Appendices for Chihuahuan Desert Network Vital Signs Monitoring Plan: Phase II Report

A. Overview of Chihuahuan Desert Network Parks

A.1. Amistad National Recreation Area (AMIS)

A.1.1. General Description

A.1.1.1. Size

Amistad National Recreation Area (NRA) encompasses 17,503 hectares (43,250 acres) of water and 5,682 hectares (14,042 acres) of land. It includes more than 868 kilometers (540 miles) of park boundary, and extends 119 kilometers (74 miles) up the Rio Grande, 22 kilometers (14 miles) up the Pecos River, and 38 kilometers (24 miles) up the Devils River.

A.1.1.2. Location

Amistad NRA is located along the Rio Grande in southwest Texas, approximately 10 kilometers (6 miles) northwest of Del Rio, Texas, and approximately 257 kilometers (160 miles) west of San Antonio, Texas. Park headquarters are located on the north edge of Del Rio, but the recreation area may be accessed from points along U.S. Highway 90 and U.S. Highway 277/377. Amistad is located in Val Verde County, Texas.

A.1.1.3. Adjacent Lands

Amistad NRA is primarily surrounded by private lands. Seminole Canyon State Historic Park is in close proximity. The country of Mexico borders the park on the south and shares administration of the lake with the park.

A.1.1.4. Elevation

The elevation of the Amistad dam is 349 meters (1,145 feet).

A.1.1.5. Park history

Among the Chihuahuan Desert Network (CHDN) parks, Amistad National Recreation Area (NRA) is unique in that it is the only park unit that includes a reservoir. Amistad NRA was established as part of a cooperative effort with Mexico to develop a combination of recreation, flood control, water storage, and power generation facilities. The stated intent was to "provide for public outdoor recreation use and enjoyment of the lands and waters associated with the United States portion of the reservoir known as Lake Amistad", and to "protect the scenic, scientific, cultural, and other values contributing to the public enjoyment of such lands and waters". The dam was completed in 1969 at a site on the Rio Grande just downstream from its convergence with the Devils River, and the reservoir was filled the following

year. The international boundary with Mexico lies underwater along the historic bed of the Rio Grande.

Amistad NRA lies in a region characterized by one of the densest concentrations of prehistoric American Indian rock art and artifacts in the New World. Several sites (including Panther and Parida Caves) are preserved at Amistad NRA and are accessible to visitors by boat when water levels permit. Other recreational uses of the area include boating, swimming, fishing, and camping.

A.1.1.6. Physical & natural characteristics

AMIS ranges in elevation from 282 to 364 meters, and is located at the convergence of three ecoregional provinces: Chihuahuan Desert, Edward's Plateau and Tamaulipan Thornscrub. Commonly associated plants include guajillo, lotebush, mesquite, guayacan, Texas prickly pear, paloverde, goatbush, yucca, sotol, desert yaupon, catclaw acacia, kidneywood, allthorn, curly mesquite, Texas grama, hairy tridens, slim tridens, and two-leaved senna. Also stands of whitethorn acacia and other acacias dominate this system, and limestone substrates appear important for at least these species.

Amistad NRA physically lies at the southern limit of the Edwards Plateau where it terminates at the Balcones Escarpment. The escarpment developed along a region of Late Cretaceous and Cenozoic fault-lines; today it separates the resistant Cretaceous limestone of the elevated plateau and northeastern Texas Hill Country from the lower elevation sediments of the southern Coastal Plain. Soils are thin, and the steep slopes and relatively impermeable bedrock increase the potential for erosion. The geography of Amistad NRA consists primarily of low hills and valleys near the dam, with steep-walled limestone canyons up to 60 meters (~ 200 feet) in height occurring upstream.

The climate at Amistad NRA is arid, with an average of 46 centimeters (18 inches) of annual precipitation, the majority of which occurs from April through October. Summers are hot and humid, with average temperatures in the mid 30s (°C/90s °F) and winters are dry and mild, with average temperatures in the teens (°C/60s °F).

A.1.2. Resource Management Concerns

A.1.2.1. Effects of reservoir fluctuation

Water levels in the reservoir are in continuous fluctuation, which has created large expanses of disturbed land that are alternately exposed and inundated. Beginning in 1993, southwest Texas experienced a prolonged drought. Demands from downstream users and low inflows into the reservoir resulted in a decrease in water volume to an historic low of 322 meters (1,058 feet) in August of 1998, which was 18 meters (59 feet) below the conservation level of 340 meters (1,117 feet). Although the reservoir level has recovered to some

degree, it has not been at conservation level since 1993. As a result, terrestrial plants and animals are now colonizing the formerly inundated areas.

A.1.2.2. Density, distribution, and effects of exotic plants

A number of common exotic plants are found at Amistad NRA. Tamarisk is found in many locations in the park, and is particularly common in the inundation zone of the reservoir. Other exotic species have been confirmed in the canyon bottoms and other microhabitats. More detailed information on the presence of exotic plants is required to understand the effects of continued low reservoir levels on the surrounding natural resources.

A.1.2.3. Livestock grazing

The meandering boundary of Amistad NRA has proven difficult to manage, and much of the park is affected by unmanaged grazing of livestock. As Amistad NRA has no complete plant list, the presence/absence of sensitive species and the effects of grazing are not well understood.

A.1.2.4. Land-use conversion

Housing development is occurring at 18 locations, occupying 89 kilometers (55 miles), along the boundary of Amistad NRA. Disturbance of the land along this boundary accelerates the encroachment of exotic plant species into the recreation area.

A.1.2.5. Water resources

Amistad National Recreation Area – Receives surface flows from all surrounding lands and three significant rivers.

A.1.2.6. Threats

- Deposition from atmospheric pollution,
- Sedimentation pollutants or contaminants from Rio Grande inflow,
- Sedimentation pollutants or contaminants from Devils and Pecos River inflow,
- Runoff from Mexican sources to the Rio Grande,
- Runoff from US sources, including adjacent ranches, exterior to the park,
- Hydrocarbons from US and Mexican watercraft,
- Possible fecal matter and debris from undocumented aliens in transit,
- Possible debris and fecal matter from US and Mexican watercraft,
- Hydrocarbons and debris from US and Mexican boat launch sites,
- Camping area runoff.

A.1.3. Species of Special Concern

The Devils River minnow (*Dionda diaboli*) is a small, native fish in the Cyprinidae (minnow) family. Its historic range included the Devils River from near the mouth of the Rio Grande to the headwater springs near Juno. As a result of the construction of Amistad Reservoir and the subsequent changes in the aquatic habitat and fish community, the species has apparently been extirpated from downstream of Dolan Falls in the Devils River. Ongoing efforts to document the current distribution of the Devils River minnow may expand the current range in the Devils River. The only other confirmed location of this species in Texas is in San Felipe Creek in the City of Del Rio. Devils River minnow was listed, without critical habitat designated, as a Federally threatened species in October 1999 (56 FR 58804).

Interior least terns (*Sterna antillarum*) are small (8 –9 inches) shorebirds that breed in isolated areas along the Missouri, Mississippi, Ohio, Red, and Rio Grande river systems. Their wintering sites include coastal areas of Central and South America. From late April to August, terns use barren to sparsely vegetated sandbars along rivers, sand and gravel pits, or lake and reservoir shorelines. Interior least terns have been documented breeders at the Amistad Reservoir since 1989. Preferred nesting habitat is found on islands with no vegetation or fire ants. These habitats occur during spring draw down of the reservoir, when islands emerge from inundation. The least tern has been listed as a Federal endangered species since 1985 (50 FR 21784).

Prior to the construction of Amistad Reservoir, a number of rare fishes may have inhabited the Rio Grande, Pecos and Devils river that are now recognized as threatened or endangered by the State of Texas. These species, now likely extirpated from the area, include: shovelnose sturgeon (*Scaphirhynchus platorynchus)*; Rio Grande silvery minnow (*Hybognathus amarus*); Rio Grande bluntnose shiner (*Notropis simus simus)*; proserpine shiner (*Cyprinella proserpina)*; blue sucker (*Cycleptus elongates)*; Conchos pupfish (*Cyprinodon eximius)*; blotched gambusia (*Gambusia senilis)*; and Rio Grande darter (*Etheostoma grahami)*. Of these eight State-listed species, three (shovelnose sturgeon, Rio Grande silvery minnow, and blotched *gambusia* are considered extirpated from Texas and the Rio Grande bluntnose shiner is considered extinct.

Bald Eagle (*Haliaeetus leucocephalus*), federally listed threatened, is found at Amistad during winter months. It is considered a rare winter visitor.

Brown Pelican (*Pelecanus occidentalis*), federally listed endangered, is found at Amistad during post-breeding dispersal and winter months. It is considered a rare visitor.

Texas Snowbells (*Styrax texanus*) and Tobusch fishhook Cactus (*Ancisrocactus tobuschii*) are Federally listed endangered. These two plants are found near Amistad, but haven't been confirmed inside the park.

Texas Tortoise (*Gopherus berlandieri*) is State listed threatened and is present inside Amistad NRA.

Threatened, Endangered, Species of Concern, and Park Endemic Species – Amistad National Recreation Area

Type	Scientific Name	Common Name	Status
Birds	*Sterna antillarum athaloassos*	Interior Least Tern	FE, TxE
	Vireo atricapillus	Black-capped Vireo	FE, TxE
	Pelecanus occidentalis	Brown Pelican	FE, TxE
	Plegadis chihi	White-faced Ibis	TxT
	Haliaeetus leucocephalus	Bald Eagle	FT, TxT
	Falco peregrinus anatum	Peregrine Falcon	TxE
Fish	*Dionda diaboli*	Devils River Minnow	FT, TxT
	Cycleptus elongatus	Blue Sucker	TxT
	Cyprinella proserpina	Proserpine Shiner	TxT
	Cyprinidon eximius	Conchos Pupfish	TxT
	Etheostoma Grahami	Rio Grande Darter	TxT
	Scaphirhynchus platorynchus	Shovelnose Sturgeon	TxT
	Hybognathus amarus	Rio Grande Silvery Minnow	FE
	Notropis simus simus	Rio Grande Bluntnose Shiner	TxTE
	Gambusia senilis	Blotched Gambusia	TxTE
Plants	*Ancistrocactus tobuschii*	Tobusch Fishhook Cactus	FE, TxE
	Styrax texanus	Texas Snowbells	FE, TxE
Reptiles	*Drymarchon corais*	Indigo Snake	TxT
	Gopherus berlandieri	Texas Tortoise	TxT
	Phrynosoma cornutum	Texas Horned Lizard	TxT
Mammals	*Ursus americanus*	Black Bear	TxT

FE = Federal Endangered
TxE = State Endangered
TE = Federal Threatened
TxT = State Threatened

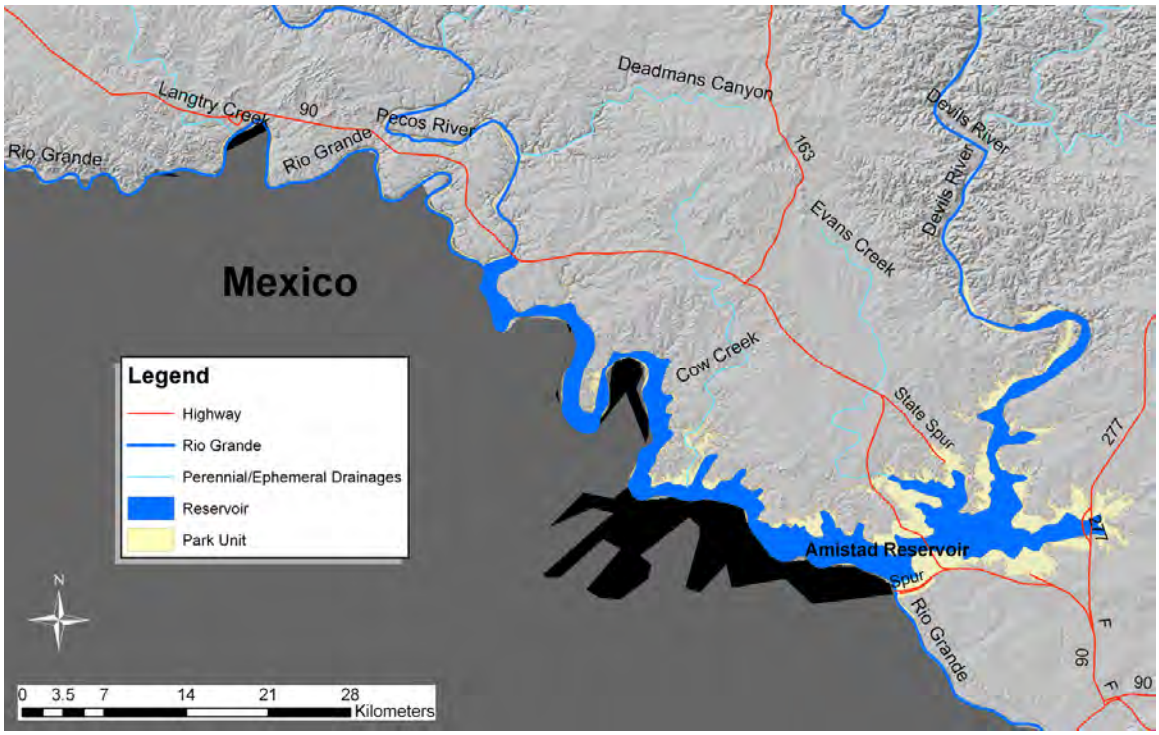

Figure A.1. Map of Amistad National Recreation Area, Texas

A.2. Big Bend National Park (BIBE)

A.2.1. General Description

A.2.1.1. Size

324,232 hectares (801,163 acres)

A.2.1.2. Location

Big Bend National Park (NP) is located along the U.S. border within the bend of the Rio Grande in southwestern Texas. The park is accessible from State Highway 118 approximately 129 kilometers (80 miles) south of Alpine, Texas, or from U.S. Highway 385, 64 kilometers (40 miles) south of Marathon, Texas. Park headquarters is located at the junction of these two highways, in the northern foothills of the Chisos Mountains. Big Bend NP is located in Brewster County, Texas.

A.2.1.3. Adjacent Lands

Big Bend NP shares much of its boundary with Mexico. In the United States much of the adjacent land is private with some state lands. Neighbors to the park, either adjacent or in close proximately, include Big Bend Ranch State Park, Black Gap State Wildlife Management Area, State of Texas General Land Office, and the Nature Conservancy.

A.2.1.4. Elevation

Park elevations range from 548 meters (1,800 feet) at the Rio Grande to 2,377 meters (7,800 feet) atop Emory Peak in the Chisos Mountains. Overall change in elevation is approximately 1,829 meters (6,000 feet).

A.2.1.5. Park history

The state of Texas established Big Bend State Park in 1933, which was comprised of approximately 64,750 hectares (160,000 acres) of state-owned school section and tax forfeit properties. In 1935, President Franklin D. Roosevelt signed a bill authorizing establishment of a national park on the site. In 1944 the state presented a deed for approximately 283,300 hectares (700,000 acres) to the President, and Big Bend National Park was dedicated on June 12, 1944.

Big Bend NP currently encompasses the largest protected area representative of the Chihuahuan Desert, and is classified as a U.S. Biosphere Reserve. It includes 216,070 hectares (533,900 acres) of recommended Wilderness and administers the 305-kilometer (190-mile) Rio Grande Wild and Scenic River.

A.2.1.6. Physical & natural characteristics

During the Cretaceous Period (65-145 million years ago) much of West Texas was part of a shallow inland sea. Gradual accumulation of sediment and marine animal skeletons resulted in the formation of extensive layers of

limestone, sandstone, and shale. By the Early Tertiary Period (50 million years ago) the sea had receded and the land was covered by extensive forests and wetlands. Basin and Range faulting action along converging fault lines formed the Appalachian Mountains to the east, the Rocky Mountains to the northwest, and the Sierra Madre range to the south, and also displaced large sections of the old seabed. The resulting cliffs and canyons continued to be shaped by erosion, while subsequent volcanic activity created the Chisos Mountains and other igneous features.

As recently as 10,000 years ago cooler and moister conditions prevailed in the Big Bend region, but climatic change gradually resulted in hotter, dryer conditions and Big Bend NP now lies near the northern edge of the Chihuahuan Desert. The relative youth of the desert combines with the dramatic topographic relief of the park to produce tremendous biological diversity. In addition to the many desert-adapted plants and animals found in the lower elevations of the park, the "sky islands" of the higher elevations retain species with origins in the cooler and moister climate of the last Ice Age.

The climate is arid, with average annual precipitation ranging from 25 centimeters (10 inches) in the lower desert to 46 centimeters (18 inches) in the Chisos Mountains. More than half of the annual precipitation occurs from July to early October. Temperatures regularly exceed 38 °C (100 °F) from June through August, but freezing temperatures are not uncommon from November to mid-March as cold air moves southward into the park from the Great Plains. Snow falls occasionally in the Chisos Mountains and rarely at the lower elevations.

A.2.2. Resource Management Concerns

A.2.2.1. Aquatic and riparian species loss due to degradation of the Rio Grande

Historically, the Rio Grande supported aquatic and riparian communities unique to the arid Chihuahuan Desert ecosystem. However, modern human impacts have severely degraded the river's potential to sustain these native plant and animal assemblages. Much of the river has been diverted upstream for agricultural, urban, and industrial purposes. Impoundments alter natural flood and flow cycles, contaminants have altered water chemistry, and exotic species invasions have disrupted native species dominance. Research indicates that at least seven fish species and one amphibian species have been extirpated from the river in recent history. Effective management of the riparian communities of Big Bend NP requires baseline data on the current status of the at-risk plant and animal species, and consistent monitoring efforts so that status changes may be noted and addressed.

A.2.2.2. Disruption of ecosystem structure by exotic plant and animal species

A host of invasive non-native plant and animal species threaten native communities and species throughout the park. Tamarisk, Buffelgrass, Giant Reed, Bermudagrass, Johnsongrass, and a variety of other exotic plants are displacing native species park wide. Feral hogs, Nutria (Myocaster coypus), Barbary Sheep (Ammotragus lervia), trespassing livestock, non-native fish species, and other exotic vertebrates continue to disrupt native ecosystems. Further research is needed on the distribution and invasiveness of exotics, and their impact upon native plant and animal habitats, if managers are to effectively monitor and control them.

A.2.2.3. Protection of isolated or rare species and habitats of mountains and desert springs

A significant part of the park's diversity is represented by isolated populations of plants and vertebrates that are found in the Chisos Mountains and in many of the desert springs distributed across the park. These species are threatened by local impacts such as fire, human disturbance, disruption of migration routes and movement corridors, and exotic species encroachment. In addition, broad-scale issues such as the potential for minor climatic shifts (such as drought) and atmospheric deposition of airborne contaminants may affect these species. Managers need inventories of species associated with imperiled vegetation communities, as well as isolated species and their habitats. This will improve understanding of the nature and sources of threats and increase the ability of managers to monitor population status changes.

A.2.2.4. Continued grassland and riparian degradation resulting from pre-park land use practices

Formerly extensive desert grasslands and shrub lands that protected soils, retained moisture, and supported diverse plant and animal communities were damaged by pre-park agricultural practices. Thin, fragile soils began eroding when grazing, plowing, development, and hydrologic alteration for water catchments reduced vegetative cover. Irreparable loss of fragile topsoil and the slow rate of soil development have resulted in continued degradation despite current land protection policies within park boundaries.

Reduced soil cover results in loss of organic soil structure and moisture retention. Increased rain runoff occurs, further contributing to downstream and back-cutting erosion, which further threatens surviving grass and shrub lands. Vegetative reproduction becomes limited to highly tolerant, invasive, and exotic species. This decrease in diversity of native grass and shrubs contributes to the fragmentation and decline of associated vertebrate populations. Managers need to understand existing conditions and the potential for remediation, and to pursue implementation of a long-term monitoring program that quantifies and tracks change in grass and shrubland-associated plants and animals.

A.2.2.5. Vegetation shifts due to climate change

The potential for climate change to create large-scale shifts in vegetation associations in the park's Chihuahuan Desert communities is immense. Many plant and animal communities are relic, unique, geographically isolated, or exist on the margin of their range. Although climate change models are not widely agreed upon, the potential is significant for indirect consequences (such as wildfire or drought) to accelerate desertification and loss of plant and animal diversity. Managers need monitoring programs that identify early signs of climate-related species declines, and provide data with which to model and characterize future risk.

A.2.2.6. Water resources

Big Bend National Park – Receives flow from two major rivers (Rio Grande and Rio Conchos) and several smaller US and Mexican tributaries (Terlingua Creek, Alamito Creek, Arroyo de Fortino). Some of the tributaries are intermittent but contribute a significant amount of sediment loading to the Rio Grande. The Rio Conchos is the only major contributor to the flow of the Rio Grande above Big Bend NP. The cities of El Paso and Juarez ordinarily take all of the Rio Grande. Irrigation return flow and occasional rainfall runoff provides some flow to the river, but the flow reaching Big Bend NP is due in large part to the contributions from the Rio Conchos.

