Ecoregional Conservation Assessment of the Chihuahuan Desert

Second Edition, Revised July 2004

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In partnership with

The Nature Conservancy

and The World Wildlife Fund

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Executive Summary

The Chihuahuan Desert (CD) Ecoregion encompasses some 70 million hectares occupying much of the Mexican states of Chihuahua, Coahuila, Durango, Zacatecas, large portions of San Luis Potosi, Nuevo Leon, and significant areas of Texas and New Mexico in the United States. The area is characterized by the basins and ranges of the Mexican Plateau, surrounded by the foothills of the Sierra Madre Oriental on the east and the Sierra Madre Occidental on the west. While wetter than some North American desert areas, the Chihuahuan Desert experiences hot summers, cool, dry winters, and intermittent rainfall mostly of monsoonal origins during the summer months. The vegetation of the ecoregion is typically grassland and desert scrub, with areas of chaparral and woodland in the mountains and narrow ribbons of riparian forest and scrub along stream channels and springs. With the notable exception of the Rio Grande and its tributaries, most river systems are within closed basins and many streams and springs are isolated.

Like other areas of the southern Great Plains and the Southwest, the Chihuahuan Desert has been subject to a long history of grazing by domestic livestock. Except along broader alluvial valleys there has, until recently, been little attempt at intensive crop agriculture. A number of large cities within the ecoregion, including El Paso, Ciudad Juarez, Durango, Saltillo, and Ciudad Chihuahua, are restricted to river valleys where water supply is adequate to support a large human population.

This conservation planning effort was carried out by an international partnership of conservation planners, scientists, and practitioners from three organizations: Pronatura Noreste, The Nature Conservancy, and the World Wildlife Fund. This exercise builds on past conservation planning efforts in the ecoregion, but our focus has been on acquiring the most robust dataset possible on the status and distribution of conservation targets, including species, natural communities, and ecological systems. Our goal was to use these data to build a conservation blueprint for the ecoregion in the form of a "portfolio", a set of priority conservation areas which, if managed in ways compatible with the biological systems and species they contain, ensure the long-term survival of the biodiversity of the Chihuahuan Desert. This mammoth undertaking entailed gathering location data on more than 800 species and 24 ecological system and vegetation site targets (embedded in these 24 are over 40 fine-scale ecological systems, 93 landcover mapping units and between 500-1000 plant associations). We used the computer program SITES using a near-optimization algorithm called "simulated annealing" to create a portfolio of terrestrial conservation areas. To this was added a suite of aquatic conservation areas which was assembled manually. This draft portfolio was reviewed and edited by scientists and land managers to create a final portfolio of sites. The result is a portfolio of 125 high priority terrestrial conservation areas covering nearly 18 million hectares, 53 G1 data points that are part of the primary portfolio but are without delineated area, an additional 464 secondary terrestrial areas needing additional data and field verification, and an overlay of 74 aquatic conservation areas covering an additional 2.7 million hectares. The final portfolio covers approximately 30 % of the Chihuahuan Desert Ecoregion.

The vast majority of the portfolio is in private ownership, most of it in Mexico. The major land management entities in the Mexican portion of the ecoregion are ejidos and large ranch owners. Some areas are contained within National Park, Biosphere Reserve, or other recognized conservation status areas, but most receive little actual conservation attention. The Texas portion, like Mexico, is dominated by private lands and relatively large ranches with a few National Parks and State wildlife lands. Within the New Mexico portion of the ecoregion most of the portfolio is on federal and state lands. The largest landowners and managers are the Department of Defense, Bureau of Land Management, and National Park Service. Conservation action on this large and complicated portfolio will require a diverse set of innovative strategies, actions, and partnerships.

Although site-based conservation planning will be an important tool in moving beyond the generalities of this document toward more detailed conservation actions, the vast area of the ecoregion, the large number of conservation areas and the large number of wide-scale threats acting upon the biodiversity within these sites necessitate development of more efficient conservation strategies. This landscape is dominated by a strong, multiple generation ranching heritage with landowners working to maintain their rural way of life. Conservation success will require implementation of creative strategies to abate such threats as altered hydrology of streams and groundwater, poor grazing practices, and invasive animals and plants, working at multiple scales, and based largely on developing and maintaining partnerships with such stakeholders.

1. CHIHUAHUAN DESERT OVERVIEW

Description of the Ecoregion

The Chihuahuan Desert is the most biologically diverse desert in the Western Hemisphere and one of the most diverse arid regions in the world. This large upland desert on the Mexican Plateau is isolated from surrounding arid regions by the high mountains of the Sierra Madre Oriental, the Sierra Madre Occidental, and the Arizona-New Mexico Mountains. This isolation has produced an area rich in endemic species, especially among plants and reptiles.

Many different definitions and boundaries have been described for the Chihuahuan Desert. Schmidt (1979) discussed various boundaries based upon climate and vegetation factors. Johnston's (1977) boundary based upon vegetation closely resembles Schmidt's preferred climatic boundary based upon the Martonne Index of rainfall and temperature. The boundary we use here is modified after the work of CONABIO (1999) and Dinerstein et al. (1995), and encorporating Bailey's (1990) boundary within the United States. The Mexican portion of the ecoregion combines the Chihuahuan Desert proper, including the Bolson of Mapimi, with the Meseta Central Ecoregion. Additional boundary adjustments were made in the Sierra Madre Occidental and Sierra Madre Oriental in Mexico and along the boundary with the Edward's Plateau and Tamaulipan Thornscrub ecoregions in Texas. With these adjustments the ecoregion embodies consistent physical and biological features but acknowledges the different concepts of biogeographers and our partners. The resulting final Chihuahuan Desert Ecoregion planning unit (Figure 1) covers 61,157,386 hectares. Adding a 25 km data buffer the area studied expands the ecoregion to some 74 million hectares (183 million acres or 285,838 mi^2). The ecoregion extends nearly 1,500 km from just south of Albuquerque, New Mexico to the Trans-Mexican Volcanic Belt just 250 km north of Mexico City, including much of the states of the Chihuahua, Coahuila, Durango, Zacatecas and San Luis Potosi, as well as large parts of New Mexico and the Trans-Pecos region of Texas.

Most of the ecoregion lies between 900 and 1500 m (about 3,000 to 5,000 feet), although foothill areas and some isolated mountain ranges in Meseta Central may rise to more than 3000 m (about 10,000 feet). Schmidt (1979) notes the relative uniformity of climate within the ecoregion; hot summers and cool to cold, dry winters. This uniformity is due to the more-or-less equal distance of most areas of the desert from moisture sources (Gulf of Mexico and the Sea of Cortez), the uniformity of elevation of surrounding mountain masses, and the position of the desert on the continent which results in little frontal precipitation (Figure 2). As a result the Chihuahuan Desert has a high percentage of its precipitation falling in the form of monsoonal rains during the summer months. This desert has more rainfall than other warm desert ecoregions, with precipitation typically ranging from 150 to 500 mm (6 to 20 inches) annually, and the average for this being about 235 mm (10 inches) (Schmidt 1979).

Figure 1: Map of the Chihuahuan Desert Ecoregion

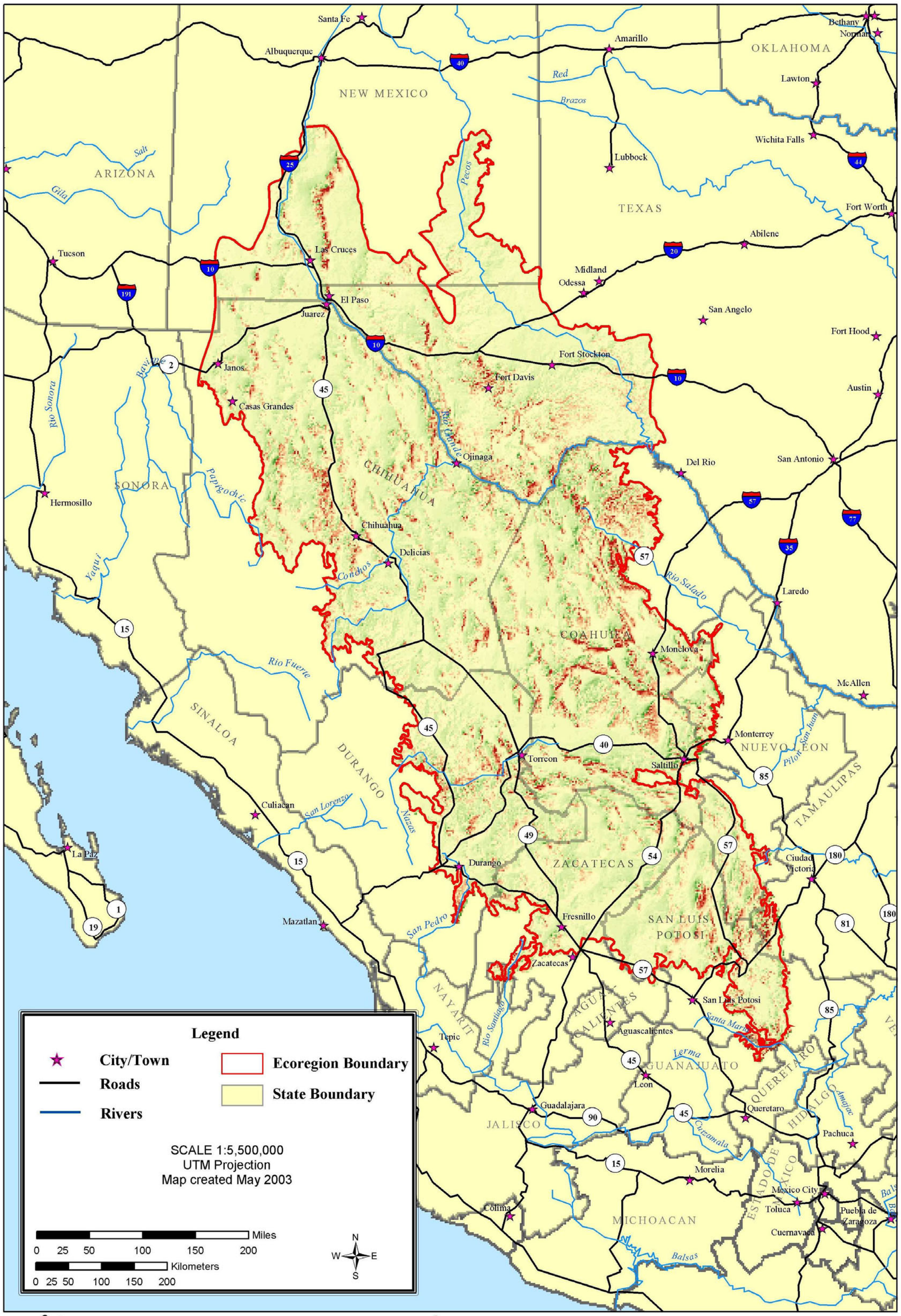
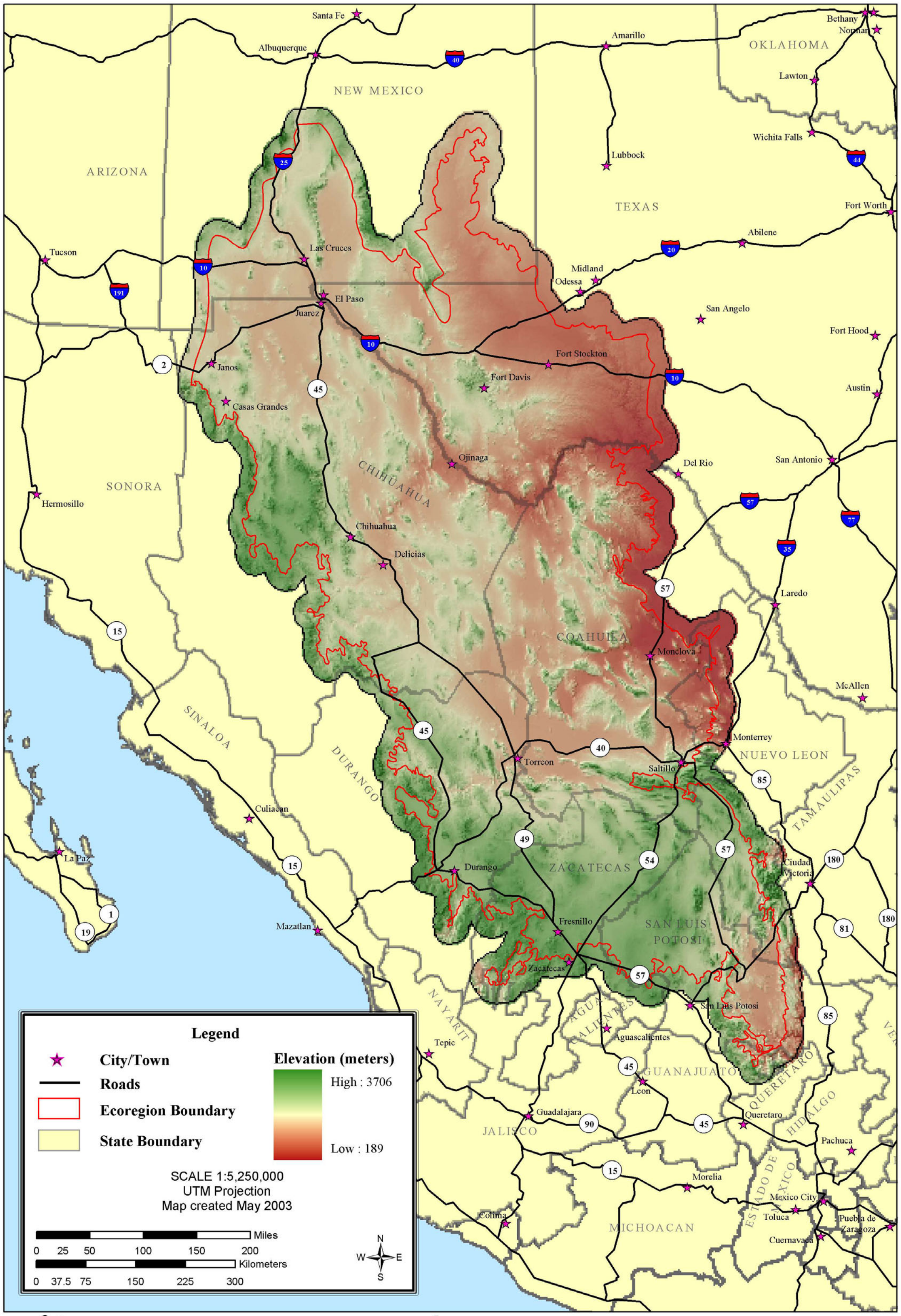


Figure 2: Topographic Relief of the Chihuahuan Desert



Ecoregional Subdivisions

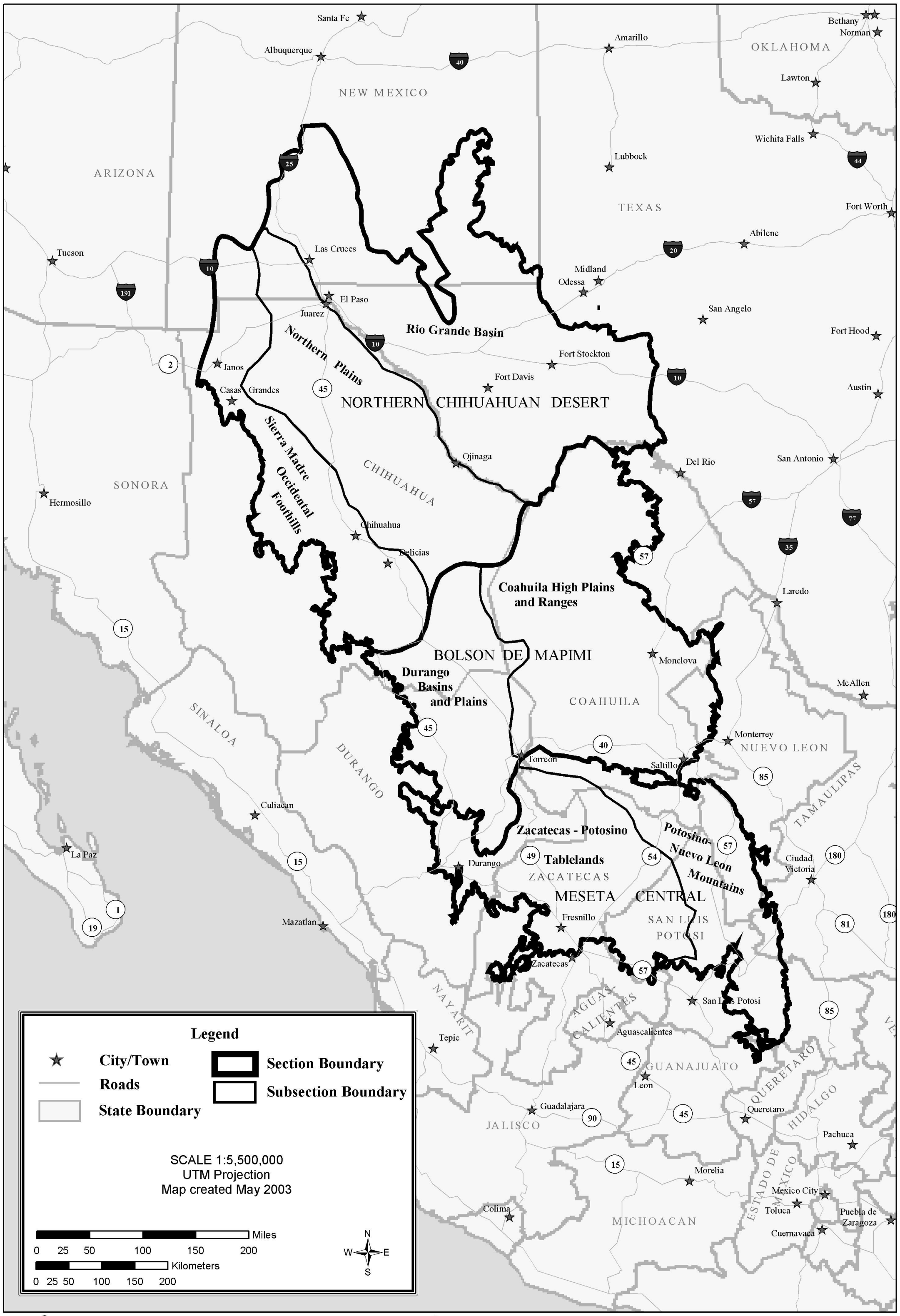
The Chihuahuan Desert Ecoregion is divided into three major *Sections* based upon patterns of geology, soils, and vegetation (Figure 3). The **Northern Chihuahuan** section includes the area of grasslands and desert scrub straddling the Rio Bravo/Rio Grande Valley, as well as a number of isolated, north-south tending mountain ranges which are notable for the "Sky Island" nature of their biotas. Johnston (1977) notes that the western margin of the northern Chihuahuan is grama grassland gradually giving way to shrub desert eastward. Grasslands generally occur on flat areas of deep alluvium while the shrublands dominate on more dissected terrain. The Northern Chihuahuan is further subdivided into three *Subsections*.

> The **Rio Grande Basin** (Cuenca del Rio Grande) lies north of the Rio Grande and includes the valley of the Pecos River, the closed Tularosa Basin which is formed from the grabben block valley formation east of the Rio Grande Rift, the basins and ranges of West Texas including the substantial grasslands of the Marfa and Marathon Basins, and the mountain massif of the Davis Mountains and the Big Bend area.
>
> The **Northern Plains** (Llanuras del Norte) is an area of low basins with numerous small desert mountain ranges lying between the Sierra Madre Oriental and the Sierra Madre Occidental. Dominated by grasslands and desert scrub, this subsection of the Northern Chihuahuan is the most arid and biologically isolated unit of the Chihuahuan Desert.
>
> The **Sierra Madre Occidentale Foothills** (Pie de Monte de la Sierra Madre Occidental) contains the headwaters of many of the basin rivers of the Northern Chihuahuan including the Casas Grandes, Santa Maria, del Carmen, and Conchas. The Foothills subsection includes some lower elevation montane habitats including grasslands and meadows, pine-oak forests and chaparral.

The **Mapimi Basin Section** (Bolson de Mapimi) consists of a series of basins and ranges with a central highland between the Sierra Madre Oriental and Rio Grande, and lying north of the Sierra Madre Oriental and the Mexican Plateau, extending across most of Coahuila into Durango. Much of this section consists of desert scrub. The most significant feature of the Mapimi is the large bolson, a closed basin in the center of the section.
The Mapimi Basin Section is further subdivided into two *Subsections*.

> The **Durango Basins and Plains** (Bolsones y Llanuras Duranguenses) contains the foothills of the Sierra Madre Occidental, with moderately high mountain ridges interspersed with deep valleys and closed basins. Most of this subsection lies between 1200 and 3000 m elevation. Many of the most important free waters of the Chihuahuan Desert drain from these foothills. Some of these are tributary to the Rio Conchos, but most drain into the closed basin of the Mapimi.

Figure 3: Section and Subsection Stratification of the Chihuahuan Desert



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The **Coahuila High Plains and Ranges** (Sierras y Llanos Altos Coahuilenses) consists of a series of isolated mountain ranges and internal basins lying south and west of the lower Rio Grande. This section is characterized by isolated closed basins including the Bolson de Mapimi and the Bolson de Cuatro Cienegas which have been important centers for evolutionary radiation.

The **Meseta Central Section** is considered by many to be a separate ecoregion from the Chihuahuan Desert. This region is surrounded by the Sierra Madre Occidental on the west, the Sierra Madre Oriental in the east, and by the Transverse Volcanic Ridge to the south. The Meseta Central is dominated by desert plains and mountains that rise up to 2400 m above sea level. The climate is dry and hot, with precipitation levels below 500 mm/year. Vegetation is typically matorral dominated by lechuguilla, acacia and agave. This section contains portions of the states of Durango, Zacatecas, San Luis Potosi, Tamaulipas, Nuevo Leon, and Coahuila. The Meseta Central Section is further subdivided into two *Subsections*.

Zacatecas - Potosino Tablelands (Meseta Zacatecano – Potosina), on the west, consist of high mesas between 1500 and 2500 m. Much of the substrate of this subsection is composed on sedimentary rocks. In this western portion of the Meseta Central the dominant vegetation is yucca and acacia matorral.

Potosino - Nuevo Leon Mountains (Sierras Potosino – Neoleonenses), to the east, lies on the western flank of the high Sierra Madre Oriental. Much of the substrate is of volcanic origin. This varied subsection includes the long rift from Torreon to San Luis Potosi, marking the western edge of the Sierra Madre Oriental uplift. As a result, this subsection includes elevations ranging from 1100 to almost 3000 m.

Biodiversity Status

The Chihuahuan Desert is a rather recent phenomenon – as recently as 9,000 years ago this area was much more mesic and dominated by coniferous woodland, typically of piñon pine (*Pinus* spp.) and juniper (*Juniperus* spp.) (Wells, 1974; Allen et al., 1998, Van Devender, 1990). Miller (1977) suggests that the region served as a post-Pleistocene dispersal route for many organisms, and that as aridity increased the result was isolation, differentiation, and extinction that led to the unique Chihuahuan biota of today.

Johnston (1977) indicates that the Sierra Madre Oriental, which forms the eastern boundary of the Chihuahuan Desert, is one of the oldest and richest centers of plant evolution on the North American continent. Johnston maintains that the northern Chihuahuan Desert, which lies on the Mexican Plateau, is essentially a broad physiographic expansion of the Sierra Madre Oriental, and that the flora of this region has its strongest affinities with this high mountain block. Johnston further indicates that there are at least 1,000 endemic plant taxa in the Chihuahuan Desert, an astonishing richness of biodiversity. This high desert area is a center for endemism of yuccas and cacti (Hernandez and Barcenas 1995). The dominant plant species throughout the

Chihuahuan Desert is creosote bush (*Larrea tridentata*), but large areas of the region are grama grasslands, with black grama (*Bouteloua eriopoda*) characteristic, and mesic swales of tobosa (*Hilaria mutica*) and giant sacaton (*Sporobolus wrightii*).

The Chihuahuan Desert also supports more than 120 species of mammals, 300 species of birds, 110 species of fish, and more than 170 species of amphibians and reptiles. The mammal and bird faunas of this area are largely comprised of widespread and common species, and there are few endemics (Findley and Caire, 1974; Phillips, 1974). Nevertheless, the Chihuahuan Desert grasslands serve as wintering grounds for a large proportion of North American Great Plains birds including a number of significantly declining species such as mountain plover (*Charadrius montanus*), ferruginous hawk (*Buteo regalis*) and Baird's sparrow (*Ammodramus bairdii*). Also of significance is that the largest remaining black-tailed prairie dog (*Cynomys ludovicianus*) towns on the continent and the only populations of the endemic Mexican prairie dog (*Cynomys mexicanus*) occur in the Chihuahuan Desert.

Morafka (1974) indicates that at least 18 species of reptiles and amphibians are endemic to the Chihuahuan Desert, including the bolson tortoise (*Gopherus flavomarginatus*), black softshell turtle (*Trionyx ater*), and the Chihuahuan fringe-toed lizard (*Uma exsul*).

A striking number of endemic fish occur in the Chihuahuan Desert – nearly half of the species in the ecoregion are either endemic or of limited distribution. Most of these are relict pupfish (Cyprinodontidae), shiners (Cyprinidae), livebearers (Poeciliidae), and Mexican livebearers (Goodeidae) found in isolated springs in the closed basins of the region. The best known of these aquatic basins is Cuatro Ciénegas in central Coahuila, but other significant areas of endemism include the Rio Nazas, Media Luna, the Guzman Basin (Miller 1974; Minkley 1974; Minkley et al., 1991), and the Pecos Plain. At least one undescribed species of trout (*Oncorhynchus* sp.) occurs in the Chihuahuan Desert ecoregion as an evolutionary isolate in headwater streams in the Sierra Madre Occidental (Hendrickson et al., 1999).

