phenomena. Regional experts were asked to identify these and use their presence as a basis for selecting taxon and final priority sites. Examples of keystone species in the ecoregion complex include black-tailed prairie dogs, buffalo, wolves, and some bats.

VIII. Long-term issues

A. Climate change

1. What changes are predicted in the region?
2. What will this do to ecoregion boundaries?
3. How does projected change affect reserve location and design?

Recommendations from the workshop include preserving intact elevational gradients, primarily for maintaining local interactions and movements. But such gradients can also provide room for ecological shifts due to climate change. Latitudinal or longitudinal shifts are not addressed through the approach used.

B. Evolutionary potential

1. Speciation
2. Mutualistic relationships
3. Evolution of species within isolated reserves

Through the conservation of representative core reserves consisting of larger blocks of intact habitat well-linked to other core reserves, we would hope to conserve some evolutionary potential in the ecoregion. Evolutionary considerations are not directly addressed, however.

IX. Current location of parks, reserves and other protected areas

The gap analysis portion of this report evaluates the current protected area network and the need for establishment of effective conservation areas at additional priority sites. Conservation actions other than strict protected areas may be viable for preserving biodiversity features in certain areas.

Appendix I : Names, Affiliations, and *Current* Addresses of Contributors

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Appendix K : Glossary of Terms

Amphipod Any of a large group of small crustaceans with a laterally compressed body, belonging to the order Amphipoda.

Apachean A subregion of the Chihuahuan Desert which includes the southeast corner of Arizona, the southwest corner of New Mexico, the northeast corner of Sonora, and the northwest corner of Chihuahua.

Arroyo An intermittent stream bed in a dry climate.

Bajada A sloped area at the base of desert mountain slopes in which a number of alluvial fans merge. An alluvial fan.

Barrancas An intermittent streambed in a dry climate, usually with steep walls.

Beta diversity Species diversity between habitats (thus reflecting changes in species assemblages along environmental gradients).

Bolson A large, wide, closed basin. An inland area which receives inflow of runoff but has no outlet to drain the water away.

Bosque Spanish for woodland or forest.

Candidate priority sites Sites deemed important for conservation based on a synthesis of the taxon overlays of nominated sites for each subregion (terrestrial taxa) or for the entire ecoregion (freshwater). A candidate priority site could be designated as outstanding on the basis of only one taxon, such as invertebrates, but typically, candidate priority sites were selected for their importance for two or more taxa. Candidate priority sites could also be identified if they address gaps in representation of habitats within a subregion or if they contribute to the conservation of areas that maintain ecological processes or phenomena, without qualifying as richness or endemism hotspots. The adjective “candidate” signifies that the site has not been ranked for priority using the integration matrix.

Ciénega Spanish for wetland or spring site.

Crasicaule Arborescent cactus scrub community.

Ecoregion A large area of land or water that contains a geographically distinct assemblage of natural communities that a) share a large majority of their species and ecological dynamics, b) share similar environmental conditions, and c) interact ecologically in ways that are critical for their long-term persistence.

Ejido A communal or cooperative form of land management practiced in Mexico.

Endemic A species or race native to a particular place and found only there.

Endemism Degree to which a geographically circumscribed area, such as an ecoregion or a country, contains species not naturally occurring elsewhere.

Gypsophilous Plants restricted to gypsum derived soils.

Herpetofauna The collective word for reptiles and amphibians.

Isopod A member of the crustacean order Isopoda; a diverse group of flattened and segmented invertebrates. Pillbugs are an example.

Izotal A community dominated by the succulent plants *Yucca* spp. and *Dasylirion* spp .

Lacustrine Lake or pond aquatic environments.

Laguna The Spanish word for a dry lake bed found in desert basins which often is covered with evaporites (salt crystals).

Madrean The term applied to plants and animals associated with and derived from the Sierra Madre Occidental of Mexico and the Sky Islands of southeast Arizona and southwest New Mexico.

Matorral A Spanish word for any number of scrub community types, e.g., matorral espinso, which is a mesquite/acacia thorn scrub community type.

Meseta Central The southernmost subregion of the Chihuahuan Desert, primarily encompassing the high plateau of Nuevo Leon, Zacatecas, Coahuila, and San Luis Potosí.

NGO Non-governmental organization.

Nominated sites Sites deemed important for conservation of a single taxon by taxonomic experts and published accounts. Nominated sites serve as the precursors to identify candidate priority sites. Not all nominated sites end up as candidate priority sites or as priority sites. All nominated sites are located on maps and named (Appendix B).

Orographic The effects of mountains, e.g., on weather.

Phytogeography Distribution patterns of plants on the earth's surface.

Playa Dry lake bed found in desert basins which often is covered with evaporites (salt crystals).

Poza Puddle, pool, spring, or pond, in Spanish.

Priority sites Sites whose contribution to ERBC have been ranked at various levels of priority using an integration matrix based on biological distinctiveness and landscape integrity for terrestrial sites (ranks 1-4), or on biological distinctiveness and habitat intactness for freshwater sites, (ranks 1-2) (see Figure 2.2).

Refugium A habitat that has allowed the persistence of species or communities because of the stability of favorable environmental conditions over time.

Representation The protection of the full range of biodiversity of a given biogeographic unit within a system of protected areas.

Subregion Biogeographic subdivisions of an ecoregion containing suites of species or higher taxa distinct from similar habitats in other subdivisions of the ecoregion.

Taxon a general term for any taxonomic category, e.g., a species, genus, family, or order.