A.2.2.7. Threats:

- Deposition from atmospheric pollution,
- Sedimentation, pollutants or contaminants from Rio Grande inflow,
- Waste water effluent discharges from Presidio and Ojinaga,
- Permitted wastewater discharge to tributary Terlingua Creek,
- Mexican livestock in and adjacent to the Rio Grande,
- Runoff from in-park concessions and camping areas,
- Fecal matter during flooding of restroom facilities at Santa Elena Canyon,
- Several contaminants possibly released in potential Rio Grande Village flooding,
- Runoff and infiltration from all Panther Junction park facilities,
- Runoff and infiltration from gasoline station west of Panther Junction,
- Runoff and infiltration from all Chisos Basin concessionaire and park facilities,
- Fecal matter from dispersed camping and hiking activities, especially along the Rio Grande and its tributaries,

- Camping debris and fecal matter near springs and seeps,
- Possible fecal matter and debris from undocumented aliens in transit,
- Vandalism by aggressive pothunters and others in and around springs and seeps,
- Hydrocarbons and debris from River Road users.

A.2.3. Species of Special Concern

Threatened, Endangered, Species of Concern, and Park Endemic Species - Big Bend National Park

	Scientific Name	Common Name	Status
Birds			
	Vireo atricapillus	Black-capped vireo	FE, TxE
	Falco peregrinus	Peregrine falcon	TxE
	Buteogallus anthracinus	Common black-hawk	TxT
	Asturina nitida	Gray hawk	TxT
	Buteo albonotatus	Zone-tailed hawk	TxT
Mammals			
	Leptonycteris nivalis	Mexican long-nosed bat	FE, TxE
	Euderma maculatum	Spotted bat	TxT
	Ursus americanus	Black bear	TxT
	Nasua narica	White-nosed coati	TxT
	Canis lupus baileyi	Mexican gray wolf	FE, TxE, (extirpated)
	Ovis canadensis nelsoni	Desert bighorn sheep	(subspecies extinct-TxRS)
Fish			
	Gambusia gaigei	Big Bend Mosquitofish	FE, TxE, AFS
	Hybognathus amarus	Rio Grande Silvery Minnow	FE, AFS, (extirpated)
	Acipenser oxyrhynchus	Atlantic Sturgeon	AFS
	Scaphirhynchus platorynchus	Shovelnose sturgeon	TxT,(extirpated)
	Campostoma ornatum	Mexican stoneroller	TxT, AFS
	Notropis chihuahua	Chihuahua shiner	TxT
	Notropis jemezanus	Rio Grande shiner	TxT

	Cycleptus elongatus	Blue sucker	TxT, AFS
	Atractosteus spatula	Alligator gar	(extirpated)
	Lepisosteus osseus	American eel	(extirpated)
	Cyprinella lutrensis blairi	Blair's red shiner	(extirpated)
	Notropis orca	Phantom shiner	TxE, AFS, (extirpated)
	Notropis simus simus	Bluntnose shiner	TxE, AFS, (extirpated)
	Moxostoma congestum	Gray redhorse	AFS
Amphibians			
	Bufo woodhouseii	Southwestern Woodhouse's Toad	(may be extirpated)
Reptiles			
	Trachemys gaigeae	Big Bend Slider	SC
	Phrynosoma cornutum	Texas horned lizard	TxT
	Tantilla rubra	Big Bend blackhead snake	TxT
	Trimorphodon biscutatus	Texas lyre snake	TxT
	Coleonyx brevis	Texas banded gecko	BE
	Coleonyx reticulatus	Reticulated (or Big Bend) gecko	BE
	Cophosaurus texanus texanus	Greater earless lizard	BE
	Cnemidophorous tigris marmoratus	Marbled whiptail	BE
Mussels			
		Tampico pearly mussel	FE
		Texas hornshell	FE
Plants			
CACTI	*Coryphantha ramillosa*	Bunched cory cactus	FT
	Coryphantha chaffeyi	Chaffey's cory cactus	Tnh
	Echinocereus chisoensis	Chisos hedgehog cactus	FT Tnh (endemic)
	Coryphantha dasyacantha	Dense cory cactus	Tnh
	Coryphantha duncanii	Duncan's cory cactus	Tnh
	Opuntia aureispina	Golden-spined prickly pear	Tnh
	Echinomastus mariposensis	Lloyd's mariposa cactus	FT, Tnh
	Opuntia imbricata var. argentea	Silver-spined cholla	Tnh
	Coryphantha albicolumnaria	White-column cactus	Tnh

SUCCULENTS	*Agave glomeruliflora*	Chisos agave	Tnh
ORCHIDS	*Hexalectris revoluta*	Chisos root coral	Tnh
	Hexalectris nitida	Glass Mountain coral root	Tnh
	Hexalectris warnockii	Texas purple spike	Tnh
TREES	*Ostrya chisosensis*	Chisos hophornbeam	Tnh
	Quercus tardifolia	Chisos Mountain oak	Tnh
	Quercus graciliformis	Slender oak	Tnh
SHRUBS	*Brogniartia minutifolia*	Little-leaf brogniartia	Tnh
	Batesimalva violacea	Purple gay mallow	Tnh
	Andrachne arida	Trans-Pecos maidenbush	Tnh
FORBS	*Bonamia ovalifolia*	Bigpod bonamia	Tnh
	Lechea mensalis	Chisos pinweed	Tnh
	Streptanthus cutleri	Cutler's twistflower	Tnh
	Aquilegia longissima	Long-spur columbine	Tnh
	Nectouxia formosa	Puckering nightshade	Tnh
	Chamaesyce golondrina	Swallow spurge	Tnh
	Castilleja elongata	Tall-stemmed paintbrush	C, Tnh
	Chamaesyce chaetocalyx var. triligulata	Three-tongue spurge	Tnh
GRASSES	*Festuca ligulata*	Guadalupe fescue	C, Tnh

FE = Federally Endangered
FT = Federally Threatened
C = Candidate for Federal Listing
TxT = Tex. State Threatened
TxE = Tex. State Endangered
Tnh=Texas Natural Heritage Program Listed
TxRS=Tex. Restoration Species
AFS=American Fisheries Society Listed
BE=Big Bend endemic

Figure A.2. Map of Big Bend National Park, Texas

A.3. Carlsbad Caverns National Park (CAVE)

A.3.1. General Description

A.3.1.1. Size

18,926 hectares (46,766 acres); 71% is wilderness (13,406 ha; 33,125 ac).

A.3.1.2. Location

Carlsbad Caverns National Park (NP) is located in Eddy County in southeastern New Mexico, about 32 kilometers (20 miles) southwest of Carlsbad, New Mexico, and 241 kilometers (150 miles) east of El Paso, Texas. The main park entrance near White's City is accessible from U.S. Highway 62-180.

A.3.1.3. Adjacent Lands

The park shares boundaries with private land and public lands managed by the US Forest Service (Lincoln National Forest), Bureau of Land Management, and the New Mexico State Lands Office. Land use is a mix of cattle ranching, oil and gas development, and irrigated agriculture.

A.3.1.4. Elevation

The elevation in the park ranges from 1,096 meters (3,595 feet) in the desert lowlands to 1,987 meters (6,520 feet) atop the Capitan Reef. The total relief is 891 meters (2,925 feet).

A.3.1.5. Park history

President Calvin Coolidge established Carlsbad Cave National Monument on October 25, 1923 (Presidential Proclamation No. 1679), under the provisions of the Antiquities Act (34 Stat. 225; June 8, 1906), to protect scenic Carlsbad Cave. Additional public lands were withdrawn by executive order on April 2, 1924 (No. 3984) and May 3, 1928 (No. 4870) for consideration for future national park status. On May 14, 1930, Congress established Carlsbad Caverns National Park (46 Stat. 279). The park was enlarged by executive order on June 17, 1930 (No. 5370), 1933, and 1939. In 1963 boundary adjustments were authorized to acquire Rattlesnake Springs (77 Stat. 818) and in 1978, Congress designated 71% of the park's surface area as Wilderness. Carlsbad Caverns NP was designated a World Heritage Site in 1995, for the protection of "physical and biological formations and groups which are of universal world-wide value and interest."

A.3.1.6. Physical characteristics

Carlsbad NP lies in the Guadalupe Mountains, near the northern end of the Capitan Reef geologic formation. The reef was formed approximately 250 million years ago at the margin of a Permian ocean basin. The sea receded late in the Permian era, covering the reef with layers of sediment. Approximately 26 million years ago, Basin and Range faulting action in the Guadalupe Block lifted parts of the reef from its original position, forming the mountains visible today. Erosion in the Guadalupe range has exposed much of the formerly buried reef, making the mountains a premier location for geological research.

Carlsbad Caverns NP preserves more than 90 known caves. Early speleogenesis of the cave systems inside the Guadalupe range may have occurred as early as the Permian era. Initial cave formation was probably caused by carbonic acid filtering through fissures in the reef. However, the presence of gypsum deposits in many of the cave systems has led geologists to believe that sulfuric acid played a role in cave formation during the uplift of the range. They speculate that the salt water that had filled the Capitan Reef was gradually displaced by incoming freshwater. Salt brine rich in hydrogen sulfide subsequently seeped upward from deposits deep under the reef. The hydrogen sulfide then combined with oxygen and freshwater to form sulfuric acid, and migrated throughout the reef. Uplift gradually lifted the upper-level caves clear of the water, and caves formed in lower regions of the reef.

Carlsbad Caverns NP lies in the northern reaches of the Chihuahuan Desert ecosystem, where desert-scrub and grassland plant communities dominate. Small pockets of coniferous woodland are found at higher elevations in the

western third of the park. The climate is arid, and characterized by warm summers and mild winters. In the summer, average highs are in the 30s (°C) (90s °F). In the winter the average highs range from 10 - 20 °C (50 - 60 °F). Average annual precipitation is approximately 37 centimeters (14.5 inches) at 4,400 feet elevation, with over 80% occurring in May – October (Gehlbach 1967). Rainfall is highly variable and localized.

A.3.2. Resource Management Concerns

The Guadalupe Mountains – Carlsbad Escarpment is rated as a highest priority terrestrial site for conservation by the WWF (Dinerstein et al. 2000). The Pecos River, including associated spring-fed tributaries like Rattlesnake Springs, are similarly rated as the highest priority for conservation among freshwater sites. Freshwater riparian areas are the most threatened resource in the Chihuahuan Desert. Riparian communities at Rattlesnake Springs and adjacent non-park lands are magnified in importance due to the rarity of similar habitat in the region, and the diversity of plant and animal life found there, including migratory birds. Seeps and springs, as well as seasonally flooded playas and arroyos, are also sites of interest as they are an important resource for wildlife in a largely arid climate. The high-elevation western escarpment, featuring deep incised canyons, relict ponderosa pine forest, maple stringers, and juniper-piñon mesas, has received scant attention in most previous biological inventories. Among well-visited park areas, Walnut Canyon is of management interest due to the presence of rare taxa (e.g., *Coryphantha sneedii* var. *leei*, *Lampropeltis alterna*, etc.) and high visitor use.

Generally speaking, specific management issues at Carlsbad Caverns National Park mirror broader threats to biodiversity that have been identified in the northern Chihuahuan Desert (e.g., Dinerstein et al. 2000). They include:

A.3.2.1. Water management

Surface flow from Rattlesnake Springs supports 1,000 meters (3,281 feet) of stream course with riparian woodlands and marsh ecosystems. The rarity of riparian corridors magnifies the importance of Rattlesnake Springs for the preservation of regional biological diversity. However, groundwater pumping for irrigated agriculture outside of the park has the potential to draw down spring flow at Rattlesnake Springs. Currently, approximately half of the surface flow is diverted towards neighboring Washington Ranch, or for irrigation of cottonwood galleries and orchards at Rattlesnake Springs. The dewatering of the natural drainage ensures that the stream course cannot connect downstream with the Black River, and creates a parallel aquatic community in the concrete-lined ditches that deliver water to Washington Ranch. Maintenance of the ditches disrupts the artificial community, where native Rio Grande leopard frogs (*Rana berlandieri*) and green-throated darters (*Etheostoma lepidum*) have become established. The concrete ditches establish an aquatic link to ponds at Washington Ranch, and may provide a corridor for the dispersal of non-native wildlife such as bullfrogs (*Rana catesbeiana*)

and largemouth bass (*Micropterus salmoides*) although desired natives such as the western river cooter (*Pseudemys gorzugi*) may also employ this corridor. The natural stream course may have once reached the Black River, at least occasionally, providing a corridor for many aquatic organisms that reside there. If so, Rattlesnake Springs would have served as a refuge for aquatic species in the Pecos River drainage that are now imperiled due to extensive water diversion.

A.3.2.2. Livestock grazing

Livestock use outside the park boundary (and infrequent episodes of trespass grazing) degrades the landscape. Historic grazing by sheep and goats has likewise altered vegetation communities inside the park boundary. Soil erosion, replacement of grasslands by shrub lands, altered fire regimes, and habitat change isolate relatively undisturbed communities from other like habitats. Current land management practices outside the park boundary include the use of herbicides to kill shrubs, and predator control against coyotes (*Canis latrans*) and cougars (*Puma concolor*). Grazing may also alter the density and distribution of native wildlife (e.g., favoring cowbirds (*Molothrus* spp.) and allow the spread of non-native plants.

A.3.2.3. Oil and gas development

Plans for developing leases on state and private lands adjacent to the park, including sections between the main body of the park and Rattlesnake Springs, pose risks to air and water quality, and degrade the surrounding land by road and well pad construction, and habitat loss. Noise and nighttime light pollution are also increased by such activities. Disturbance may be expected to favor the spread of non-native plants.

A.3.2.4. Exotic species

Barbary sheep (*Ammotragus lervia*) are established in the park. Feral goats are also occasionally noted. Non-native plants, especially Russian olive (*Elaegnus angustifolia*) and johnsongrass (*Sorghum halapense*), are now major components of the vegetation at Rattlesnake Springs. These species may suppress the cottonwood-willow riparian woodlands and native grasses that occur there. Other non-native plants that have potential to spread in disturbed areas include Malta starthistle (*Centaurea melitensis*), common horehound (*Marrubium vulgare*), and tree-of-heaven (*Ailanthus altissima*).

A.3.2.5. Illegal hunting and poaching

The illegal collection of reptiles and cacti (as well as rocks, paleontological resources, and cultural artifacts) probably occur in and outside the park. In addition to legal sport and depredation hunts for cougar in New Mexico, illegal trapping and hunting likely persists outside of the park boundary. Cougar hunting is currently unregulated in Texas.

A.3.2.6. Aircraft overflights

Occasional military aircraft flyovers have the potential to disturb wildlife and impact wilderness values.

A.3.2.7. Human population/recreation use

More than 500,000 people visit the park every year, and most of them tour Carlsbad Cavern (NPS 1996). Visitor impacts in the cave include the introduction of lint, trash and food into the cave environment. Vandalism and theft of speleothems are also well-documented problems. The accommodation of visitors in the cave has led to significant modifications to the cave environment, including systems of trails, electric lights, elevators, restrooms, a cafeteria, and gift shop. These impacts may affect the climate in the cave, pollute cave pools, permit the growth of algae and photosynthetic plants, and alter nutrient cycles and the distribution of cave invertebrates. On the surface, visitor impacts are concentrated in Walnut Canyon. Most visitors arrive at the park by automobile, via the 2-lane highway from White's City. The nighttime speed limit has been lowered to 30 mph (daytime limit is 40 mph) to help prevent the loss of wildlife on the road. Automotive pollutants along the highway and in parking areas above Carlsbad Cavern may be harmful, particularly to the cave environment. Primitive roads and trails designed for visitor access are in poor condition, causing erosion of gravel and soil outside the bed into areas containing native plants and wildlife.

A.3.2.8. Lack of baseline inventories

Park managers recognize that improved knowledge of the presence, abundance, and distribution of plants and wildlife is vital to informed decision-making in the areas of fire management, visitor use, and others. The results of such research can assist in the stewardship of park resources, and contribute to the knowledge of broader subjects in ecology such as climate change, migration, and evolution. Research needs for various park taxa include:

I. Amphibians. The lack of any park-wide survey for amphibians is identified as a serious deficiency in resource knowledge and park management. Native amphibians are of special interest due to general declines throughout the southwest, the potential negative impact of non-native bullfrog (Rana catesbeiana) on local populations, and the susceptibility of anurans to wildlife diseases and environmental contaminants. One instance of deformity has been noted in an adult bullfrog from Rattlesnake Springs, collected in 2000. The native riparian habitat and system of irrigation ditches and ponds at Rattlesnake Springs and the adjoining Washington Ranch and Black River are host to native Rio Grande leopard frog (R. berlandieri) as well as non-native bullfrog populations. The degree of competition between these frogs is unknown. Water management by the park and other landowners (i.e., surface water diversions for irrigation and groundwater pumping) alter the available habitat for these and other species. The park needs to develop a consistent plan for bullfrog management, monitoring of bullfrog and leopard frog populations, and recommendations for irrigation practices that take into account the habitat preferences of native

species. Cricket frogs (Acris crepitans) were formerly collected at Rattlesnake Springs (Kansas University Museum of Natural History 13420-60), but have not been noted in recent years. Cricket frogs may still occur in flooded grassland habitat at nearby Blue Spring (7.5 km E of White's City). Investigation of this site may shed light on the apparent extirpation of cricket frogs from Rattlesnake Springs, and possibly provide a model for habitat restoration and a source for eventual reintroduction. Several species of amphibians are possible for the park, including eastern barking frogs (Eleutherodactylus augusti) which have been noted in the plains a short distance from the park in July 2000 (Chosa Draw, 6.8 km E of Rattlesnake Spring), Woodhouse's toad (B. woodhousii), plains leopard frogs (R. blari), and plains spadefoot toad (Spea bombifrons).

II. Reptiles. Although 49 species of reptiles have been noted for the park, many of these are not verified through specimens or adequate voucher photographs. There is a special interest in having a thorough assessment of riparian-associated species that are known from the nearby Black River, and which may occur at Rattlesnake Springs, including, snapping turtle (*Chelydra serpentina*), painted turtle (*Chrysemys picta*), spiny softshell (*Trionyx spiniferus*), western ribbon snake (*Thamnophis proximus diabolicus*), and blotched water snake (*Nerodia erythrogaster transversa*). Gray-banded kingsnake (*Lampropeltis alterna*) is of particular interest to the park. This species is notoriously difficult to document through standard pitfall trap methods, and is highly sought by reptile collectors. Illegal collection of this and other colorful species likely occurs at Carlsbad Caverns National Park. Several species of reptiles are listed as threatened or endangered by various agencies. These are western river cooter (*Pseudemys gorzugi*, NM state threatened), Texas horned lizard (*Phrynosoma cornutum*, USFS Region 3 sensitive), gray-banded kingsnake (NM state endangered), common kingsnake (*Lampropeltis getula splendida*, USFS Region 3 sensitive), blotched water snake (NM state endangered), western ribbon snake (not known from park; NM state threatened), mottled rock rattlesnake (*Crotalus lepidus lepidus*, NM state threatened), and desert massasauga (*Sistrurus catenatus edwardsi*, not known from park; USFS Region 3 sensitive).

III. Plants. Key management needs at Carlsbad Caverns National Park are an understanding of the distribution of vegetation communities, the response of these communities and rare species to fire, the control of non-native plants, and inventory and monitoring for state and federally listed species. The park has contracted with the New Mexico Natural Heritage Program (NMNHP) to conduct a survey of park vegetation and classify the vegetation communities. The vegetation map will be completed in early 2002. Protection of the federally threatened Lee's pincushion cactus (*Coryphantha sneedii* var. *leei*) is a focus of park management, as the species is restricted in range to the park and immediate surroundings. The park has conducted surveys for Lee's pincushion cactus, monitored some populations to determine mortality from fire events, and contracted a study of the morphometric properties of *C. s.*

var. *leei* and related species. The presence and population densities of *C. s.* var. *leei* and other rare plants are poorly understood for the park. The park needs a rare plant survey to document the distributions of these species and describe the habitats and conditions in which they are found.

IV. Birds. Birds of special concern include riparian obligate species, particularly the state threatened Bell's vireo (*Vireo bellii*) and yellow-billed cuckoo (*Coccyzus americanus occidentalis*, USFS Region 3 species of concern). The federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*) is an observed migrant at Rattlesnake Springs, and may eventually find suitable habitat for nesting there. Brood parasitism by brown-headed cowbirds (*Molothrus ater*) has a negative effect on nesting success in Bell's vireo at Rattlesnake Springs, and may affect species in other habitats as well. The park may also provide habitat for the federally threatened Mexican spotted owl (*Strix occidentalis lucida*), and the state threatened peregrine falcon (*Falco peregrinus anatum*), gray vireo (*Vireo vicinior*), and varied bunting (*Passerina versicolor*). Cave swallows (*Hirundo fulva*) reach their northern range limit at the park, and are of interest to ornithologists and the general public. The distribution and abundance of upland breeding and wintering birds are poorly understood at Carlsbad Caverns.