2. ECOREGIONAL ASSESSMENT PROCESS

The Chihuahuan Desert Portfolio was developed through a joint effort of Pronatura Noreste, World Wildlife Fund and The Nature Conservancy (See the List of Team Participants, page i). The portfolio complements the recent World Wildlife Fund Chihuahuan Desert Biological Assessment (Dinerstein et al. 2000). Other organizations and individuals contributed substantial information and expertise. The tasks of compiling and processing data, generating a portfolio and assessing results were accomplished across agency, state and international boundaries. The portfolio is comprehensive in scope as it combines ample quantitative data, a powerful computer model, the knowledge and guidance of experts, and results of previous conservation efforts to produce a vision for Chihuahuan Desert conservation. It is our belief that involvement of a spectrum of participants and tools increases the relevance and usefulness of the portfolio.

The goal of the portfolio is to identify those areas that, if managed appropriately, will conserve viable examples of the biodiversity of the entire ecoregion (The Nature Conservancy 2000). A companion goal is that the portfolio should be efficient in size, in recognition of practical limits on our ability to implement conservation on an ecoregional scale. Conservation areas must also be sufficiently intact and functional to sustain the ecoregion's ecosystems and biota. Finally, the portfolio should compensate, where possible, for biodiversity losses that have resulted from accelerated human impacts, particularly over the past 100-200 years (Pimm et al. 1995).

We chose a two-tiered multi-scale approach to portfolio assembly. In this approach ecological systems (vegetation types combined with landscape features), vegetation-sites, indicator species and keystone species are considered coarse-filter conservation targets. These targets approximate ecosystems in scale and complexity. Though rare species are the traditional focus of conservation efforts, a consensus has grown in recent years that species persist only in the context of functional ecosystems, and that these systems are at risk and should be conserved (Franklin 1993, Flather et al. 1998). The aim of the coarse filter is to embrace the most central ecological processes and components of the Chihuahuan Desert, and in so doing act as an umbrella to capture the plants and animals that depend on those systems. Fine-filter targets comprise the second tier of our approach. These are rare taxa and those that are characteristic of the Chihuahuan Desert. The fine-filter ensures that all biological components of the desert, including those that might slip by the coarse-filter, are represented.

Biodiversity may be defined as the biological and ecological systems and processes that occur at multiple scales and comprise the planet's biosphere (Poiani et al. 2000). These systems and processes include such diverse elements as genes, populations, species, evolution, habitats, ecosystems, nutrient cycles, etc. Human-mediated changes are typically not included in this definition. For the purpose of assembling a portfolio, the coarse and fine-filter targets are considered practical surrogates for biodiversity conservation.

The huge area of the Chihuahuan Desert presents a technical problem for creating a single ecoregion-wide portfolio of conservation areas. In particular, the SITES computer model (Davis et al. 2001), which we used to generate the draft terrestrial portfolio, has computational limits that are exceeded by an ecoregion the size of the Chihuahuan. As a solution we developed a separate portfolio for each of the three major sections of the ecoregion. During the portfolio review process we carefully assessed proposed conservation areas associated with section boundaries to ensure that the three portfolios are compatible and make sense as an ecoregion-wide conservation solution.

3. ASSEMBLING THE TERRESTRIAL PORTFOLIO

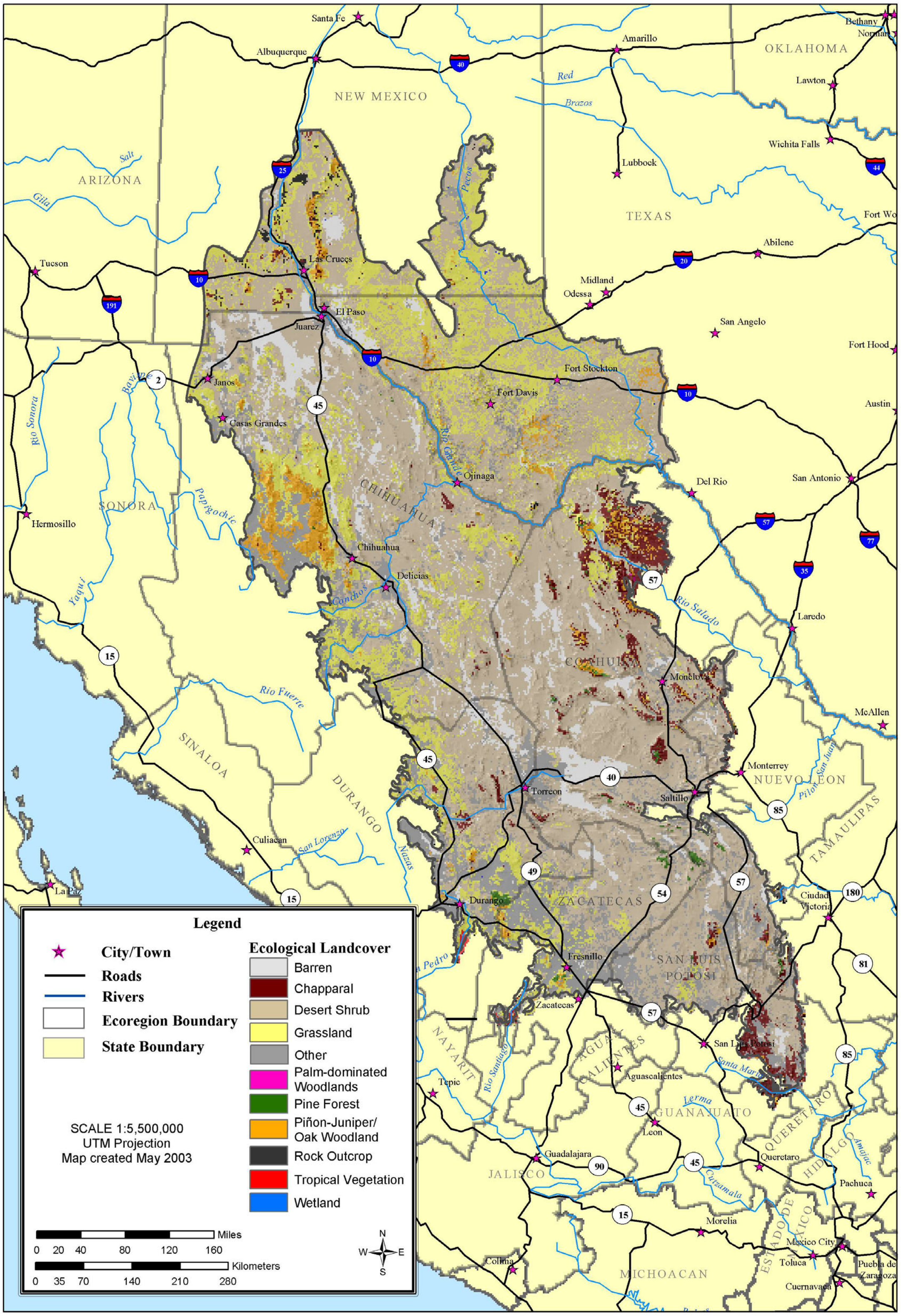
Overview

Portfolio assembly was actually carried out at the level of the planning units, which are 2000-hectare hexagons that cover the ecoregion. Planning units of uniform size and shape have the advantage of “leveling the playing field” so that conservation areas are identified based on clear parameters, rather than factors that may be difficult to understand or quantify. These parameters include the known distributions of conservation targets, numeric and area goals for capturing targets, the degree of human impacts and the overall size of the portfolio. SITES can select planning units individually or in aggregation, depending on the specific targets and goals. The chief disadvantage of these planning units is that they do not, of themselves, represent conservation areas, even when aggregated. However, they provide a useful way to point us to potential conservation areas, which then will become more real as conservation area planning is applied to each site.

Portfolio assembly entailed several steps. Criteria for identifying conservation targets were established and a conservation target list was developed. Location records for targets were compiled from various sources and standardized. Species locations were processed to approximate populations. Ecological system and vegetation-site locations were honed using a landcover map of the ecoregion. Quantitative goals, intended to support target viability, were set and govern each target’s level of representation in the portfolio. An impacts assessment was developed for the ecoregion that highlights intact areas and those with low human impacts. SITES, which is designed to meet conservation goals while constraining portfolio size, produced a draft portfolio. Results were reviewed by a team of scientists, planners and land managers who adjusted the portfolio as necessary to better meet goals and reflect biological and practical reality. The review team balanced the computer-driven output of SITES with first-hand knowledge of the ecoregion. Both at the SITES phase and during review previous Chihuahuan Desert conservation efforts were acknowledged and, to some extent, integrated into the portfolio. In the final step the portfolio was assessed as to how it compares to the ecoregion in terms of physical and biological composition, human population distribution, and fragmentation.

A large amount of information was collected, analyzed and generated through the portfolio assembly process. Tabular data were managed in a relational database, Microsoft Access 2000, and spatial data were managed using ArcView 3.2 and ArcInfo 8 Geographic Information System (GIS) software (ESRI 2000). Supportive data layers developed for this project include a Digital Elevation Model (DEM), a landcover map, a biophysical model and a fragmentation model.

Figure 4: Ecoregional Landcover Map of the Chihuahuan Desert



It is important to acknowledge that the data for portfolio assembly were obtained from diverse sources and differ in quality, spatial resolution, and comprehensiveness. Though we standardized information as much as possible several limitations of the Chihuahuan Desert dataset should be noted. The ecoregional landcover map (Figure 4) was developed from U.S. state GAP analysis landcover maps and a national landcover map of Mexico developed by INEGI, all of which have accuracy shortcomings and landcover classifications that only partly conform between maps. Locations of species targets in the U.S. were largely drawn from well-established biodiversity data archives, such as state Biological Conservation Databases (BCD), while occurrence data for Mexico was specifically compiled as a part of this project. Additionally, the relatively large portion of the ecoregion that overlaps Mexico compared to the U.S. naturally presented more of a data-inventory challenge.

Target List

A crucial first step in portfolio assembly was the creation of a Chihuahuan Desert conservation target list (Appendix I – Conservation Target List). Targets directly and indirectly represent the full complement of ecoregional biodiversity, and include ecological systems, selected vegetation sites, plant communities and species. To encompass the range of elements and processes that comprise ecoregional biodiversity, targets should occur at different geographic and ecological scales, from intact portions of the landscape to individual species populations. Targets should also include elements that are characteristic of an ecoregion such as endemics, and rare and declining elements that might be overlooked but need immediate protection.

A draft list of potential terrestrial targets was compiled from Pronatura Noreste, the Natural Heritage Information Systems (NatureServe 2002, New Mexico Natural Heritage Program 2002, Texas Conservation Data Center 2002), the 1997 World Wildlife Fund Chihuahuan Desert Conservation Workshop (Dinerstein et al. 2000), experts and the literature. This list was circulated among biologists and ecologists for review and modification. Reviewers were asked to ensure that the list was complete and confirm that targets met at least one of the following criteria: (1) *Rare*, having TNC global ranks G1-G3/T1-T3, or deemed rare by an expert; (2) *Endemic* to the Chihuahuan Desert; (3) *Limited* to 2-3 ecoregions including the Chihuahuan Desert; (4) *Disjunct* populations important for evolution; (5) Key *Indicators* of quality habitat, such as fish species that indicate pristine aquatic conditions; (6) *Keystone* taxa, such as prairie dogs; (7) Taxa for which the Chihuahuan Desert is key to the target's overall success, such as wintering migratory songbirds that are declining in their breeding range; (8) Taxa or plant communities for which we have evidence of serious immediate or impending decline but which lack documentation; or (9) Ecological systems that represent all naturally occurring plant communities in the ecoregion.

As the identification and use of terrestrial ecological systems for conservation at the ecoregional scale is a recent development it was necessary to develop an ecological system classification for the Chihuahuan Desert (Appendix II - Ecological System Classification). To clarify, ecological systems are associations of vegetation types and their physical surroundings. For example, desert grassland might be considered an ecological system, since it links a biological element, grasslands dominated by warm-season grasses, to the physical features of lower elevation mountain basins and plains and a semi-arid climate. Ecological systems are important tools for conservation since they are comparable to ecosystems, which are a coarse filter for other biodiversity elements, and can be spatially represented using landcover maps and digital elevation models. A classification of ecological systems of the Chihuahuan Desert was developed by a team of ecologists and draws on vegetation classifications by Brown, Lowe and Pace (1979), Jimenez-Guzman and Zuniga-Ramos (1991), Muldavin et al. (2000), Rzedowski (1978), Villarreal and Valdez (1993) and Wood et al. (1997, 1999). All naturally occurring vegetation types of the Chihuahuan Desert are embedded in the classification; however, we ultimately targeted very coarse ecological system classes, similar to vegetation types, due to limitations in our occurrence data.

Since vegetation is poorly known over large portions of the Chihuahuan Desert we were challenged to distinguish high quality, intact examples of ecological systems. Goals for minimum area and an evaluation of human impacts are indirect measures of condition, but inadequate to ensure that SITES captures superior occurrences of ecological systems. Our Chihuahuan Desert landcover map is similarly limited since it does not address vegetation condition. Consequently, we decided to create a special class of targets called vegetation sites. These are well-known occurrences of major vegetation types of conservation concern, including desert grasslands and montane forests.

The accepted list of terrestrial targets is summarized below and presented in its entirety in Appendix I. The list includes 650 targets, of which 626 are species targets, 13 are ecological systems and 11 are vegetation sites (Table 1). There are 299 rare targets and 499 endemics (Tables 2 and 3). Note that this summary is for unique elements across the ecoregion undifferentiated by section or subsection (each target occurring within each section and subsection was treated as a unique target in order to calculatate goal attainment within each stratification unit.

Table 1. Terrestrial Targets by Group (n = 650)

Group	Number of Targets
Plants	514
Birds	15
Mammals	34
Herps	19
Inverts	44
Vegetation Sites	11
Ecological Systems	13

Table 2. Rare Targets (n = 298)
Rare targets were assigned Global Ranks (NatureServe 2002) of G1/T1 through G3/T3. There are a number of targets that were not ranked for rarity due to lack of information.

	Number of Targets				
	G1	**G1G2**	**G1G3**	**G2**	**Other Ranking**
Plants	38	1	-	67	105
Birds	-	-	-	1	8
Mammals	1	1	-	3	17
Herps	2	1	-	4	7
Inverts	7	-	2	11	22

Table 3. Terrestrial Ecoregional Endemics and Species of Limited Distribution
Designations of endemic and limited are preliminary and based on available information. Limited targets occur in 2-3 ecoregions including the Chihuahuan Desert. (n = 558).

	Number of Targets	
	Endemic	**Limited**
Plants	430	51
Birds	3	3
Mammals	24	5
Herps	16	2
Inverts	18	6

Target Occurrences

Occurrence (location) records for species, ecological systems and vegetation-sites were gathered from diverse sources. Species occurrences were compiled from the Biological Conservation Database, Pronatura Noreste, other agencies, museum collections, experts and the literature. Species occurrences were typically point-locations. Ecological system and vegetation-site occurrences were processed as discrete polygons representing type patches. Occurrences for ecological systems were derived from landcover coverages of the 2000 Inventario Nacional Forestal (SEMARNAP 2000), New Mexico Gap Analysis Program (GAP; Thompson et al. 1996) and Draft Texas GAP (Texas Cooperative Fish and Wildlife Research Unit 2001). Vegetation site occurrences were provided by Pronatura Noreste, World Wildlife Fund and The Nature Conservancy.

We consolidated population occurrences for species since many original point-location records for species are ambiguous as to whether they represent individuals or populations (Morris et al, 1999). This process was cumbersome but significantly improved the suitability of the original data for developing a portfolio. This creates a problem for setting goals for the portfolio since we define species viability largely in terms of population number and distribution (see Target Goals, page 18). Point locations are also problematic since viability is related to associated habitat. Our solution was to consolidate species occurrences based on proximity, and represent populations as polygons. Multiple occurrences of same-species targets that overlap the same 2000 hectare planning unit were merged into single occurrences. We used 2000 hectares as a cut-off because that is the size of the actual planning units used to select conservation areas, and SITES cannot distinguish areas smaller than a planning unit. The planning units doubled as the consolidation patches, and consolidated occurrences were shifted to patch center-points.

Next, we estimated the minimum area required to support viable populations of each species (Appendix III – Minimum Area). This information was gleaned from the literature (Appendix IV – List of References). In cases where there is little information on minimum size we extrapolated from similar and better-known species.

We interpret consolidated occurrences for species with minimum areas equal to or less than 2000 hectares as single populations. Though consolidation entails some generalization and a loss of locational accuracy the trade-off of gaining population data useful for goal-setting is worthwhile[1]. Since SITES is limited to planning units, any consolidated occurrence that it selects actually requires that the entire 2000 hectare patch is selected. This is an indirect way to capture not only a point location of a population but also a representation, at least in area, of its habitat.

[1] Consolidation results in generalizing occurrences of the same species with minimum areas *less* than 2000 hectares that do not overlap, but occur within the same 2000 hectare patch, as single populations. Additionally, original locations are shifted to planning unit center-points. However, these are practical compromises for portfolio assembly since targets must be represented at the planning unit scale for SITES.

Species with larger minimum areas presented a particular challenge. It was misleading to cast a single consolidated point occurrence (and its overlapping 2000 hectare patch) as accurately representing the population location and habitat requirements of a species with a large minimum area. However, simply converting the species' minimum area into an occurrence would result in a loss of locational accuracy[2]. We decided on a two-layered strategy. Consolidated points were buffered by their minimum areas. Resultant polygons were considered single populations. However, the consolidated points themselves were retained as "accuracy points" so that the actual locations of the original records were not ignored. Both the buffered points and consolidated points were assigned goals for SITES. Limitations of the SITES procedure and landcover map ultimately convinced us to use species polygon occurrences to influence portfolio assembly rather than as strict targets.

To create a spatial representation of ecological systems we developed a draft Chihuahuan Desert landcover map based on the 2000 Inventario Nacional Forestal, New Mexico GAP and draft Texas GAP landcover maps (Figure 4). To accomplish this the separate maps were standardized to the same spatial resolution, vegetation types were cross-walked, and the maps merged. Vegetation types were cross-walked to the Chihuahuan Desert ecological system classification, and mapping units were re-classified as ecological systems (Appendix V – Landcover Map/Ecological System Crosswalk). Each discrete landcover patch, re-classified to ecological system, is considered an occurrence. A major drawback of the Chihuahuan Desert landcover map is that it is only reliable across state and international boundaries at the coarsest ecological system level (Appendix IV – Ecological System Classification). This is due to significant inconsistencies between the component Inventario Nacional Forestal and GAP landcover maps. These inconsistencies extend to plant community dominants, species composition, lifeform structure (i.e. tree, shrub, herb) and terrain associations, for example of soils and landforms. Additionally, an internal review found that the New Mexico and Texas GAP maps appear to be inaccurate in parts of the ecoregion. Even the coarse ecological systems are not well-matched across some segments of state and international boundaries.

The final ecological system mapping units designated as conservation targets were Aspen, Barren/Sparse (includes some dunelands and playas as well as other sparsely vegetated types), Desert Scrub, Grassland, Chaparral, Pinon-Juniper &/or Oak Woodland, Lower Montane Pine Forest, Mixed Conifer Forest/Subalpine Vegetation, Palm Grove, Rock Outcrop (includes outcrops as well as some grasslands on lava and other vegetation with rocky substrates), Tropical Vegetation, Riparian Vegetation and Wetland. Of these, Aspen, Mixed Conifer Forest/Subalpine Vegetation, Palm Grove, Riparian and Wetland were not targeted in SITES as their patches tended to be very small and some were inaccurately mapped in the landcover map. As part of the portfolio review process the portfolio was modified to make certain that these types were captured. We estimated the minimum area required to support viable examples of ecological systems based on the literature and consultation with ecologists (Table 4). Minimum areas for the highly fragmented ecological system Pine Forests were adjusted downwards.

[2] This occurs if same-species' minimum areas overlap or are contiguous and goals are met by capturing a portion of the overlapping or contiguous areas, which may entirely miss the original consolidated point locations.

Table 4. Minimum Areas (ha) for Ecological Systems Targeted in SITES

Ecological System	Minimum Area (ha)
Barren/Sparse	1000
Chaparral	4000
Desert Scrub	5000
Grasslands	10000
Lower Montane Pine Forests	500
Pinon-Juniper &/or Oak	5000
Rock Outcrop	100
Tropical Vegetation	500

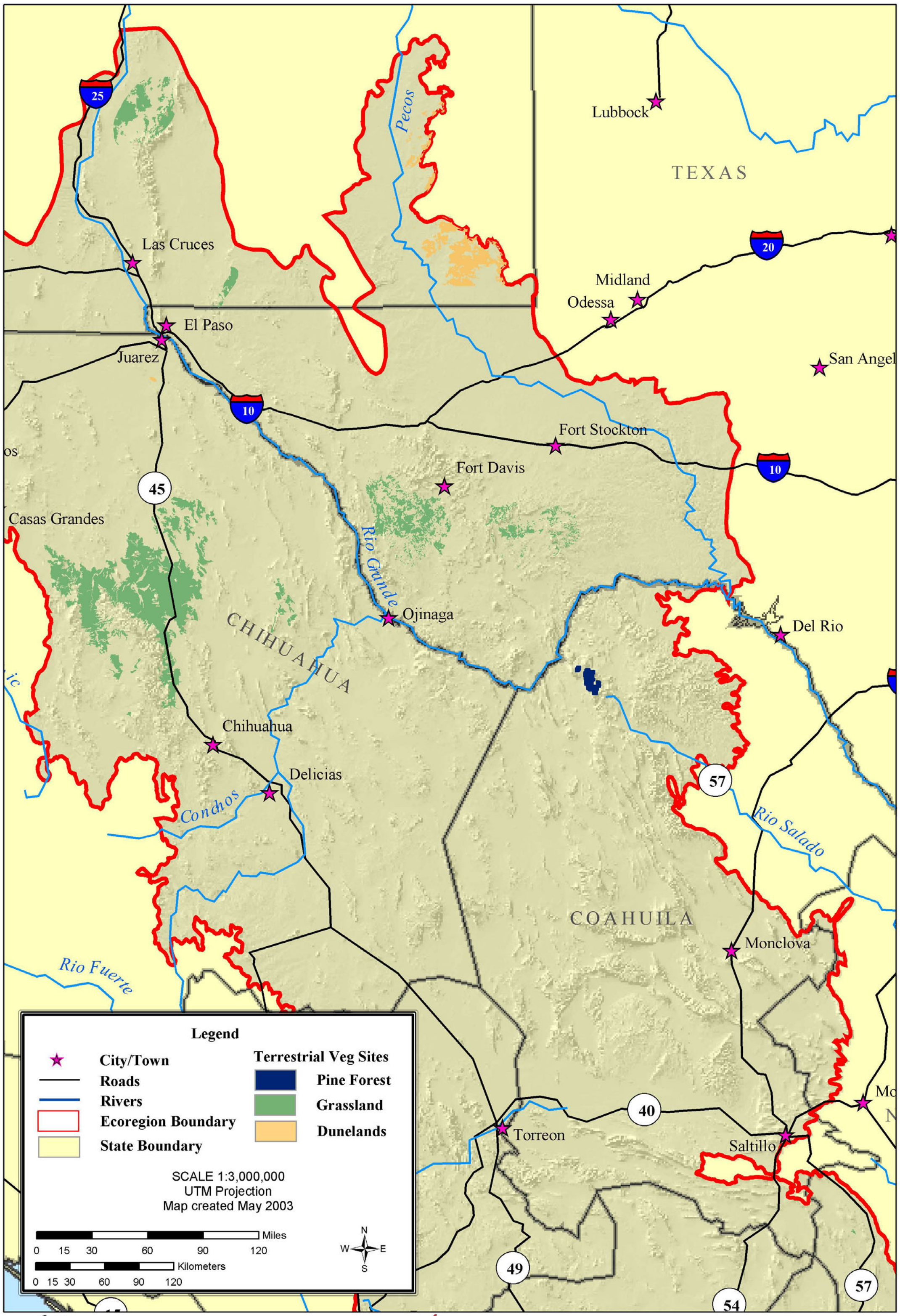
We obtained vegetation site boundaries in the form of digitized polygons that were created to roughly estimate the boundaries of important vegetation sites. To improve their resolution we overlaid the Chihuahuan Desert landcover map and isolated their dominant vegetation types. For example, the grassland mapping unit of the landcover map was intersected with the Marfa Grasslands polygon and the site was re-defined by the common area of intersection. Vegetation sites are shown in Figure 5. Though the landcover map has limited accuracy, we consider it a productive tool for honing the very rough vegetation-site polygons. Minimum areas for vegetation sites are simply those used for their dominant vegetation type; in the case of the Marfa Grasslands the minimum area is 10,000 hectares, which is the same for grasslands.

In total, there were 4236 acceptable consolidated point occurrences, 165 buffered point occurrences, 2550 polygons covering the vegetation sites, and 203,479 polygons covering the ecological systems targeted in SITES (Table 5).

Table 5. Target Occurrences by Group (n = 210,423)

Group	Number of Occurrences
Birds (pts)	218
Birds (buffered)	84
Herps (pts)	164
Inverts (pts)	211
Mammals (buffered)	367
Mammals (pts)	74
Plants (pts)	3276
Vegetation Sites	2550
Ecological Systems	203,479

Figure 5: Terrestrial Vegetation Sites



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Target Goals

We established conservation goals for all conservation targets (Table 6; Appendix VI). Goals ensure that the portfolio captures sufficient occurrences to support viable populations of targets in the ecoregion over the long-term. The portfolio adequately represents a species target if its populations are sufficiently numerous and spatially dispersed to withstand local extinctions and sustain genetic diversity and are associated with habitat patches of suitable size (Morris et al. 1999). Ecological systems are considered viable if they occur in patches large enough to maintain dynamic ecological processes such as fire, are spatially dispersed, and comprise a reasonable proportion of their historical extents. We defined viability in practical terms that can be addressed through the target occurrence data. Thus goals are expressed in terms of the number of populations (species targets) or total area (ecological systems and species populations), and their geographic distribution within the ecoregion. Species and ecological system viability are also greatest where human impacts are lowest, which we addressed directly through the impacts assessment and indirectly by setting minimum area requirements. Other measures of viability, such as richness and seral diversity in plant communities are not explicitly addressed. However, the SITES program inherently clusters target occurrences and therefore provides an ad hoc means to increase target richness.