V. Fish. The park needs to implement monitoring for green-throat darters (*Etheostoma lepidum*, New Mexico state-threatened species) and roundnose minnows (*Dionda episcopa*) in various habitats at Rattlesnake Springs (e.g., spring pond, irrigation ditches, natural stream channel, etc.). Cleaning and repair of concrete irrigation ditches are especially problematic, as the removal of aquatic vegetation and interruption of water flow destroys habitat for the greet-throat darters. Green sunfish (*Lepomis cyanellus*) are native to the area but possibly introduced to the pond area at the springs. Largemouth bass (*Micropterus salmoides*) have also been introduced to the pond habitat. The park needs to assess the need for management of these larger species, and determine the suitability of this habitat for other native fishes that may have once been present (e.g., *Gambusia nobilis*).

VI. Mammals. Carlsbad Caverns National Park has lost some native mammals, including the extinct Merriam's elk (*Cervus elaphus merriamii*), and extirpated desert bighorn sheep (*Ovis canadensis*). Although there are no confirmed park records, prairie dogs (*Cynomys ludovicianus*), gray wolf (*Canis lupus*) and other species may have been historically present. The park contains many bat species that are listed as sensitive by the state of New Mexico or the BLM, including cave myotis (*Myotis velifer*), fringed myotis (*M. thysanodes*), long-legged myotis (*M. volans*), eastern red bat (*Lasiurus borealis*), and Townsend's big-eared bat (*Corynorhinus townsendii*). The status of these and other bat species, particularly the colony of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) that reside in Carlsbad Cavern, are of keen public and management interest at the park. Many other mammal species are listed as sensitive by the state of New Mexico, notably the spotted skunk (*Spilogale gracilis*), which has not been seen in the park in several decades.

Park management of cougar (*Puma concolor*) and mule deer (*Odocoileus hemionus*) has often been controversial with various publics. The park has committed to monitoring populations of cougar and mule deer in a 1986 Mountain Lion Management Plan and Environmental Assessment (NPS 1986). Non-native Barbary sheep (*Ammotragus lervia*) are established in the park. Removal of Barbary sheep and restoration of native desert bighorn sheep are goals for park management. Data on the distribution and abundance of park mammals, including verification of all known collected specimens (n = 1,186) at seven institutions is to be published in 2002 by the University of Nebraska State Museum (Geluso in press).

A.3.2.9. Water Resources

Receives no significant surface flows from surrounding lands.

A.3.2.10. Threats:

- Deposition from atmospheric pollution,
- Runoff and infiltration to caves from all headquarters area park facilities.
- Oil and gas drilling in the catchment for Rattlesnake Springs has the potential to cause irreparable damage to the Springs. During high flow, there has been trace amounts of toluene detected, indicating that some of the adjacent, subsurface water courses have been contaminated and can spill over into the underground channel that feeds Rattlesnake Springs. Grazing and agriculture within the Rattlesnake Springs catchment also poses a threat to the water from high nitrates and phosphates.

A.3.3. Species of Special Concern

Threatened, Endangered and Species of Concern—Carlsbad Caverns National Park

	Scientific Name	Common Name	Status
Birds			
	Butorides virescens	Green heron	FS
	Falco peregrinus anatum	American peregrine falcon	NM-T, FS
	Buteo regalis	Ferruginous hawk	SOC, FS, BLM
	Buteo swainsoni	Swainson's hawk	FS
	Buteo albonotatus	Zone-tailed hawk	FS
	Athene cunicularia hypugea	Western burrowing owl	SOC, BLM
	Otus flammeolus	Flammulated owl	FS
	Micrathene whitneyi whitneyi	Elf owl	FS
	Strix occidentalis lucida	Mexican spotted owl	FT, NM-S, FS

	Coccyzus americanus occidentalis	Yellow-billed cuckoo	FS
	Ceryle alcyon	Belted kingfisher	FS
	Lanius ludovicianus	Loggerhead shrike	SOC, BLM
	Empidonax traillii extimus	Southwestern willow flycatcher	FE, NM-E, FS
	Vireo bellii	Bell's vireo	NM-T, FS
	Vireo vicinior	Gray vireo	NM-T, FS
	Dumetella carolinensis ruficrissa	Gray catbird	FS
	Anthus spragueii	Sprague's pipit	FS
	Setophaga ruticilla tricolora	American redstart	FS
	Ammodramus bairdii	Baird's sparrow	SOC, NM-T, FS, BLM
	Calcarius mccownii	McCown's longspur	FS
	Passerina versicolor	Varied bunting	NM-T, FS
Fish			
	Etheostoma lepidum	Greenthroat darter	NM-T
Mammals			
	Myotis ciliolabrum melanorhinus	Western small-footed myotis	SOC, NM-S, BLM
	Myotis yumanensis yumanensis	Yuma myotis	SOC, NM-S, BLM
	Myotis velifer	Cave myotis	SOC, NM-S, BLM, FS
	Myotis volans interior	Long-legged myotis	SOC, NM-S, BLM
	Myotis thysanodes thysanodes	Fringed myotis	SOC, NM-S, BLM
	Lasiurus borealis	Eastern red bat	NM-S, FS
	Corynorhinus townsendii pallescens	Pale Townsend's big-eared bat	SOC, NM-S, BLM, FS
	Nyctinomops macrotis	Big free-tailed bat	SOC, NM-S, BLM
	Tamias canipes canipes	Gray-footed chipmunk	SOC, BLM
	Thomomys bottae guadalupensis	*Guadalupe pocket gopher*	*SOC, NM-S, BLM, FS*
	Chaetodipus nelsoni canescens	Nelson's pocket mouse	NM-S
	Bassariscus astutus	Ringtail	NM-S, FS
	Spilogale gracilis	Western spotted skunk	NM-S
	Conepatus mesoleucus	Common hog-nosed skunk	NM-S

Reptiles			
	Pseudemys gorzugi	Western river cooter	NM-T, FS
	Phrynosoma cornutum	Texas horned lizard	SOC, FS, BLM
	Phrynosoma douglasi hernandesi	Mountain short-horned lizard	TX-T
	Lampropeltis alterna	Gray-banded kingsnake	NM-E
	Lampropeltis getula splendida	Desert kingsnake	FS
	Nerodia erythrogaster transversa	Blotched water snake	NM-E, FS
	Thamnophis proximus diabolicus	Arid land ribbon snake	NM-T, FS
	Crotalus lepidus lepidus	Mottled rock rattlesnake	NM-T, FS
	Sistrurus catenatus edwardsii	Desert massasauga	FS
Plants			
	Amsonia tharpii		NM-E
	Aquilegia chrysantha var. chaplinei	Chapline's columbine	NM-T
	Astragalus gypsodes	Gypsum milkvetch	NM-T
	Chaetopappa hersheyi	Mat leastdaisy	SOC, NM-T
	Chrysothamnus nauseosus var. texensis	Guadalupe rabbitbrush	SOC, NM-T
	Coryphantha scheeri var. scheeri		NM-E
	Coryphantha sneedii var. leei	Lee's pincushion cactus	FT
	Coryphantha sneedii var. sneedii	Sneed's pincushion cactus	FE
	Echinocereus fendleri var. kuenzleri	Kuenzler's hedgehog cactus	FE
	Eriogonum gypsophilum	Gypsum buckwheat	FT
	Escobaria guadalupensis	Guadalupe pincushion cactus	SOC, NM-T
	Hedeoma apiculatum	McKittrick pennyroyal	NM-T
	Hexalectris nitida	Shining coral root orchid	SOC, NM-E
	Justicia wrightii	Wright's justicia	NM-T
	Nama xylopodum	Yellowseed nama	NMRPTC-R
	Peniocereus greggii var. greggii		NM-E
	Penstemon cardinalis ssp. regalis	Cardinal penstemon	NM-T
	Perityle quinqueflora	Five-flowered rock daisy	NM-T
	Polygala rimulicola var.	Guadalupe milkwort	NM-T

	rimulicola		
	Proboscidea sabulosa		NM-T
	Pseudocymopterus longiradiatus		NM-T
	Salvia summa	Mountain sage	NM-T
	Selaginella pilifera	Resurrection plant	NM-T
	Sibara grisea	Gray sibara	NM-T
	Sophora gypsophila var. guadalupensis	Guadalupe smooth aster	NM-T
	Stipa curvifolia	Curl-leaf needlegrass	NMRPTC-R
	Streptanthus sparsiflorus	Few-flowered jewelflower	NM-T
	Valeriana texana	Texas valerian	NM-T

FT = Federally Threatened
NM-T = New Mexico State Threatened
FE = Federally Endangered
NM-S = New Mexico Sensitive
SOC = Federal Species of Concern
C = Candidate for Federal Listing
FS = Forest Service Region 3 Sensitive
TX-T = State of Texas Threatened
BLM = Bureau of Land Management Sensitive
NMRPTC-R = New Mexico Rare Plant Technical Council Rare

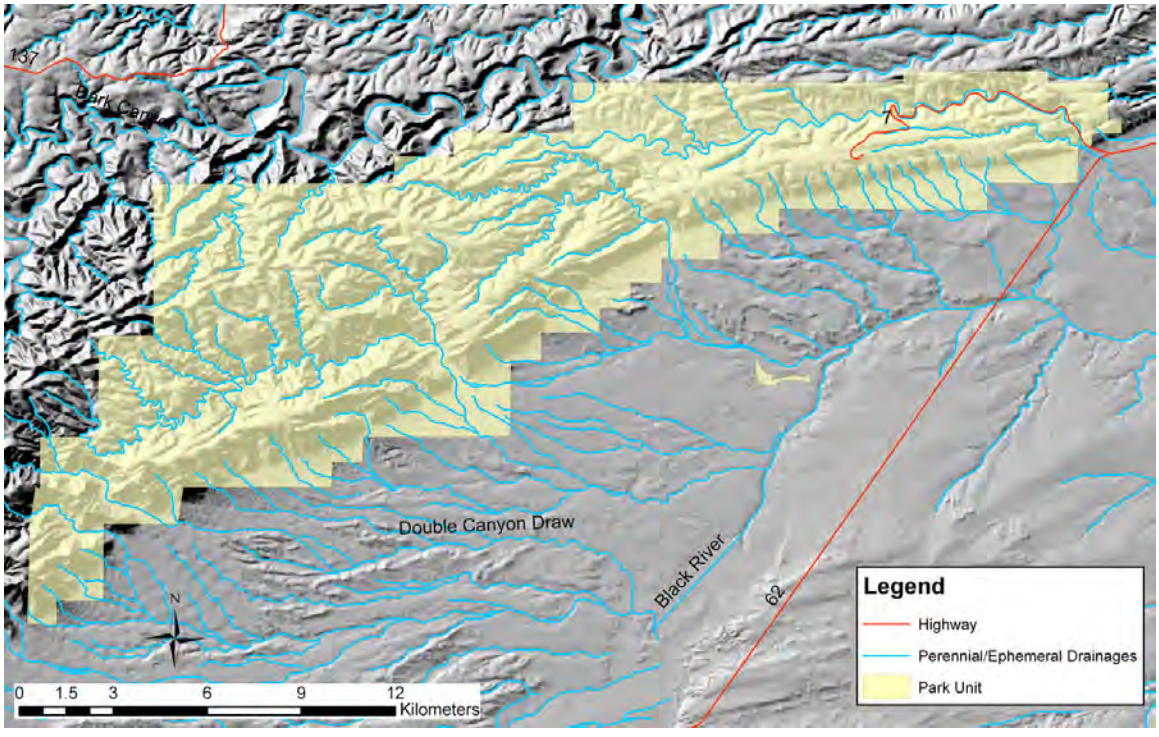

Figure A.3. Map of Carlsbad Caverns National Park, New Mexico.

A.4. Fort Davis National Historic Site (FODA)

A.4.1. General Description

A.4.1.1. Size

(192 hectares) 474 acres

A.4.1.2. Location

Fort Davis National Historic Site (NHS) is located at the southeast edge of the Davis Mountains in the Trans-Pecos region of West Texas on the northern edge of Fort Davis, Texas in Jeff Davis County. It may be reached via State Highways 118 and 17, approximately 330 kilometers (205 miles) southeast of El Paso, Texas, and 249 kilometers (155 miles) southwest of Odessa, Texas. The site is bordered to the northwest by Davis Mountain State Park and by private land on the other sides.

A.4.1.3. Adjacent Lands

Fort Davis NHS is bordered to the northwest by Davis Mountains State Park and by private land on the other sides. The Nature Conservancy is a neighbor in close proximity, as is the McDonald Observatory and the Chihuahuan Desert Research Institute.

A.4.1.4. Elevation

The elevation at Fort Davis NHS ranges from approximately 1,487 meters (4,880 feet) at the fort to approximately 1,591 meters (5,220 feet) in the Davis Mountains. Overall change in elevation is approximately 104 meters (340 feet).

A.4.1.5. Park history

Fort Davis NHS was authorized on September 8, 1961 and established on July 4,1963. In its presently preserved condition, this site symbolizes the era of westward migration and the essence of the late 19th century U. S. Army. The park preserves 110 historic buildings, ruins, and foundations and the landscape associated with two forts (active from 1854-1862 and 1867-1891).

A.4.1.6. Physical characteristics

Fort Davis NHS is situated at the eastern side of the rugged Davis Mountains, which were formed by volcanic eruptions that occurred during the Tertiary geologic period, which began approximately 65 million years ago. The historic site is located adjacent to Davis Mountains State Park, which covers 1,096 hectares (2,709 acres).

The entrance area, or foreground, of the site features the Chihuahuan Desert grassland community common to the Davis Mountains, and provides visitors with their first view of the fort. It also contains a spring and associated

historic grove of cottonwood trees that provide visitors with a shaded picnic area. The historic core provides the visitor with opportunities to view Fort Davis' historic buildings, ruins, foundations, parade ground, and cultural landscape, and to learn about the history of the fort. The fort is located in the middle of an alluvial floodplain and natural drainages run through the site. Historic ditches and dikes are maintained for flood control. Behind the main fort area rise the volcanic cliff walls of Hospital Canyon and a rugged steep escarpment running north/south that forms the prominent backdrop view from the lower elevations. Mixed vegetative cover is found throughout this zone, where desert-scrubland intermixes with cacti and pinyon-juniper woodland. This scenic backdrop ensures that the fort maintains its late 19th century appearance.

The climate of the Davis Mountains is arid, as is typical of the northern Chihuahuan Desert, with annual rainfall averaging 48 centimeters (19 inches). The elevation of the site results in relatively mild temperatures, but extremes of more than 35 °C (95 °F) during the summer are common. Winter temperatures may reach below – 6 °C (20 °F).

A.4.2. Resource Management Concerns

The primary resource concern is maintaining the historic landscape, viewshed, and sounds both inside the park and on private and State of Texas lands bordering the park. The intent is when visitors enter the park they should be able to look and listen in all directions and feel they are on an active military post in the mid to late 19th century. Most of the park's viewshed is protected by natural barriers, however adjacent private land to the northeast could be developed and impact the viewshed. Noise pollution is a minor problem from aircraft overflights, passing traffic on the highway, and vehicles idling in the parking lot.

The Draft General Management Plan was completed and signed in November 2002 and it is currently being revised. It breaks the park down into three Resource Opportunity Areas (ROAs) - Foreground, Historic Core, and Natural Backdrop.

A.4.2.1. The Foreground

This area is generally left in a natural state except for irrigation and mowing in the cottonwood grove and mowing in the area adjacent to the cavalry stables foundation.

A.4.2.2. The Historic Core

This is the most heavily impacted area in the park, due to both visitor use and maintenance activities to maintain the cultural landscape. The parade ground and areas adjacent to the buildings and foundations are mowed annually. The interiors and outer perimeters of the foundations are cleared of weeds and grasses and the historic drainage ditch is cleared of vegetation

annually. Also, the trees and shrubs along Officers' Row are irrigated and gravel pathways and roads are maintained.

A.4.2.3. The Natural Backdrop

The area behind the fort contains the bulk of the hiking and natural viewing opportunities at the site, and is maintained in its natural state. Maintenance activities are generally limited to yearly repair of the hiking trails.

A.4.2.4. Lack of baseline data

Cultural resources have been the main focus throughout the park's existence with minimal attention being given to natural resources management. Natural resources generally have been managed with the goal of maintaining the historic late 19th century landscape of the fort. Current information is available for the vascular plants, so the priority for the inventory program is inventory of the vertebrate taxa. Through inventory and monitoring, the park will learn more about what exist and be able to compare it to what existed in the late 19th century, and be able to incorporate the information into management of the historic landscape. Such information could also be used on a regional basis and shared with neighbors such as Davis Mountains State Park and the Chihuahuan Desert Research Institute.

A.4.2.5. Water Resources

Receives surface flows from adjacent Davis Mountains State Park

A.4.2.6. Threats:

- Deposition from atmospheric pollution,
- Groundwater infiltration from adjacent urban sources,
- Groundwater infiltration from park facilities,
- Flood inflows to Hospital Canyon Arroyo (NPS 1999a).

A.4.3. Species of Special Concern

The following list was compiled by Davis Mountains State Park (DMSP). Although the flora and fauna were identified on DMSP land, they very likely could be located at Fort Davis NHS also since the resources are the same.

Threatened, Endangered and Species of Concern—Fort Davis National Historic Site

	Scientific Name	Common Name	Status
Plants			
	Allolepis texana	Texas false saltgrass	SOC
	Croton suaveolens	Scented croton	SOC
	Coryphantha dasyacantha var. dasyacantha	Dense cory cactus	SOC
	Astragalus mollissimus var.	Withered locoweed	SOC

	marcidus		
Birds			
	Buteo regalis	Ferruginous Hawk	SOC
	Charadrius montanus	Mountain Plover	SOC
	Lanius ludovicianus	Loggerhead Shrike	SOC
	Strix occidnetalis lucida	Mexican Spotted Owl	SOC
	Empidonax traillii extimus	Southwestern Willow Flycatcher	FE
	Haliaeetus leucocephalus	Bald Eagle	FT
	Buteo albonotatus	Zone-tailed Hawk	FT
	Buteo anthracinus	Common Black-Hawk	FT
	Buteo nitidus	Gray Hawk	FT
	Falco peregrinus	Peregrine Falcon	FT
Mammals			
	Thomomys bottae limpiae	Limpia Botta's Pocket Gopher	SOC
Reptiles			
	Phrynosoma cornutum	Texas Horned Lizard	FT
	Tantilla rubra	Big Bend Blackhead Snake	FT

SOC = Species of Concern
FE = Federally Endangered
FT = Federally Threatened

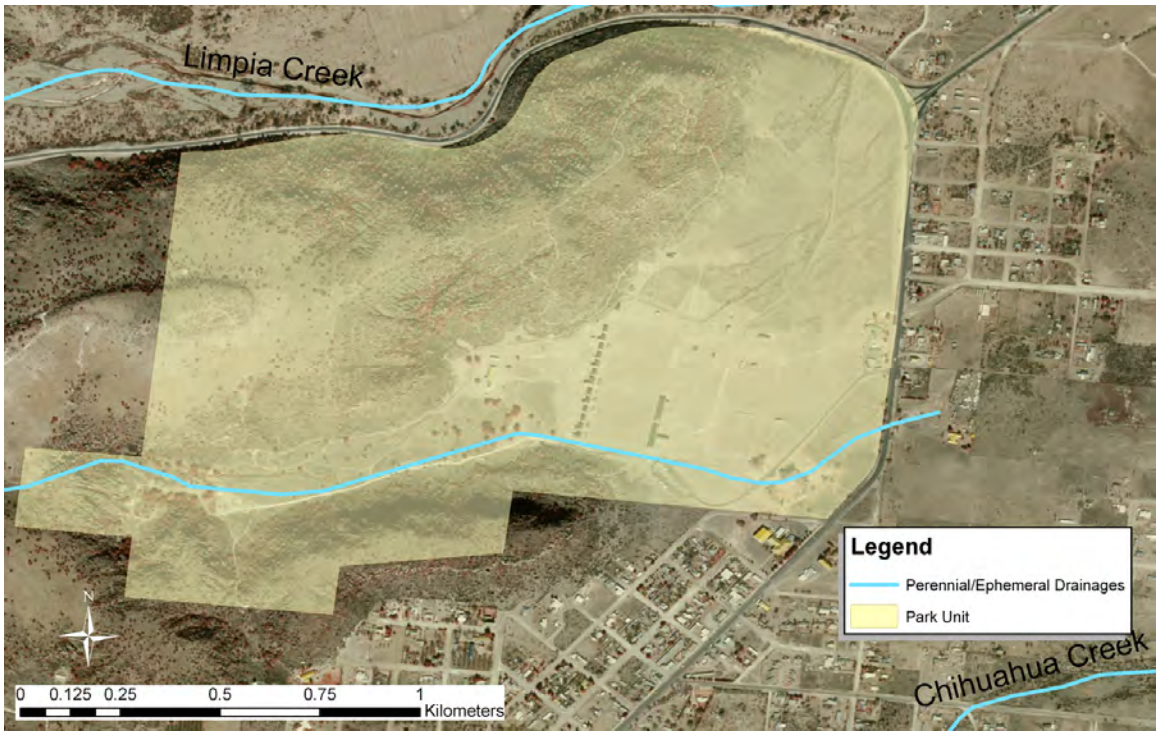

Figure A.4. Map of Fort Davis National Historic Site, Texas.

A.5. Guadalupe Mountains National Park (GUMO)

A.5.1. General Description

A.5.1.1. Size

35,272 hectares (86,416 acres)

A.5.1.2. Location

Guadalupe Mountains National Park (NP) is located in the Trans-Pecos region of west Texas just south of the Texas/New Mexico border. The park is approximately 177 kilometers (110 miles) east of El Paso, Texas, and 88 kilometers (55 miles) southwest of Carlsbad, New Mexico. Three main entrances to the park, as well as the park headquarters, may be accessed from U.S. Highway 62/80. A fourth entrance, through Dog Canyon, may be accessed by taking U.S. Highway 285 north from Carlsbad for 19 kilometers (12 miles), then turning west on New Mexico Highway 137 and following it 93 kilometers (58 miles) into the canyon. The west side of the park may be accessed through Dell City, Texas. Guadalupe Mountains NP is located in Culberson and Hudspeth Counties, Texas.

A.5.1.3. Adjacent Lands

Most of the lands surrounding Guadalupe Mountains NP are private lands in the state of Texas. The only public land is owned by the General Land Office or the Texas Department of Transportation for the highway. The park lies on the state line with New Mexico. In New Mexico adjacent land owners include private lands, State of New Mexico Public Lands, Federal Bureau of Land Management lands in two BLM Resource Areas—Carlsbad and Las Cruces, and U.S. Forest Service lands on the Guadalupe Ranger District of the Lincoln National Forest.

A.5.1.4. Elevation

The elevation at Guadalupe Mountains NP ranges from approximately 1,204 meters (3,624 feet) on the alkali flats to 2,584 meters (8,479 feet) atop Guadalupe Peak, which is the highest point in Texas. Total elevation change is 1,480 meters (4,855 feet).

A.5.1.5. Park history

Geologist Dr. G.G. Shumard described the fossil reef in 1855 while accompanying an expedition looking for artesian water. When petroleum was discovered in the Permian Basin in the 1920s, further studies of the Guadalupe Range were undertaken. Geologist Wallace Pratt studied the Guadalupe Mountains extensively and in the 1960s, and donated more than 2,020 hectares (5,000 acres) of his property in McKittrick Canyon to be used in the creation of the park.

The park was created by an Act of Congress in 1966 and formally established in 1972. From its establishment in 1972 until 1987, Guadalupe Mountains NP was administered jointly with Carlsbad Caverns NP from headquarters in Carlsbad, New Mexico. During this period, a manager lived at the park and oversaw day-to-day operations. Since October of 1987, Guadalupe Mountains NP has had a resident superintendent, and management of the two parks has been separate except for shared administrative services.

Today, the park preserves the world's most significant fossilized reef outcrops of Permian-age limestone, as well as the associated Chihuahuan Desert and mountain forest ecosystems. Approximately half of the park (18,960 hectares/46,850 acres) is designated as Wilderness area.

A.5.1.6. Physical Characteristics

Guadalupe Mountains NP is located in the southern portion of the Guadalupe Mountains near the western edge of the Capitan Reef geologic formation. The reef was formed approximately 250 million years ago at the margin of a Permian ocean basin, and was later covered with layers of sediment as the sea receded. Beginning approximately 26 million years ago, Basin and Range faulting action and subsequent erosion exposed parts of the reef. The Western Escarpment of the reef was lifted approximately 3 kilometers (2 miles) above its original position, and is most visible today at the dramatic El Capitan rock face.

During cooler, moister climatic conditions about 15,000 years ago, coniferous forest covered much of the area around the park, and remnants of this forest survive today at higher elevations in the Guadalupe Mountains. The mountains contain a number of deep, sheer-sided canyons, distinguished by high levels of biodiversity. The most notable of the canyons is McKittrick Canyon (often described as "the most beautiful spot in Texas"), which contains the park's only perennial stream, McKittrick Creek. The creek, as well as a number of springs, seeps, and ephemeral washes, support riparian plant communities.

The westernmost portion of the park encompasses several square miles of the alkali flats that dominate the valley west of the mountains. These flats began forming about 7 million years ago when faulting created a basin valley with no drainage outlets. As water entered the basin, broad shallow lakes were created, and evaporation and sedimentation resulted in a concentration of salts on the valley floor. Today, wind has eroded sections of the flats, piling quartz and gypsum sand dunes up against the western foothills of the Guadalupe Mountains. The mountain foothills and surrounding plains are characterized by Chihuahuan Desert vegetation, including specialized desert scrub communities found in the salt flat and dune areas.

Winter temperatures at the park reach average highs of 13 °C (56 °F) and lows of 1 °C (33 °F), with average precipitation of less than 3 centimeters (1 inch). Snowfalls may linger for long periods in the high country. High winds are common during the spring months. The summers bring afternoon thunderstorms that may cause flash-flooding and intense lightening. The average summer precipitation is approximately 7 centimeters (3 inches) and average temperatures range from highs around 30 °C (80s °F) to lows in the mid-teens °C (60s °F). Autumn ushers in milder weather, cold nights, and the occasional rainfall.

A.5.2. Resource Management Concerns

A.5.2.1. Baseline inventories

Park managers would like to establish baseline inventory information for vascular plants and vertebrates present on cultural landscape sites that are scheduled for potential restoration, as well as in areas of potential disturbance from routine maintenance activities and future road, trail and park facility development. Obtaining knowledge of the presence or absence of exotic, pioneer, listed, and sensitive species would aid managers in prioritizing and planning construction and restoration projects. In addition to establishing inventory and/or collection sites at target locations, researchers could revisit sites established in the 1970s; duplication of vertebrate and plant collection protocols at these would be a first step in examining changes in species composition over time. Finally, baseline inventories of the vegetation near trails and camp pads would help to assess the level of soil compaction, and the effects of trampling, on vegetation composition in areas of heavy visitor use.

A.5.2.2. Environmental effects

Park managers are interested in the environmental effects of fire and air pollutants. Inventories of vegetation and vertebrates in areas recently affected by wild-land or prescribed fire could be compared with historic species lists and baseline data from 1970s to help identify changes in community composition, and dendro-chronological research in the higher elevations forests would also help refine fire management strategies. Establishment of sample plots of sulfate-sensitive vegetation would allow long-term monitoring of the effects of increasing levels of airborne sulfates.

A.5.2.3. Riparian areas

Research is required to investigate the impact of exotic fish species on native amphibian populations. An inventory of the vegetation and vertebrate species at seeps and springs throughout the park and measurements of current water levels are also desirable. Comparison of current data with past records may help managers to determine whether any changes in the riparian community structure are correlated with changes in the historic water levels.

A.5.2.4. Community dynamics

In higher elevations of the park, a complete inventory of forest species is needed, as well as research to determine relationships between forest composition and species of concern such as the Mexican spotted owl (*Strix occidentalis lucida*). Inventories of vegetation and vertebrates are also need on lands recently acquired by the park and in the northwest quadrant of the park, which is difficult to access. Comparison inventories conducted on adjacent land may help determine the rate of grazing recovery, and how such vegetative recover affects populations of birds and small mammals. Particular attention is to be given to species of concern such as the ferruginous hawk (*Buteo regalis*) and loggerhead shrike (*Lanius ludovicanus*).

A.5.2.5. Taxa/species-specific research

Park managers are interested in supporting various research projects relating to specific species or taxa, including the following:

An analysis of potential forage in areas deemed appropriate for prairie dog and pronghorn restoration.

An inventory of areas suspected to provide suitable habitat for Montezuma quail (*Cyrtonyx montezumae*) and Merriam's turkey (*Meleagris gallopavo*) to assess the success of past reintroduction projects.

Research on the ecology of exotic Barbary Sheep; in particular, their affect on vegetation composition (particularly at upper elevation seep and spring communities), their role in the dispersal of exotic plant species, and how their impact differs from that of native ungulates.

Re-visitation of established pellet transects to assess current sizes of elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) herds. Additionally,

analysis of forage available to native ungulates may help managers determine appropriate herd sizes and management strategies.

Inventory carnivores in front and backcountry areas of the park through the use of bait stations, cameras and hair snares, and identify key habitat components of carnivores such as black bears (*Ursus americanus*), mountain lions (*Puma concolor*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and gray fox (*Urocyon cineoargenteus*).

Inventory breeding birds and assess the impact of cowbird parasitism on their reproductive success.

Inventory fall and spring migrant birds to assess which areas are important for forage and shelter during migration.

Analysis of the relationship between winter-resident birds, the distribution of mistletoe in oak woodlands, oak mortality rate, and establishment of receptor fuels for fire in developed zones of the park.

A.5.2.6. Water Resources

The park in large part receives no significant surface flows from surrounding lands. However, the Salt Basin dune field in the park is hydrologically connected to Basin ground waters.

A.5.2.7. Threats:

- Deposition from atmospheric pollution,
- Runoff and infiltration from park facility areas,
- Runoff from US 62-180 through park,
- Camping area runoff,
- Hiker fecal matter from trail through McKittrick Canyon,
- Possible groundwater changes from water development in the Salt Basin.

A.5.3. Species of Special Concern

Threatened, Endangered and Species of Concern—Guadalupe Mountains National Park

	Scientific Name	Common Name	Status
Birds			
	Asturina nitida	Gray hawk	ST
	Athene cunicularia hypugea	Western Burrowing Owl	SOC
	Buteo regalis	Ferruginous hawk	SOC

	Buteo albonotatus	Zone-tailed hawk	ST
	Buteogallus anthracinus	Common black-hawk	ST
	Crytonyx montezumae	Montezuma Quail	SOC*
	Falco peregrinus	American Peregrine Falcon	SE
	Lanius ludovicanus	Loggerhead shrike	SOC
	Meleagris gallopavo	Merriam's Turkey	SOC*
	Strix occidentalis lucida	Mexican Spotted Owl	FT, ST
Invertebrates			
	Cincindela politula petrophila	Guadalupe Mountains Tiger Beetle	SOC
Mammals			
	Thomomys umbrinus guadalupensis	Guadalupe Southern Pocket Gopher	SOC
	Cynomys ludovicianus	Black-tailed prairie dog	SOC*
	Ursus americanus	Black Bear	ST
Plants			
	Aquilegia chrysantha chaplinei	Chapline's Columbine	GE
	Chaetopappa hersheyi	Mat Leastdaisy	SOC
	Chrysothamnus nauseosus texensis	Guadalupe Rabbitbrush	SOC
	Escobaria guadalupensis	Guadalupe Pincushion Cactus	SOC
	Festuca ligulata	Guadalupe Fescue	C
	Hedeoma apiculatum	McKittrick Pennyroyal	ST
	Hexalectris revoluta	Chisos coral-root	SOC
	Lepidospartum burgessii	Gypsum Scalebroom	SOC
	Lesquerella valida	Scaly Bladderpod	GE
	Nama xylopodum	Yellowseed Nama	GE
	Penstemon cardinalis regalis	Cardinal Penstemon	GE
	Perityle quinqueflora	Five-flowered Rock Daisy	GE
	Pinaropappus parvus	Dwarf Rock Lettuce	GE
	Polygala rimulicola	Milkwort	GE
	Salvia summa	Mountain Sage	GE
	Selinocarpus lanceolatus	Gypsum moonpod	SOC
	Senecio warnockii	Warnock's groundsel	GE
	Sophora gypsophila guadalupensis	Guadalupe Mountain Laurel	GE
	Streptanthus sparsiflorus	Few-flowered Jewelflower	SOC
	Symphoricarpos	McKittrick Snowberry	SOC

	guadalupensis		
	Valeriana texana	Texas Valerian	GE
	Viola guadalupensis	Guadalupe Mountains Violet	SOC
Reptiles			
	Phrynosoma cornutum	Texas horned lizard	ST, SOC
	Phrynosoma douglasi hernandesi	Mountain Short-horned Lizard	ST

FT = Federally Threatened
FE = Federally Endangered
C = Candidate for Federal Listing
ST = State Threatened
SE = State Endangered
SOC = Fed. Species of Concern
GE = Guadalupe Mountains endemic species
SOC* = Guadalupe SOC – re-introduction species

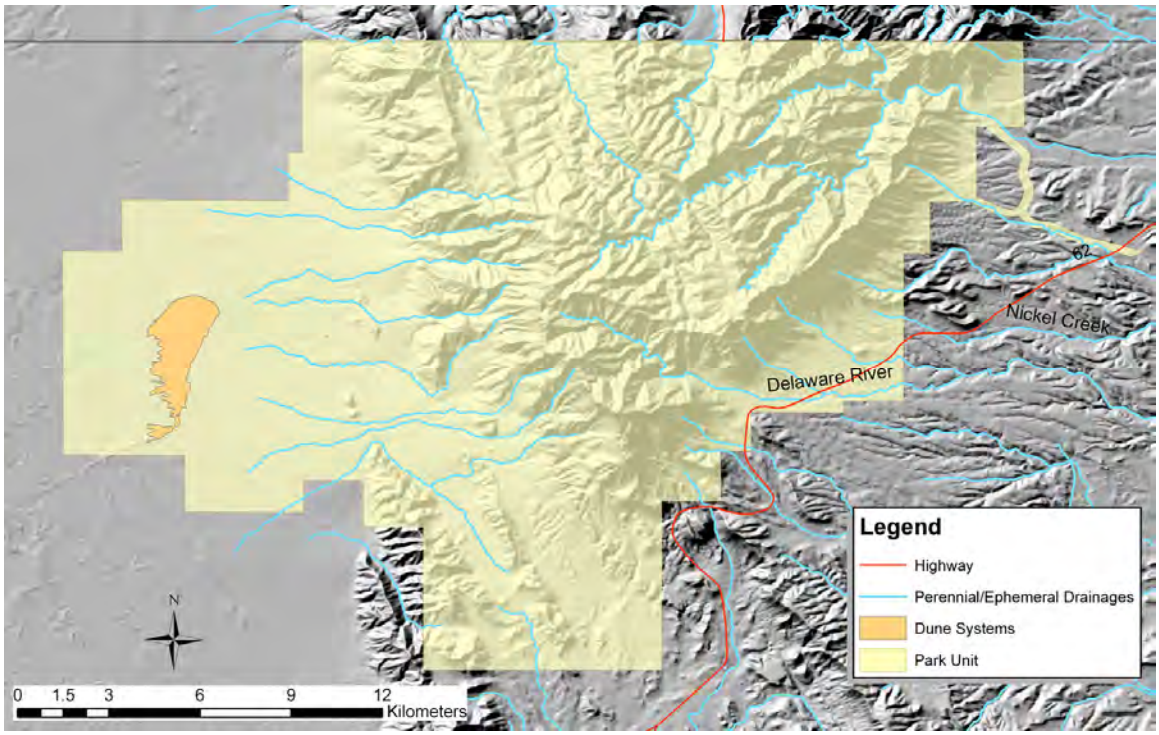

Figure A.5. Map of Guadalupe Mountains National Park, Texas.

A.6. White Sands National Monument (WHSA)

A.6.1. General Description

A.6.1.1. Size

58,169 hectares (143,733 acres)

A.6.1.2. Location

White Sands National Monument (NM) is located in south-central New Mexico, about 24 kilometers (15 miles) southwest of Alamagordo, New Mexico, and 84 kilometers (52 miles) northeast of Las Cruces, New Mexico. The main park entrance and park headquarters are accessible from U.S. Highway 70. White Sands NM is located in Otero and Donna Anna Counties, New Mexico.

A.6.1.3. Adjacent Lands

White Sands National Monument is surrounded by military land, White Sands Missile Range. Its closest neighbor is Holloman Air Force Base.

A.6.1.4. Elevation

The elevation within the monument ranges from 1,186 meters (3,891 feet) at Lake Lucero to 1,254 meters (4,114 feet) in the foothills of the San Andreas Mountains on the west side of the monument. Total elevation change is 68 m (223 ft).

A.6.1.5. Park history

White Sands National Monument was established in 1933 by President Herbert Hoover, acting under the authority of the "Antiquities Act of 1906". It currently preserves more than half of the world's largest gypsum sand dune field.

A.6.1.6. Physical Characteristics

The Tularosa Basin extends 240 kilometers (150 miles) north to south, and up to 96 kilometers (60 miles) east to west. The basin represents the easternmost extent of the Basin and Range geologic province. Originally, the San Andres Mountains to the west and the Sacramento Mountains to the east were connected by the rock that comprises the floor of the Tularosa Basin. Beginning approximately 29 million years ago, pressure from inside the earth caused the crust over the basin to thin and stretch. Simultaneous faulting action caused the mountain ranges to rise as the basin dropped, creating the landscape that is seen today.

There are no outlets for the few perennial streams that flow into the Tularosa Basin. The surrounding mountain ranges are drained by ephemeral streams, which primarily flow during periods of heavy precipitation. During cooler,

wetter Pleistocene times the western half of the basin contained shallow Lake Otero, which dried up as the climate became more arid. Today, the lowest point of the basin, Lake Lucero, will contain a few inches of water only in rare wet seasons. However, the groundwater table lies close to the surface of the Tularosa Basin, creating high levels of humidity. Evaporation results in the formation of calcium sulfate, calcium bicarbonate, calcium magnesium bicarbonate, and sodium chloride deposits throughout the basin. Calcium sulfate (which forms selenite crystals when evaporated) is primarily derived from rainwater dissolving exposed gypsum rich formations exposed on the San Andres Mountains, washing down to the valley floor, evaporating, and reprecipitating the calcium sulfate. Gypsum remains in the basin because of the lack of surface drainage leaving the basin. White Sands NM encompasses a major portion of this dune field; the rest of the field is contained in military land north of the monument.

The climate is arid and subject to rapidly changing weather conditions. The average annual precipitation of approximately 20 centimeters (8 inches) falls primarily during summer thunderstorms. Summer temperatures average 35 °C (95 °F). Winter temperatures are typically mild but may drop below -18 °C (0 °F). Snowfall is infrequent but occasionally heavy. The prevailing southwesterly wind is a dominant climatic factor here, especially from March through May, when gale-force windstorms may last for days. This is the time of the greatest dune movement, when living conditions for dune animal and plant communities become extremely harsh.

A.6.1.7. Resource Management Concerns

A.6.1.8. Amphibians

Amphibians are the taxon of greatest concern at White Sands NM. They are the least known and observed of local vertebrates, due to habitat preferences for inaccessible areas and to long periods of seasonal dormancy. Generalized local loss of interdunal wetland ecosystems may be affecting amphibian populations on the monument. Between the 1980s and early 1990s, staff observations indicated drying and loss of isolated wetland areas along the base of the dune field, in inter-dunal valleys, and at an artificial pond (now almost dry). There is no obvious cause of drying, such as prolonged drought or pumping of groundwater outside the monument. Riparian plants, such as cattails (Typha spp.) and willows, are still visible in these areas but appear dead and exhibit no signs of re-growth. Loss of mesic vascular plant species due to riparian degradation is also of concern.

It is unknown if local amphibian populations are also being affected by any of the variety of factors affecting amphibians elsewhere in the U.S. To the extent made possible by multi-park inventory and monitoring, the NPS should be involved in studying this very vulnerable group of animals.

A.6.1.9. Lack of baseline data

White Sands NM is lacking current baseline information concerning the status of site-specific floral and faunal species. Of particular interest is data

relating to the composition, structure and boundaries of the monument's plant communities, and the presence, distribution, and population trends of herps, small and medium-sized mammals, and birds. Establishment of consistent and repeatable inventory and monitoring protocols would allow managers to monitor changes in floral and faunal populations, resulting from natural or man-made environmental effects.

A.6.1.10. White Sands Pupfish

Prior to 1996, the Lost River, a small perennial stream, flowed into the monument and provided habitat for the White Sands Pupfish. The pupfish is state listed endangered, and is protected by an interagency management team and conservation plan, supported by U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, Army White Sands Missile Range, Holloman Air Force Base, and White Sands National Monument. Under current conditions, a sand dune 300 meters upstream of the monument boundary recently shifted and blocked water of the Lost River from flowing into the monument. This may change in the future, in which case pupfish habitat will again occur in the monument.

A.6.1.11. Mammal Status Unknown, Extirpation Possible

Porcupine were common and conspicuous in cottonwoods in the housing area and dunefield until 1995, and then precipitously disappeared. Since 1995, no porcupine or sign have been sighted by park staff members. Ringtail were common in and near headquarters buildings in the 1980s. None have been reported since about 1990. Other mammal species may have declined, however baseline data is so sketchy that no change of status is known.

A.6.1.12. Water Resources

Receives surface and groundwater flows from surrounding lands.