Initial ecoregional goals (Table 6) for each target were based on global conservation rank and geographic range drawn from a literature review and consultation with experts. These "optimal conservation" goals were used to develop goals for each subsection based on the distribution of the target across the Ecoregion to meet the overall requirement of stratification of occurrences to represent the geographic and genetic variability of each target within the Ecoregion. These goals are termed "ecological" goals. "Applied" subsection goals, used in SITES, were reduced from ideal goals based upon actual target occurrences. Subsection goals were adjusted based on estimated target abundance: if a target was not expected to occur in a subsection its goal was zeroed, if it was incidental its goal was lowered, goals in other subsections were increased to compensate. This increased the odds that the portfolio would capture actual target locations, and supported SITES, which requires goals to be achievable for optimal performance. Section goals were then set to the sum of subsection goals. Revised ecoregion goals were set to the sum of section goals (Table 6). Ecoregion & section goals were considered met only if all goals of their respective sections & subsections were met. Ecoregion & section goals were considered met only if all nested goals were met.

For most species targets we estimated the minimum area required to support a population of 1,000 individuals, which represents our operational concept of a minimum viable population for 100 years. For wide-ranging species we estimated minimum areas for 250 individuals instead of 1,000. Minimum areas for each target were based on the lowest published population densities (see Appendix IV), representing required area under suboptimal environmental conditions. When we could not find specific population density information on a species we used information on closely related species. Minimum areas for ecological systems were based on a combination of the habitat area of a typical associated species with large habitat requirements and the minimum area needed

Table 6. Target Goal Guidelines

<table>
<tr><th>Target</th><th>Initial Ecoregional Goal</th><th>Revised Ecoregion Goal</th><th>Section Goal</th><th>Initial Subsection Goal</th><th>Initial Minimum Area</th><th>Adjusted Goal/Minimum Area</th></tr>
<tr><td>G1/T1</td><td>Determined on a case-by-case basis depending on current and past distribution of the target</td><td>All section goals</td><td>All nested subsection goals</td><td>Usually all known viable occurrences.</td><td rowspan="8">Minimum area required to support a population of 1000 individuals or a functional vegetation stand</td><td rowspan="8">Goals- adjusted to reflect available occurrences

Minimum area- reduced by half for species polygon occurrences</td></tr>
<tr><td>G2/T2, G2G3, T2T3</td><td>At least 15 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 5 viable occurrences (5 * min area for polygons)</td></tr>
<tr><td>Endemic G3-G5</td><td>At least 15 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 5 viable occurrences (5 * min area for polygons)</td></tr>
<tr><td>Limited G3-G5</td><td>At least 10 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 2 viable occurrences (2 * min area for polygons)</td></tr>
<tr><td>Disjunct G3-G5</td><td>At least 5 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 3 viable occurrences (3 * min area for polygons)</td></tr>
<tr><td>Peripheral G3-G5</td><td>At least 5 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 2 viable occurrences (2 * min area for polygons)</td></tr>
<tr><td>Widespread G3-G5</td><td>At least 5 viable occurrences</td><td>All section goals</td><td>All nested subsection goals</td><td>At least 2 viable occurrences (2 * min area for polygons)</td></tr>
<tr><td>Key Vegetation Site</td><td colspan="4">The goals are the same as the minimum area for the characteristic vegetation type of the site.</td></tr>
<tr><td>Ecological System</td><td colspan="6">30% of estimated historical extent. This compensates for increases in some vegetation types (e.g. desert scrub) and decreases in others (e.g. grasslands) over the past ~130 years.</td></tr>
</table>

to support dynamic ecological processes such as fire. In cases of declining ecological systems, such as grasslands, minimum area also reflects the reality that existing stands function at smaller scales than in the past.

Goals for species targets take into account their abundance and ecoregional distribution. Since we modified species location records in order to regard them as populations (see Target Occurrences, page 14), population count goals were actually aimed at the modified target locations. As a practical matter, selecting a location for a target with a minimum area at or below 2000 hectares is the same as selecting the overlapping 2000 hectare planning unit, and so by default incorporates a minimum size criterion. Species targets with minimum areas above 2000 hectares have both point locations and buffered point, or polygon locations populations (see Target Occurrences, page 14). Consequently these targets have count, minimum area and total area goals. Count goals were converted to total area goals by multiplying times minimum area. Count goals increase the likelihood of capturing accurate target locations while area goals ensure that sufficient habitat is captured. For example, locations for the Mountain Plover, *Charadrius montanus*, were buffered 5000 hectares, the minimum area estimated to support a population. In the Meseta Central the plover has a count goal of five occurrences, a minimum area of 5000 hectares, and a total area goal of 25,000 hectares.

Total area goals for ecological systems were determined with reference to historical conditions of 125-150 years ago. This was done for two reasons. First, the historical extents of vegetation types are thought to depict a more natural ecological pattern less influenced by human impacts. Second, since ecological systems are a coarse filter for all other targets setting goals in reference to their historical extents may help compensate for recent human-induced biodiversity losses. There is strong evidence that the vegetation of the southwestern U.S. and northern Mexico, including components of Chihuahuan Desert ecological systems, have significantly declined or expanded in response to increased human impacts starting in the mid to late 1800s (Bahre 1991, Brown, Lowe and Pace 1979, Buffington and Herbel 1965, Dick-Peddie 1993, Schlesinger et al. 1990, York and Dick-Peddie 1969). Riparian vegetation, wetlands and desert grasslands have declined dramatically while shrublands have shown the strongest increase. We estimated the historical extents of ecological systems and subsequent change based on vegetation time-change studies (e.g. Buffington and Herbel 1965) and views of ecologists. Thirty percent of the estimated historical extent was then applied as the total area goal for each ecological system. Though a generalization, the specific use of thirty percent is based on empirical evidence that coarse ecological system filters are effective at capturing fine-scale targets at approximately this level (Pat Comer, pers. comm.). Ultimately, the success of ecological system goals for implementing a coarse filter is limited by the broad class of ecological systems that we accepted as conservation targets. Without higher resolution of ecological system targets there is no assurance of capturing the range of ecosystem variation that the ecological systems are intended to reflect.

Total area goals for vegetation-sites were set the same as the minimum areas of their dominant ecological system. Thus the minimum area and total area goal for the Marfa Grasslands is 10,000 hectares, which is the minimum area for grasslands. The rationale for limiting vegetation site area goals is linked to the fact that capturing a vegetation site is akin to capturing that site's dominant ecological system. While we wanted to capture function-size ecological system patches to represent vegetation sites, we did not want these patches to be so large as to unduly influence the attainment of ecological system area goals throughout the ecoregion.

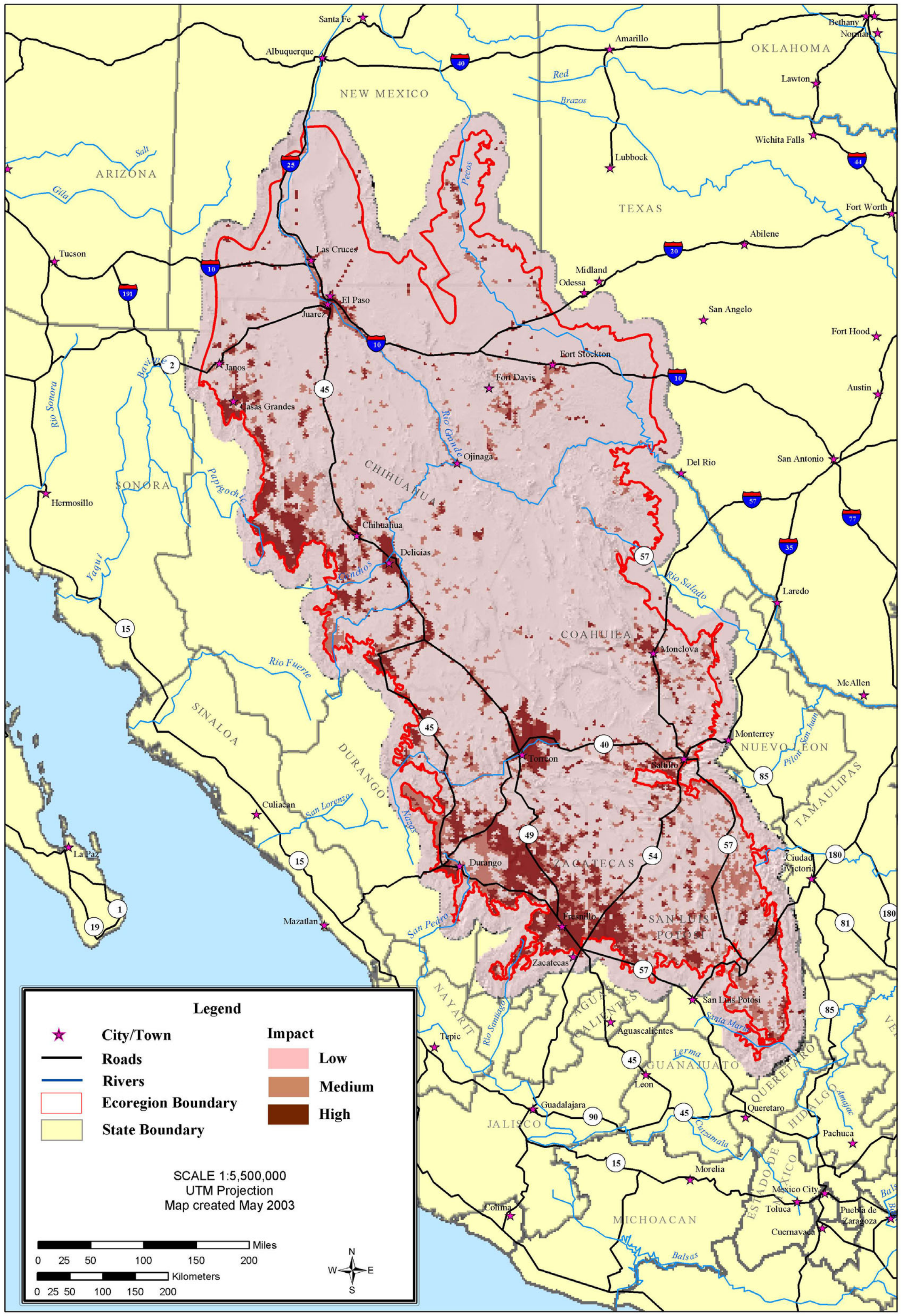
After ecological goals were determined they were adjusted to reflect actual target occurrence data. Goals exceeding available occurrences were reduced, and those equal to or below available occurrences were retained. In preliminary SITES runs we found that SITES was often unable to meet goals for targets with large minimum area requirements. This was the case for the majority of species polygon (buffered point) occurrences. We conjectured that such large areas were too expensive for SITES, and that since these targets usually had few locations SITES had few alternatives. As discussed below (see Selecting Conservation Areas Using SITES, page 25) SITES essentially runs a cost/benefit analysis in an attempt to meet a complex set of target goals in a portfolio that is relatively small in size. Apparently, *not* meeting the original minimum area requirements for species polygon occurrences was the cheapest solution for SITES. When SITES cannot meet minimum area at all for a target it drops that target altogether. To force SITES to meet as many goals as possible, but preserve some measure of minimum habitat area, we reduced minimum areas of species polygon occurrences by half. As explained below (Interpreting the Portfolio) we ultimately considered the species polygon occurrences as useful tools to influence portfolio assembly rather than strict targets.

Impacts Assessment

We quantified major human impacts and identified intact areas across the ecoregion (Figure 6). Specifically, we calculated the relative area or density of urban areas, tilled agricultural lands, roads, railroads, powerlines, protected areas and sites considered to be intact. Results were used to deter or restrict SITES from selecting impacted areas, to encourage SITES to select protected and intact areas, and to assess portfolio results. It should be noted that the information we obtained on impacts varied in quality, extensiveness and availability between states and countries. Therefore, we were obliged to exclude some types of impacts from our spatial analysis including dam, well and mine locations, and the distribution and intensity of logging, mining and livestock grazing.

Sources for the locations and areas of urban and crop lands were the 2000 Inventario Nacional Forestal, New Mexico GAP and draft Texas GAP landcover maps. Road, railroad and powerline spatial layers are from The Nature Conservancy's GIS data archive. Protected area data were obtained from the New Mexico GAP land protection status coverage, The Nature Conservancy of Texas, and Pronatura Noreste. Typically, government lands with limited public access, such as parks, refuges and military reservations, along with non-governmental land trusts and preserves, are considered dedicated protected areas. Intact areas were obtained from the 1997 World Wildlife Fund Chihuahuan Desert Conservation Workshop.

Figure 6: Impact Assessments Map



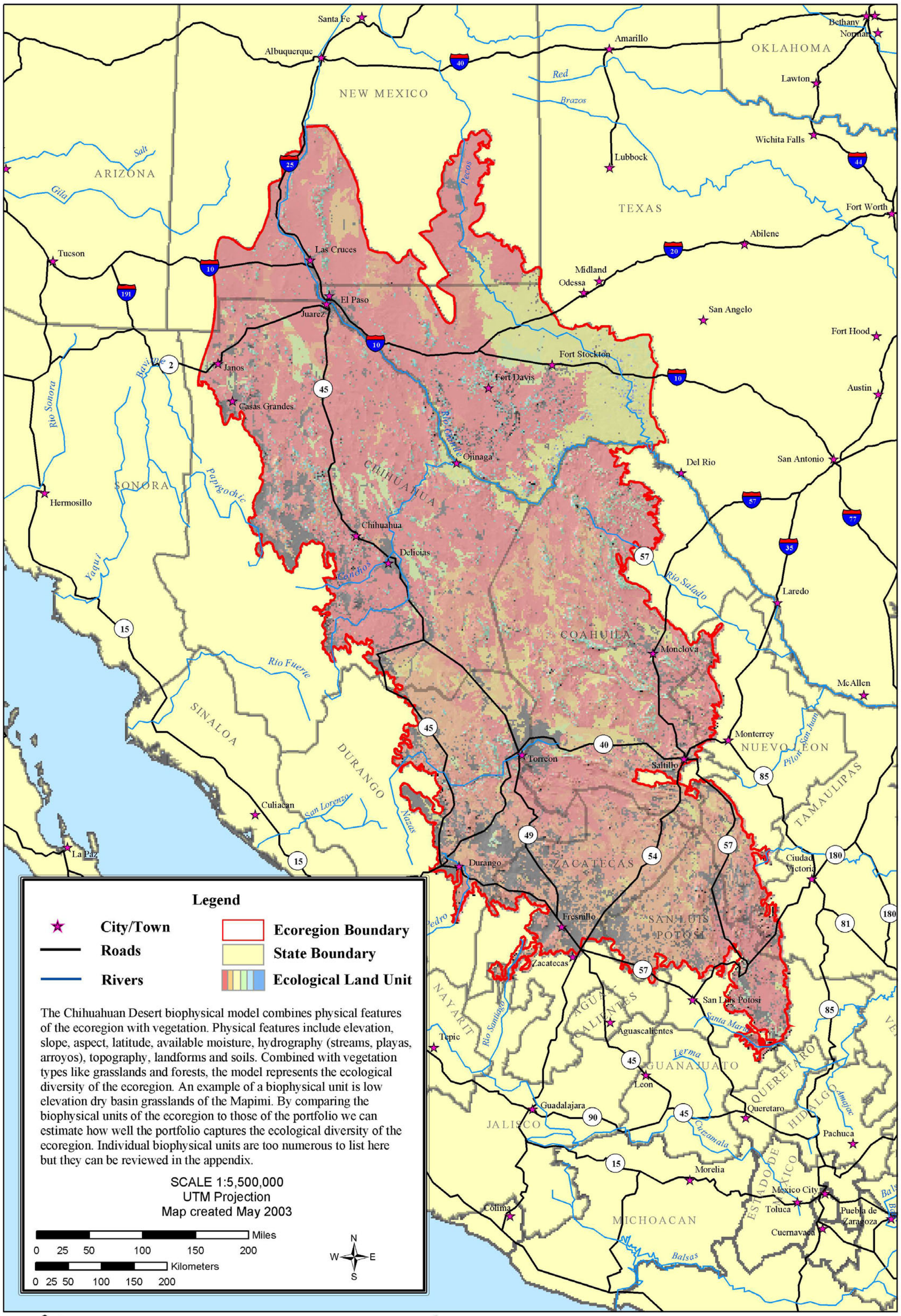
Biophysical Model

We developed a biophysical model for the Chihuahuan Desert that combines biotic and abiotic features of the ecoregion (Figure 7, Appendix VII Biophysical Analyses). The model was a means to represent the biological, ecological and physical diversity of the ecoregion. As such, we considered it as a rough surrogate for the ecosystems of the Chihuahuan Desert. It was especially useful to augment the ecological systems, which were unavoidably broad so that their ability to act as a coarse filter for ecoregional biodiversity was uncertain. Due to time constraints the model was not used to designate actual targets for portfolio assembly but instead was used to help evaluate the portfolio. By comparing the portfolio to the ecoregion we estimated the proportion of biophysical variation captured in the portfolio.

Abiotic features of the model were elevation, slope, slope-aspect, landform, an index of moisture availability, intermittently wet arroyos, playas and wetlands, and soils (Appendix VII). These are widely accepted physical components of ecosystems that were easily represented in a GIS. The model was developed separately for each ecoregional section to isolate large-scale physiographic influences such as latitude and regional weather systems. Except for soils and intermittently wet areas these data were derived from a 60 m digital elevation model. Locations of intermittently wet areas were obtained from The Nature Conservancy's GIS data archive. We used soils instead of geology as we were unable to obtain an ecoregion-wide geology coverage. Soils may also be a better predictor of vegetation composition and local climate than geology. We obtained a standardized soils classification of Mexico and the U.S. from the National Resources Conservation Service (Almaraz and Eswaran 1998). That classification was cross-walked to the State Soil Geographic Data Base, or STATSGO (http://www.nrcs.usda.gov/technical/techtools/stat_browser.html), and then generalized to common soil texture and chemistry qualities. An example of an abiotic mapping unit is "Northern Chihuahuan Desert mid-elevation south-facing lower montane dry moderately-steep slopes with gravelly soils".

Biological features of the model were ecological systems. Though the Chihuahuan Desert ecological systems were intended to represent both vegetation and their associated physical features, and so should be similar to biophysical units, they were more or less generalized to vegetation types. The biophysical model, in part, estimated the range of variation within ecological systems. An illustration of a biophysical mapping unit is obtained by combining the abiotic example above with the ecological system chaparral, as in "Northern Chihuahuan Desert mid-elevation south-facing lower montane dry moderately-steep slopes with gravelly soils and chaparral". In this example the particular combination of physical features may be interpreted as a finer-resolution type of the broadly-defined chaparral ecological system.

Figure 7: Biophysical Model Map



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Human-dominated agricultural and urban landcover, as well as the poorly mapped riparian and wetland ecological systems, were excluded from the biophysical model. The version of the model used for portfolio assessment also excluded any biophysical units that comprised less than one percent of their associated ecological system's area in their respective ecoregional section. For example, all biophysical units containing chaparral in Meseta Central that were less than one percent of the total area of chaparral in that section were excluded. This follows a convention of other TNC ecoregional efforts to eliminate biophysical units that may be GIS artifacts or are otherwise unreliable based on their small size. Exceptions were made for types that naturally occur as small patches, including intermittently wet areas and very steep slopes (>70 %), which represent cliff communities. These units were retained if they comprised more than 0.05% of their associated ecological system's area in their respective section. Note that filtering was based on total biophysical unit area and not individual patch area; thus minimum size was not applied. The filtered biophysical units were not deleted from the Chihuahuan Desert dataset, and in fact are an important resource for identifying areas of the ecoregion that may represent undocumented ecosystems that should be inventoried further. However, in lieu of such study we considered these units impractical for conservation planning at an ecoregional scale.

The model contained 9,118 unfiltered biophysical units and 594 units after filtering. Of the filtered units, 83 were intermittently wet types and 75 were very steep (cliff) types. There were over 900,000 unfiltered biophysical unit patches.

Previous Efforts

The Chihuahuan Desert portfolio is intended to enhance previous regional conservation efforts through an expanded international and multi-organization partnership and a largely data-driven portfolio assembly process. We recognize the significant value of those other efforts and integrated their results where appropriate. In particular, we adopted the conservation sites of the 1997 World Wildlife Fund Chihuahuan Desert Conservation Workshop (Dinerstein et al. 2000) as starting points, and used a layer of intact areas developed at that workshop as part of our impacts assessment (see Impacts Assessment, page 21). The WWF sites and intact areas were given enhanced value in SITES, which increased the likelihood that they would be selected. During the review process the portfolio was modified to accept portions of conservation areas identified by other efforts (see Portfolio Review, page 27). The addition of these areas helped compensate for a substantial data gap in some parts of the Mexican portion of the ecoregion.

Selecting Conservation Areas Using SITES

We used the SITES computer program (Davis et al. 2002, see Appendix XIX for details) to identify potential conservation areas). SITES and related applications, including SPEXAN and MARXAN (http://www.ecology.uq.edu.au/marxan.htm), have been used by The Nature Conservancy and others to create networks of potential conservation areas.

SITES was developed to simplify the task of identifying conservation areas across large areas where options are overwhelming and information is complex or, in some places, lacking (a recent new compiling of the algorithm called "SPOT: The Spatial Portfolio Optimization Tool" has recently been developed by the Conservancy and is now available for use, Shoutis 2003, see Appendix XX). SITES meets target goals while simultaneously avoiding impacted areas and limiting total portfolio size. SITES uses a partial optimization algorithm (Possingham et al, 2000, Pressey et al. 1996, McDonnell et al., 2002) that is capable of processing huge datasets and comparing millions of alternative networks of conservation areas. Though the algorithm does not compare all possible networks it is considered an effective and practical means for identifying conservation areas at the ecoregional scale. A particular advantage for our purposes is that SITES is formulated to accept large amounts of spatial data and generate solutions that can be quantitatively assessed.

SITES is conveniently viewed as a cost/benefit analysis. Costs increase with larger portfolios and greater impacts, and benefits are accrued by capturing targets and meeting target goals. Costs and benefits are specified interactively, and it is their balance that determines the ultimate shape of the portfolio. For the current version of SITES the task of setting costs and benefits is something of an art. Costs and benefits are devised so that a large portfolio and highly impacted areas are avoided, but target goals are met. However, it is a matter of trial and error to achieve the desired balance, a problem that hopefully will be addressed in a future version of SITES.

In summary, we covered the ecoregion with 2000-hectare hexagons created using Patch Analyst (http://flash.lakeheadu.ca/~rrempel/patch/) and designated these as the basic planning units. Input data – target lists, target locations, target goals, impacts and intact areas – were formatted for SITES. Scores were assigned to targets, impacts and intact areas that correspond to costs and benefits for SITES. SITES parameters that discount more clustered (rather than scattered) conservation areas were selected. The SITES model was run 10 times for each ecoregional section, each run consisting of 10 million iterations, or groupings, of possible conservation areas. Ultimately, each run generated a single proposal for a conservation area network, or 10 proposals per section.

Of the 10 initial conservation area networks proposed for each ecoregional section SITES ranked one as most effective at meeting target goals while keeping impacts and overall portfolio size low. After an evaluation to ensure that these "best" networks met minimal expectations we accepted them as our draft section-level portfolios. Collectively, they comprise the draft Chihuahuan Desert portfolio.

Only targets for which we obtained locational data were included in the SITES model. Landcover types that may be inaccurately mapped in the source landcover maps, or tend to occur as small patches, were excluded. These correspond to riparian, wetland and upper montane ecological systems. Very rare targets, including those ranked G1 in the Biological Conservation Database, were excluded since they often occur at isolated locations, and could drive SITES to select widely scattered and tiny conservation areas. Additionally, areas with unacceptably high levels of human impacts were flagged as not suitable. As part of the review process (see Portfolio Review, below) we examined missing and under-represented ecological system and species targets on a case-by-case basis and added them back into the portfolio as warranted.

REVIEWING THE PORTFOLIO

The draft portfolio generated by SITES was reviewed by Pronatura Noreste, Texas, New Mexico, and Mexico Nature Conservancy programs, and Mexico and U.S. World Wildlife Fund representatives. Biologists, ecologists, conservation strategists and technical experts familiar with GIS and the SITES selection procedure participated. Review sessions were held in Monterrey, Mexico and Santa Fe and San Antonio in the U.S. The review was intended to weed-out areas without apparent conservation value, add areas that SITES overlooked, modify (e.g. consolidate or split) areas based on ecological considerations, and identify information gaps.

The tangible result of the review was the creation of two tiers of the portfolio: a prioritized, or primary portfolio, and a secondary portfolio (Figure 8). The primary portfolio is the fully reviewed and modified ecoregional conservation portfolio. It balances the expertise and guidance of scientists with SITES output. We consider it critical for protecting targets with the greatest conservation needs, such as those that are rare and declining, or represent intact ecosystems, and so it serves as an immediate guide to conservation strategy and implementation. All locations of very rare (global ranks G1 and T1) targets not captured in conservation areas but within the ecoregion were added to the primary portfolio. The secondary portfolio is that part of the SITES output, in Mexico, that lies outside the primary portfolio. It also contains a World Wildlife Fund site, Cuenca del Rio Nazas, and all uncaptured locations of invertebrate targets with global ranks of G2, G3, T2 and T3. The purpose of the secondary portfolio is to call attention to targets and places with limited or uncertain conservation needs. These include some common species with significant ecoregional distributions (e.g. common Chihuahuan Desert endemics), vegetation stands with questionable viability, and targets that were simply overlooked by SITES. For the most part the secondary portfolio represents an information gap for ecoregional conservation, encompassing potential targets that require further assessment to determine their conservation needs. The secondary portfolio is limited to Mexico since the comparatively smaller U.S. portion of the ecoregion was better known to reviewers. There is a small overlap between the primary and secondary portfolios due to the addition of Cuenca del Rio Nazas. There is also some redundancy where rare targets that fall outside one portfolio were added to that portfolio, but also overlap another portfolio. For example, G1s and T1s that fall outside of but were added to the primary, but which also overlap the secondary's conservation areas, are counted twice. This redundancy is unavoidable, since these "outside" target occurrences and the entire secondary portfolio, including Cuenca del Rio Nazas, have not been spatially resolved into formal conservation areas. That task is better accomplished at the level of site conservation planning (conservation area planning).

Although we strived for consistent reviews the Mexican and U.S. portions of the portfolio were treated somewhat differently. This was necessary to accommodate distinct institutional approaches among the conservation partners and to acknowledge the coarser level of biodiversity information available in Mexico (see Overview, page 9). Specifically, the review of the Mexican portion integrated results of other regional conservation efforts to help compensate for more limited data about conservation targets in Mexico. These other efforts include CONABIO (2000), Naturalia and The Wildlands Project (List et al. 1999), Fierro (2001) and World Wildlife Fund (Dinerstein et al. 2000). SITES results for Mexico were regularly consolidated with conservation areas of these other and numerous poorly known areas selected by SITES were assigned to the secondary portfolio. In contrast, the review of the U.S. portion was largely confined to SITES results, and areas selected by SITES not retained in the primary portfolio were eliminated entirely. Bear in mind, though, that WWF sites played an important role in SITES throughout the ecoregion (see Previous Efforts, page 25).

Figure 8a: Portfolio of Potential Terrestrial Conservation Areas (map 1 of 5)

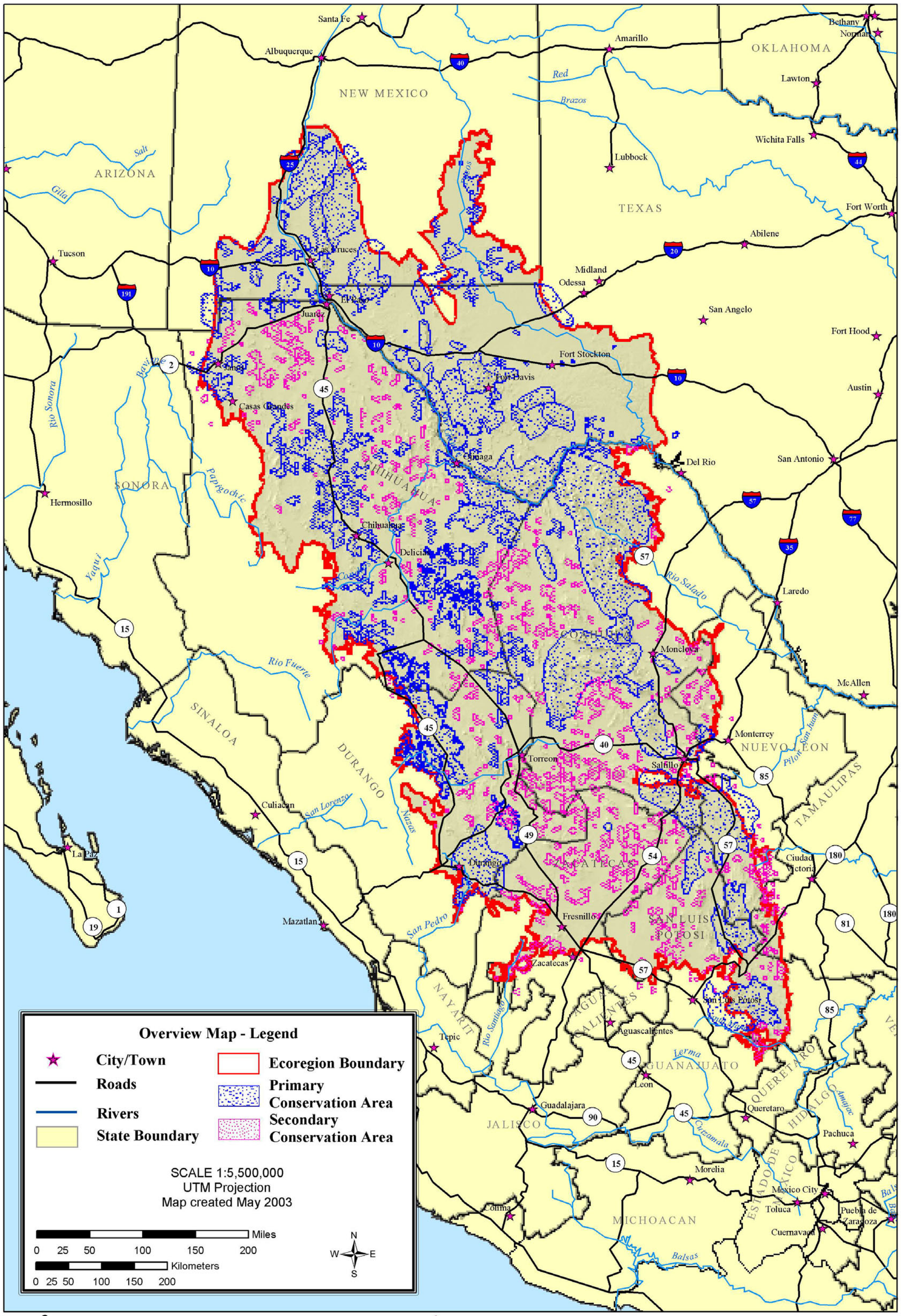

Figure 8b: Primary Potential Terrestrial Conservation Areas

Northern Chihuahuan Desert Areas

Map ID	Conservation Area Name	Map ID	Conservation Area Name
1	Alamito Creek	53	Mesa/Pecos Plain
2	Antelope Ridge	54	Mimbres Hot Spring
3	Apache Mountains	55	Monahans
4	Cerros del Colorados	56	Musquiz Canyon
5	Big Bend Triangle	57	Noelke Hill
6	Black River Basin	58	Northern Brokeoff Mountains
7	Borancho	59	Northern Jornada Basin
8	Border	60	Nutt Grasslands
9	Borderland	61	Organ Mountains
10	Bosque Wilderness Area	62	Otero Mesa
11	Bullis Gap	63	Palomas
12	Canon de Santa Elena	64	Pastizales de la Campana
13	Caballo Lake	65	Potrillo Mountains
14	Caballo Mountains/Southern Jornada	66	Quitman Mountains North
15	Cedar Mountains	67	Rancho Cerros Prietos
16	Cedar Station/Dryden	68	Rancho De Victor Achaval
17	Cerro Chihuahua	69	Rancho El Colorado
18	Chalk Bluffs	70	Rancho El Vallecillo
19	Clint	71	Rancho Galiliea
20	Cook's Peak	72	Rancho Las Vacas
21	Cornudas	73	Rancho Monteseco
22	Crawford Ranch	74	Red Light Draw
23	Crow Flats/Ishee Lakes	75	Red Mountain
24	Davis Mountains	76	Remuda / Big Sinks
25	Devils River Megasite	77	Roberts Mesa
26	Dona Ana Mountains	78	Robledo & Las Uvas Mountains
27	Dryden/Sanderson	79	Saddle Butte
28	Eagle Mountains	80	Salt Basin
29	Pastizales de Janos/Mesa de Guacamaya	81	Samalayuca
30	Sierra del Virolento/Sierra de Hechiceros	82	San Andres - Oscura Mountains
31	Florida Mountains	83	San Vicente Wash/Walnut Creek
32	Franklin Mountains	84	Seven Rivers
33	Glass Mountains	85	Sierra Aguja
34	Guadalupe Mountains	86	Sierra Chaconena
35	Hackberry Draw	87	Sierra De Alamillo
36	Hagerman	88	Sierra De Encinillas
37	Hatchet & Alamo Hueco Mountains	89	Sierra Del Pajarito
38	Hope	90	Sierra Diablo & Delaware Mtns
39	Hueco Mountains	91	Sierra Pastorias
40	Sierra del Capulin	92	Sierra Vieja-Chinati Mountains
41	Kenzin	93	Sitting Bull Falls
42	La Calosa	94	Sorcerer's Cave
43	La Perla	95	South of Halfway
44	Lake Amistad	96	Strauss Sinks
45	Lake Toyah Basin	97	Sunland Border
46	Lanark	98	TorC West
47	Langtry	99	Tularosa Basin Desert
48	Livingstone Ridge	100	Van Horn
49	Longfellow Grasslands	101	Villa Ahumada
50	Majalca	102	West of Fort Stockton
51	Marathon Basin Grasslands	103	Western Sierra Diablos
52	Marfa Grassland	104	Yeso Hills

Figure 8b: Primary Potential Terrestrial Conservation Areas (continued).

Bolson de Mapimi Areas

Map ID	Conservation Area Name	Map ID	Conservation Area Name
105	Complejo de Cuatro Cienegas	112	Cuchillas de la Zarca
106	Complejo Maderas del Carmen, El Burro y La Encanta	113	Estacion Conejos
107	Complejo Mapimi 1	114	San Miguel
108	Complejo Mapimi 2	115	Sierra de la Gloria
109	Complejo Mapimi 3	116	Sierra de la Paila
110	Complejo Mapimi 4	117	Sierra El Rosario
111	Corredor Saltillo, Monterrey	118	Sierra Los Remedios
		119	Sierra Santa Fe del Pino

Meseta Central Areas

Map ID	Conservation Area Name	Map ID	Conservation Area Name
120	El Huizacle y Pa	123	Pico de Teyra
121	El Tokio	124	Sierra de Alvare
122	Organos Malpais	125	Yerbaniz

Figure 8b: Portfolio of Potential Terrestrial Conservation Areas (map 2 of 5)

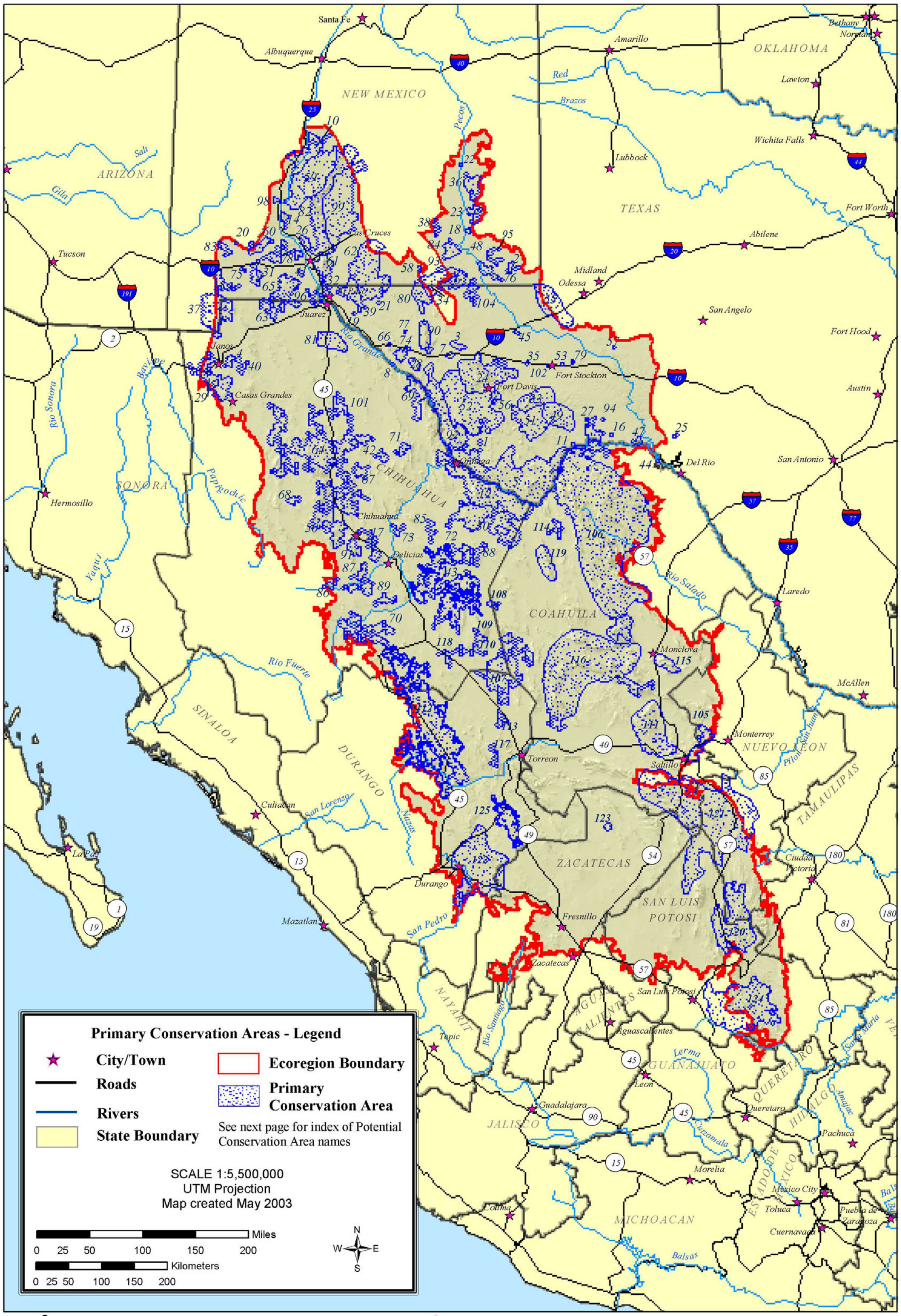

Figure 8c: Secondary Potential Terrestrial Conservation Areas (Northern Chihuahuan Desert Section)

Map ID	Conservation Area Name
1001	12 De Marzo
1002	Agostadero De Abajo
1003	Alcalifero
1004	Altamirano
1005	Angstura
1006	Aqua Termales
1007	Argelia
1008	Arroyo Bandejas
1009	Arroyo de la Cochina
1010	Arroyo De Las Moras
1011	Arroyo de San Joaquin
1012	Arroyo del Carrizo
1013	Arroyo del Mulato
1014	Arroyo El Coyamito
1015	Cerro Colorado
1016	Cerro De La Aguja
1017	Cerro de las Vibores
1018	Cerro del Chino
1019	Cerro Del Mogote
1020	Cerro Pelon
1021	Cerros Colorados
1022	Cerros Prietos
1023	Cerros Reyados
1024	Colonia Bosque Bonito
1025	Colonia Galyan
1026	Colonia Pacheco
1027	Coyame
1028	Cuatro Pinos
1029	Cuchillo Parado
1030	Cumbre del Pulpito
1031	El Castillo
1032	El Cinco
1033	El Consuelo
1034	El Faro
1035	El Juguete
1036	El Llano
1037	El Mezquite
1038	El Salado
1039	El Traque
1040	El Vienticuatro
1041	Guadalupe Bravo
1042	Guitarria
1043	Guzman
1044	Hacebuche

Map ID	Conservation Area Name
1062	North Northwest
1063	Pascualeno
1064	Poso de la Escarmuza
1065	Potrero del Llano
1066	Puerto de Lobos
1067	Puerto Escondida
1068	Racncho Las Moras
1069	Rancho Bola
1070	Rancho El Nogal
1071	Rancho El Quemado
1072	Rancho El Ranchito
1073	Rancho El Robote
1074	Rancho El Solita
1075	Rancho Los Hechizos
1076	Rancho Los Nogales
1077	Rancho Monumento
1078	Rancho Moro
1079	Rancho Numaro
1080	Rancho Ojo Caliente
1081	Rancho Rancheria
1082	Rancho Recuerdo
1083	Rancho San Jose
1084	Rancho Santa Marfa
1085	Rancho Tanque
1086	Rio Viejo
1087	Sabinal
1088	San Jose De Los Pozos
1089	San Jose del Sitio
1090	San Pablo
1091	Santa Rita
1092	Santa Rosalia del Ballo
1093	Sierra Boquilla
1094	Sierra De Chorreras
1095	Sierra De Chuchupate
1096	Sierra de Gomez
1097	Sierra de la Escondida
1098	Sierra de la Gloria
1099	Sierra de la Lagrima
1100	Sierra de la Nariz
1101	Sierra de las Vacas
1102	Sierra de Ojuelos
1103	Sierra de Sols
1104	Sierra Del Bronce
1105	Sierra del Gorrion

Map ID	Conservation Area Name
1045	Josefina V de Familiar
1046	Julimes East
1047	La Bandera
1048	La Esperanza
1049	La Pelea
1050	Laguna del Cuervo
1051	Las Chivas
1052	Las Cuatas
1053	Las Veras
1054	Llano Blanco
1055	Los Guerigos
1056	Los Sabinos
1057	Los Volcanes
1058	Mesa de Guacamaya
1059	Mesa del Oregano
1060	N.C.P. Los Pinos
1061	Nicolas Bravo

Map ID	Conservation Area Name
1106	Sierra del Hueso
1107	Sierra del Jabalin
1108	Sierra del Perido
1109	Sierra del Pino
1110	Sierra del Puerto
1111	Sierra del Torreno
1112	Sierra La Medina
1113	Sierra Matasaguas
1114	Sierra Placer de Guadalupe
1115	Sierra Prieta Occidental
1116	Sierra Santa Lucia East
1117	Tanque Paredes
1118	Torre Alta
1119	Tres Castillos
1120	Trinchera
1121	Urrutia
1122	Villa Ahumada

Figure 8c: Portfolio of Potential Terrestrial Conservation Areas (map 3 of 5)

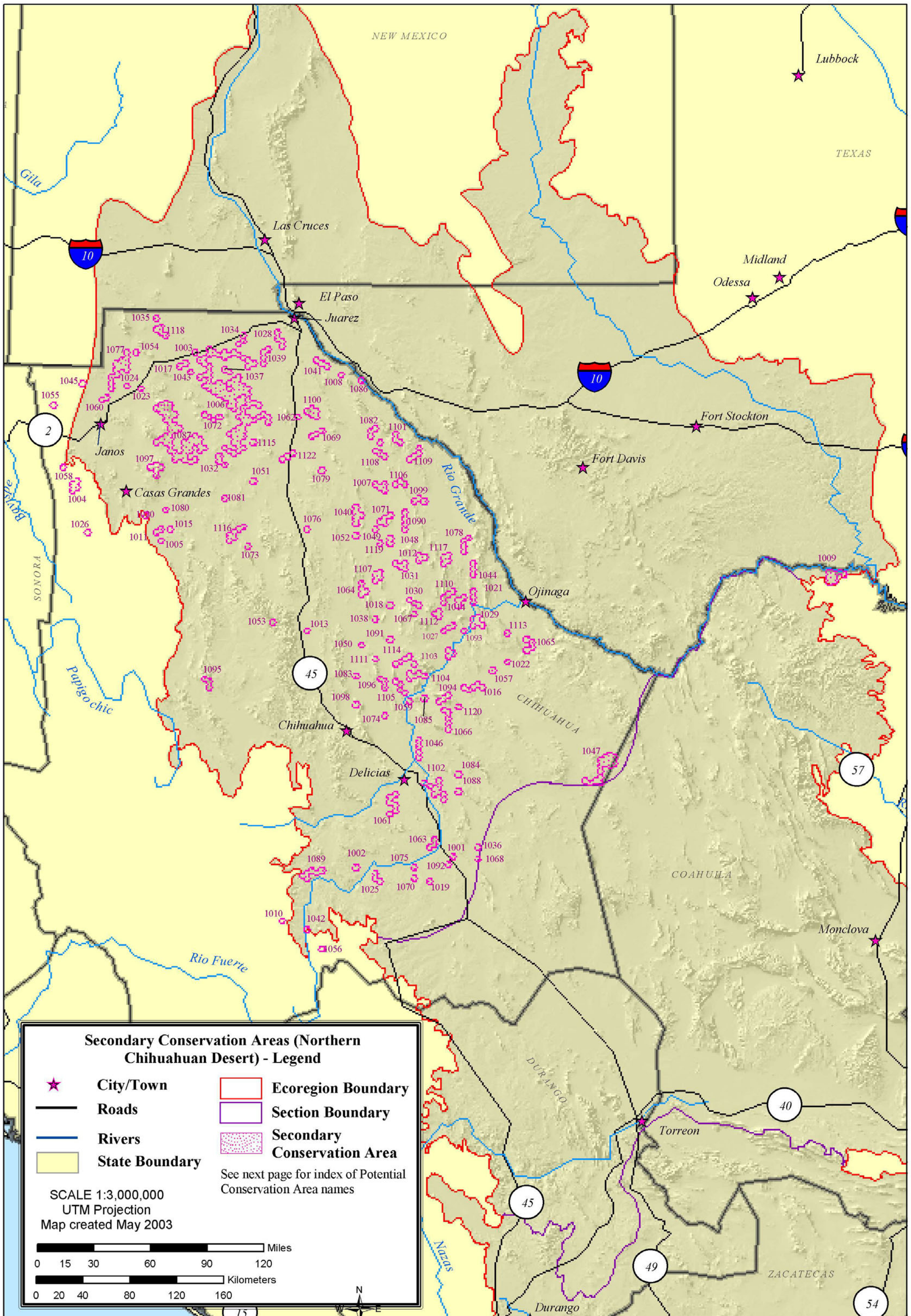

Figure 8d: Secondary Potential Terrestrial Conservation Areas (Mapimi Section)

Map ID	Conservation Area Name	Map ID	Conservation Area Name
1123	Abasolo	1199	Los Pioneros
1124	Acambaro	1200	Los Remedios
1125	Acevedo	1201	Los Tobosos
1126	Atotonilco	1202	Macuyu
1127	Australia	1203	Mapimi
1128	Bachimba	1204	Matrimonio
1129	Boruquillas	1205	Mayran
1130	Cadillal	1206	Minerva
1131	Ceballos	1207	Nazas
1132	Cerro De Leija	1208	Ninos Heroes De Mexico
1133	Chocolate	1209	Noria 133
1134	Cienega Del Carmen	1210	Noria De Los Medrano
1135	Corrientes	1211	Nueva Candelaria
1136	Covadonga	1212	Nueva Italia
1137	Cruz Rodriguez	1213	Nueva Salinas
1138	Cuates De Abajo	1214	Nuevo Yucatan
1139	Cuatros Vientos	1215	Paila
1140	Cuesta Los Alazanes	1216	Palitos Blancos
1141	De Garza	1217	Palo Alto
1142	Don Bosco	1218	Palomas
1143	Don Bucho	1219	Parras
1144	El Alicante	1220	Pedernales Pass
1145	El Barril	1221	Penoles
1146	El Barron	1222	Picacho Hermanas
1147	El Casco	1223	Picos De Los Alamenos
1148	El Celo	1224	Pino Real
1149	El Chaparral	1225	Porvenir De Jalpa
1150	El Consuelo	1226	Presa De Trincheras
1151	El Diablo	1227	Puebla
1152	El Diamante	1228	Rancho La Presa
1153	El Gigante	1229	Rancho Las Norias
1154	El Jaralito	1230	Rancho Nuevo
1155	El Recreo	1231	Rancho Renjamo
1156	El Refugio De Las Cajas	1232	Rodriguez
1157	El Retiro	1233	Rosa Liz
1158	El Revolcadero	1234	Sabaneta
1159	El Rosario	1235	San Bernardo
1160	El Venadito	1236	San Jorge
1161	Emiliano Zapata	1237	San Jose De Carranza
1162	Escuadron Doscientos Uno	1238	San Lazaro
1163	Esmeralda	1239	San Lorenzo El Reves
1164	Estacion Jazminal	1240	San Marcos
1165	Eusebio Berlanga Valdes	1241	San Nicolas
1166	Explosivos Monclova	1242	San Pedro Del Tongo
1167	Gachupines	1243	San Rafael
1168	Guadalupe	1244	San Rafael De Los Milagros

Map ID	Conservation Area Name	Map ID	Conservation Area Name
1169	Guanajuato	1245	Sandra
1170	Hacienda La Mora	1246	Santa Elena
1171	Hormigas	1247	Santa Elena
1172	Huizache	1248	Sierra Azui
1173	Independencia Y Reforma	1249	Sierra De La Rata
1174	Jaral Grande	1250	Sierra De Las Margaritas
1175	Jesus Hernandez Molina	1251	Sierra De Parras
1176	Jesus Maria	1252	Sierra Del Burro
1177	La Enramada	1253	Sierra El Caballo
1178	La Flaca	1254	Sierra El Carmen
1179	La Gloria	1255	Sierra El Pedregoso
1180	La Grulla	1256	Sierra Gamon
1181	La Joya	1257	Sierra La Cadena
1182	La Joyita	1258	Sierra La Campana
1183	La Leche	1259	Sierra Los Alamos
1184	La Loma	1260	Sierra Los Flores
1185	La Luz	1261	Sierra Mojada
1186	La Madriguera	1262	Sierra Morena
1187	La Marsella	1263	Sierra San Antonio
1188	La Muralla	1264	Sierra Tlahualilo
1189	La Pistola	1265	Sombreretillo
1190	La Refugio Praderas	1266	Tabalopes Del Morada
1191	La Zorra	1267	Tacubaya
1192	Las Maravillas	1268	Talia
1193	Las Margaritas	1269	Tizco
1194	Las Tetillas	1270	Torrecillas
1195	Las Tres Lomitas	1271	Valencia
1196	Los Alamos	1272	Vallecillos
1197	Los Corrales	1273	Ventanillas
1198	Los Nogales	1274	Zayalza

Figure 8d: Portfolio of Potential Terrestrial Conservation Areas (map 4 of 5)