A.6.1.13. Threats:

- Deposition from atmospheric pollution,
- Runoff from surrounding military facilities, including range Road 7,
- Groundwater transport into park from surrounding military facilities,
- Infiltration from park headquarters area facilities,
- A park concern is the ecological impact of possible drop of the water table from basin groundwater resource development.
- Isolated cottonwood stands occur at a number of dune field locations. Their presence implies perennial ground water of rather high quality. Precipitation catching clay lenses or local higher quality, subsurface flows have been suggested as reasons for their persistence. This lack of understanding leads, therefore, to no known threats to these

A.6.2. Species of Special Concern

	Scientific Name	Common Name	Status
Birds			
	Haliaeetus leucocephalus	Bald Eagle	FT
	Sterna antillarum	Interior Least Tern	FE
	Falco femoralis septentrionalis	Northern Aplomado Falcon	FE
	Empidonax trailii extimus	Southwestern willow flycatcher	FE
	Athene cunicularia hypugea	Western Burrowing Owl	
	Buteo regalis	Ferruginous Hawk	
	Charadrius alexandrinus nivosus	Western Snowy Plover (interior)	
	Ammodramus bairdii	Baird's Sparrow	
	Childonias niger	Black Tern	
	Numenius americanus	Long-billed Curlew	
	Lanius ludovicianus	Loggerhead Shrike	
Fish			
	Cyprinodon tularosa	White sands pupfish	ST
Plants			
	Argemone pleiacantha extimus	Sacramento prickly poppy	FE
	Coryphantha sneedii sneedii	Sneed pincushion cactus	FE
	Peniocereus greggii	Night blooming cereus	SE
	Opuntia arenaria	Dune prickly pear	SE
Mammals			
	Neotoma micropus leucophaea	White Sands Woodrat	
	Perognathus flavescens apachii	Apache Pocket Mouse	WCS
Reptiles			
	Phrynosoma cornutum	Texas horned lizard	
	Holbrookia maculata ruthveni	Bleached earless lizard	WCS
	Sceloporus undulates	Cowles prairie lizard	WCS
	Cnemidophorus inornatus	Little striped whiptail	WCS
Amphibians			
	Scaphiopus couchii	Spadefoot toad	WCS
Insects			
	Ammobaenites phrixocnemoides arenicolus	Camel cricket	WCS

	Daihinoides hastiferum larvale	Camel cricket	WCS
Arachnids			
	Cibolancris parviceps arida	Locustid spider	WCS

WCS=White Colored Species
FT = Federally Threatened
FE = Federally Endangered
ST = State Threatened
SE = State Endangered

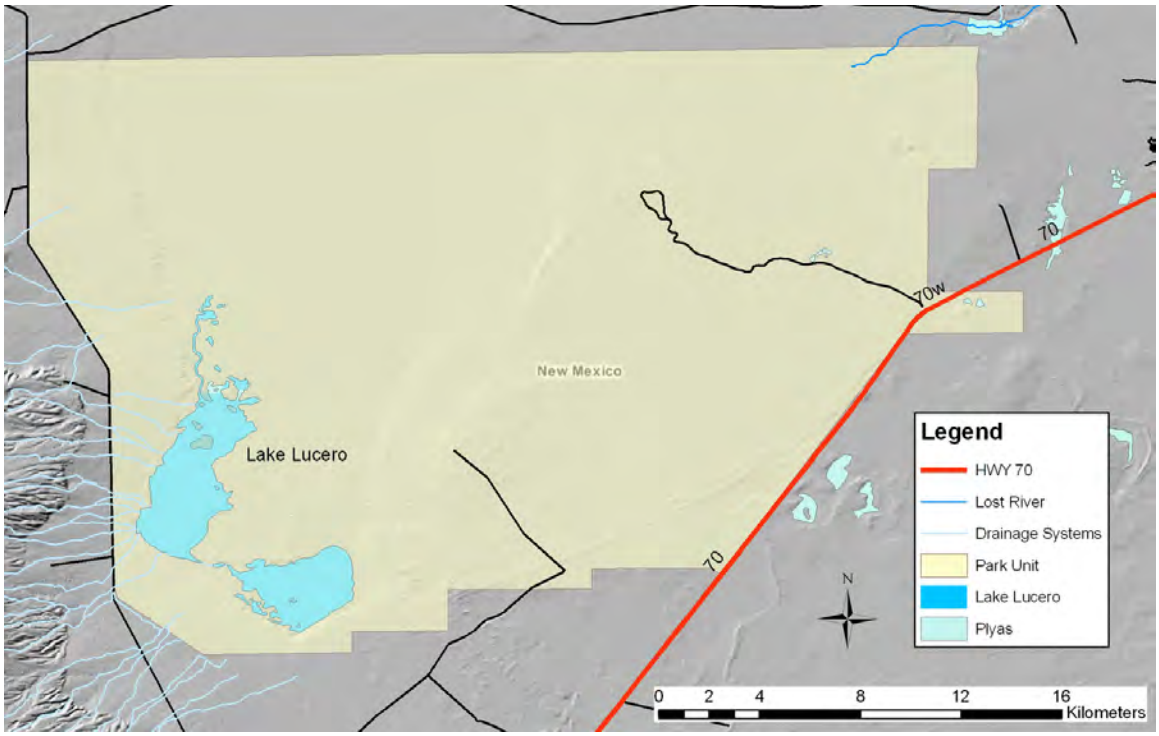

Figure A.6. Map of White Sands National Monument, New Mexico.

B. Appendix - Exotic Plants List for CHDN Parks

COMMON NAME	Park Units						
	AMIS	BIBE	CAVE	FODA	GUMO	RIGR	WHSA
Trees							
Saltcedar	S	X	m		w	X	X
Russian olive			M				w a
Siberian elm			S		m		+ b
Tree of heaven			M-S				
Lombardy poplar			M				
Weeping willow			+				
Vitex	M						
China berry	m						
Tobacco tree	M	X					
various fruit tree species			+				
Mulberry sp.	m		m-M				
Aquatic-Associated							
African/Giant reed (arundo)	S	X				X	
Hydrilla	M						
Golden algae (blooms)	m	X				X	
Forbs							
African rue			w		x		x
Russian knapweed							x
Russian thistle	m	x	m-M		M		x
Malta starthistle	w		M		X		
Yellow starthistle	M		w				
Wooly mullen	?		M		M		
Castor beans	M				m		
White or common horehound	S	x	M		M		
Scotch thistle			w				
Kochia			m		w		
Bindweed (field morning-glory)			M-S				
Tumble mustard			m-M				
London rocket	"+"		m-M		x		

	Park Units						
Amaranth (pigweed)	w				x		X
Common ragweed	w						X
Prickly lettuce	?		M				
Puncturevine (goathead)			m-M		m		
Common dead nettle			m				
Spearmint			m		+		
Filaree (crane's bill)			m		m		
White sweetclover			m-M		m		
Yellow sweetclover	?		m-M				
Watercress	w		M		+		
Broadleaf plantain	w		m				
Grasses							
Buffelgrass	S	X				X	
Lehman's love grass	m	X	S				
Johnsongrass	m	x	S		m		
King Ranch bluestem	S	x					
Bermuda grass	S	x	m-M	x	m	x	
Klein grass			M				
Sandbur			m		m		
Crabgrass			m				
Wild oat	"+"		?		+		
Rescuegrass	m		?		m		
Japanese brome			?		m		
Red brome	w		m-M				
Barnyardgrass			?		m		
Goosegrass	w		?				
Stinkgrass	"+"		?		m		
Mediterranean barley			?				
Annual bluegrass			?		m		
Rabbitfoot grass	m		?		m		
Feather fingergrass							x

PRESENCE/PROBLEM CODES:
S = Significant/major/widespread problem; ? = unknown; M = Moderate problem; m = minor/localized problem
+ = simply present & not considered a threat or likely to spread
w = watch list (species exists nearby to the park or have been found in the park, but eradicated)
Large "X" = significant problem; Small "x" = minor problem; Italicized "x" = potential problem;
a = eradicated in 2000, park still does annual surveys; b = 1 small tree present

C. Appendix - Exotic Animal List for CHDN Parks

COMMON NAME	Park Units						
	AMIS	BIBE	CAVE	FODA	GUMO	RIGR	WHSA
Mammal							
Mouflon sheep	eliminated from AMIS as of 1/06						
Barbary (aoudad) sheep	X	X	X		x		
Oryx (gemsbock)							X
Trespass livestock	X	X	X	x	x	X	
Nutria	x					x	
Feral hogs	x	X			*x*		
Eastern foxtail squirrel			X				
Feral house cats	x		X		*x*		
Birds							
European starling	x						x
House sparrow	x	x		x	x		x
Rock dove (pigeon)	x				*x*		x
Eurasian collared dove	x				x		x
Amphibians/Reptiles							
Red-eared slider	x	X				X	
Bullfrog		x	X		*x*	x	
Green anole		x					
Mediterranean gecko	x	x					
Fish							
Rainbow trout					X		
Green sunfish			X		x		
Large-mouth bass			X				
numerous game fish species							
-- impact unknown	X	X				X	
Invertebrates							
Imported red fire ants	X	X					
Asiatic clam	X	X				X	
Africanized honey bees	X	X	X		x		
European honey bees			X				
Zebra mussel	x					x	

PRESENCE/PROBLEM CODES:
Large "X" = significant problem; Small "x" = minor problem; Italicized "*x*" = potential problem

D. Appendix – Summary of Legislation, National Park Service Policy and Guidance Relevant to Development and Implementation of Natural Resources Monitoring in CHDN National Parks

Modified from NPS Inventory & Monitoring website:
http://science.nature.nps.gov/im/monitor/LawsPolicy.htm

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
National Park Service Organic Act of 1916 (16 USC 1 et seq. [1988], Aug. 25, 1916).	The 1916 National Park Service Organic Act is the core of park service authority and the definitive statement of the purposes of the parks and of the National Park Service mission. The act establishes the purpose of national parks: . To conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.
Wilderness Act of 1964 (16 USC 1131 et seq.)	Establishes the National Wilderness Preservation System. In this act, wilderness is defined by its lack of noticeable human modification or presence; it is a place where the landscape is affected primarily by the forces of nature and where humans are visitors who do not remain. Wilderness Areas are designated by Congress and are composed of existing federal lands that have retained a wilderness character and meet the criteria found in the act. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes from management activities on adjacent lands.
National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)	Congress set forth in NHPA includes preserving the historical and cultural foundations of the Nation and preserving irreplaceable examples important to our national heritage to maintain cultural, educational, aesthetic, inspirational, economic, and energy benefits. NHPA established the National Register of Historic Places composed of places and objects significant in American

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
	history, architecture, archeology, engineering, and culture. NHPA requires federal agencies take into account for effects of actions on historic (state and federal) properties.
Wild and Scenic Rivers Act of 1968 (P.L. 90-542 as amended) (16 U.S.C. 1271-1287)	Provides for a National Wild and Scenic Rivers System and their administration.
National Environmental Policy Act of 1969 (42 USC 4321-4370)	The purposes of NEPA include encouraging harmony between [humans] and their environment and promote efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of [humanity]. NEPA requires a systematic analysis of major federal actions that includes a consideration of all reasonable alternatives as well as an analysis of short-term and long-term, irretrievable, irreversible, and unavoidable impacts. Within NEPA the environment includes natural, historical, cultural, and human dimensions. Within the NPS emphasis is on minimizing negative impacts and preventing impairment of park resources as described and interpreted in the NPS Organic Act. The results of evaluations conducted under NEPA are presented to the public, federal agencies, and public officials in document format (e.g. EAs and EISs) for consideration prior to taking official action or making official decisions.
General Authorities Act of 1970 (16 USC 1a-11a-8 (1988), 84 Stat. 825, Pub. L. 91-383	The General Authorities Act amends the Organic Act to unite individual parks into the National Park System. The act states that areas of the National Park System, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that individually and collectively, these areas derive increased national dignity and recognition of their superb environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States.

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
Environmental Quality Improvement Act of 1970 (42 U.S.C. 56 4371)	Directs all Federal agencies, whose activities may affect the environment, to implement policies established under existing law to protect the environment.
Federal Advisory Committee Act of 1972 (5 USC App. 1—16; PL 92-463)	Creates a formal process for federal agencies to seek advice and assistance from citizens. Any council, panel, conference, task force or similar group used by federal officials to obtain consensus advice or recommendations on issues or policies fall under the purview of FACA.
Clean Water Act of 1972 (33 USC 1251-1376)	The Clean Water Act, passed in 1972 as amendments to the Federal Water Pollution Control Act, and significantly amended in 1977 and 1987, was designed to restore and maintain the integrity of the nation's water. It furthers the objectives of restoring and maintaining the chemical, physical and biological integrity of the nation's waters and of eliminating the discharge of pollutants into navigable waters by 1985. Establishes effluent limitation for new and existing industrial discharge into U.S. waters. Authorizes states to substitute their own water quality management plans developed under S208 of the act for federal controls. Provides an enforcement procedure for water pollution abatement. Requires conformance to permit required under S404 for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.
Endangered Species Act of 1973, as amended (ESA) (16 USC 1531-1544)	The purposes of the ESA include providing a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. According to the ESA all federal departments and agencies shall seek to conserve endangered species and threatened species and each federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. The ESA states that, "All other Federal agencies shall….utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species…" (Section 7(a)(1). The USFWS (non-marine species) and the National Marine

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
	Fisheries Service (NMFS) (marine species, including anadromous fish and marine mammals) administers the ESA. The effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the USFWS or NMFS, as appropriate [Section 7(a)(2)].
Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 36 1642	Mandates that the Secretary of Agriculture inventory and monitor renewable natural resources in National Forests, and has been cited as congressional authorization for the inventory and monitoring of natural resources on all federal lands. While this is not specifically directed in the act it is perhaps indicative of a national will to account for and manage the nation's natural heritage in manner that sustains these resources in perpetuity.
Redwood National Park Act of 1978 (16 USC 79a-79q (1988), 82 Stat. 931, Pub. L. 90-545	This act includes both park-specific and system-wide provisions. This act reasserts system-wide protection standards for the National Park System. This act qualifies the provision that park protection and management "shall not be exercised in derogation of the values and purposes for which these areas have been established by adding except as may have been or shall be directed and specifically provided for by Congress. Thus, specific provisions in a parks enabling legislation allow park managers to permit activities such as hunting and grazing.
Clean Air Act (42 USC 7401-7671q, as amended in 1990)	Establishes a nationwide program for the prevention and control of air pollution and establishes National Ambient Air Quality Standards. Under the Prevention of Significant Deterioration provisions, the act requires federal officials responsible for the management of Class I Areas (national parks and wilderness areas) to protect the air quality related values of each area and to consult with permitting authorities regarding possible adverse impacts from new or modified emitting facilities. The act establishes specific programs that provide special protection for air resources and air quality related values associated with NPS units. The EPA has been charged with implementing this act.
Lechuguilla Cave Protection	Asserts that congress finds Lechuguilla Cave and adjacent

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
Act , 1993 (PL 103-169)	public lands to have internationally significant scientific, environmental and other values and should be…protected against…activities presenting threats to the areas.
Government Performance and Results Act (GPRA) of 1993 (31 USC 1115 et seq.4; PL 103-62)	Requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS Strategic Plan contains four GPRA goal categories: park resources, park visitors, external partnership programs, and organizational effectiveness. In 1997, the NPS published its first GPRA-style strategic plan, focused on measurable outcomes or quantifiable results.
National Parks Omnibus Management Act, 1998 (P.L. 105-391)	Requires Secretary of Interior to continually improve NPS ability to provide state-of-the-art management, protection, and interpretation of and research on NPS resources.. Section 5939 states that the purpose of this legislation is to: (1) More effectively achieve the mission of the National Park Service; (2) Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) Ensure appropriate documentation of resource conditions in the National Park System; (4) Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, and (5)Encourage the publication and dissemination of information derived from studies in the National Park System.

EXECUTIVE ORDERS	SIGNIFICANCE TO INVENTORY AND MONITORING
Off-Road Vehicle Use (Executive Orders 11644 and 11989)of 1977	Executive Order 11644, enacted February 8, 1972 and amended by Executive Order 11989 on May 24, 1977, regulates off-road vehicle use. If the enabling legislation allows the use of off-road vehicles, NPS is required to designate specific areas for off-road vehicle use. These areas must be located to minimize damage to soil, watershed, vegetation, or other resources (Section (3)(a)(1)). If it is determined that such use is adverse to resources, the NPS is to immediately close such areas or trails until the impacts have been corrected.
Floodplain Management (Executive Order 11988) of 1977	This Order 11988 was enacted May 24, 1977. It requires all federal agencies to reduce the risk of flood loss,... minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values served by flood plains. E. O. 11988 is implemented in the National Park Service through the Floodplain Management Guidelines (National Park Service, 1993b). It is the policy of the National Park Service to 1) restore and preserve natural floodplain values; 2) to the extent possible, avoid environmental impacts to the floodplain by discouraging floodplain development; 3) minimize the risks to life and property when structures and facilities must be located on a floodplain;…"
Protection of Wetlands (Executive Order 11990) of 1977	Executive Order 11990 was enacted May 24, 1977. It requires all federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands. Unless no practical alternative exists, federal agencies must avoid any activities that have the potential to adversely affect wetland ecosystem integrity. NPS guidance pertaining to this Executive Order is stated in Floodplain and Wetland Protection Guidelines (National Park Service, 1980).
Invasive Species (Executive Order 13112) of 1999	This executive order was signed into law on February 3, 1999, to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species

EXECUTIVE ORDERS	SIGNIFICANCE TO INVENTORY AND MONITORING
	cause. Among other things, this Executive Order It established the National Invasive Species Council and required the preparation of a National Invasive Species Management Plan to recommend specific, performance-oriented goals and objectives and specific measures of success for Federal agency efforts concerning invasive species.
Protection of Migratory Birds (Executive Order 13186) of 2001	This Order provides additional protection for migratory birds, such that Federal agencies should "design migratory bird habitat and population conservation principles, measures, and practices, into agency plans and planning processes (natural resource, land management, and environmental quality planning, including, but not limited to, forest and rangeland planning, coastal management planning, watershed planning, etc.) as practicable, and coordinate with other agencies and nonfederal partners in planning efforts."

NPS POLICIES AND GUIDANCE	SIGNIFICANCE TO INVENTORY AND MONITORING
NPS Management Policies 2001 (NPS Directives System)	This is the basic NPS servicewide policy document. It is the highest of three levels of guidance documents in the NPS Directives System. The Directives System is designed to provide NPS management and staff with clear and continuously updated information on NPS policy and required and/or recommended actions, as well as any other information that will help them manage parks and programs effectively.
NPS Directors Orders	Second level of NPS Directives System. Directors Orders serve a vehicle to clarify or supplement Management Policies to meet the needs of NPS managers. Relevant Directors Orders: DO-2.1 Resource Management Planning DO-12 Environmental Impact Assessment DO-14 Resource Damage Assessment & Restoration DO-24 Museum Collections Management DO-41 Wilderness Preservation & Management DO-47 Sound Preservation & Noise Management DO-77 Natural Resource Protection
NPS Handbooks and Reference Manuals	This is the third tier in the NPS Directives System. These documents are issued by Associate Directors. These documents provide NPS field employees with a compilation of legal references, operating policies, standards, procedures, general information, recommendations and examples to assist them in carrying out Management Policies and Director's Orders. Level 3 documents may not impose any new service wide requirements, unless the Director has specifically authorized them to do so. Relevant Handbooks and Reference Manuals: NPS-75 Natural Resources Inventory & Monitoring NPS-77 Natural Resources Management Guidelines NPS Guide to Fed. Advisory Committee Act Website: Monitoring Natural Resources in our National Parks, http://science.nature.nps.gov/im/monitor

E. Appendix - International Treaties and Conventions Relevant to CHDN Border Parks (AMIS, BIBE, RIGR)

from: http://www.ibwc.state.gov)

TREATY OR CONVENTION	SIGNIFICANCE
Treaty of February 2, 1848	Established the United States–Mexico Boundary
Treaty of December 30, 1853	Established the United States-Mexico Boundary as it exists today.
Convention of November 12, 1884	Established the rules for location of the boundary when meandering rivers transferred tracts of land from the one bank of the river to the other.
Convention of March 1, 1889	Established the International Boundary Commission (IBC) to apply the rules in the 1884 Convention, and was modified by the Banco Convention of March 20, 1905 to retain the Rio Grande and Colorado River as the international boundary.
Treaty of February 3, 1944	Water treaty for "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande." Distributed the waters in the international section of the Rio Grande From Fort Quitman, Texas to the Gulf of Mexico. Changed the name of the IBC to the International Boundary and Water Commission (IBWC), and entrusted the IBWC to give preferential attention to the solution of all border sanitation problems.

TREATY OR CONVENTION	SIGNIFICANCE
Treaty of November 23, 1970	Resolved all pending boundary differences. Provides procedures designed to avoid the loss and gain of territory by either country incident to future changes in the river.