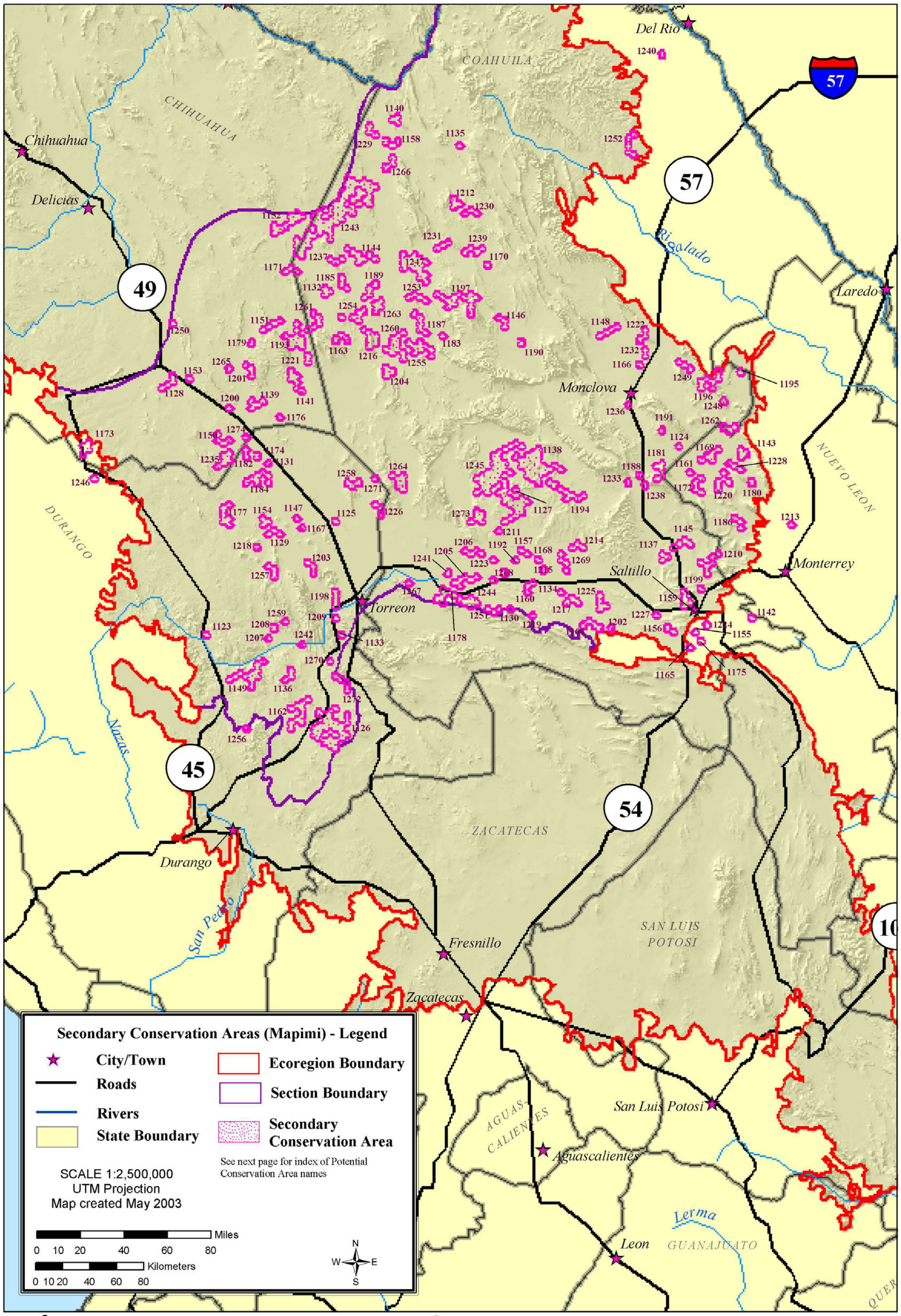

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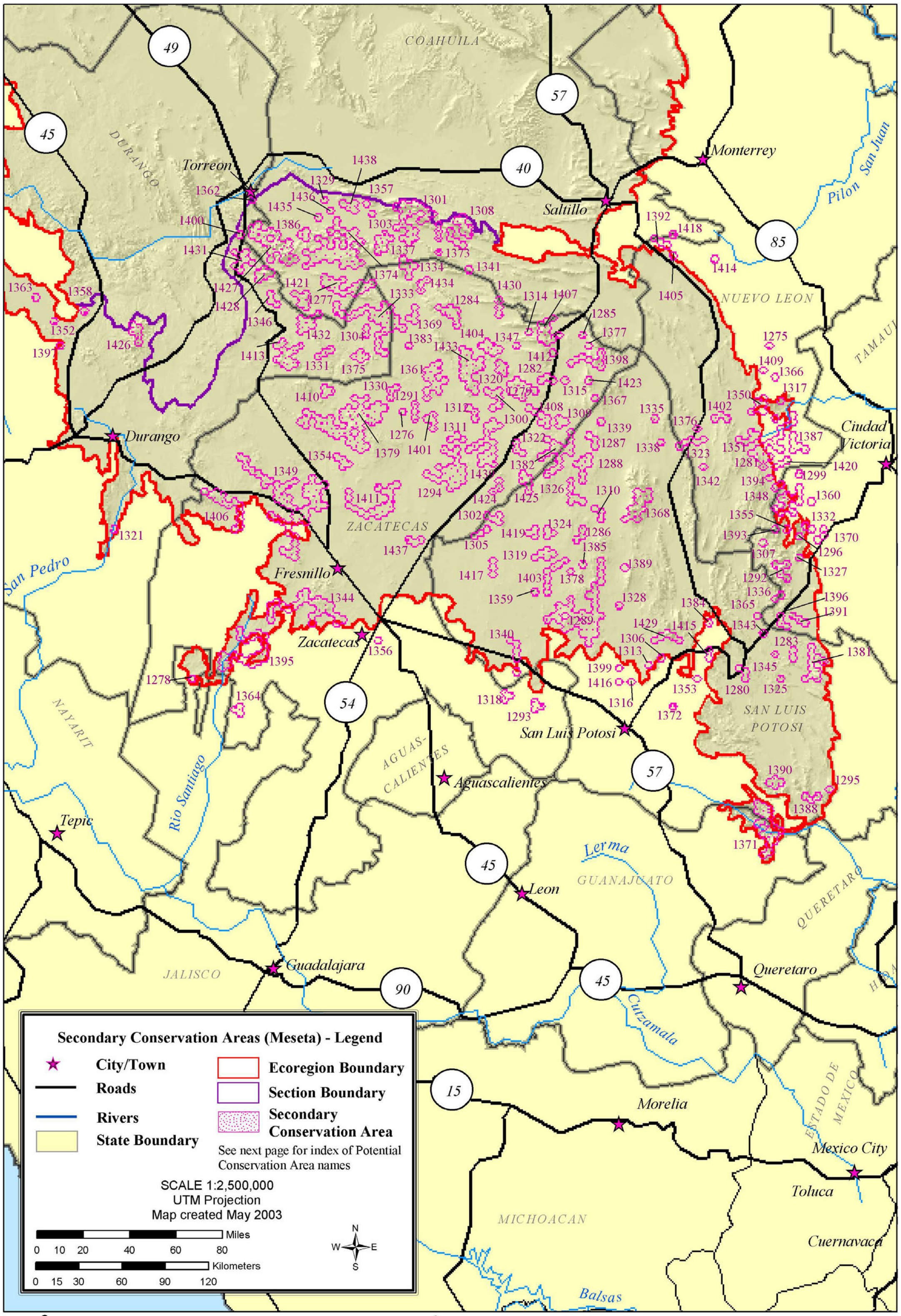
Figure 8e: Secondary Potential Terrestrial Conservation Areas (Meseta Section)

Map ID	Conservation Area Name	Map ID	Conservation Area Name
1275	Alamar De Abajo	1358	Las Cruces
1276	Alamillo	1359	Las Encinitas
1277	Apartadero Darias	1360	Las Norias
1278	Atitanac	1361	Leocadio Guerrero 1
1279	Banderitas	1362	Lerdo
1280	Bosque Y Caldera	1363	Llano Hermosa
1281	Caliche	1364	Los Alamos
1282	Campo Experimental	1365	Los Anteojos
1283	Cantaranas	1366	Los Encinos
1284	Caopas	1367	Los Encinos
1285	Casas Nuevas	1368	Los Huingaros
1286	Cerro Blanco	1369	Los Laureles
1287	Cerro La Borrega	1370	Los Pinos
1288	Charco Del Mono	1371	Los Pocitos
1289	Cuchilla Las Aranas	1372	Los Tanquitos
1290	Del Barreal	1373	Los Yeguales
1291	El Celoso	1374	Luz Maria
1292	El Crispin	1375	Magallanes
1293	El Gato	1376	Majada El Mirador
1294	El Porvenir	1377	Majada Los Tanquitos
1295	El Aguacate	1378	Majadita Blanca
1296	El Aguacate	1379	Matias Ramos
1297	El Alegre	1380	Milpillas
1298	El Amparo	1381	Montebello
1299	El Aserradero	1382	Montoya
1300	El Calabazal	1383	Mortero
1301	El Capulin	1384	Nogalitos
1302	El Cerrito Blanco	1385	Noria De Gutierrez
1303	El Corazon	1386	Norias Plan Viesca
1304	El Ensueno	1387	Ojo De Agua
1305	El Grullo	1388	Paso De Jesus
1306	El Huayule	1389	Paso De Los Caballos
1307	El Macuate	1390	Paso De Los Herreros
1308	El Mezquite	1391	Pastores
1309	El Mirador	1392	Pinal Alto
1310	El Mosca	1393	Plutarco Elias Calles
1311	El Nuevo Murcurio	1394	Pompeya
1312	El Paisanito	1395	Potrero De Mulas
1313	El Palmito	1396	Pozo Numero Tres
1314	El Pozo	1397	Predio El Pozole
1315	El Punto	1398	Progreso
1316	El Refugio	1399	R. El Polvito
1317	El Refugio	1400	Rancho 6 Potrillos
1318	El Refugio	1401	Refugio De Santa Rita
1319	El Relicario	1402	Rinconada De Martinez

Map ID	Conservation Area Name	Map ID	Conservation Area Name
1320	El Rosario	1403	Rodrigo Becerra
1321	El Salitre	1404	Saband Grande
1322	El Salitrillo	1405	Samaniego Y La Becerra
1323	El Tepetate	1406	San Antonio De Belen
1324	El Tepetate	1407	San Antonio De La Ciguena
1325	El Venadito	1408	San Francisco De Los Quijano
1326	El Venadito	1409	San Isidro
1327	El Xichu	1410	San Isidro
1328	El Zacaton	1411	San Isidro
1329	Emiliano Zapata	1412	San Jose Carbonertitas
1330	Estacion Opal	1413	San Jose De Flechas
1331	Estacion SImon	1414	San Juan de Mimbre
1332	Felipe Angeles	1415	San Nicolas
1333	Francisco I. Madero	1416	San Rafael
1334	Francisco Villa I	1417	Santa Ana
1335	Gallos Blancos	1418	Santa Anita Del Penasco
1336	Gazmones	1419	Santa Efigenia
1337	Heroes De La Revolucion	1420	Santa Lucia
1338	Hidalgo	1421	Santa Rosa
1339	Ignacio Zaragoza	1422	Servando Canales
1340	Jacalon	1423	Sierra De Rodriquez
1341	La Barranca	1424	Sierra De Sarteneja
1342	La Chiripa	1425	Sierra El Bozal
1343	La Crucero Viga	1426	Sierra Gamon
1344	La Cruz Verde	1427	Sierra Jimulco
1345	La Encarnacion	1428	Sierra La Piedra Blanca
1346	La Lagunilla	1429	Sierra La Ruda
1347	La Mejorada	1430	Sierra Zuloaga
1348	La Perdida	1431	Sombreritillo
1349	La Pimienta	1432	Tanque
1350	La Trinidad	1433	Tanque La Union
1351	La Zorra	1434	Veintiuno De Marzo
1352	Laguna Santiaguillo	1435	Venustiano Carranza
1353	Lagunillas	1436	Villa De Bilbao
1354	Las Alechuzas	1437	Villa De Cos
1355	Las Antonias	1438	Villita
1356	Las Boquillas	1439	Zambrano
1357	Las Buras		

Figure 8e: Portfolio of Potential Terrestrial Conservation Areas (map 5 of 5)



Interpreting The Portfolio

The portfolio is summarized below and presented in detail in Appendices IX, X, and XI (portfolio summary and goal attainment appendices). Goal attainment is summarized below and in the appendices only for the combined portfolio (non-redundant aggregation of primary and seconday portfolio (Appendix X and XI). Targets for which we were unable to obtain occurrences are not reported3. The summary emphasizes ecoregion-wide results with section, subsection and individual conservation area results provided in the appendices. Though the same patterns tend to characterize the portfolio at all geographic levels bear in mind that targets and goals were identified at the section and subsection levels, and SITES was run separately for each section. Consequently, the ecoregion-wide summary is really a tally across sections and subsections, and should be regarded as more of an overview.

To grasp this more thoroughly the distinction between an “ecoregional target” and section and subsection targets should be made. The ecoregional targets, invented here for reporting purposes only, are the unique species, ecological systems and vegetation sites undifferentiated by the sections and subsections in which they occur. The section and subsection targets are the actual targets of portfolio assembly. For example, *Gopherus flavomarginatus*, the bolson tortoise, occurs in both subsections of Mapimi, and so was treated as one section target and two subsection targets, with separate goals for each. In contrast, the ecoregion-wide bolson tortoise had no initial ecological or applied (SITES) goals, since ecological goals aggregated section and subsection goals, and SITES was run at the section and subsection levels (ecological goals are optimal goals for conservation, applied or SITES goals are ecological goals reduced to available occurrence amounts). We created pseudo-ecoregional goals, based on section and subsection goals, but only to assess the portfolio at the ecoregional level. An ecoregional goal was considered met only if each section and subsection goal was met. Consequently, goal attainment tends to be lower for ecoregional targets. On the other hand, there is a greater chance of capturing one unique element among all of the sections and subsections than in any one of these. Thus the proportion of uncaptured targets tends to be higher for sections and subsections. Clearly, it is important to review goal results at all geographic levels of the portfolio (Appendix X and XI).

The primary portfolio combines the data-driven output of SITES, the knowledge of experts and the results of other conservation efforts. The secondary portfolio represents those areas selected in the SITES process that fall outside of the reviewed primary portfolio. As such it illustrates the evolution of the portfolio. The secondary portfolio contains important biodiversity targets that complete the conservation blueprint of the portfolio, but we feel there is insufficient ground-truth information to warrant the veracity of these areas. Once the secondary portfolio is re-assessed a clearer picture of that scope will emerge. The SITES process was most directly linked to available data on the status and distribution of conservation targets in the ecoregion. All of the secondary portfolio lies within Mexico.

[3] In our initial target list some targets were identified for which we were unable to locate occurrences. This was due to limitations of existing inventories, extirpations or extinctions.

The success of the portfolio in meeting target goals is reported for ecological and applied (SITES) goals. Recall that ecological goals were based on expected distributions and were converted to applied goals to reflect actual target locations (see Target Goals, page 18). Ecological goals provide a sense of what full target conservation would entail if biodiversity data were complete and resources were abundant. Applied goals represent a more practical conservation approach since they are based on occurrence data. Typically, there were far fewer target locations than stipulated by ecological goals. This accounts for the fairly high proportion of unmet ecological goals. In contrast, applied goals were set equal to or less than actual target location amounts. Unmet applied goals occurred where costs of impacts and portfolio size outweighed the benefits of meeting target goals or where minimum areas could not be met. Thus we did not expect to meet ecological goals, but did expect to meet most SITES goals.

In our goals assessment we emphasize the percent of ecoregion-wide targets meeting all (100%) of goals. However, it is also useful to check the percent of goals met when it is below 100%, to assess results for individual targets, and to check goal attainment for targets at the section and subsection levels. This information is provided in Appendix XI (goal attainment for targets) and to some extent summarized in Table 7 (Mean % of Goals Met). For example, though only 42% of ecoregion-wide herp targets in the primary portfolio met all goals (Table 7), on average herps met 86% of goals. Similarly, no primary portfolio ecological systems met all goals as ecoregional targets (Table 7), however, in addition to their fairly high average goal attainment (88%), most met a high proportion of goals at the section and subsection levels and when considered individually (Figure 5).

SITES filtered out polygon target occurrences that did not meet minimum size as part of its conservation area selection process. However, the actual procedure that SITES employed was to sum the areas of polygons over adjacent hexagons and count them as single occurrences, even if the polygons were unconnected. Thus SITES selected some hexagons to meet polygon target goals where the polygons themselves, if summed individually, would not have met minimum size. The rationale is that the planning units (hexagons) were assumed to be comparable in size to the smaller viable polygon target occurrences, and that the intervening non-target areas were not substantial enough to fragment the polygon. In other words, selecting a hexagon to meet a goal for an overlapping polygon occurrence, even if that polygon was less than minimum size, would not produce a serious threat to target integrity and viability. This presented a challenge as to how to assess goal attainment for polygon occurrences. We found a number of ecological system patches in the SITES-generated portfolio that probably should not have been accepted due to their size and separation from other same-ecological system patches. Assessing polygon target goals using SITES' minimum size concept resulted in considerably higher goal attainment than if each patch were checked against minimum size individually, regardless of its overlap with adjacent hexagons. In our final assessment we decided to treat patches individually to better estimate the true extent of polygon targets captured in the portfolio, though we acknowledge this conflicts with the approach SITES took in pursuing target goals.

Table 7. Ecoregion Target Goal Results For Target Group

Results are for unique elements by ecoregion and section. Subsection results are summarized in **Appendix X**. Only attainment for ecological goals is reported since applied (SITES) goals were implemented only at the section and subsection levels. Results include all G1 and T1 locations not captured in conservation areas but retained in portfolio.

Group	# Tgts	# Uncaptured Tgts	% Uncaptured Tgts	# Tgts Meeting 100% Ecological Goal	% Tgts Meeting 100% Ecological Goal	Mean % Ecological Goals Met
Ecoregion						
All Targets	645	12	2%	61	9%	59%
G1s-T1s	73	0	0%	7	10%	65%
Ecological System	8	0	0%	6	75%	129%
Vegetation Sites	11	4	36%	7	64%	593%
Birds	15	0	0%	2	13%	62%
Herptiles	19	0	0%	4	21%	48%
Invertebrates	44	2	5%	12	27%	78%
Mammals	34	1	3%	8	24%	202%
Plants	514	5	1%	22	4%	30%
Bolson de Mapimi						
All Targets	448	222	50%	35	8%	191%
G1s-T1s	24	15	63%	3	13%	34%
Ecological System	7	1	14%	4	57%	128%
Vegetation Sites	1	0	0%	1	100%	1082%
Birds	13	11	85%	0	0%	3%
Herptiles	11	4	36%	3	27%	70%
Invertebrates	8	7	88%	0	0%	3%
Mammals	17	6	35%	1	6%	29%
Plants	391	193	49%	26	7%	22%
Meseta Central						
All Targets	332	85	26%	26	8%	110%
G1s-T1s	7	3	43%	0	0%	8%
Ecological System	7	0	0%	5	71%	119%
Vegetation Sites	2	2	100%	0	0%	0%
Birds	12	8	67%	1	8%	23%
Herptiles	11	3	27%	1	9%	18%
Invertebrates	0	NA	NA	NA	NA	NA
Mammals	15	5	33%	3	20%	469%
Plants	285	67	24%	16	6%	30%

Group	# Tgts	# Uncaptured Tgts	% Uncaptured Tgts	# Tgts Meeting 100% Ecological Goal	% Tgts Meeting 100% Ecological Goal	Mean % Ecological Goals Met
Northern Chihuahuan Desert						
All Targets	543	168	31%	71	13%	169%
G1s-T1s	67	2	3%	6	9%	59%
Ecological System	7	0	0%	2	29%	101%
Vegetation Sites	8	2	25%	6	75%	679%
Birds	15	1	7%	7	47%	124%
Herptiles	9	3	33%	1	11%	29%
Invertebrates	44	2	5%	13	30%	90%
Mammals	29	2	7%	11	38%	134%
Plants	431	158	37%	31	7%	29%

As explained above (see Target Goals, page 18) minimum sizes for species polygon targets were significantly cut to facilitate the SITES procedure (SITES tended to drop these targets rather than meet their original minimum sizes). Even at these reduced areas the polygon buffers were simple spheres around point occurrences that were not required to match the habitat types of their intended targets. We did not use the landcover map to delineate specific habitats due to its coarseness, partial inaccuracies and inconsistencies across states and nations (see Target Occurrences, page 14). Consequently, we re-conceptualized species polygon targets as an aid to prompt SITES to gather areas greater than the point locations themselves for targets with medium to large habitat requirements. Given the problems of treating these occurrences as strict targets with attainable goals we did not assess them in the portfolio summary, and suggest that such an exercise be deferred until their habitat patches are more reliably discerned.

As a generalization, a successful portfolio should reflect the natural vegetation and physical diversity of the ecoregion, though it should over-represent declining systems such as grasslands and under-represent human-dominated landscapes such as agricultural and urban lands (The Nature Conservancy 2000). To assess this we compared the portfolio to the ecoregion in terms of elevation, landcover and biophysical features (recall that biophysical units are unique combinations of slope, aspect, landform, elevation, soils, moisture and ecological system). The Chihuahuan Desert landcover map formed the foundation of both the landcover and biophysical assessment (see Target Occurrences, page 14). Though we have reservations about the accuracy of that map it contains the best available information about landcover at the ecoregional scale.

Human impacts diminish ecological intactness and functionality. The impacts assessment (Impacts Assessment, page 21) was used to steer SITES away from highly impacted areas. To compare impacts among the ecoregion and portfolios we estimated the extent of human impacts on the portfolio and the ecoregion by calculating the percent-area of agricultural and urban landcover and the density of roads, railroads and powerlines.

4. CHIHUAHUAN DESERT TERRESTRIAL PORTFOLIO

Portfolio Size

The total area of the primary portfolio is 17,748,591 hectares (43,857,549 acres) or 29% of the ecoregion (24 % of the buffered ecoregion; Figure 9). There are 125 primary conservation areas with a mean size of 141,988 hectares (350,860 acres). As shown in Figure 10 this represents a substantial decrease in the number of conservation areas and increase in average size compared to the secondary and combined portfolios and the SITES output. The high level of consolidation of conservation areas and assignment of small areas to the secondary portfolio in Mexico were the main factors producing this result. For example, primary portfolio conservation areas in Mexico average 239,704 hectares and those in the U.S. average 76,844 hectares.

Figure 9. Terrestrial Portfolio Area Compared to Ecoregion

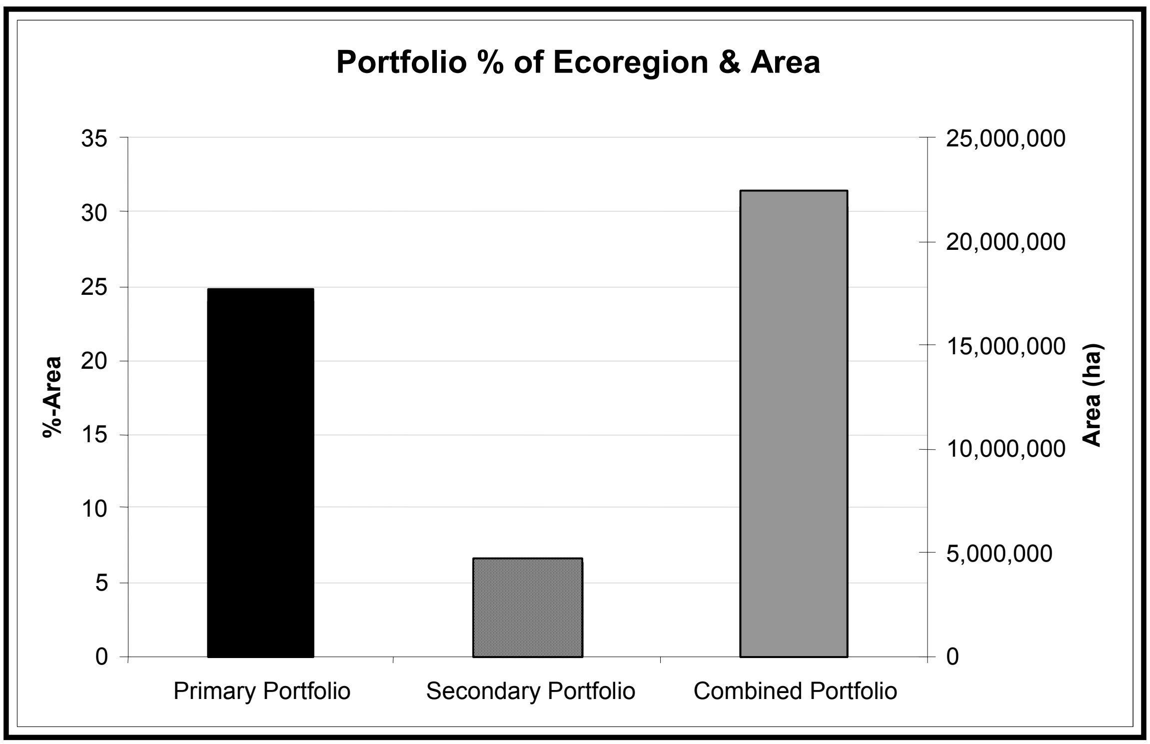
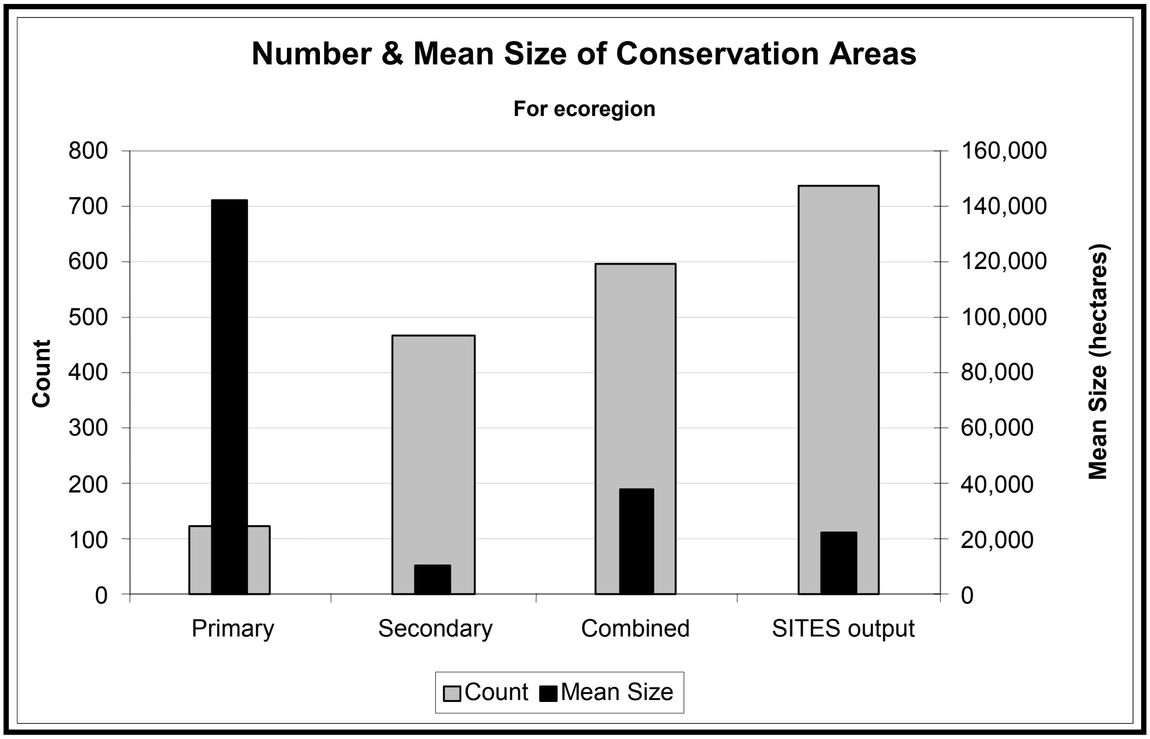


Figure 10. Number and Mean Size of Conservation Areas for the Ecoregion

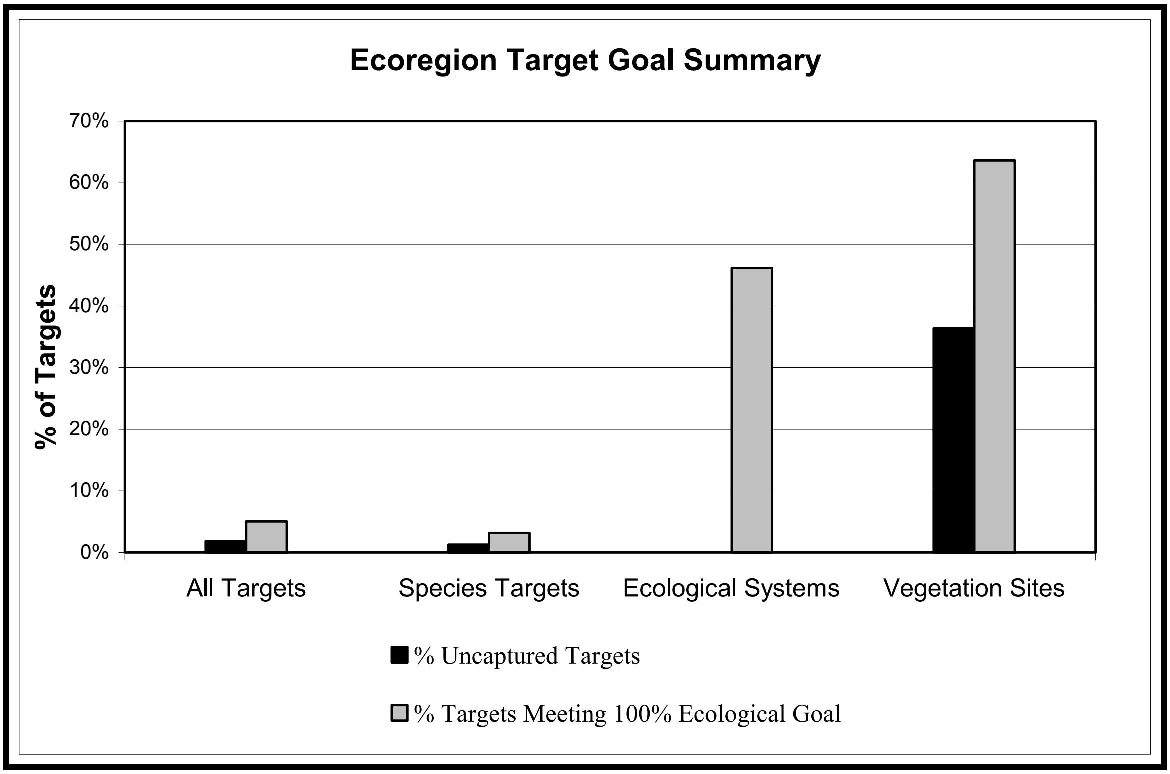


Goal Attainment

Several features of the following goal attainment assessment should be re-emphasized (see Interpreting Portfolio). Goals are reported for unique targets across the ecoregion; that is, for ecoregion-wide targets not stratified by section and subsection. Ecoregion-wide targets tend to have higher capture rates and lower goal attainment than stratified targets. Results include all G1 and T1 occurrences not captured within conservation areas. Results are for the combined portfolio (non-redundant overlap of primary and secondary portfolios).

The combined portfolio captured 98% of all conservation targets (Table 7, Figure 11), however, the sectional portfolios were much less efficient at capturing targets. We failed to capture at least 25% of all targets in each of the sectional portfolios. Only 9% of all targets achieved 100% of ecological goals. Note that goal attainment is much higher for Ecological Systems (100% of targets captured and 75% of targets meeting 100% of ecological goals) and Vegetation Sites (64% of targets captured and 64% meeting 100% of ecological goals) than for species targets. However, it should be noted that species targets captured and goals attained are underestimated because we had insufficient species distribution data on some targets to adequately represent their distribution in the various sections and subsections of the ecoregion (Table 7, Appendices X and XI).

Figure 11. Ecoregion Terrestrial Target Goal Summary. For targets in all sections & subsections. For greater detail refer to Table 7 and Appendix X.



When assessed individually and at the section level rather than as ecoregion-wide targets (see discussion above in Interpreting the Portfolio, page 42) ecological systems generally had high goal attainment (Figure 12, Appendix X and XI). Exceptions include chaparral in the Northern Chihuahuan and grasslands and pinon-juniper-oak woodlands in Meseta.

Portfolio Compared to Ecoregion

ELEVATION

The mean elevations of the primary and combined portfolios are 1446 and 1470 meters (4777 and 4823 feet) above sea level (Table 8). On average, the secondary portfolio is between 88 and 112 meters higher (289 to 368 feet). The lowest elevations are similar among the three portfolios and the secondary portfolio's highest point is 198 meters (650 feet) lower than that of the primary and combined portfolios. The elevational features of the ecoregion are similar to those of the primary and combined portfolios, except for the somewhat lower elevations of the former.

Figure 12. Percent of Goals Met For Individual Ecological Systems
Results are for section-level targets and primary portfolio only.

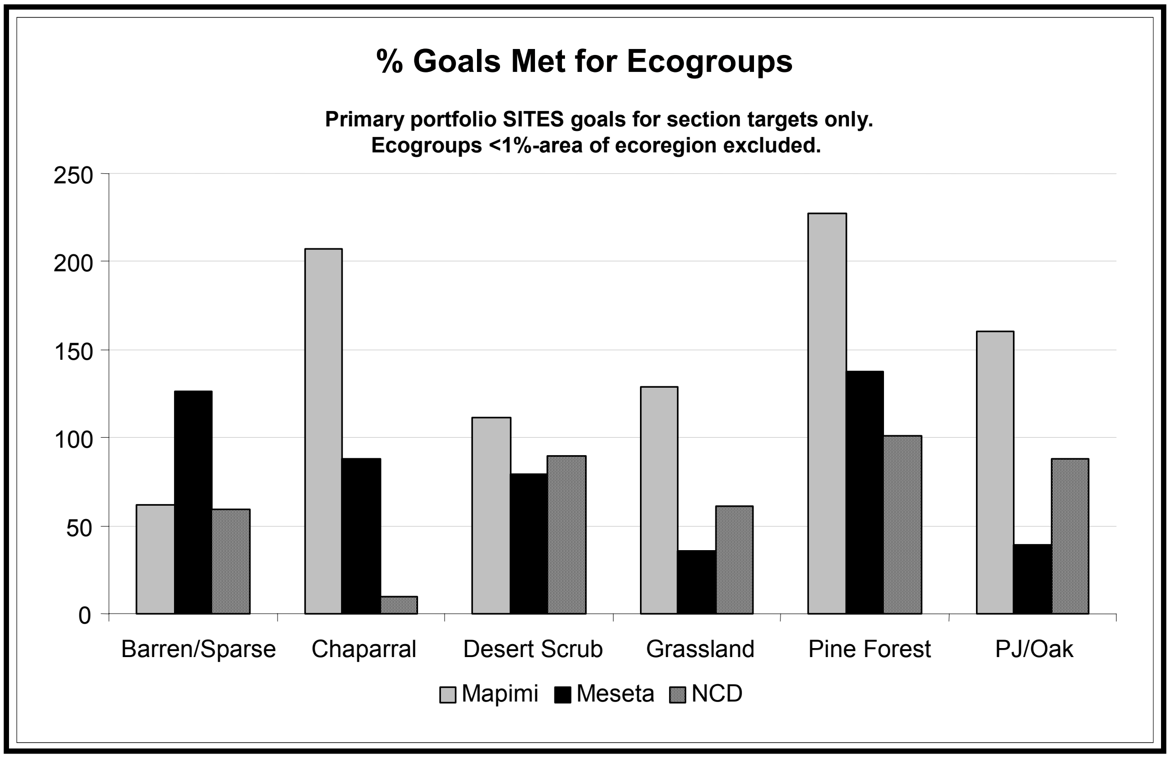


Table 8. Elevation of the Ecoregion and Portfolio

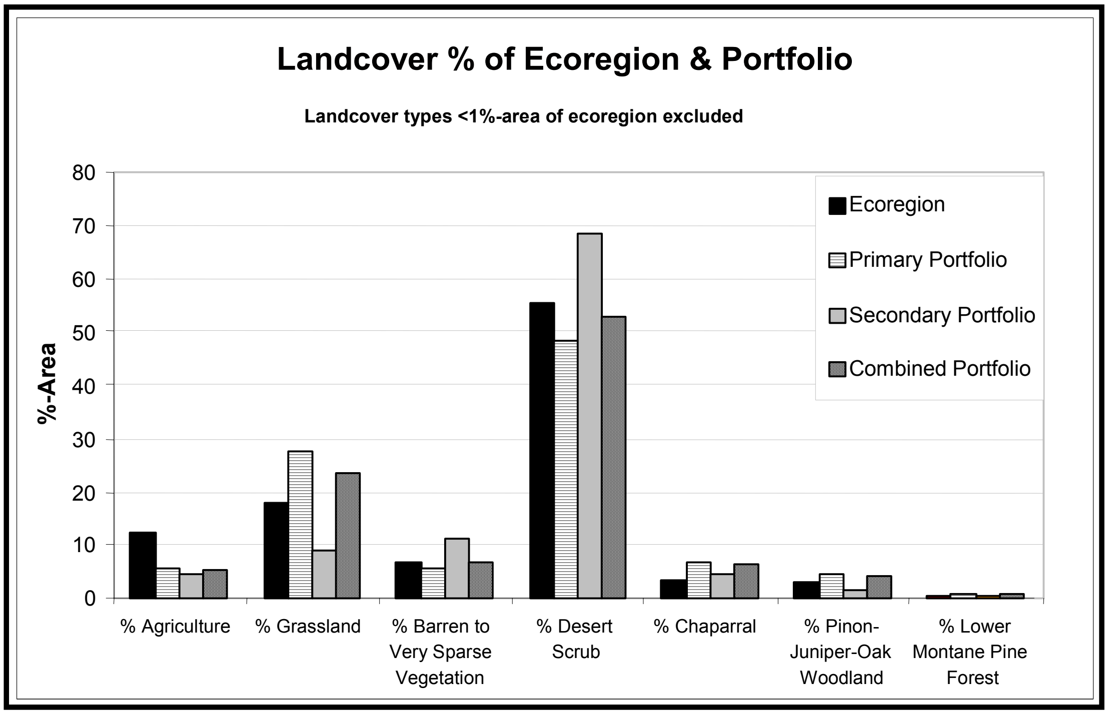
	Mean Elevation (meters)	Minimum Elevation (meters)	Maximum Elevation (meters)	Range (meters)
Ecoregion	1454	189	3706	3517
Primary Portfolio	1446	310	3706	3396
Secondary Portfolio	1558	314	3508	3194
Combined Portfolio	1470	310	3706	3396

LANDCOVER

The overall pattern of landcover (Figure 13) for the primary and combined portfolios compared to the ecoregion is that of over-representation of natural vegetation, except desert scrub, and under-representation of human-dominated types. This is highlighted by a strong drop in agricultural area and a rise in grassland area. Percentages of urban area, which are not shown in the figure, are also lower in the portfolios than the ecoregion–

0.1% compared to 0.5%. The rather large percentages of desert scrub in the portfolios were unavoidable since it dominates the ecoregion and so had the greatest likelihood of indirect selection when meeting goals for other targets.

Figure 13. Landcover Percent-Area of the Ecoregion and Portfolio



BIOPHYSICAL MODEL

The biophysical model provides a comprehensive means to assess how well the combined, primary and secondary versions of the portfolio represent the ecological character of the ecoregion, since it integrates ecological systems and physical features. The biophysical diversity of the ecoregion was fairly well captured by all portfolios (Table 9). More than 90% of the ecoregion's biophysical units (BPUs) overlap the primary and combined portfolios and almost 74% overlap the secondary portfolio. Table 10 groups biophysical units by their associated ecological systems. Counts of BPUs estimate the ecological variation within ecological systems. For example, 61 types of grassland, distinguished by physical features such as elevation and soil, are predicted in the ecoregion, combined and primary portfolios Barren/Sparse BPUs have the most variation and Palm Grove, Pine Forest and Tropical Vegetation BPUs have the least. BPU total area indicates dominance. Desert Scrub BPUs dominate the ecoregion and all three portfolios, and Grassland BPUs are secondary dominants in all but the secondary portfolio. Similarly Desert Scrub and Grassland BPUs have the highest average areas and the largest single BPUs. The largest individual BPUs vary in consistency between the ecoregion and portfolios. For example, the largest Barren/Sparse BPU is number 1964 for the ecoregion and combined portfolio, but different for the primary and secondary. (BPU

1964 is between 980-1637 meters, has a wet moisture regime, loamy soil, and occurs on intermittent lake beds, bajadas, gentle slopes and/or montane valleys). Appendix VIII lists specific BPUs, their composition, and their level of representation in the ecoregion and portfolios. This information provides a means to assess the finer-scale ecological diversity of the portfolios, since the ecological system targets were fairly coarse (see Target Occurrences above).

Table 9. Biophysical Diversity of Portfolio and Ecoregion

BPU = Biophysical Unit, unique combinations of ecological systems and physical features such as aspect, soil etc.

Small biophysical units and riparian and wetland types have questionable accuracy and are excluded from this table.

	Total Count BPUs	Captured BPUs
Ecoregion	594	100%
Primary Portfolio	543	91%
Secondary Portfolio	439	74%
Combined Portfolio	573	97%

Table 10. Biophysical Features Grouped by Associated Ecological System

BPU = Biophysical Unit, unique combinations of ecological systems and physical features such as aspect, soil etc.

Small biophysical units and riparian and wetland types have questionable accuracy and are excluded from this table.

Associated BPU Ecological System	Ecoregion	Primary Portfolio	Secondary Portfolio	Combined Portfolio
A. BPU Counts				
Barren/Sparse	121	104	103	119
Chaparral	95	94	81	95
Desert Scrub	66	66	66	66
Grassland	61	61	53	61
Palm Grove	24	23	0	23
Lower Montane (Pine) Forest	95	74	45	78
Pinon-Juniper-Oak	89	87	70	89
Rocky Areas	22	21	1	22
Tropical Vegetation	21	13	20	20

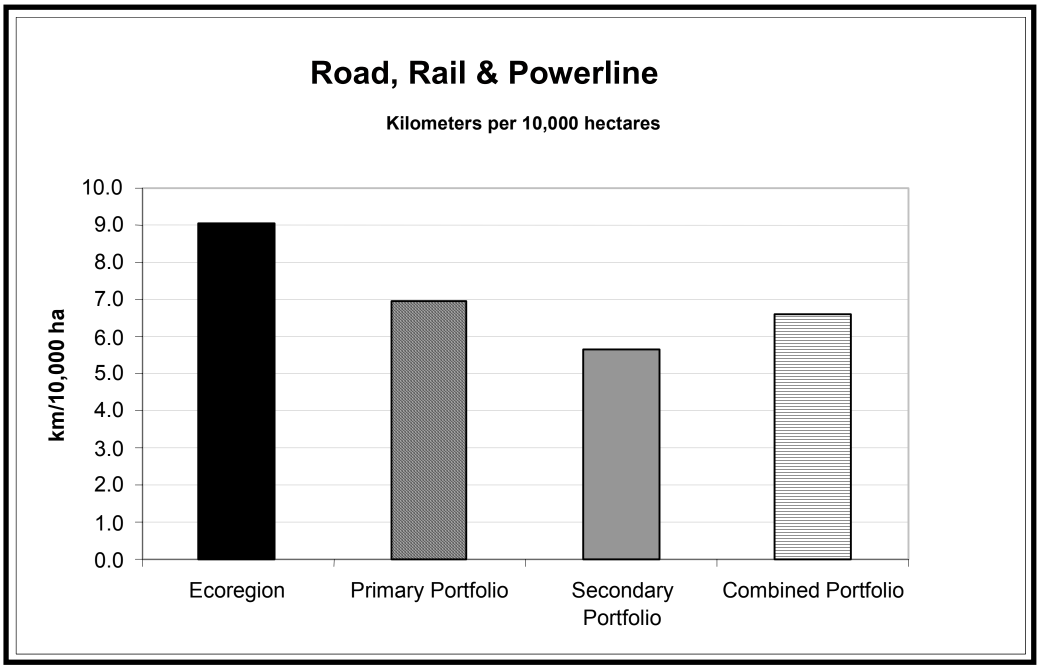
Table 10. Biophysical Features Grouped by Associated Ecological System (continued)

Associated BPU Ecological System	Ecoregion	Primary Portfolio	Secondary Portfolio	Combined Portfolio
B. BPU Total Area (ha, % of ecoregion or respective portfolio in parentheses)				
Barren/Sparse	3,250,208 (6%)	730,527 (4%)	439,352 (10%)	1,169,506 (6%)
Chaparral	1,478,429 (3%)	869,552 (5%)	155,316 (3%)	1,014,555 (5%)
Desert Scrub	24,237,875 (40.7%)	5,528,147 (33%)	2,325,885 (51%)	7,828,670 (37%)
Grassland	8,162,909 (14%)	3,436,026 21%)	338,206 (8%)	3,763,703 (18%)
Palm Grove	1918 (0.003%)	1342 (0.01%)	0	1342 (0.01%)
Lower Montane (Pine) Forest	183,052 (0.3%)	107,461 (0.7%)	16,123 (0.4%)	123,584 (0.6%)
Pinon-Juniper-Oak	1,242,856 (2%)	561,121 (3%)	46,903 (1%)	608,025 (3%)
Rocky Areas	121,638 (0.2%)	66,545 (0.4%)	21 (0.0005%)	66,566 (0.3%)
Tropical Vegetation	50,203 (0.08%)	8674 (0.05%)	8185 (0.2%)	16,858 (0.08%)
C. BPU Mean Area (ha)				
Barren/Sparse	26,861	7024	4266	9828
Chaparral	15,562	9251	1917	10,679
Desert Scrub	367,241	83,760	35,241	118,616
Grassland	133,818	56,328	6381	61,700
Palm Grove	80	58	0	58
Lower Montane (Pine) Forest	1927	1452	358	1584
Pinon-Juniper-Oak	13,965	6450	670	6832
Rocky Areas	5529	3169	21	3026
Tropical Vegetation	2391	667	409	843
D. Area of largest BPU (ha of total/not continuous area, BPU codes in parentheses)				
Barren/Sparse	183,279 (1964)	56,156 (6584)	40,059 (7600)	65,208 (1964)
Chaparral	174,201 (406)	142,868 (406)	24,539 (3673)	145,113 (406)
Desert Scrub	1,450,605 (5534)	434,359 (5614)	169,020 (68)	544,768 (68)
Grassland	906,230 (5290)	356,397 (5290)	53,143 (3838)	378,164 (5290)
Palm Grove	397 (1523)	289 (1521)	0	289 (1521)
Lower Montane (Pine) Forest	40,120 (3407)	20,769 (3407)	3982 (3407)	24,751 (3407)
Pinon-Juniper-Oak	152,523 (5324)	50409 (5324)	8690 (4047)	52,983 (5324)
Rocky Areas	40,640 (5955)	21,614 (5955)	21 (922)	21,614 (5955)
Tropical Vegetation	11,377 (4621)	3675 (4634)	213 (4621)	4222 (4634)

IMPACTS

The combined, primary and secondary versions of the portfolio have lower densities of roads, railroads and powerlines than the ecoregion as a whole (Figure 14). The primary and combined portfolios have similar densities and that of the secondary is lowest (Figure 14, Appendix XII). As noted above (see Landcover, page 49) agricultural and urban lands are proportionally higher in the ecoregion than the portfolios.

Figure 14. Road, Railroad and Powerline Density of the Ecoregion and Portfolio



Conclusions for the Terrestrial Portfolio

Most targets did not meet 100% of their ecological goals, and goal attainment varied by target group. Goal attainment was highest for the combined and primary portfolios and lowest for the secondary[4]. In terms of ecological representation, the primary and combined portfolios are similar to the ecoregion in elevation, landcover and biophysical features, and the secondary portfolio is somewhat different. These results are explained as follows. Ecological goal attainment tended to be low because ecological goals, by definition, are optimal conservation goals and often not achievable (c.f. applied/SITES goals, deliberately designed to be achievable since they are based on availabe occurrence amounts).

[4] Based on a comparison of goal attainment among these three portfolio components.

It was determined through the portfolio review that Chihuahuan Desert ecological systems are adequately represented in the primary portfolio. However, the lack of information about the distribution of finer-scale ecological systems (Appendix III) in the ecoregion warrants continued tracking of these systems as portfolio work progresses. A rough measure of portfolio success for capturing ecological diversity can be attained by examining results for ecological systems and vegetation sites (Goals section of Interpreting the Portfolio; Appendix XI). By targeting vegetation sites, which represent significant occurrences such as desert grasslands in good condition, we were able to compensate somewhat for the coarseness of ecological system targets. It is also useful to review how well biophysical units, grouped by their associated ecological systems, are represented (Biophysical Model section of Interpreting the Portfolio). Results can be assessed in greater detail by matching finer-scale ecological system classes (Appendix III) to specific biophysical units and reviewing their level of representation in the ecoregion and portfolios (Appendix VIII). For example, to assess desert grasslands we could check for BPUs containing grasslands of basin bottoms and bajadas at low to mid elevations with sandy to loamy soils.

Some ecological systems have lower than desired goal attainment (Figure 12, Appendix X). It appears that this is due to differences in how SITES evaluates minimum area in contrast to how minimum area is evaluated in this report (see Interpreting the Portfolio). As mentioned, SITES tallies proximal but spatially separate ecological system patches as single patches when evaluating minimum area. However, we report ecological system goal attainment only for individual ecological system patches that meet minimum area. This results in lower ecological system goal attainment compared to SITES. For example, Figure 12 shows that chaparral in the Northern Chihuahuan Desert met only 9% of its goals but that number climbs to over 100% if proximal chaparral patches are lumped (Appendix X). Though we hope that new versions of SITES will permit minimum area to be interpreted flexibly, our present solution is to carefully review the few ecological system targets that have low goal attainment and to increase their representation in the portfolio, as necessary.

Goal attainment for vegetation sites is quite high for the combined and primary portfolios. This was likely due to the fact that vegetation sites have fairly low area goals (the same as their minimum areas) and that by capturing vegetation sites SITES incidentally captured increased goal attainment for overlapping ecological systems.

Though the combined and primary portfolios are fairly representative of the ecoregion's biophysical character overall, some of the largest biophysical units (BPUs) differ among the ecoregion, primary and combined portfolios (Table 10, part D). This suggests that ecoregional and portfolio composition and size distribution may vary at the level of individual BPUs. Such a result might be expected since biophysical units were not targeted in SITES, and since the ecoregion and portfolios have non-overlapping portions. Further analysis is necessary to elucidate such differences.

Human-impacts (agricultural and urban lands, road, railroad and powerline density) are lower in the combined and primary portfolios than the ecoregion and grassland area is higher. This is a desirable outcome that was facilitated by ambitious SITES goals for grasslands (Table 6, Appendix VI- goals) and prohibitive costs for areas containing high impacts (Appendix X). A common feature of the combined and primary portfolios is that conservation areas comprise 24-30% of the ecoregion (Figure 9, Appendix IX- portfolio summary). This conforms to the standard TNC guideline that a portfolio should include 20-30% of the ecoregional area to capture representative ecosystems and biodiversity, but that larger portfolios are unrealistic for conservation action.