F. Appendix - Complete GPRA Goals for CHDN Park Units

			GPRA Goals By Unit					
	AMIS	BIBE	CAVE	FODA	GUMO	RIGR	WHSA	# of Participating units
Ia1A		x			x			2
Ia1B	x	x		x	x	x	x	6
Ia1C				x				1
Ia1D				x				1
Ia1E		x		x				2
Ia01B					x			1
Ia01C		x	x		x		x	4
Ia01D		x	x		x	x	x	5
Ia01E					x		x	2
Ia2A	x	x			x	x		4
Ia2B		x						1
Ia2C	x	x			x	x	x	5
Ia02A		x						1
Ia02B	x				x		x	3
Ia3		x			x			2
Ia4A	x	x		x	x	x	x	6
Ia4B	x	x						2
Ia4C		x			x	x		3
Ia04C							x	1
Ia5		x			x			2
Ia6		x			x	x		3
Ia8		x			x			2
Ia09		x			x			2
Ia10		x			x			2
Ib01					x	x		2
Ib2		x						1
Ib2A		x			x			2
Ib2B		x			x			2
Ib2C		x			x			2
Ib2D		x			x	x		3
Ib2E		x			x			2

			GPRA Goals By Unit					
Ib2F		x			x			2
Ib3A	x	x	x	x	x	x	x	7
Ib3B	x	x	x	x	x	x	x	7
Ib5		x			x			2

G. Appendix - Climate Summary for CHDN Parks and Additional Areas within the Region

Reid, W. H. and M. H. Reiser. 2006. General summary on the climate of Chihuahuan Desert Network Parks and some nearby protected lands. National Park Service, Chihuahuan Desert Network, Las Cruces, NM, USA. 22 p.

H. Appendix - Descriptions of Terrestrial Habitat Types Found in CHDN Parks

H.1. Desert Scrub and Woodlands

IA. *Larrea* desert scrub:

The Creosotebush Alliance is widely distributed throughout the Chihuahuan Desert. There are numerous associations with this habitat type (Muldavin 2000). Since most of the park units within the network have not have detailed vegetation mapping, only a broad description will be provided. This alliance is most commonly found on gravelly alluvial fans. However, it also extends onto the fine-soiled, alluvial plains of basin bottoms, onto surrounding foothill slopes, and into the uplands via drainages. No particular aspects are dominant and slopes tend to be gentle to moderate. In the last 150 years there has been an expansion of creosotebush on shallow, sandy and gravelly calcareous soils, as well as, fine silty and clayey soils on alluvial flats and plains (Buffington and Herbel 1965, Stein and Ludwig 1979). Some of this expansion may be due to removal of grass vegetation. Removal of grass opens up non-competitive microsites where creosotebush seedlings can become established (Montana et al. 1995). The mature shrubs exploit subsurface water sources, so they do not compete with grasses, but changes in soil characteristics that accompany the removal of grasses may gradually exclude grasses in some areas (Schlesinger et al. 1990). There is evidence, however, that creosotebush inhibits its own and other shrub species' roots, which may provide an additional competitive advantage to the creosotebush during the early growing stages (Mahall and Callaway 1991). Areas dominated by creosotebush have increased by about 2000% since 1858 (Buffigton and Herbel 1965). As creosotebush is extremely poor forage for both wildlife and livestock, this increase has probably had substantial negative impacts on wildlife and range condition (Stubbendieck et al. 1992). Long-term disturbances that remove vegetation and change soil characteristics will promote shrub dominance. *Larrea* desert scrub is found in all of the CHDN parks, except Amistad NRA.

IB. Mixed Desert scrub:

This is another habitat type which covers a number of alliances.

Chihuahuan Desert Scrubland:

Chihuahuan Succulent Desert Scrub –

This ecological system is found in the Chihuahuan Desert on colluvial slopes, upper bajadas, sideslopes, ridges, canyons, hills and mesas. Sites are hot and dry. Gravel and rock are often abundant on the ground surface. The vegetation is characterized by the relatively high cover of succulent species such as *Agave lechuguilla, Euphorbia antisyphilitica, Fouquieria splendens, Ferocactus* spp., *Opuntia engelmannii, Opuntia imbricata, Opuntia spinosior, Yucca baccata,* and many others. Perennial grass cover is generally low. The abundance of succulents is diagnostic of this desert scrub system, but desert shrubs are usually present. This system does not include desert grasslands or shrub-steppe with a strong cacti component.

Chihuahuan Mixed Desert and Thorn Scrub –
This is a widespread Chihuahuan Desert land cover type. This cover type includes the mixed desert scrub in the foothill transition zone above, sometimes extending up to the lower montane woodlands. Vegetation is mixed with thornscrub and other desert scrub such as *Agave lechuguilla, Aloysia wrightii, Fouquieria splendens, Dasylirion leiophyllum, Flourensia cernua, Leucophyllum minus, Mimosa aculeaticarpa var. biuncifera, Mortonia scabrella, Opuntia engelmannii, Parthenium incanum, Prosopis glandulosa, and Tiquilia greggii*. Stands of *Acacia constricta, Acacia neovernicosa or Acacia greggii* dominated thornscrub are included in this system, and limestone substrates appear important for at least these species. Grasses such as *Dasyochloa pulchella, Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua ramosa, Muhlenbergia porteri* and *Pleuraphis mutica* may be common, but generally have lower cover than shrubs.

Tamaulipan Thornscrub Alliances:

A mixture of these two alliances are found within Amistad NRA.

South Texas Plains Scrubland -
The South Texas Plains brushland consists of woody plants mostly less than nine feet tall which are dominant and grow as closely spaced individuals, clusters or closed canopied stands (greater than 10% canopy cover). Typically there are continuous, impenetrable shrubs covering over 75% of the ground (McMahan et al. 1984). This scrubland is also known as the *ceniza-blackbrush-creosote* association which is normally found on the slopes of the Rio Grande basin, Stockton Plateau and South Texas plains which occur from Val Verde County, in the city of Langtry, to Zapata County near San Ygnacio (McMahan et al. 1984, Diamond 1993). This community typically grows on shallow soils (Diamond 1993). Commonly associated plants include guajillo, lotebush, mesquite, guayacan, Texas prickly pear, paloverde, goatbush, yucca, sotol, desert yaupon, catclaw acacia, kidneywood, allthorn, curly mesquite, Texas grama, hairy tridens, slim tridens, pink pappusgrass and two-leaved senna (McMahan et al. 1984). This community is common and widespread. ,

Edward's Plateau Scrubland -
Within the Edwards Plateau Ecoregion, this association is found along the Rio Grande Valley to each side of the Pecos and Devil's rivers. This community typically grows on shallow soils (Diamond 1993). Commonly associated plants include guajillo, lotebush, mesquite, guayacan, Texas prickly pear, paloverde, goatbush, yucca, sotol, desert yaupon, catclaw acacia, kidneywood, jessamine, curly mesquite, Texas grama, hairy tridens, slim tridens, pink pappusgrass and two-leaved senna (McMahan et al. 1984).

IC. Yucca woodland

Commonly associated plants include catclaw acacia, whitethorn acacia, sotol, cholla cactus, Torrey yucca, palmella, brickellbush, mesquite, javelina bush, beargrass, black grama, chino grama, fluffgrass, broom snakeweed and jimmyweed (McMahan et al. 1984). This association prefers soils which are shallow and rocky, occurring at elevations below 4,500 ft. On sandy soils at lower elevations, the lower layers are dominated by grasses. The primary grasses associated with these yucca woodlands are black or blue grama (*Bouteloua eriopoda, B. gracilis*), galleta (*Hilaria jamesii*), and mesa dropseed (*Sporobolus flexuosus*). This habitat can be found around Carlsbad Caverns NP and north of White Sands NM.

ID. Izotal (Dasylirion-Yucca-Agave)

Sotol (*Dasylirion leiophyllum*) or yucca species (*Yucca thompsoniana, Y. faxonia, Y. elata*) are the most common dominants with skeletonleaf goldeneye (*Viguiera stenoloba*) occurring in the understory. Lechuguilla (*Agave lechuguilla*) may also be very prevalent, and may co-dominant on some sites. This system is common in mid-elevations at Carlsbad Caverns NP. The grass layer typically consists of sideoats or black grama (*Bouteloua curtipendula, B. eriopoda*), but purple and sixweeks threeawns (*Aristida purpurea, A. adscensionis*) dominant in grazed areas.

IE. Mesquite scrub

Chihuahuan Mesquite Upland Scrub
This ecological system occurs as upland shrublands that are concentrated in the extensive grassland-shrubland transition in foothills and piedmont in the Chihuahuan Desert. It extends into the Sky Island region to the west and the Edwards Plateau to the east. Substrates are typically derived from alluvium, often gravelly without a well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers. *Prosopis* spp. and other deeprooted shrubs exploit this deep soil moisture that is unavailable to grasses and cacti. Vegetation is typically dominated by *Prosopis glandulosa* or *Prosopis velutina* and succulents. Other desert scrub that may codominate or dominate includes *Acacia neovernicosa, Acacia constricta, Juniperus monosperma,* or *Juniperus coahuilensis*. Grass cover is typically low.

During the last century, the area occupied by this system has increased through conversion of desert grasslands as a result of drought, overgrazing by livestock, and/or decreases in fire frequency. It is similar to Chihuahuan Mixed Desert and Thorn Scrub, but is generally found at higher elevations where *Larrea tridentata* and other desert scrub are not codominant.

IF. Gypsophilous scrub (also known as Chihuahuan Mixed Salt Desert Scrub

This system includes extensive open-canopied shrublands of typically saline basins in the Chihuahuan Desert. Stands often occur on alluvial flats and around playas. This habitat type occurs on White Sands NM, and Guadalupe Mountains NP. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of one or more *Atriplex* species such as *Atriplex canescens, Atriplex obovata*, or *Atriplex polycarpa* along with species of *Allenrolfea, Flourensia, Salicornia, Suaeda*, or other halophytic plants. Graminoid species may include *Sporobolus airoides, Pleuraphis mutica*, or *Distichlis spicata* at varying densities.

IG. Lowland riparian woodland

This habitat is described for arroyos and for areas adjacent to perennial streams throughout the Chihuahuan Desert.

Desert Wash/Riparian Woodland and Shrubland -
This ecological system occurs in intermittent washes or arroyos that dissect bajadas, mesas, and plains of the Chihuahuan Desert. This habitat type occurs as linear or braided strips within desert vegetation matrix in all of the parks in CHDN. This is not common in Amistad NRA. The vegetation can be quite variable ranging from sparse to moderately dense often on the banks, but can occur within the steam channel. Species that are dominant in this system include catclaw acacia (*Acacia greggii*), cut-leaf brickellia (*Brickellia laciniata*), desert broom (*Baccharis sarothroides*), desert willow (*Chilopsis linearis)*, Apache plume, burro brush (*Hymenoclea monogyra* and *H. salsola*), mesquite, littleleaf sumac (*Rhus microphylla*), and greasewood (NatureServe 2004b).

Desert Riparian Woodland and Shrubland –
This ecological system consists of low elevation (<1200 m) riparian corridors along medium to large perennial streams throughout canyons and the desert valleys of the southwestern United States and adjacent Mexico. The vegetation is a mix of riparian woodlands and shrublands. Dominant trees include *Acer negundo, Fraxinus velutina, Populus fremontii, Salix gooddingii, Salix lasiolepis, Celtis laevigata var. reticulata*, and *Juglans major*. Shrub dominants include *Salix geyeriana, Shepherdia argentea*, and *Salix exigua*. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the water table for growth and reproduction. This feature is restricted to the few perennial water ways in the CHDN parks (e.g., Rio Grande through

Big Bend NP, Rio Grande WSR, portions of Amistad NRA, Choza Springs in Guadalupe Mountains NP).

Desert Riparian Mesquite Bosque –
This ecological system consists of low-elevation (<1100 m) riparian corridors along intermittent streams in valleys of southern Arizona and New Mexico, and adjacent Mexico. Dominant trees include *Prosopis glandulosa* and *Prosopis velutina*. Shrub dominants include *Baccharis salicifolia, Pluchea sericea*, and *Salix exigua*. Vegetation, especially the mesquites, tap groundwater below the streambed when surface flows stop. Vegetation is dependent upon annual rise in the water table for growth and reproduction. True Mesquite Bosque in not common in CHDN parks.

IH. Playa

This ecological system is comprised of barren to sparsely vegetated playas (generally <10% plant cover) found throughout the intermountain west and into northern portions of the Trans-Pecos region. Playas form with intermittent flooding, followed by evaporation, leaving behind a saline residue. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. The water is prevented from percolating through the soil by an impermeable layer of clay or calishe and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Large desert playas tend to be defined by vegetation rings formed in response to salinity. Given their common location in wind-swept desert basins, dune fields often form downwind of large playas. The largest continuous playa in the CHDN is Lake Lucero, origin of the famed gypsum dunefields at White Sands NM. In turn, playas associated with dunes often have a deeper water supply. Species may include iodinebush (*Allenrolfea occidentalis*), lemmon's alkali grass (*Puccinellia lemmonii*), *Suaeda* spp., inland saltgrass (*Distichlis spicata, D. stricts*), *Eleocharis palustris, Oryzopsis spp., Sporobolus spp., Tiquilia* spp., or saltbush (*Atriplex* spp.). Ephemeral herbaceous species may have high cover periodically. Adjacent vegetation is typically Chihuahuan Mixed Salt Desert Scrub or Chihuahuan Creosotebush Basin Desert Scrub. Playas can also be found in the western portion of Guadalupe Mountains NP.

H.2. Grasslands

IIA. Grama Grassland

Chihuahuan Piedmont Semi-Desert Grassland –
This ecological system is a broadly defined desert grassland, mixed shrub-succulent or xeromorphic tree savanna that is typical of the Borderlands of Arizona, New Mexico and northern Mexico [Apacherian region], but extends west to the Sonoran Desert, north into the Mogollon Rim and throughout much of the Chihuahuan Desert. It is found on gently

sloping bajadas that supported frequent fire throughout the Sky Islands and on mesas and steeper piedmont and foothill slopes in the Chihuahuan Desert. It is characterized by typically diverse perennial grasses. Common grass species include *Bouteloua eriopoda, Bouteloua hirsuta, Bouteloua rothrockii, Bouteloua curtipendula, Bouteloua gracilis, Eragrostis intermedia, Muhlenbergia porteri, Muhlenbergia setifolia, Pleuraphis jamesii, Pleuraphis mutica, and Sporobolus airoides*, succulent species of *Agave, Dasylirion*, and *Yucca*, and tall-shrub/shorttree species of *Prosopis* and various oaks (e.g., *Quercus grisea, Quercus emoryi, Quercus arizonica*). Many of the historical desert grassland and savanna areas have been converted, some to Chihuahuan Mesquite Upland Scrub (*Prosopis* spp.-dominated), through intensive grazing and other land uses.

IIB. Sacaton grassland

Chihuahuan Sandy Plains Semi-Desert Grassland –
This ecological system occurs across the Chihuahuan Desert and extends into the southern Great Plains where soils have a high sand content. These dry grasslands or steppe are found on sandy plains and sandstone mesas. The graminoid layer is dominated or codominated by *Achnatherum hymenoides, Bouteloua eriopoda, Bouteloua hirsuta, Hesperostipa neomexicana, Pleuraphis jamesii, Sporobolus cryptandrus, Sporobolus airoides*, or *Sporobolus flexuosus*. Typically, there are found scattered desert shrubs and stem succulents such as *Ephedra torreyana, E. trifurca, Fallugia paradoxa, Prosopis glandulosa, Yucca elata*, and *Y. torreyi* that are characteristic of the Chihuahuan Desert.

IIC. Tobosa grassland

There are two common associations described within the Tobosa grassland alliance.

Chihuahuan-Sonoran Desert Bottomland and Swale Grassland –
This ecological system occurs throughout the northern Chihuahuan Desert (e.g., White Sands Missile Range, and Otero Mesa in the Tularosa Basin of south-central New Mexico, Sky Islands of southeastern Arizona and Sonoran Desert), as well as limited areas of the southern Great Plains and Edwards Plateau in relatively small depressions on broad mesas, plains and valley bottoms that receive runoff from adjacent areas. Water generally infiltrates relatively quickly. These depressions have deep, fine-textured soils that are neutral to slightly saline/alkaline. Vegetation is typically dominated by *Pleuraphis mutica* (tobosa swales) or other mesic graminoids such as *Pascopyrum smithii, Panicum obtusum, Sporobolus airoides,* or *Sporobolus wrightii*. With tobosa swales, sand-adapted species such as *Yucca elata* may grow at the swale's edge in the deep sandy alluvium that is deposited there from upland slopes. *Sporobolus airoides* and *Sporobolus wrightii* are more common in alkaline soils typically found around White Sands NM.

Tobosa-black grama association -
This grass system is found principally in low elevation plains of Jeff Davis, Presidio, Brewster, Culberson and Hudspeth counties (McMahan et al. 1984) where Big Bend NP is located. It typically occurs in heavy igneous soils and also on flat limestone areas that sometimes receive excessive runoff from the surrounding areas. This explains why these grasslands are represented within small, internally drained basin bottoms (Diamond 1993). Commonly associated plants found in this subclass consist of blue grama, sideoats grama, chino grama, hairy grama, burrograss, bush muhly, Arizona cottontop, javelina bush, creosote, butterfly bush, palmella, whitethorn acacia, cholla cactus, broom snakeweed and rough menodora (McMahan et al. 1984). The *Tobosa-black grama* community has been invaded by desert shrubs and are now compacted because of over-grazing.

IID. Gypsum grassland

Chihuahuan Gypsophilous Grassland and Steppe –
This ecological system is restricted to gypsum outcrops or sandy gypsiferous and/or often alkaline soils that occur in basins and slopes in the Chihuahuan Desert. Elevation range is from 1100-2000 m. These typically sparse grasslands, steppes or dwarf-shrublands are dominated by a variety of gypsophilous plants, many of which are endemic to these habitats (Dick-Peddie 1993). Characteristic species include *Tiquilia hispidissima, Atriplex canescens, Calylophus hartwegii, Ephedra torreyana, Frankenia jamesii, Bouteloua breviseta, Mentzelia perennis, Nama carnosum, Calylophus hartwegii (=Oenothera hartwegii), Selinocarpus lanceolatus, Sporobolus nealleyi, Sporobolus iroides*, and *Sartwellia flaveriae*. This habitat is common on White Sands NM and is found in a small component at Guadalupe Mountains National Park.
.

IIE. Lowland riparian marshland

This ecological system occurs throughout the arid and semi-arid regions of New Mexico, and is a rare association among the parks in the CHDN, but is found around Rattlesnake Springs in Carlsbad Caverns NP. Soils have anaerobic characteristics and plants that occur are adapted to saturated soil conditions. Common plants to these small wetlands include such species as spikerush (*Eleocharis palustris*), rush (*Juncus* spp.), pondweed (*Potamogeton* spp.), bulrush or sedges(*Scirpus* spp.), broadleaf cattail (*Typha latifolia*), inland saltgrass (*Distichlis spicata*) and reed (*Phalaris* spp.) (NatureServe 2004b). Saltcedar (*Tamarisk* spp.) is a common invader.

H.3. Montane Chaparral and Montane Woodlands

IIIA. Montane chaparral

Coahuilan Chaparral - This ecological system occurs in mountains across southeastern New Mexico (Guadalupe Mountains) and Trans-Pecos Texas (Chisos Mountains in Big Bend NP). It often dominants along the mid-elevation transition from the Chihuahuan Desert into mountains (1700-2500 m). It occurs on foothills, mountain slopes and canyons in drier habitats below the encinal and pine woodlands and is often associated with more xeric and coarse-textured substrates such as limestone, basalt or alluvium, especially in transition areas with more mesic woodlands. The moderate to dense shrub canopy includes many shrub oak species such as *Quercus intricata, Quercus pringlei, Quercus invaginata, Quercus laceyi, Quercus grisea, Quercus emoryi, Quercus toumeyi*, several widespread chaparral species such as *Arctostaphylos pungens, Ceanothus greggii, Fallugia paradoxa*, and *Garrya wrightii*, and species characteristic of this system such as *Arbutus arizonica, Arbutus xalapensis, Fraxinus greggii, Fendlera rigida, Garrya ovata, Purshia mexicana, Rhus virens var. choriophylla*, and endemics *Salvia lycioides, Salvia roemeriana*, and *Salvia regla*. Most chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Stands occurring within montane woodlands are seral and a result of recent fires. This habitat is also common in Carlsbad Caverns NP.

IIIB. Juniper-pinyon woodland

Southern Rocky Mountain Juniper Woodland and Savanna –
This ecological system occupies the lower and warmest elevations, growing from 1370 to 1830 m in a semi-arid climate, primarily along the east and south slopes of the southern Rockies and Arizona-New Mexico mountains. It is best represented just below the lower elevational range of ponderosa pine and often intermingles with grasslands and shrublands (Dick-Peddie 1993). This system is best described as a savanna that has widely spaced, mature (>150 years old) juniper trees and occasionally *Pinus edulis*. *Juniperus monosperma* and *Juniperus scopulorum* (at higher elevations) are the dominant tall shrubs or short trees. These savannas may have inclusions of denser juniper woodlands and have expanded into adjacent grasslands during the last century. Graminoid species are similar to those found in Western Great Plains Shortgrass Prairie, with *Bouteloua gracilis* and *Pleuraphis jamesii* being most common. In addition, succulents such as species of *Yucca* and *Opuntia* are typically present. This habitat is more common in Carlsbad Caverns NP and Guadalupe Mountains NP.