5. ASSEMBLING THE AQUATICS PORTFOLIO

Overview

In contrast to the terrestrial portfolio, which was assembled using the SITES algorithm by computer, the aquatics portfolio was assembled entirely as a manual operation. Lacking sufficient system data to take the SITES approach, the aquatics effort was largely dependent upon species target occurrences. A general lack of element data required a much larger data-mining effort of museum collections for occurrence information, and resulting in our adding more than 2,000 data occurrence records to the combined dataset. The manual approach required a great deal of manual iterative adjustment to arrive at a set of sites that approached the SITES results in balancing meeting conservation goals with portfolio efficiency.

Again, portfolio assembly entailed several steps. Criteria for identifying conservation targets were established and a conservation target list was developed. Location records for targets were compiled from various sources and standardized. Quantitative goals, intended to support target viability, were set and govern each target's level of representation in the portfolio. We lacked the necessary data to assemble a classification of aquatic community types for the Chihuahuan Desert. Therefore we were unable to take a coarse-filter approach to portfolio assembly and were forced to rely upon species occurrence data. The aquatics portfolio was heavily influenced by occurrence data on native fishes, although a few additional aquatic taxa were included in the analysis.

As a starting point we used the Priority Aquatic Sites identified through the experts workshop held by the World Wildlife Fund in Monterrey, MX, in 1998. The large polygons from the WWF process were used to identify critical stream reaches and wetland areas from a compiled hydrology dataset in GIS. These stream reaches were, in turn, used to identify sets of viable occurrences of aquatic targets. Additional stream reaches, springs, and other aquatic features were then added to the draft portfolio in order to capture additional occurrences of targets necessary to achieve conservation goals.

Locations of species target occurrences in the U.S. and Mexico were largely drawn from well-established biodiversity data archives, such as state Biological Conservation Databases (BCD) and collections of various museums and universities. Because of a severe lack of recent collections in most areas of the ecoregion, we frequently relied upon older occurrence data to imply the location of extant populations of target species. This is a questionable approach, and means that most of the aquatics portfolio, particularly those in Mexico, need ground-truthing to determine in the target elements still occur on those sites and are actually viable populations.

The portfolio results were reviewed by scientists, planners and land managers who helped us adjust the portfolio as necessary to better meet goals and reflect biological and practical reality.

Target List

A draft list of potential targets was compiled from Pronatura Noreste, the Natural Heritage Information Systems (NatureServe 2002, New Mexico Natural Heritage Program 2002, Texas Conservation Data Center 2002), the 1997 World Wildlife Fund Chihuahuan Desert Conservation Workshop (Dinerstein et al. 2000), experts and the literature. This list was circulated among biologists and ecologists for review and modification. Reviewers were asked to ensure that the list was complete and confirm that targets met at least one of the following criteria: (1) *Rare*, having TNC global ranks G1-G3/T1-T3, or deemed rare by an expert; (2) *Endemic* to the Chihuahuan Desert; (3) *Limited* to 2-3 ecoregions including the Chihuahuan Desert; (4) *Disjunct* populations important for evolution; and (5) targets which are *Peripheral* in their distribution in relation to the Chihuahuan Desert.

The final list of targets is summarized below and presented in its entirety in Appendix XIII (Aquatic target list). The list includes 168 targets, of which 167 are species targets (Table 11); a single aggregated system-type of Riparian/Aquatic was included, but further field work is required to differentiate these systems which were identified from coarse-scale vegetation mapping. Such systems typically occur on the landscape at a finer scale than is often detected from remote sensing efforts. Since we relied so heavily upon species targets to select sites, we tried to be comprehensive in including native fish species as targets and in identifying extant occurrences of these. There are 123 rare targets and 51 endemics (Tables 12 and 13). Species known or thought to be extinct were included in the list. Note that this summary is for unique elements across the ecoregion, undifferentiated by section or subsection.

Table 11. Aquatic Targets by Group (n = 165)

Group	Number of Targets
Fish	111
Inverts	48
Amphibians	1
Reptiles	4
Aquatic Habitats	1

Table 12. Rare Aquatic Targets (n = 166)
Rare targets were assigned working Global Ranks of G1/T1 through G3/T3. There are a number of targets that were not ranked for rarity due to lack of information.

Group	Number of Targets				
	G1	G2	G2G3	G3	Other Ranking
Fish	39	19	-	17	36
Herps	2	-	-	2	1
Inverts	27	11	1	4	5

Table 13. Aquatic Ecoregional Endemics and Species of Limited Distribution
(n = 132)
Designations of endemic and limited are preliminary and based on available information. Limited targets occur in 2-3 ecoregions including the Chihuahuan Desert.

	Number of Targets	
Group	**Endemic**	**Limited**
Fish	52	25
Herps	4	1
Inverts	44	6

Target Occurrences

Occurrence (location) records for species, ecological systems and vegetation-sites were gathered from diverse sources. Species occurrences were compiled from the Biological Conservation Database, Pronatura Noreste, other agencies, museum collections, experts and the literature. An especially valuable data source was the Neotropical Fish Database (Neodat II) searchable on the internet (http://www.neodat.org) that accesses 24 different databases of neotropical fish collections. Species occurrences were processed as point-locations, and museum collections without latitude and longitude information were georeferenced where sufficient locality information allowed, otherwise the data was discarded. For little-explored areas of Mexico old point occurrences from museum records were accepted as records of potentially extant populations, but this is an area requiring corroborating data. In total, there were almost 3000 target occurrences for the ecoregion, including more than 2800 occurrences of fish.

Target Goals

We established goals for all of the aquatics conservation targets (Table 6– guidelines; Appendix XIV - goals). Target-specific goals were initially based on expected distribution drawn from a literature review and consultation with experts and were modified to reflect recorded locations. Goals were stratified by ecoregional section and subsection, but only for review purposes – portfolio assembly was not based upon stratification units since aquatic systems are not generally tied to terrestrial stratification.

Goals are higher for rare targets, those with endemic or limited ecoregional distributions, and those that are declining. A goal of zero (0) was set for targets known to be extinct. Minimum area goals were not set for aquatic species or systems; rather, element occurrences were aggregated such that entire reaches and stream networks were treated as viable target occurrences for the purposes of site selection.

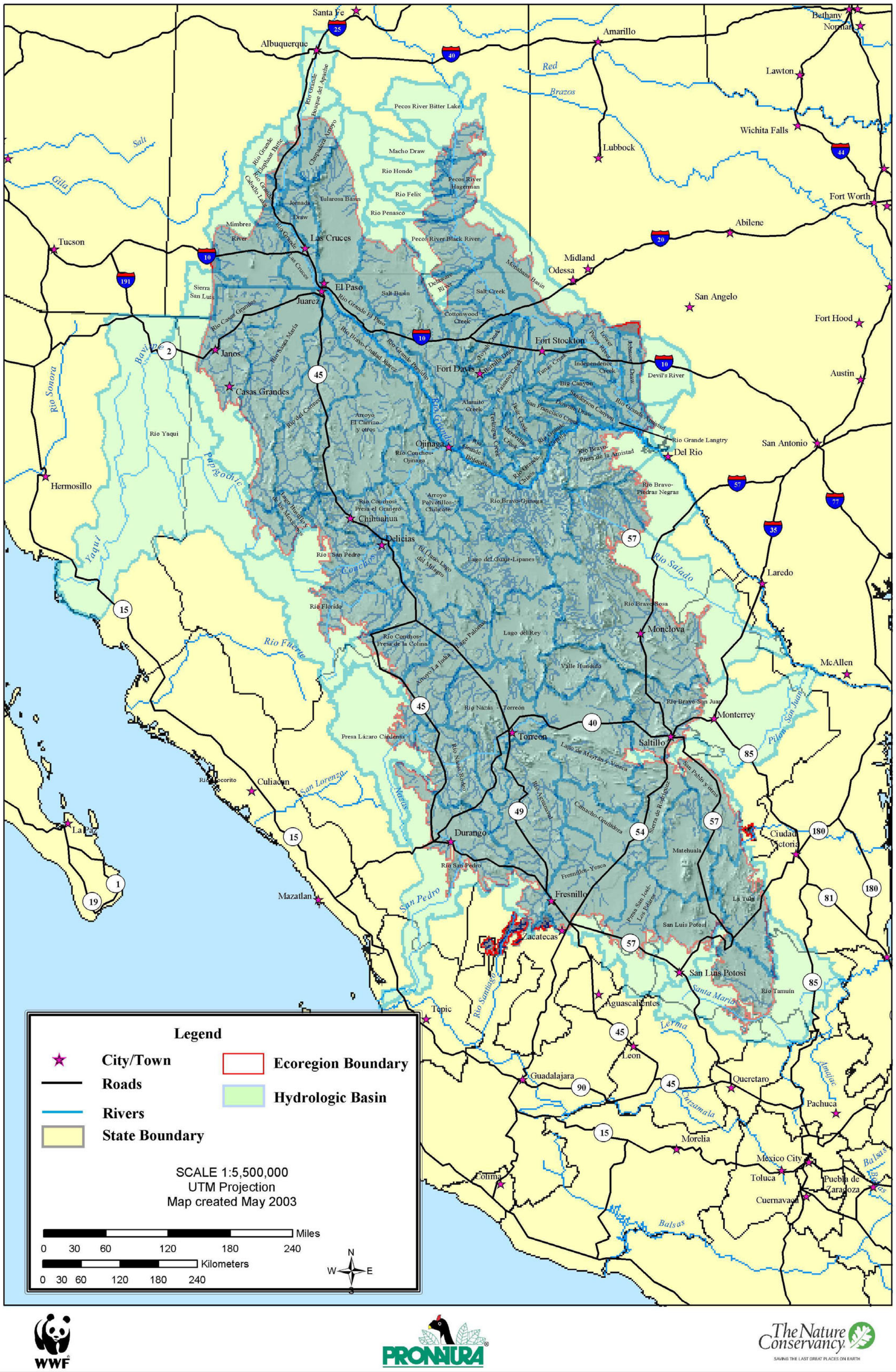
REVIEWING THE PORTFOLIO

The draft aquatics portfolio was reviewed by Pronatura Noreste, Texas, New Mexico, and Mexico Nature Conservancy programs, and Mexico and U.S. World Wildlife Fund representatives, biologists, ecologists, conservation strategists and technical experts. Review sessions were held in Monterrey, Mexico and Santa Fe, Albuquerque and San Antonio in the U.S. The review was intended to weed-out areas without apparent conservation value, add areas that we had overlooked, modify (e.g. consolidate or split) areas based on ecological considerations, and identify information gaps.

INTERPRETING THE PORTFOLIO

The portfolio is summarized below and presented in detail in Appendix XV and XVI (portfolio summary and goal attainment appendices). Only targets for which we were able to obtain occurrences are reported. The summary emphasizes ecoregion-wide results with section, subsection and individual conservation area results provided in the appendices. In contrast to the terrestrial portfolio assembly process, stratification at the section and subsection level is provided for reporting purposes only. Aquatic systems do not typically conform to terrestrial ecoregion boundaries, and the section and subsection delineations have little meaning in the context of an aquatics portfolio. Aquatic sites are also assigned to hydrologic basins (Figure 15).

Figure 15: Hydrologic Basins



6. CHIHUAHUAN DESERT AQUATICS PORTFOLIO

Portfolio Size

We identified 73 aquatic conservation areas across the entire Chihuahuan Desert (Figure 16), comprising 2,727,839 hectares (6,740,611 acres) or about 3.7% of the ecoregion. Predictably, there were three main areas of conservation priority: (1) the Pecos River and its tributaries, (2) the Rio Bravo/Rio Grande and its tributaries, and (3) streams and rivers flowing from the Sierra Madre Occidental into the interior basins.

Goal Attainment

Goals are reported for unique elements across the ecoregion; that is, for targets not differentiated by section and subsection. The portfolio captured at least 90% of aquatic targets (Table 14). Most fish and herp species were captured. With little data on invertebrates, the attainment of goals for these species was more problematic.

Table 14. Ecoregional Aquatic Target Goal Results by Target Group
Results are for unique elements; i.e. targets not differentiated by section and subsection.

Target Group	Target Count	# Uncaptured Targets*	% Uncaptured Targets*	Number of Targets Meeting 100% of Goals*	% of Targets Meeting 100% of Goals*
Aquatics Targets					
All Targets	165	11	5	129	78
G1s & T1s	78	11	14	61	78
Fish	111	2	2	103	98
Herptiles	5	0	0	3	60
Invertebrates	48	9	19	22	46
System	1	0	0	1	100

* *Does not include extinct species*

Conclusions for the Aquatics Portfolio

There is really no surprise that in a region as rugged, isolated, and dry as the Chihuahuan Desert, that there should be so many rare and imperiled aquatic targets. Neither should it be a surprise that the portfolio of sites making up the aquatics portfolio is under extreme threat from a plethora of factors including pollution, dewatering of streams, lowering of water tables, and introduction of invasive species. The reported size of the aquatics portfolio is really done for convenience only, since the actual boundaries of each aquatics conservation area must be more carefully defined based upon the populations of the

Figure 16: Portfolio of Potential Aquatic Conservation Areas

WWF

PRONATURA

The Nature Conservancy

targets they contain, the effective watershed of the area, and the identified threats to each area. Nevertheless, while the area of the identified portfolio is relatively small (only 3.6% of the ecoregion), the biological and conservation value of the aquatics portfolio is extremely high.

Finally, it should also be noted that this portfolio was developed based solely upon target species and riparian and aquatic habitat occurrences. In the future a second iteration of this portfolio should be developed based upon an as yet to be developed aquatic system classification. That approach is critical to capturing and conservation the full range of aquatic biodiversity in the ecoregion.

7. SETTING PRIORITIES FOR CONSERVATION

Analysis of Multi-scale Threats

We conducted a preliminary analysis of the major threats to the targets within the portfolio areas and that threaten the viability of biodiversity across the Ecoregion. This is a cursory attempt at threats analysis and we emphasize that more detailed analysis of these threats is necessary, especially at the scale of individual conservation areas. It is important to distinguish between threats (or stresses), which are factors that act directly upon biodiversity, and sources of threat which are the ultimate activities or situations that lead to those threats. For example stream sedimentation is considered a serious **threat** to aquatic biodiversity and one that has a number of direct effects on the system including reduction of water oxygen content, reduced visibility, covering of food, siltation of nest sites and killing of eggs. But sedimentation can be caused by a number of different **sources** including grazing, residential or commercial development, channelization, construction of ditches, dikes and diversions, conversion to agriculture, and crop production practices. Conversely, one source of threat may result in many different threats. For example, grazing management may result in sedimentation, streambed alteration, and direct destruction of native plants. The matrix in Table 15 demonstrates how a number of different stresses can be caused by many different sources of stress.

Table 15. Example Matrix of Stresses vs. Sources of Stress

	Stresses											
Sources of Stress	**Habitat Destruction**	**Habitat**	**Altered Stream Flow**	**Lowered Water Table**	**Erosion/Sedimentation**	**Reduced Water**	**Catastrophic Fire**	**Parasites/Disease**	**Wildlife Harassment**	**Altered Composition**	**Increased Competition**	**Reduced Air Quality**
Residential Development	*	*	*	*	*	*		*	*	*		*
Channelization	*	*	*	*	*	*				*		
Surface Water Diversion	*	*	*	*	*	*			*	*		
Dam Construction	*	*	*	*	*	*		*	*	*		
Water Mining (wells)	*	*	*	*		*						
Fire Suppression	*	*	*	*	*	*	*		*	*		
Inappropriate Grazing	*	*	*	*	*	*		*	*	*	*	
Invasive Plants	*	*	*	*	*	*	*			*	*	
Invasive Animals	*							*	*	*	*	
Off Road Vehicle Use	*	*			*	*			*			*
Oil and Gas Exploration	*	*		*	*	*			*	*		*
Mining	*	*	*	*	*	*						*

Our objective in this process is to identify those sources of threat, which are having the most pervasive impacts on the biodiversity of the ecoregion, and to try to determine which of those sources of threat might be addressed through various multi-site strategies to abate the threats that they cause. Thus, while deer poaching may be a problem in some areas, deer were not identified as a target in this effort.

There are three different measures of sources of stress:

a) **Severity**. Severity is the degree to which an identified source of stress actually threatens the integrity of a site and the targets it contains. For example, altered fire regime may have no impact on an aquatic site but may be a severe threat to fire-adapted communities such as ponderosa pine woodland or bunchgrass prairie. For each threat we asked the experts to rank severity as; 1 (Low), 2 (Medium), or 3 (High).

b) **Immediacy**. Immediacy is the likelihood that a particular source of stress will affect a site regardless of the severity. We asked the experts to rank immediacy as; 1 (likely to occur in the next 20 years), 2 (likely to occur in the next five years), or 3 (occurring now).

c) **Reversibility**. This is the degree to which a source of stress can be removed, its effects erased, and a site restored. For example, loss of a natural fire regime might be highly to moderately reversible in some systems through the introduction of fuel management and prescribed fire. On the other hand, the loss of habitat through urbanization or the construction of highways is not likely to be reversed. We asked the experts to rank each source of stress at each site as; 1 (easily reversed), 2 (can be reversed with high cost and effort), or 3 (effects irreversible).

For each conservation area we attempted to identify the sources of stress affecting each, and assign scores for severity, immediacy, and reversibility. It is important here to note that, in most cases, the listing of a source of threat does not necessarily mean that that source or activity is incompatible with conservation of the portfolio. Conservation of a portfolio will, under most circumstances, mean ensuring that such threats/activities are managed so as to minimize their impact on the conservation targets. Definitions for each source of threat are provided in Appendix XVIII.

The complete threats scoring matrix is provided as a Microsoft Excel spreadsheet in Appendix XVII. The results of this analysis are summarized in Tables 16 and 17. There are two summary statistics noted; the number of conservation areas for which a particular threat was identified as occurring at moderate to severe level, and a combined measure of the severity, immediacy, and irreversibility of all of the sources of threat identified for each area. These two different ways of rolling up the threat information provide us with two different metrics for approaching conservation in the ecoregion. The first identifies the most important ecoregion-wide sources of threat, and thereby helps to direct our attention to those threats that might be best abated by taking corrective action on a broad policy (i.e. non-site based) scale. The second identifies those conservation areas that are most in need of direct (i.e. site based) conservation action. This "Combined Threat Score" sums the scores for severity, immediacy, and reversibility for all threats at a site, divides by the number of threats to find the average, and multiplies by the square root of the number of threats. This gives decreasing weight to additional (lower rated) threats, but still gives some value to multiple threats. These results (Table 17) are summarized for Mexico, New Mexico, and Texas. It should also be noted that in calculating threat values for each area, we excluded our preliminary scores for Climate Change. The team felt that additional information on the effects of climate change is needed for the Chihuahuan Desert portfolio. A recent paper by Peterson et al. (2002) makes an interesting case that the Chihuahuan Desert may be the area of Mexico most severely affected by changes in climate.

Table 16 Source of Threat Summary. (Number of conservation areas at which each source of threat was identified as occurring at moderate or high severity).

Source of Threat	# of Sites
Climate Change	174
Small Population Size	105
Poor Grazing Practices	99
Groundwater Manipulation	94
Invasive Plants	80
Invasive Animals	79
Lack of Education	79
Insufficient Laws/ Enforcement	78
Ditches, dikes, diversions	63
Recreation Use	60
Roads and/or Utilities	54
Channelization	53
Fire Management	52
Recreational Vehicles (ORV)	52
Conversion to Agriculture	46
Residential Development	46
Sewage Discharge	44
Livestock Production Practices	39
Dam construction/ operation	37
Research Activities	37
Oil & Gas Development	33
Trails Development	33
Crop Production Practices	28
Parasites/ Pathogens	28
Species Management	25
Military Activities	21
Industrial Pollution	18
Commercial/ Industrial Development	18
Excessive Harvest/ Poaching	17
Mining Practices	16

Table 17. Conservation Area Sources of Threat Summary
(a) Mexico

Site Code	Site Name	Combined Threat Score
Terrestrial Areas		
105	Complejo de Cuatro Ciénegas	27.4
111	Corredor Saltillo, Monterrey	23.4
40	Sierra del Capulin	22.5
4	Cerros del Colorados	19.9
63	Palomas	19.4
43	La Perla	19.3
29	Pastizales de Janos/Mesa de Guacamaya	19.0
81	Samalayuca	18.5
12	Cañon de Santa Elena	17.9
121	El Tokio	17.6
101	Villa Ahumada	16.6
108	Complejo Mapimi 2	14.4
109	Complejo Mapimi 3	14.4
110	Complejo Mapimi 4	14.4
107	Complejo Mapimi 1	14.4
64	Pastizales de la Campana	14.3
30	Sierra del Virolento/Sierra de Hechiceros	13.5
106	Complejo Maderas del Carmen, El Burro y La Encanta	13.4
116	Sierra de la Paila	11.5
119	Sierra Santa Fe del Pino	9.2
115	Sierra de la Gloria	9.2
112	Cuchillas de la Zarca	9.2
125	Yerbaniz	9.2
122	Organos Malpais	9.2
123	Pico de Teyra	9.2
124	Sierra de Alvare	9.2
120	El Huizacle y Pa	9.2
Aquatics Areas		
NCD-Agua-34	Lower Rio Conchos	25.1
MAP-Agua-15	Rio Monclova	24.7
MES-Agua-01	Potosi	24.0
NCD-Agua-42	Bustillos	23.4
MAP-Agua-12	Muzquiz	22.9
MES-Agua-02	Sandia	22.3
MAP-Agua-07	Rio Nazus	21.7
NCD-Agua-43	Sauz Basin	21.2
NCD-Agua-47	Rio San Pedro	20.7
MAP-Agua-17	Chorro	20.4
MAP-Agua-16	Rio Santa Catarina	20.0
MAP-Agua-08	Rio Mezquital	19.8
MES-Agua-04	Venado-Moctezuma	19.1
NCD-Agua-35	Ojo Solo	19.0
MAP-Agua-14	Cuatro Ciénegas	18.9

Site Code	Site Name	Combined Threat Score
MAP-Agua-03	Valle de Allende	18.5
MAP-Agua-11	Arroyo del Pino	18.4
MAP-Agua-13	Ocampo	18.4
MAP-Agua-04	Cadena	18.0
NCD-Agua-36	Guzman Basin	17.8
NCD-Agua-37	Rio Casas Grandes	17.8
NCD-Agua-38	Rio Santa Maria	17.8
NCD-Agua-40	Rio del Carmen	17.7
MES-Agua-03	Media Luna/Rio Verde	17.6
NCD-Agua-46	Ojo Julimes	17.4
NCD-Agua-50	Ojo de San Gregorio	17.1
MES-Agua-05	Illesces	17.0
MAP-Agua-09	La Concha	16.5
MAP-Agua-01	Ojo de Dolores	16.3
MAP-Agua-02	Ojo de Villa Lopez	16.3
MAP-Agua-05	Rio de Ramos	15.9
MES-Agua-06	Upper Aguanaval	15.9
NCD-Agua-49	Rio Balleza	15.2
NCD-Agua-45	San Diego de Alcala	13.9
MAP-Agua-06	Rio Guatimape	12.5
NCD-Agua-39	Ojo de Galeana	12.1
NCD-Agua-48	Upper Conchos	11.5
NCD-Agua-44	Rio Chuviscar	9.9
NCD-Agua-33	Arroyo El Nogal	9.8
MAP-Agua-10	Lower Rio Nazas	No Data
NCD-Agua-41	Rio Torrero	No Data

(b) New Mexico

Site Code	Site Name	Combined Threat Score
Terrestrial Areas		
61	Organ Mountains	24.5
32	Franklin Mountains	24.5
82	San Andres - Oscura Mountains	22.2
59	Northern Jornada Basin	21.4
99	Tularosa Basin Desert	21.1
54	Mimbres Hot Spring	20.2
62	Otero Mesa	18.6
83	San Vicente Wash/Walnut Creek	18.0
65	Potrillo Mountains	15.1
10	Bosque del Apache	15.1
95	Halfway South	14.7
23	Crow Flats/Ishee Lakes	14.7
48	Livingstone Ridge	14.7
2	Antelope Ridge	14.7
75	Red Mountain	14.7

Site Code	Site Name	Combined Threat Score
41	Kenzin	14.7
18	Chalk Bluffs	14.7
76	Remunda / Big Sinks	14.7
84	Seven Rivers	14.7
58	Lanark	13.9
46	Northern Brokeoff Mountains	13.9
34	Guadalupe Mountains	13.5
36	Hagerman	13.0
31	Florida Mountains	12.1
93	Sitting Bull Falls	11.5
6	Black River Basin	10.5
78	Robledo and Las Uvas Mountains	9.8
97	Hatchet and Alamo Hueco Mountains	8.7
37	Sunland Border	8.7
26	Doña Ana Mountains	8.5
13	Hope	6.4
38	Caballo Lake	6.4
98	TorC West	5.8
14	Caballo Mountains/Southern Jornada	5.8
15	Cedar Mountains	5.7
96	Strauss Sinks	5.0
60	Nutt Grasslands	4.2
22	Crawford Ranch	4.0
20	Cook's Peak	4.0
Aquatics Areas		
NCD-Agua-04	Lower Hondo	30.6
NCD-Agua-21	Mimbres River	24.0
NCD-Agua-12	Rattlesnake Springs	22.7
NCD-Agua-13	Black River	22.7
NCD-Agua-11	Blue Spring	22.2
NCD-Agua-02	Bitter Lake	20.9
NCD-Agua-08	Pecos River Delaware	20.8
NCD-Agua-16	Oscura Salt Creek	20.8
NCD-Agua-17	Tularosa Creek	20.8
NCD-Agua-18	Lost River	20.8
NCD-Agua-03	Pecos River Roswell	20.4
NCD-Agua-05	Pecos River Carlsbad	20.4
NCD-Agua-07	Bottomless Lakes	18.9
NCD-Agua-09	Cottonwood Springs	17.9
NCD-Agua-10	Sitting Bull Falls	17.3
NCD-Agua-19	Rio Grande Elephant Butte	17.0
NCD-Agua-20	Rio Grande Caballo	17.0
NCD-Agua-01	Pecos River High Plains	15.5
NCD-Agua-06	Rio Felix	13.9
NCD-Agua-14	Clayton Basin Lakes	No Data
NCD-Agua-15	Laguna Plata	No Data

(c) Texas Conservation Areas

Site Code	Area Name	Combined Threat Score
	Terrestrial Areas	
24	Davis Mountains	31.6
52	Marfa Plateau Grassland	29.6
9	Borderland	29.1
19	Clint	29.1
44	Lake Amistad	28.2
92	Sierra Vieja-Chinati Mountains	27.6
33	Glass Mountains	27.6
51	Marathon Basin Grasslands	26.5
5	Big Bend	26.0
25	Devils River Megasite (Terrestrial Site)	24.5
1	Alamito Creek	24.1
80	Salt Basin	24.0
90	Sierra Diablo.	22.8
56	Musquiz Canyon	21.7
94	Sorcerer's Cave	21.6
27	Dryden/Sanderson	20.0
47	Langtry	19.6
35	Hackberry Draw	19.3
39	Hueco Mountains	18.6
16	Cedar Station/Dryden	18.6
55	Monahans Sandhills	18.0
49	Longfellow Grasslands and Mesas	16.7
3	Apache Mountains	16.6
74	Red Light Draw	16.4
28	Boracho	16.3
7	Eagle Mountains	16.3
66	Quitman Mountains North	15.7
21	Cornudas	15.1
45	Lake Toyah Basin	14.8
77	Roberts Mesa	14.3
53	Mesa/Pecos Plain	13.9
100	Van Horn	13.0
79	Saddle Butte	12.1
104	Yeso Hills	11.5
102	West of Fort Stockton	11.5
11	Western Sierra Diablos	11.0
103	Bullis Gap	11.0
57	Noelke Hill	8.5
8	Border	No Data
	Aquatics Areas	
NCD-Agua-24	Balmorhea Springs Complex	31.8
NCD-Agua-25	Diamond Y Springs and Draw	30.9
NCD-Agua-29	Rio Grande Ojinaga	29.3
NCD-Agua-31	Alamito Creek (Terrestrial Site)	25.5

Site Code	Area Name	Combined Threat Score
NCD-Agua-27	Devil's River	24.5
NCD-Agua-23	Little Aguja Creek	23.8
NCD-Agua-22	Salt Creek	23.5
NCD-Agua-30	Terlingua Creek	23.5
NCD-Agua-26	Lower Pecos	23.1
NCD-Agua-28	Rio Grande Big Bend	20.8
NCD-Agua-32	Hot Springs	No Data

Biological Irreplaceability of the Conservation Portfolio

A second metric for setting priority for conservation action among conservation areas is the degree of biological uniqueness of each site. There are a number of different ways of measuring the biological uniqueness or value of particular areas, including measures of species richness and biological diversity. In our analysis we are interested in the degree of irreplaceability of an area; in other words, how likely are we to be able to find another area containing the same conservation targets of a conservation area if that site is lost or compromised. The simplest measure of irreplaceability might be the number of conservation targets found only on that particular site. But for our analysis we need to take into account all targets that are seriously limited in distribution within the portfolio; i.e. all targets for which that site is critical to meeting conservation goals. In order to capture this definition in a single metric we summed the total of the number of all targets at each site divided by the number of sites at which those targets were found. In other words, in our target sum, all targets that are at or below conservation goals and found only on one site get a score of 1; all targets found on only two sites get a score of 0.5; all targets found on only three sites get a score of 0.3334, etc. Table 18 summarizes the results of this analysis. We report separate tabulations for Mexico, New Mexico and Texas, and also separate out the terrestrial and aquatic portfolios in this comparison.