Madrean Pinyon-Juniper Woodland –
This system occurs on foothills, mountains and plateaus in the Sierra Madre Occidentale and Sierra Madre Orientale in Mexico, Trans-Pecos Texas, southern New Mexico and Arizona, generally south of the Mogollon Rim. Substrates are variable, but soils are generally dry and rocky. The presence of *Pinus cembroides, Pinus discolor*, or other Madrean trees and shrubs is diagnostic of this woodland system. *Juniperus coahuilensis, Juniperus deppeana, Juniperus pinchotii, Juniperus monosperma*, and/or *Pinus edulis* may be present to dominant. Madrean oaks such as *Quercus arizonica, Quercus emoryi, Quercus grisea,* or *Quercus mohriana* may be codominant. *Pinus ponderosa* is absent or sparse. If present, understory layers are variable and may be dominated by shrubs or graminoids. This habitat occurs on Fort Davis NHS and in Big Bend NP.

IIIC. Pine-oak woodland

This association of gray oak-pinyon pine-alligator juniper is typically found in sheltered canyons, at cliff bases and north-facing slopes occurring in mid-elevations from 1500-2300 m (4,500 to 7,500 ft.). Typically this community is found in the major mountain ranges such as the Davis (near Fort Davis NHS), Guadalupe (Guadalupe Mountains NP) and Chisos Mountain (Big Bend NP) ranges (McMahan et al. 1984, Diamond 1993, Bezanson 2000). Fires are frequent with perhaps more crown fires than ponderosa pine woodlands, which tend to have more frequent ground fires on gentle slopes. This association is mostly evergreen and typically found in alluvial soils in mountain valleys. Deciduous gray oak-oak series also occur in these areas but are restricted to the bottomlands of mesic mountain canyons. Many of the associated plants are very distinctive and restricted to this plant association alone (Diamond 1993). These plants include Emory oak, silverleaf oak, Gambel's oak, mountain mahogany, evergreen sumac, mountain snowberry, Texas madrone, southwestern chokecherry, bullgrass, Pringle needlegrass, finestem needlegrass, pine dropseed, sideoats grama, blue grama, pine muhly, pinyon ricegrass, largeleaf oxalis, heartleaf groundcherry and Torrey antherium (McMahan et al. 1984). The *gray oak-pinyon pine-alligator juniper* is fairly common throughout the southwestern United States. However, within the CHDN, this community only occurs in a few isolated mountain ranges within the Trans-Pecos making it fairly rare, and therefore, existing habitats should probably be monitored.

III.D. Mixed-conifer forest

The following two forests types, primarily occur in Guadalupe NP.

Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland –
This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year with

summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. *Pseudotsuga menziesii* and *Abies concolor* are most frequent, but *Pinus ponderosa* may be present to codominant. *Pseudotsuga menziesii* forests occupy drier sites, and *Pinus ponderosa* is a common codominant. *Abies concolor*-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. *Picea pungens* is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including *Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii*, and *Festuca arizonica*. This system was undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval. Naturally occurring fires are characterized by a high degree of variable return intervals and lethality due to the range of moisture found in this habitat.

Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland –
These are mixed-conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland . Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently. *Pseudotsuga menziesii* and *Abies concolor* are most common canopy dominants, but *Picea engelmannii, Picea pungens*, or *Pinus ponderosa* may be present. This system includes mixed conifer/*Populus tremuloides* stands. A number of cold-deciduous shrub species can occur, including *Acer glabrum, Acer grandidentatum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Robinia neomexicana, Vaccinium membranaceum*, and *Vaccinium myrtillus*. Herbaceous species include *Bromus ciliatus*, *Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia virescens, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale*, and *Thalictrum fendleri*. Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions. Naturally occurring fires are characterized by a high degree of variable return intervals and lethality due to the range of moisture found in this habitat.

IIIE. Montane deciduous woodland

This ecological system occurs in cool ravines, on toeslopes and slump benches associated with riparian areas in New Mexico and the Trans-Pecos of Texas. These canyons and

montane riparian woodlands are found in mesic canyons and valleys sheltered from the heat and wind of the desert (Bezanson 2000). Typically these areas act as isolated microhabitats for many species especially during the summer months (Bezanson and Wolfe 2001). In areas where water flows occasionally, such as at the base of an intermittent waterfall, standing pools of water are typically found creating miniature oases with lush vegetation and great amounts of wildlife activity. Associated species include bigtooth maple, chinkapin oak, western hophornbeam, netleaf hackberry, velvet ash, little walnut, Mexican buckeye, acacia species, Emory oak, alligator juniper, evergreen sumac, Texas madrone, beargrass, Arizona grape, different grasses, sedges and forbs (Bezanson 2000). These habitats are isolated, very small and uncommon. There are scattered, tiny patches in the Chisos Mountains within Big Bend National Park as well as about 300 ac. in McKittrick Canyon (Guadalupe Mountains NP). It is suggested that these habitats are of high priority for protection due to the relative rareness and high importance of these habitats for desert wildlife species (Bezanson 2000).

H.4. Literature Cited

Bezanson, D. 2000. Natural vegetation types of Texas and their representation in conservation areas. The University of Texas at Austin, TX.

Buffington, L.C. and C.H. Herbel. 1965. Vegetation Changes on a semidesert grassland range form 1858 to 1963. Ecological Monographs 35(5): 139-164

Diamond, D. D. 1993. Plant communities of Texas (series level). Texas Natural Heritage Program, TX.

Dick-Peddie, W. A. 1993. New Mexico Vegetation Past, Present, and Future. University of New Mexico Press, Albuquerque. 244 pages.

Marshall, B.E. and R.M. Callaway. 1991. Root communication among desert shrubs. Ecology 88: 874-876

McMahan, C. A., R. G. Frye and K. L. Brown. 1984. The vegetation types of Texas including cropland. Texas Parks and Wildlife, Wildlife Division, Austin, TX.

Montana, C., B. Cavagnaro and O. Briones. 1995. Soil and water used by co-existing shrubs and grasslands in the Southwest Chihuahuan Desert, Mexico. Journal of Arid Environments 31: 1-13

Muldavin, E., P. Durkin, M. Stuever and P. Mehlhop. 2000. Handbook of Western Vegetation Communities of New Mexico. Volume I: Classification and Community Descriptions. Final Report submitted to the New Mexico Environmental Department, Surface Water Quality Bureau, Santa Fe, NM.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer.

Schlesinger, W.H., J.F. Reynolds, G.L. Cunningham, L.F. Huenneke, W.M. Jarrell, R.A. Virginia and W.G. Whitford. 1990. Biological feedbacks in global desertification. Science 247: 1043-1048

Stein , R.A. and J.A. Ludwig. 1979. Vegetation and soil patterns in the Chihuahuan desert bajada. American Midlands Naturalist: 101(1): 28-37

Stubbendieck, J., S.L. Hatch and C.H. Butterfield. 1992. North American Range Plants, 4th edition. University of Nebraska Press, Lincoln, Nebraska. 493 p.

I. Appendix - Chihuahuan Desert Network Water Resource Information and Assessment Report

Reid, W. and M. H. Reiser. 2005. Chihuahuan Desert Network Water Resource Information and Assessment Report, Phase I. National Park Service, Chihuahuan Desert Network, Las Cruces, NM, USA

Huff, G. F., M. H. Reiser, and J. T. Richie. 2006. Chihuahuan Desert Network Water Resource Information and Assessment Report, Phase II. National Park Service, Chihuahuan Desert Network, Las Cruces, NM, USA.

J. Appendix - Water Quality Monitoring Needs Identified in the Chihuahuan Desert Network

(taken from Reid and Reiser 2005)

• Plan, in coordination with the parks, in-park monitoring requirements meeting both park-specific and Inventory and Monitoring Program objectives. This will include planning later implementation by common protocols meeting professional standards. It is noted that where groundwater issues are a significant park concern, these will be included in water quality monitoring plans.
• Investigate extant methodologies and protocols (and their cost) for monitoring of submerged riverbed and reservoir springs in Amistad National Recreation Area, Big Bend National Park and The Rio Grande Wild and Scenic River.
• Investigate appropriate protocols (and their cost) for adequate monitoring of subterranean waters in (1) caves open to public use and (2) caves protected from visitor contamination at Carlsbad Caverns.
• Continued support and participation at the network level in the TCEQ/IBWC monitoring for the Rio Grande Segments 2305-6, including portions of the Pecos and Devils rivers.
• Building on already important interaction with Mexico by Amistad National Recreation Area and Big Bend National Park, the Chihuahuan Desert Network with participate in the already extant programs by state and federal agencies.
• Develop and maintain ongoing network-level communication with the several state and federal agencies involved with water quality and quantity matters in and near the network parks. Some specific matters include: (1) Increased communication between CHDN/FODA and TCEQ/TPWD on waters adjacent to the park (Limpia Creek) or entering the park (Hospital Canyon). (2) Ongoing CHDN/WHSA communication with Holloman Air Force Base on water quality monitoring of Lost River and other nearby waters. (3) CHDN/WHSA interaction with WSMR on issues relating to surface water runoff and groundwater monitoring.
• Develop a detailed, network-level procedure for entry of new park water quality data on the NPS database.
• Develop a detailed, network-level database detailing park water bodies. With more that 500 water bodies (albeit, mostly springs and seeps) such a database is essential to further monitoring planning. The flow of many of these has profoundly declined in recent decades according to (often anecdotal) reports. In the decades ahead it is important to understand and document ongoing changes.

K. Appendix - Air Quality Assessment for the Chihuahuan Desert Network

Chihuahuan Desert Network Assessing the risk of foliar injury from ozone on vegetation in parks in the Chihuahuan Desert Network. 2004.

Information from Ellen Porter, Air Resources Division, National Park Service
Provided to the CHDN, January 2006

Tonnie Maniero, Air Quality Ecological Effects Coordinator, Northeast Region, National Park Service
Provided to the CHDN, January 2006

L. Appendix - Summaries of Interviews with CHDN Park Staffs

L.1. Questionarie used in park staff interviews in preparartion for Phase I Vital Signs Scoping Workshops.

CHIHUAHUAN DESERT NETWORK QUESTIONAIRE FOR VITAL SIGNS PHASE I SCOPING MEETING #1

Park Unit: **Date:**
Staff Name:
Position: **Yrs. at Park:**
Areas of Expertise:
Other areas of expertise:

1. What are the park's most valuable/important/significant species of concern?

2. What are the park's stated species of concern?

3. What are the park's most important resource management issues?

4. What are the greatest current threats to significant park resources?

5. What are the greatest potential threats to significant park resources?

6. What are the park's most significant resource needs?

7. Are there current research, inventory, or monitoring projects being conducted in the park?

8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's ecosystems?

9. Are you working with other agencies/land owners on any inventory, monitoring, research, or restoration projects? Please provide & indicate in what capacity.

10. Does climatological data (historic through present) exist in electronic format for your park?

11. Which ecosystem components are most important to protect? Why?

12. In your opinion, which stressor is the most significant? Why?

13. In your opinion, what are the park's top three monitoring questions?

14. If you could only have one long-term monitoring project in your park, what would it be and why?

15. What 3 GIS themes should have the highest priority for completion?

16. What 3 other data layers should you have in your park's GIS database?

17. We want information produced by the Inventory and Monitoring Program to be widely interpreted. What is the best way to make this information available to interpretive staff and the public?

18. Are there problems perceived by local government officials, other federal or state agencies or military as to management of the park's resources?

19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?

20. Are there any real or perceived impacts due to routine maintenance activities or NPS/park activities?

21. Are there other issues you would like considered? For example, interdisciplinary topics, landscape level changes, or topics about which you think we need more information to help us further identify important monitoring needs?

22. Are there any other comments you would like to make?

L.2. Amistad National Recreation Area (21-22 March 2005)

Summary of staff interviews for the Amistad Lake National Recreation Area Vital Signs Phase I scoping meeting.

Questions/Respondents	A	B	C	D	E
1. What are the park's most valuable/important/significant species of concern?	interior least tern, peregrine falcon, brown pelican, Devil's River minnow, bald eagle, great blue heron rookery, cacti, tamarisk, bamboo, turkey	Texas Tortoise, Indigo Snake, Western Coral Snake, Trans-Pecos Rat Snake, Texas Horned Lizard, Mexican free-tailed bat, Cave Myotis, Yuma Myotis, Townsend's Big-eared bat, Pallid Bat, Western Mastiff Bat, Western Red Bat, Monarch Butterfly, Proserpine Shiner, Blue Catfish, Interior Least Tern, Snowy Plover, Neo-tropical migrant breeders (e.g., Yellow-billed Cuckoo, Painted Bunting, Yellow-breasted Chat, Bell's Vireo, White-eyed Vireo, Black-chinned Hummingbird), Olive Sparrow, Long-billed Thrasher; beaver; Guayacan/Iron Wood (Guaiacum angustifolium), Plateau Oak (Quercus fusiformis), Texas Pistache (Pistacia texana);Val Verde Agave Borer; echinocereous cactus; agave butterfly; beaver	Seasonal diversity of birds; Interior Least Tern; butterflies (some fairly rare), giant skipper; monarch butterflies; Mountain lion & bobcat, blue sucker & Devil's River minnow, cliff thistle, rydberg skirfpea, white-tailed deer	interior least tern	game fish; endangered fish; gray-banded kinsnake

Questions/Respondents	A	B	C	D	E
2. What are the park's species of concern?	NR	Devils River minnow; interior least tern; Texas Tortoise	Interior Least Tern, Black-capped Vireo; Texas tortoise; Great-horned lizard; Devil's River minnow; Texas trumpet flower; Wright's trumpet flower	see GMP	not determined
3. What are the park's most important natural resource management issues?	fluctuating lake levels, interior least tern nest sites, trespass grazing, exotic plants	International Management of Fisheries and Water (Quantity and Quality); Grazing; Interior Least Tern nesting areas; Off-road driving; Encroachment from housing developments; riparian habitat below dam; Old barbed-wire fence in hunt areas; Excessive motorized boat use on upper reaches of rivers; hunter/deer take levels in hunt areas; use of hunt area 2 as park gun range and drying location for fish cleaning stations; Maintenance/protection of Huisache (Acacia farnesiana) woodlands; Protection of bat colonies in Train Tunnel on upper reaches of Rio Grande	Exotic animals; Trespass livestock grazing; Exotic plants; Encroachment from private development; Maintaining water quality & water quantity	exotic species; encroachment	border impacts; unrestricted camping; fluctuating lake levels; illegal grazing; encroachment; exotics

Questions/Respondents	A	B	C	D	E
4. What are the greatest current threats to significant park natural resources?	grazing, exotic plants, lake fluctuation, bamboo, fires	Minimum communication with Mexico and State of Texas counterparts/managers. Current loss of Plateau oak motts/habitat found within the boundary of the park due to over grazing. Loss of monitoring effort on deer herds and vegetation within hunting areas of park. Mouflon sheep in area 5; Expansion of bufflegrass (exotic); Access of motorized boats; exotic wildlife impacts on vegetation and cultural resources (Audad and Mouflon).	Trespass livestock; invasive plants	illegal grazing	as in 3
5. What are the greatest potential threats to significant park resources?	catastrophic flooding, human caused damage (drug smugglers, aliens)	Loss of Opuntia spp., to exotic borer moth; Loss of riparian habitats; Loss of plateau oak habitats; Increased motor boat use; Road mortalities on species of concern; Loss of breeding colonies of Tern species due to visitor use/harassment; Potential air quality impacts; loss of water quantity; Sediment loading in upper reaches of reservoir.	Encroachment; flooding; wave action & shoreline erosion & currents;Exotic animals & spread of invasive plants	exotics; alien/drug traffic	

Questions/Respondents	A	B	C	D	E
6. What are the park's most significant natural resources needs?	data on nongame fish,spring flow monitoring	Regular/frequent communication with State of Texas and Mexico counterparts; Staffing to continue with resource monitoring projects; close the historic train tunnel; create non-motorized zones; Fence out sheep livestock at oak mott sites; Remove excess hunt area roads.	biologist, hydrologist, Resource Staff or in-house expertise, GIS, data on water quality & aquatic biological assessment & riparian assessment.	staffing	biologist on staff; get natural history collections
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?	monarch butterfly migration monitoring; water quality; mammal, reptile, plant inventories completed	White-tailed Deer Census Program;Interior Least Tern populations; "Range Inventory"; inventory and monitoring of fisheries resources ; MAPS station; Large-mouth Bass mortality; herp surveys; bat inventory and monitoring; Monarch Butterfly monitoring; cave map; Floristic Survey; one water quality sampling station; Creel census; "Water Resources Scoping Report"	annual Interior Least Tern surveys; deer surveys; limited water quality monitoring; air quality monitor; sport fish monitoring; Devil's River & other aquatic resources.	binational fisheries management plan (NPS, Mexico, TPW)	yes

Questions/Respondents	A	B	C	D	E
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?	pre dam arch studies with photos; 1970's Sul Ross mammal thesis	Texas Parks and Wildlife fish inventories and monitoring sites; Range Inventory vegetation transects; MAPS station below dam; Least Tern Surveys; Sediment monitoring by IBWC on upper reaches of reservoir.	Water quality resources scoping report; Historic deer population data; Scudday (Sul Ross State Univ) 1970's mammal biogeorgraphy on islands; Red-eared slider "replacing" Rio Grande slider study; Trophic modeling in AMIS in the reservoir; Monitoring approaches to biological health of reservoirs vs spring ecology; Muttiha: published a paper on mixing patterns of hydrologic dynamics; Matt Boehm mammal inventory thesis (Sul Ross)	TECQ may have historic water data	IBWC; Ray Camp limnology project
9. Are you working with other agencies/land owners on any inventory, monitoring, research, or restoration projects? Please provide list & indicate in what capacity.	Arizona group working on human border issues	TPWD and Mexico (SAGARPA) in the management of fisheries resources in the park; TPWD deer surveys & censusing protocols & herp inventories. .	Binational Fisheries Cooperative agenda	TECQ, TPWD	Texas State University limnology study

Questions/Respondents	A	B	C	D	E
10. Does climatological data (historic through present) exist in electronic format for your park?	nothing electronic	90+ years of climatological data from the Del Rio National Weather Station at the airport	IBWC might have original weather data in electronic format. Park gets summary info: precip, tempt, but paper only. Airforce base will also have weather data;	univeristy air quality study, TECQ qir quality monitoring	historic NOAA station
11. Which ecosystem components are most important to protect? Why?	native plants; Aoudad sheep; mouflon	Oak motts-Most rare neotropical migrants and residents occur in these areas including eastern screech-owl, elf owl, Yellow-billed cuckoo. Hunt areas-Very little trespass grazing, but some at low water.	Upland terrestrial resources, because there is so little of it & the park is surrounded by private lands (agricultural uses primarily); Riparian zones are scarce resources, extreme condition exists for riparian zones in the park, largely untouched & impt to protect.	fisheries	water; air quality
12. In your opinion, which stressor is the most significant? Why?	drought; grazing	Reservoir water level fluctuations (fish populations and spawning potential. Loss of vegetation and riparian habitats once water levels increase)	Anything that grazes or browsing whether trespass or exotic animal; Fluctuating lake level – differential impacts to wildlife pops. & ecological communities.	fluctuating lake levels	Mexico as source of air/water pollution; silt
13. In your opinion, what are the park's top three monitoring questions?	interior least tern; monarch butterflies; fisheries (including commercial fishing impacts)	Water quality; Fish populations; Visitor Use and Park Management Impacts on Resources	upland terrestrial plant communities; Impact to native veg by exotics; riparian areas	water quality; exotics; illegal alien activities	air; water aulity; fish community structure

Questions/Respondents	A	B	C	D	E
14. If you could only have one long-term monitoring project in your park, what would it be, and why?	interior least tern	visitor use; veg transects; Fish monitoring & water; quality bat	Riparian zone monitoring.	fisheries	water quality and biodiversity (especially draw down zone)
15. What 3 GIS themes should have the highest priority for completion?	caves; backcountry use sites; vegetation; grazing	Vegetation community, including low reservoir hab types; Recent DOQQs; Fenceline survey & condition assessment	historic nesting sites for least terns	boundary map; aerial photography	lake surface
16. What 3 other important data layers should you have in your park's GIS database?	ranch property boundaries/fences; livestock (especially in relation to arch sites)	Lake Bathymetry; Boundary cadastral survey near developments; lake Water Quality Data and/or Model	Veg/plant community map; tamarisk & other invasive plants; Aoudad sheep	NR	fire
17. We want information produced by the Inventory and Monitoring Program to be widely interpreted. What is the best way to make this information available to interpretive staff and the public & other park staff?	website; interpretive staff	Newsletter; localized publications for the network on I&M topics; Web site, etc,.	Websites; brochure	website	distribute to resource managers; website; butlletin; newspaper; educators to classrooms

Questions/Respondents	A	B	C	D	E
18. Are there problems perceived by local government officials, other federal or state agencies or military as to management of the park's resources?	local fire dept called for fires set by drug smugglers and aliens but park letting them burn	Mexico counterparts have had concerns in the past about fish stocking procedures and species used by TPWD. TPWD has had concerns about commercial fishing program on Mexico side. Bi-national management of fisheries was initiated in 1999/2000 to deal with these perceived conflicts	fish stocking complaints	tie to community economics (keep lake full of fish); TX controls water	homeland security does what want
19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?	collectors of fossils, cactus, arch remains; backcountry use (waste, veg cutting, fires)	Noise from motorized watercraft; Excessive wave action; Garbage; tires along shoreline; Fishing gear entanglements; Fires and fire rings; Vegetation extraction, cactus removal; Reptile/amphibian removal; excessive hunting pressures; 2-stroke engines and water pollution; Improper fish handling	social roads; backcountry camping	very little (mostly to cultural)	invasive fish; impacts fishing; unregulated camping
20. Are there any real or perceived impacts due to routine maintenance activities or other NPS activities?	boat ramp problems	Perceived problem between law enforcement & resources; Law enforcement gun range in hunt area 2; Excessive roads in hunt areas; Excessive motorized boat tours by NPS staff in upper reaches of park (Pecos, Devil's River).	maintenance in visitor use areas: cutting back/down native vegetation.	clear boat facilities that had been at low levels	road grading (especially to arch sites); ranger activities in caves

Questions/Respondents	A	B	C	D	E
21. Are there other issues you would like considered? For example, interdisciplinary topics, landscape-level changes, or topics about which you think we need more information to help us further identify important monitoring needs?	NR	NR	NR	NR	NR
22. Are there any other comments you would like to make?	NR	NR	NR	NR	thanks to I&M for interest in park/monitoring

L.3. Big Bend National Park (28 Feb – 2 March 2005)

Summary of staff interviews for the Big Bend National Park and Rio Grande Wild & Scenic River Vital Signs Phase I scoping meeting.