Table 18. Conservation Area Irreplaceability Index Summary
(a) Mexico

PCA Code	PCA Name	Irreplaceability Index
Terrestrial Areas		
121	El Tokio	125.50
106	Complejo Maderas del Carmen, El Burro y La Encanta	60.67
105	Complejo de Cuatro Ciénegas	41.62
120	El Huizacle y Pa	22.75
116	Sierra de la Paila	22.53
107	Complejo Mapimi 1	19.20
43	La Perla	17.26
64	Pastizales de la Campana	14.99
12	Cañon de Santa Elena	9.49

PCA Code	PCA Name	Irreplaceability Index
112	Cuchillas de la Zarca	8.50
124	Sierra de Alvare	7.75
30	Sierra del Virolento/Sierra de Hechiceros	7.65
29	Pastizales de Janos/Mesa de Guacamaya	6.36
111	Corredor Saltillo, Monterrey	4.83
122	Organos Malpais	4.17
109	Complejo Mapimi 3	3.08
119	Sierra Santa Fe del Pino	2.50
110	Complejo Mapimi 4	2.12
115	Sierra de la Gloria	2.08
108	Complejo Mapimi 2	1.83
81	Samalayuca	1.52
125	Yerbaniz	1.42
101	Villa Ahumada	1.09
4	Cerros del Colorados	0.61
123	Pico de Teyra	0.42
63	Palomas	0.15
40	Sierra del Capulin	0.01
Aquatics Areas		
MAP-Agua-14	Cuatro Ciénegas	12.41
MES-Agua-03	Media Luna/Rio Verde	8.00
MAP-Agua-12	Muzquiz	5.11
MES-Agua-01	Potosi	4.00
NCD-Agua-47	Rio San Pedro	3.43
NCD-Agua-45	San Diego de Alcala	3.17
NCD-Agua-35	Ojo Solo	3.00
NCD-Agua-37	Rio Casas Grandes	2.40
NCD-Agua-46	Ojo Julimes	2.17
MAP-Agua-01	Ojo de Dolores	2.00
MAP-Agua-02	Ojo de Villa Lopez	2.00
MES-Agua-02	Sandia	2.00
MAP-Agua-08	Rio Mezquital	1.83
MAP-Agua-16	Rio Santa Catarina	1.83
NCD-Agua-29	Rio Grande Ojinaga	1.52
MES-Agua-04	Venado-Moctezuma	1.50
NCD-Agua-49	Rio Balleza	1.43
MAP-Agua-09	La Concha	1.40
NCD-Agua-40	Rio del Carmen	1.40
MAP-Agua-15	Rio Monclova	1.38
MAP-Agua-07	Rio Nazus	1.33
NCD-Agua-48	Upper Conchos	1.29
NCD-Agua-36	Guzman Basin	1.20
NCD-Agua-42	Bustillos	1.20
MAP-Agua-04	Cadena	1.00
MAP-Agua-17	Chorro	1.00
NCD-Agua-39	Ojo de Galeana	1.00
NCD-Agua-50	Ojo de San Gregorio	1.00

PCA Code	PCA Name	Irreplaceability Index
MAP-Agua-03	Valle de Allende	0.96
MAP-Agua-06	Rio Guatimape	0.75
NCD-Agua-41	Rio Torrero	0.66
MAP-Agua-05	Rio de Ramos	0.53
MES-Agua-05	Illesces	0.50
NCD-Agua-44	Rio Chuviscar	0.49
MES-Agua-06	Upper Aguanaval	0.40
NCD-Agua-38	Rio Santa Maria	0.40
MAP-Agua-13	Ocampo	0.38
MAP-Agua-10	Lower Rio Nazas	0.20
NCD-Agua-33	Arroyo El Nogal	0.17
NCD-Agua-43	Sauz Basin	0.17
NCD-Agua-34	Lower Rio Conchos	0.14
MAP-Agua-11	Arroyo del Pino	0.00

* We have manually adjusted the Irreplaceability score of Pastizales de Janos/Mesa de Guacamaja from medium to high. We consider it to be highly irreplaceable since this site contains the largest remaining black-tailed prairie dog complex in the world. This is a good example of the difficulty in deriving a single measure of biological value, and the need to review such ordinal data in more detailed conservation area planning.

(b) New Mexico

Site Code	Site Name	Irreplaceability Index
Terrestrial Areas		
34	Guadalupe Mountains	19.45
82	San Andres - Oscura Mountains	18.18
61	Organ Mountains	13.54
99	Tularosa Basin Desert	8.09
59	Northern Jornada Basin	5.14
6	Black River Basin	4.84
37	Hatchet and Alamo Hueco Mountains	4.36
10	Bosque del Apache	3.86
32	Franklin Mountains	3.65
93	Sitting Bull Falls	2.68
31	Florida Mountains	2.24
14	Caballo Mountains/Southern Jornada	2.11
84	Seven Rivers	1.86
65	Potrillo Mountains	1.32
62	Otero Mesa	1.17
98	TorC West	1.01
38	Hope	1.01
54	Mimbres Hot Spring	1.01
76	Remunda / Big Sinks	0.69
58	Northern Brokeoff Mountains	0.54
48	Livingstone Ridge	0.53
26	Doña Ana Mountains	0.49

Site Code	Site Name	Irreplaceability Index
18	Chalk Bluffs	0.28
22	Crawford Ranch	0.26
78	Robledo and Las Uvas Mountains	0.18
60	Nutt Grasslands	0.18
20	Cook's Peak	0.17
75	Red Mountain	0.15
41	Kenzin	0.15
13	Caballo Lake	0.15
97	Sunland Border	0.15
46	Lanark	0.03
96	Strauss Sinks	0.03
15	Cedar Mountains	0.03
36	Hagerman	0.01
95	Halfway South	0.01
23	Crow Flats/Ishee Lakes	0.01
83	San Vicente Wash/Walnut Creek	0.01
2	Antelope Ridge	0.01
Aquatic Areas		
NCD-Agua-03	Pecos River Roswell	2.73
NCD-Agua-19	Rio Grande Elephant Butte	2.56
NCD-Agua-11	Blue Spring	2.28
NCD-Agua-02	Bitter Lake	2.13
NCD-Agua-13	Black River	1.90
NCD-Agua-08	Pecos River Delaware	1.81
NCD-Agua-04	Lower Hondo	1.19
NCD-Agua-05	Pecos River Carlsbad	0.92
NCD-Agua-01	Pecos River High Plains	0.59
NCD-Agua-20	Rio Grande Caballo	0.56
NCD-Agua-16	Oscura Salt Creek	0.33
NCD-Agua-17	Tularosa Creek	0.33
NCD-Agua-18	Lost River	0.33
NCD-Agua-06	Rio Felix	0.29
NCD-Agua-07	Bottomless Lakes	0.27
NCD-Agua-21	Mimbres River	0.20
NCD-Agua-09	Cottonwood Springs	0.00
NCD-Agua-10	Sitting Bull Falls	0.00
NCD-Agua-12	Rattlesnake Springs	0.00
NCD-Agua-14	Clayton Basin Lakes	0.00
NCD-Agua-15	Laguna Plata	0.00

(c) Texas Sites

Site Code	Site Name	Irreplaceability Index
Terrestrial Areas		
5	Big Bend	50.87
24	Davis Mountains	23.26
92	Sierra Vieja-Chinati Mountains	9.44
51	Marathon Basin Grasslands	7.36
39	Hueco Mountains	4.36
11	Bullis Gap	3.44
56	Musquiz Canyon	3.29
55	Monahans Sandhills	3.03
33	Glass Mountains	2.78
80	Salt Basin	2.75
49	Longfellow Grasslands and Mesas	2.28
27	Dryden/Sanderson	1.78
52	Marfa Plateau Grassland	1.68
45	Lake Toyah Basin	1.36
90	Sierra Diablo.	1.26
47	Langtry	1.19
28	Eagle Mountains	1.03
3	Apache Mountains	1.01
25	Devils River Megasite	1.00
44	Lake Amistad	0.83
103	Western Sierra Diablos	0.59
8	Border (in Mexico technically?)	0.53
104	Yeso Hills	0.53
100	Van Horn	0.51
53	Mesa/Pecos Plain	0.36
35	Hackberry Draw	0.36
16	Cedar Station/Dryden	0.36
79	Saddle Butte	0.36
1	Alamito Creek	0.34
57	Noelke Hill	0.34
66	Quitman Mountains North	0.33
74	Red Light Draw	0.28
7	Boracho	0.26
9	Borderland	0.15
19	Clint	0.15
77	Roberts Mesa	0.03
102	West of Fort Stockton	0.01
94	Sorcerer's Cave	0.01
21	Cornudas	0.01
Aquatic Areas		
NCD-Agua-28	Rio Grande Big Bend Lower Canyons	7.44
NCD-Agua-25	Diamond Y Draw/Leon Creek & Springs	4.58
NCD-Agua-24	Balmorhea Springs Complex	3.25
NCD-Agua-23	Little Aguja Creek	3.00

Site Code	Site Name	Irreplaceability Index
NCD-Agua-27	Devil's River	2.50
NCD-Agua-26	Lower Pecos	2.19
NCD-Agua-29	Rio Grande Ojinaga	1.52
NCD-Agua-30	Terlingua Creek	1.00
NCD-Agua-32	Hot Springs	0.50
NCD-Agua-31	Alamito Creek	0.46
NCD-Agua-22	Salt Creek	0.14

Setting Priorities Among Portfolio Areas for Conservation Action

Rather than try to derive a single metric for the conservation priority of a site, we used a single, simple three-by-three matrix of Degree of Threat vs. Degree of Irreplaceability to identify those conservation areas considered of High, Medium and Low conservation priority (Table 19). We used natural breaks in the score metrics to identify high, medium and low threat and high, medium and low irreplaceability for each conservation area. Separate priority matrices were developed for Mexico, New Mexico, and Texas to avoid the obvious problems in comparing such data across political boundaries and because different conservation actors will be involved in taking conservation action within these three political divisions. In each table highest priority areas (high irreplaceability and high threat) are shown in bold red text. Secondary priority areas are shown in black bold text.

While this approach gives us a rough way of identifying what are probably the highest priority areas for undertaking site based conservation activities, it must be emphasized that our ability to identify, measure, and summarize the threats on individual areas within the vast Chihuahuan Desert Ecoregion is crude at best. A more intensive site-by-site analysis of threats is necessary before any actions should be taken on any individual site. In addition, our knowledge of the distribution of conservation targets on these areas is, in many cases, rudimentary and/or based on out-of-date field data. We have not provided threat or irreplaceability scores for the Secondary Terrestrial Portfolio because we lack any on-the-ground information on the state of these sites or even the actual presence of the biodiversity for which these areas were identified in the portfolio.

Table 19. Priorities for Conservation Action among Conservation Areas

(a) Mexican Terrestrial Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**Complejo de Cuatro Ciénegas**	**Corredor Saltillo Monterrey**	Palomas
	Medium	**La Perla** **El Tokio** **Complejo Mapimi 1** **Pastizales de la Campana** **Complejo Maderas del Carmen, El Burro y La Encanta** **Pastizales de Janos/ Mesa de Guacamaya** **Sierra de la Paila**	Sierra del Virolento/ Sierra de Hechiceros Cañon de Santa Elena Complejo Mapimi 3 Complejo Mapimi 4	Cerros del Colorados Samalayuca Villa Ahumada Complejo Mapimi 2
	Low	El Huizacle y Pa	Sierra de Alvare Organos Malpais Cuchillas de la Zarca Sierra de la Gloria Sierra Santa Fe del Pino	Pico de Teyra Yerbaniz

* Note that we have manually ranked the Pastizales de Janos/Mesa de Guacamaya area as High irreplaceability. See the section, "Biological Irreplaceability of the Portfolio Conservation Areas", above.

(b) Mexican Aquatic Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**Cuatro Ciénegas** **Media Luna/Rio Verde** **Muzquiz** **Potosi** **Rio San Pedro** **Ojo Solo**	**Rio Casas Grandes** **Ojo Julimes** **Sandia** **Rio Mezquital** **Rio Santa Catarina** **Rio Grande Ojinaga** **Venado-Moctezuma** **Rio del Carmen** **Rio Monclova** **Rio Nazus** **Guzman Basin** **Bustillos**	Cadena Chorro Ojo de San Gregorio Valle de Allende Illesces Rio Santa Maria Ocampo Sauz Basin Lower Rio Conchos Arroyo del Pino
	Medium	**San Diego de Alcala**	**La Concha** **Ojo de Villa Lopez** **Ojo de Dolores** **Rio Balleza** **Upper Conchos**	Upper Aguanaval Rio de Ramos Rio Guatimape Ojo de Galeana
	Low			Rio Torrero Lower Rio Nazas Arroyo El Nogal Rio Chuviscar

(c) New Mexico Terrestrial Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**San Andres - Oscura Mountains** **Organ Mountains**	**Mountains/Southern Jornada** **Franklin Mountains** **Mimbres Hot Spring** **Northern Jornada Basin** **Otero Mesa** **Tularosa Basin Desert**	San Vicente Wash/Walnut Creek
	Medium	**Guadalupe Mountains**	**Bosque del Apache** **Potrillo Mountains** **Seven Rivers** **Florida Mountains** **Sitting Bull Falls** **Black River Basin**	Chalk Bluffs Kenzin Remunda / Big Sinks Antelope Ridge Red Mountain Livingstone Ridge Crow Flats/Ishee Lakes Halfway South Northern Brokeoff Mountains Hagerman Lanark Robledo and Las Uvas Mountains
	Low		Hatchet and Alamo Hueco Mountains Caballo Hope TorC West	Sunland Border Doña Ana Mountains Caballo Lake Strauss Sinks Cedar Mountains Cook's Peak Crawford Ranch Nutt Grasslands

(d) New Mexico Aquatic Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**Blue Spring** **Black River** **Lower Hondo**	**Oscura Salt Creek** **Mimbres River**	Rattlesnake Springs
	Medium	**Bitter Lake** **Pecos River Delaware** **Pecos River Roswell**	**Lost River** **Tularosa Creek**	
	Low	Rio Grande Elephant Butte	Bottomless Lakes Pecos River High Plains Pecos River Carlsbad Rio Grande Caballo Rio Felix	Cottonwood Springs Sitting Bull Falls Clayton Basin Lakes Laguna Plata

(e) Texas Terrestrial Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**Big Bend** **Davis Mountains**	**Devils River Megasite** **Dryden/Sanderson** **Glass Mountains** **Marathon Basin Grasslands** **Marfa Plateau Grassland** **Musquiz Canyon** **Salt Basin** **Sierra Diablo.** **Sierra Vieja-Chinati Mountains**	Alamito Creek Borderland Clint Lake Amistad Sorcerer's Cave
	Medium		**Langtry** **Longfellow Grasslands and Mesas** **Hueco Mountains** **Monahans Sandhills** **Apache Mountains** **Eagle Mountains** **Lake Toyah Basin** **Bullis Gap**	Hackberry Draw Cedar Station/Dryden Red Light Draw Boracho Cornudas Quitman Mountains North Roberts Mesa Mesa/Pecos Plain Van Horn West of Fort Stockton Saddle Butte Western Sierra Diablos Yeso Hills
	Low			Border Noelke Hill

(f) Texas Aquatic Areas

		Degree of Irreplaceability		
		High	Medium	Low
Degree of Threat	High	**Rio Grande Big Bend** **Lower Canyons** **Diamond Y Draw/Leon Creek & Springs** **Balmorhea Springs Complex** **Little Aguja Creek**	**Devil's River** **Lower Pecos** **Rio Grande Ojinaga** **Terlingua Creek**	Terlingua Creek Alamito Creek Salt Creek
	Medium			Hot Springs
	Low			

8. NEXT STEPS AND RECOMMENDATIONS

Data Management and Archiving

A compiled species target occurrence database for the Chihuahuan Desert is not provided as part of this report. State Heritage programs and the Northeast Mexico Conservation Data Center (CDC) maintain element occurrence databases for their respective regions, and data from these Heritage Programs and the CDC used in developing this document were used under license agreement. Nevertheless, all species occurrence data used in developing the portfolio for the Chihuahuan Desert are available through these Heritage and CDC programs. All new occurrence data mined and developed for this study will be archived and submitted to the Northeast Mexico CDC, the New Mexico Natural Heritage Program, and the Texas CDC for quality checking and inclusion with their master data sets.

Other data sets developed for this study, including the DEM, landcover, biophysical model and fragmentation model, are included on the CD that accompanies this report. Questions regarding this data should be directed to Pronatura Noreste or The Nature Conservancy of New Mexico.

Data Gaps

Ecoregional planning efforts can always be improved upon as more and better data become available. A lack of comprehensive data is always a stumbling block to such efforts, especially for such a large, complex, and incompletely understood region such as the Chihuahuan Desert. There are a number of areas where data are lacking or incomplete for the Chihuahuan Desert, and we encourage the collection and archiving of more comprehensive data by which the assumptions made in this plan can be checked and the results refined through future iterations. There are three main areas where data are lacking or incomplete – target occurrences, vegetation mapping, and an aquatic system classification.

Numerous data gaps were encountered for conservation targets. Data were completely lacking for some species. Occurrence data were out of date for others. In some cases we lack up-to-date taxonomic assessments of species or groups of species; for example the status of the trout (*Oncorhynchus* spp.) of the Sierra Madre Occidental has not yet been clarified. While many museums are now making their collection data available online, many occurrence locations have yet to be spatially referenced, and many collections from the Mexican portion of the ecoregion are very old.

Vegetation data for the ecoregion is incomplete and classification systems are often incompatible across political boundaries. The New Mexico and Texas GAP vegetation data sets both suffer from incomplete ground-truthing and a number of flawed delineations were discovered in the Chihuahuan portion of these datasets. The vegetation mapping for the Mexican portion of the ecoregion, developed by INEGI, was updated in time for this project, but lacks any resolution of some vegetation classes, most notably grasslands. A better, seamless vegetation spatial dataset for the ecoregion is a top priority for improving upon future iterations of the plan.

An even greater limiting factor to this effort was the complete lack of an aquatic classification system for the ecoregion, or even access to adequate data sets to develop such a classification. The first priority in this regard must be a complete hydrologic spatial dataset for Mexico such as exists in the National Hydrologic Database (NHD) for the United States.

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10. ACKNOWLEDGEMENTS

This project could not have been completed without the generous support of The Nature Conservancy's Migratory Bird Program and Ian Cummings and the Consevancy's Ecoregional Planning Support Team. Special thanks go to Craig Groves, Laura Landon, and Renee Mullen for their advice and support. Funding also came from The Nature Conservancy's New Mexico, Mexico, and Texas Programs. Thanks to Rosario Alvarez, Juan Bezaury, Brian Houseal, Pat Patterson, Robert Potts, Bruce Runnels, James Sulentich and William Waldman for their institutional support. Some data and methodology used in this analysis was developed with the assistance of grant funding from the National Aeronautics and Space Administration (NASA). Thanks to Woody Turner of NASA for his support of our work in the Chihuahuan Desert.

Special thanks to the Conservation Data Center operated by Pronatura Noreste for Northeastern Mexico, the Texas Conservation Data Center and Texas Parks and Wildlife Department, Wildlife Diversity Program, as well as the New Mexico Natural Heritage Program. Locational data and other supporting information was provided by a host of experts in the United States and Mexico. Thanks to all those who participated in an experts workshop hosted by the World Wildlife Fund in Monterrey, Mexico, in October, 1997. We would especially like to acknowledge Ernesto Enkerlin, David Olson, and Chris Williams for their assistance. Pronatura Noreste coordinated the mining of additional locational data for Mexico. Experts providing data for that effort were Eduardo Estrada, Héctor Arturo Garza, Francisco González, Pablo Lavín, Arnulfo Moreno, Jesús Valdez, and Patricia Vela. Thanks also to Mauricio Cotera, María Elena García, Mario García, David González, and Cynthia Redendiz for their assistance with this effort.

We also thank the technical team members who assisted in the development and review of taxonomic target lists and to those who provided additional data on species distributions; David Anderson, David Baumgardner, Michael Bogan, David Bowles, Bill Carr, Steve Cary, Alberto Contreras-Arquieta, Miguel Angel Cruz, Eduardo Estrada, Jennifer Frey, Gary Garrett, Mark Goering, Chris Hoagstrom, Amber Hobbs, Denny Hugg, Rebecca Keeshen, Barry Knisely, Brian Lang, Robert R. Larsen, Juan Medel, Artie Metcalf, Angel Montoya, Charlie Painter, Steve Platania, Jackie Poole, Andy Price, Dave Propst, Christopher Rustay, Robert Sivinski, Richard Spellenberg, Phil Tonne, Jesus Valdes, Tom Wendt, and Kendal Young.

Linda Delay provided invaluable assistance in developing data layers for the biophysical model. Michael Heiner, Dan Dorfman, and Pat Comer assisted in developing the biophysical model and helped with other GIS problems. Russell Almaraz of NRCS helped build an ecoregion-wide soils map. Bob Unnasch assisted in developing metrics to measure threat and irreplaceability for conservation areas. Other GIS and technical assistance was provided by Tom Alnutt, Marilyn Altenbach, Debbie Benesh, Frank Biasi, Brooke Cholvin, Edwin Falconer, Chris Frasier, Steven Gilbert, Anne Gondor, Larry Gorenflo, Gordon Harris, Xaojun Li, Colby Loucks, Jason McNees, Cherie Moritz, Teri Neville, Paul Neville, Michael Schindel, Dorinda Scott, and Ryan Smith. Other assistance, advice, and support was provided by Barbara Adler, Susan Anderson, Sarah

Buckley, Wendy Dinner, Kristi Echols, Lee Elliot, Ingrid Etienne, Keene Haywood, Crawford Marginot, Patrick McCarthy, Patricia Mehlhop, Daran Moon, Deborah Nethers, Wayne Ostlie, Marco Antonio Paredes, Laura Paulson, Townsend Peterson, Christina Rhoe, Peter Russell, Jason Spensley, and Leni Wilsman.

We are grateful to Jennifer Hall, Steve Chaplin, and all the participants of the November 2000 Ecoregional Planning workshop in Colorado Springs, Colorado, hosted by The Nature Conservancy, for early input and assistance in developing this assessment. Thanks also to those who reviewed technical approaches, draft technical documents, and provided editorial advice on the final document.