Questions/Respondents	A	B	C	D	E
1. What are the park's most valuable/important/significant species of concern?	NR	aquatic species (especially assoc with Rio Grande, mussels, molluscs, fish, reptile (BIBE slider), amphibians); Endangered species; Large broad ranging animals (black bear, mt. lion,	NR	Mariposa cactus; Bunched-cory cactus; Chisos hedge-hog cactus; Guadalupe fescue; bufflegrass, saltcedar, & Lehmans's lovegrass.	Black bear; Mt. lion; mule deer; Peregrine Falcon

Questions/Respondents	A	B	C	D	E
		desert big horned sheep); Exotic/invasive plant & animals (feral hog, aodad barabary sheep); buffelgrass			
2. What are the park's species of concern?	NR	NR	NR	only listed species	Black-capped vireo; Black bear; Mt. lion; Peregrine Falcon
3. What are the park's most important natural resource management issues?	air quality; water quality/quantity; exotics	air quality; loss biological diversity in Rio Grande; soil/grasslands; lack staffing/funding	groundwater/surface water interactions; air quality	Exotic plants; Water quantity & quality; encroachment; Climate change; air quality; Restoration; Veg management in developed areas; prescribed fire management; fire effects and urban interface; Relationships of T&E species/exotics & fire	air quality; water quality & quantity; exotics

Questions/Respondents	A	B	C	D	E
4. What are the greatest current threats to significant park natural resources?	air quality; water quality/quantity	river flow changes; exotics; camping impacts/feeding animals; soil erosion/grassland loss	air quality; water development; upland degredation	as in 3	Vandalism of arch sites; Poaching; encroachment; herbicides; high visitation
5. What are the greatest potential threats to significant park resources?	coal-fired plants; exotics	encroachment; air quality	water development	as in 3	encroachment, poaching
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?	NR	wter source; air quality; black-capped vireo; perigrine falcon; BB Gambusia; amphibians; wildlife-human conflicts; reptile inventories; Neotropical migrrants; exotics; nutria; exotic plants	spring surveys; Rio Grande water qualityNorth Rosillos restoration site; response Rio Grande channel to diminishing flows	annual monitoring of 4 endangered plant species; annual Agave survey tied in with Mex long-nosed bat; Spring surveys; Air & water quality; Weed mapping & monitoring	black bear study; I&M herp inventory
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?	NR	veg monitoring back to 30's; general biological surveys; fish inventories; 30 years of spring data	spring inventory; grassland restoration project; geology BB	Warnock veg transects remeasured since 1955; Circular plot data from 1955; Dunham veg plots; Fire plots	PEFA research started in 1972; 2 Mt. Lion dissertations on this animal

Questions/Respondents	A	B	C	D	E
11. Which ecosystem components are most important to protect? Why?	NR	Rio Grande, Chisos Mtns.; desert oases; desert grasslands/soil; broad-ranging mammals	aire, water soil	What meet NPS mission. Landscape integrity; Biodiversity surrogate.	Chisos Mts; Desert grasslands; Rio Grande
12. In your opinion, which stressor is the most significant? Why?	exotics; tresspass cattle	exotics; altered Rio Grande flow; grazing; air quality	lower elevations-grazing effects; higher elevations-air quality; Rio Grande-loss flow and regulation; loss groundwater	Long-term climate change; Exotics; Air & water quality	Drought; Lack of water in the river; grazing
13. In your opinion, what are the park's top three monitoring questions?	air quality; water; saltcedar; drug smugglers/illegal alien	exotics; aquatic species; large broad-ranging mammals	impact air quality & climate on soils and water quality; relation river level & invasive species; riffles as food base	Effects exotics; Diversity at different at landscape scales; climate; Water quality & quantity; Loss of spatial diversity	Short and long-term effects of air quality on flora & fauna, and humans; What is happening on the river to the flora & fauna
14. If you could only have one long-term monitoring project in your park, what would it be, and why?	air quality	exotics	surface/spring water	everthing	River health & function.
19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?			hand-dug well safety	Trampling, digging up plants, vandalizing, collecting firewood, spreading weeds;	off-road driving; viewshed/backcountry campsites; air pollution is impacting night skies.

Questions/Respondents	A	B	C	D	E
				Landscape level, poaching may or may not be an issue..	
20. Are there any real or perceived impacts due to routine maintenance activities or other NPS activities?			Road maintenance; homeland security requires no NEPA; plane low-level flights	ground disturbance, road maintainence, construction; Mowing shoulders – spread of weeds	Other divisions & employees see the science & resource management activities may be impacting the park; Mowing & blading roads;
21. Are there other issues you would like considered? For example, interdisciplinary topics, landscape-level changes, or topics about which you think we need more information to help us further identify important monitoring needs?					monitor landscape level changes; redo Warnock plots

L.4. Carlsbad Caverns National Park (23 March 2005)

Summary of staff interviews for the Carlsbad Caverns National Park Vital Signs Phase I scoping meeting.

Question	A	B	C	D	E	F	G
1. What are the park's most valuable/important/significant species of concern?	NR	Mexican free-tailed bats; rare/T&E cactus, spotted owl, barbary sheep, lions	barbary sheep, Lee's pincushion cactus, spotted owl	free-tailed bats, endangered cacti, mt. lions, spotted owl, cave microbe community	Varied Bunting (Passerina versicolor), Bell's Vireo (Vireo bellii) ST *, Gray Vireo (Vireo vicinior) ST, Yellow-billed Cuckoo, Montezuma Quail, Black-throated Sparrow, Cave Swallow, MSOW, Vermillion flycatcher, Painted bunting, Western River Cooter (Pseudemys gorzugi) ST, Gray Banded Kingsnake (Lampropeltis alterna) SE, Plain Bellied Watersnake, Red-eared Slider, Yellow Mud turtle, Rio	Texas Madrone (Arbutus xalapensis); Chinkapin Oak (Quercus muehlenbergii) ; Netleaf Hackberry (Celtis laevigata var. reticulata); Gooding's Willow; Green Sotol (Dasylirion leiophyllum); Pincho Juniper (Juniperus pinchotii); Lee's pincushion cactus (Corypantha sp.); Greenthroat Darter (Etheostoma lepidium) ST *; Roundnose Minnow	invertebrates

Question	A	B	C	D	E	F	G
					Grande Leopard Frog, Extirpated cricket frog (still at Blue Spring, 10mi NE on pvt land), Mottled rock rattlesnake, In general almost all of the snakes, Bats as a group, esp cave myotis, fringed myotis & Mex freetail, Nelson's pocket mouse, Puma, Mule deer, Bobcat, western spotted skunk (carnivores in general), Lee's pincushion cactus, relic species of Texas madrone, chinqupin oak, range limit on soapberry, edge for ponderosa pine, Veg community: curly-leaf muhly grass (unique type associated with 1-seed juniper),	(Micropterus salmoides) *; Bairds Sparrow (Ammodramus bairdii) ST; Varied Bunting (Passerina versicolor) ST; Peregrine Falcon (Falco peregrinus anatum) ST; Common Ground Dove (Columbina passerina pallesens) SE; Bell's Vireo (Vireo bellii) ST *; Gray Vireo (Vireo vicinior) ST; Bald Eagle (Haliaeetus leucocephalus) ST; Common Blackhawk (Buteogallus anthracinus) ST; Cowbird (Molothrus ater) NP *; Cave Swallow (Hirundo fulva); Mexican Free-tailed Bat	

Question	A	B	C	D	E	F	G
					Gooding willow & netleaf hackberry &cottonwood at RSS	(Tadarida brasiliensis mexicana); Fringed Myotis (Myotis thysanoides); Cave Myotis (Myotis velifer); Ringtail (Bassariscus astutus); Pocket Gopher (Pappogeomys castanops); Banner Tail Kangaroo Rat (Dipodomys spectabilis); Spotted Skunk (Spilogale putorius); Mule Deer (Odocoileus hemionus); Mountain lion (Felis concolor); Western River Cooter (Pseudemys gorzugi) ST; Gray Banded Kingsnake (Lampropeltis alterna) SE;	

Question	A	B	C	D	E	F	G
						Plain-Bellied Watersnake (Nerodia erythrogaster) SE; Mottled Rock Rattlesnake (Crotalus lepidus lepidus) ST	
2. What are the park's species of concern?	bats	free-tailed bats, mountain lion, barbary sheep	Lee's pincushion cactus, Mexican free-tailed bat	all bats, highlight free-tailed		Bell's Vireo (Vireo bellii); Mexican Free-tailed Bat (Tadarida brasiliensis mexicana); Mule Deer (Odocoileus hemionus); Mountain Lion (Felis concolor); Lee's pincushion cactus	see fire plan

Question	A	B	C	D	E	F	G
						(Corypantha sp.)	
3. What are the park's most important natural resource management issues?	ground-level infrastructure causing cave contamination	cave preservation, maintain wilderness while provide public access, oil/gas development	oil/gas development, lack baseline data	visitor impacts	Role of prescribed fire ; Water allocation at RSS and irrigation management.	Wildland fire management; Invasive species; Subterranean resource management, enabling legislation, little biological inventory; needs systematic inventories; Wilderness management; T&E species; visitation, primarily for cave resources	lack of info on sensitive communities, vistor impacts, noise/light impacts on bats, spotted owl, endangered cacti, rattlesnake spring management plan, tresspass grazing
4. What are the greatest current threats to significant park natural resources?	ground-level infrastructure causing cave contamination	oil/gas development, visitor impacts in caves	oil/gas development impacts on cave and water	human visitors, park infrastructure, oil/gas development, light pollution	Oil & gas develop; air & water quality; Configuration of the park (long & narrow); Nonnative/invasive plants; barbary sheep,	Oil & gas development; Lack of landscape-base fire management approach; Felis concolor control on non	visitor impacts to bats, park infrastructure, drought, oil/gas, herbicides, BLM

Question	A	B	C	D	E	F	G
					bullfrog, eastern foxtail squirrel; cowbird parasitism	NPS lands; Visitation activities in caves	grassland burning, cowbirds, lack park constituency
5. What are the greatest potential threats to significant park resources?	ground-level infrastructure causing cave contamination	oil/gas development, visitor impacts in caves	oil/gas development; decrease air quaility	oil/gas development, especially to Rattlesnakes Springs	House sparrow; Wildlife disease; Current administration; Climate change; Water development at RSS; Pesticide from ag feedlots around RSS, increase cowbird	Oil & gas development; Lack of Resource Management Plan; Current DOI Administration, undermining the stewardship mission; Visitation	as above

Question	A	B	C	D	E	F	G
6. What are the park's most significant natural resources needs?	research	bat migration data, water resources, cave microbial communities	understand role of fire, baseline data on cave invertebrates, bat migration patterns, soil inventory, relation between vegetation and stressors	Rattlesnakes Springs underground watershed	Fire ecology; invertebrates; ecological modeling (including need for state & transition models; Understanding desired future conditions (DFC); Lack of knowledge or planning to handle issues outside of our expertise	T&E species ID and mapping; Exotic species eradication, control & monitoring; RMP; Cave macro-invertebrate inventory; Reintroduction of extirpated species (Bighorn Sheep, Montezuma's quail), listed in the GMP; green-throated darter	research/monitoring, data gaps

Question	A	B	C	D	E	F	G
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?	cave surveys of physical features; cave microbial communities; human impacts; photo monitoring of Lechugilla Cave; monitor cave floor; vertebrate cave use; photo monitoring backcountry	barbary sheep, bat population, cave mapping	cave microbes, cave invertebrates	photo monitoring in cave, cave microbes	Cougar sign, DNA, and scent stations; live mammal trapping; winter bat work in NM, variation in Mex freetail echolocations; bat outflights by sex	Thermal imaging Tadarida population; (Barbary Sheep; Vireo bellii nest mapping and reproductive success; Fish found in RSS are native to region, but were never native or historical known from RSS. Fish species eradication at Rattlesnake Spring.	
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?	NR	NR	little knowledge about past activities	some spring flow and water chemistry	1980's cougar radiotelemety; 70's fire study; 50's bats in Left Hand Tunnel; Myotis research; diet of freetails; rare plant surveys; Herp inventory; 1997 survey of herps	Cave invertebrate study; Tadarida research; Vegetation map; Odocoileus hemionus population dynamics	Rattlesnake springs mollusks, DDT spraying, cave swallow

Question	A	B	C	D	E	F	G
					at RSS; Habitat model for Lees pinchushin cactus		
11. Which ecosystem components are most important to protect? Why?	caves; above cave surface	cave and karst system	geological resoures	park surface, backcountry caves, geomicrobial	riparian areas; Mex free-tailed bats; Migratory birds; big predators	Ecosystem integrity of cave resources; Plant community diversity; Rattlesnake Springs resource base; T&E species; Air quality; wilderness character:	all

Question	A	B	C	D	E	F	G
12. In your opinion, which stressor is the most significant? Why?	human use; carbon	NR	oil/gas development	human impacts in caves, infrastructure over caves	Level & timing of precipitation	climate, fire, visitation	role of fire
13. In your opinion, what are the park's top three monitoring questions?	Cave floor processes; social trails in caves; cave visitors	NR	spotted owls, Lee's pincushion cactus, vandalism	air quality, water quality	Mex free-tailed bats; Invasive plants; Predator pop	Effects of fire on ecosystem structure and function; Impacts of Felis concolor predation on ungulate populations; What is the diversity of macro invertebrate populations in Carlsbad Cavern;	

Question	A	B	C	D	E	F	G
						Impacts of non-native animals on vegetation communities	
14. If you could only have one long-term monitoring project in your park, what would it be, and why?	not known	NR	pincushion cactus, free-tailed bats	air or water quality	Mex free-tailed bat; Riparian/water resources;	Air quality; Cave macro-invertebrates	
19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?	vandalism	visitor impacts	vandalism in caves, visitor impacts on bats	vandalism, lint, lunchroom oder/visual impact	Automobiles & pollution; fires started by visitors; indirect with the infrastructure; water & sewage use.	Impacts to biological & geological cave resources from visitor activity.	noise at bat flight
20. Are there any real or perceived impacts due to routine maintenance activities or other NPS activities?	lighting, cave exploration	lighting	maintenance does not know where T&E species are located	salt on trails, irrigation at rattlesnake springs	Irrigation ditch clean-up; a lot of seasonal activities scheduled to avoid at RSS or in the caves at the wrong time of year; Flood	Cave maintenance, lighting system, cleaning trails, etc.; Road maintenance, shoulder maint & loop road;	no maintenance standards, trail maintenance

Question	A	B	C	D	E	F	G
					irrigation at RSS; mowing at RSS	Trail maintenance, terrestrial: little done on backcountry trails, time frames are so far apart, they are "starting" over; issues with T&E plants; doing clearances & compliance before action	

L.5. Fort Davis National Historic Site (30-31 March 2005)

Summary of staff interviews for the Fort Davis National Historic Site Vital Signs Phase I scoping meeting.

Questions/Respondents	A	B	C	D	D cont.
1. What are the park's most valuable/important/significant species of concern?	unknown	historic cottonwood grove	no comment	Foothill grasslands community are conservation concern ; Other species low ranked: scented croton (limited distribution in TX), found base of mountains in the rocks; dense corycactus (Escobaria dasycantha); Cassin's sparrow; Chihuahuan desert subspecies of meadowlark; Kit fox; Davis Mt. cottontail, landscape perpective-black bear & pronghorn; guild of grassland birds	Springs, streams & riparian corridors; cottonwoods; neotropical guild; bats; Texas false saltgrass; Warnock's coralroot (may be in Hospital Canyon), G2 ranked plants: Murray's plum; trans-pecos butterfly weed, Davis Mts. horse nettle; Tx. Horned lizard; Lichen flora
2. What are the park's species of concern?	none noted	list in study plan	no comment	see question #1	see question #1

Questions/Respondents	A	B	C	D	D cont.
3. What are the park's most important natural resource management issues?	resource stewardship plan (fire, historic scene, tree); flood mitigation	maintain cultural landscape; trail maintenance; prescribed fire; mechanical thinning	no comment	Maintaining or improving grasslands; reducing shrub encroachment; maintaining shrub comm., groundwater quantity; cottonwood genetics & maintaining grove with as genetically similar a species to the natives as possible (need to be maintaining age structure & recruitment with plantings every 20 yrs or so.)	
4. What are the greatest current threats to significant park natural resources?	lack knowledge	human use; exotics; dogs; irrigation; view shed	no comment	Groundwater in relation to cottonwoods; town of Ft. Davis water corporation groundwater pumping; development pressures have already occurred (built up to the boundary already); park may be important linkage	

Questions/Respondents	A	B	C	D	D cont.
				to Davis Mt. State Park	
5. What are the greatest potential threats to significant park resources?	encroachment; groundwater depletion; drought; altered fire regime; air quality	development affecting water table	no comment	Push by some town folks to expand housing & tourist attractions, which means more water consumption (most likely from groundwater) & septic tank issues; what happens if population goes from 1000 people to 5000. General concern in the area is the future of ranchlands, biggest threat intergenerational transfer of lands – subdivides, & inheritance taxes	

Questions/Respondents	A	B	C	D	D cont.
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?	herp study, riparian bird study, fern study	ferns, herps, riparian birds	no comment	Sul Ross State – vascular plant survey completed, (check with Jim Zech (432-837-8114) & Martin Terry (botantists at Sul Ross State); Mammals of Davis Mts (Texas Tech) Ferns – Yarbourough Birds – Meyers; fire science project with TNC, long-term fire history & climate change in the Chisos, Davis & Maderas del Carmen; Analysis not completed; Penn State professor (former advisor to Mills), doing similar study in the Guadalupe Mts.	

Questions/Respondents	A	B	C	D	D cont.
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?	TNC conservation assessment for Davis Mountains	1997-98 veg study with comparision to historical conditions	no comment		
11. Which ecosystem components are most important to protect? Why?	native species; drought impacts; wildlife; land use patterns	discuss with outside participants at scoping meeting	Grasslands, one of the most threatened ecosystem because of human pop growth. Grasslands are in a "tension" situation because of climatological issue. Any water associated situation, riparian & spring systems.	Water resources (spring reduction in high country); very large Rio Grande Basin study just started. Researchers at Sul Ross & Texas State University (San Marcos). The study focused on hydrology & ecosystem function of the Trans-Pecos portion of the basin (Pecos & Rio Grande mainstem & main tributaries; Limpia Creek is a trib. To Pecos River. Kevin Urbanczyk (head of geology dept.) kevenu@sulross.edu (432-837-8259).	

Questions/Respondents	A	B	C	D	D cont.
				Started in the last year.	
12. In your opinion, which stressor is the most significant? Why?	drought; routine mowing	drought; ground water depletion (green houses)	Population growth in terms of human occupation; unsustainable water use. Doesn't think fire played a key role in maintaining mid-elevation grasslands (4,000'-6,000'); historic records evidence from fire in high plains or PIPO communities; altered disturbance regime but to what degree; climate much more important.	Climate change & aridification in the Davis Mts.; possibly altered fire regimes.	

Questions/Respondents	A	B	C	D	D cont.
13. In your opinion, what are the park's top three monitoring questions?	groundwater; exotics; vegetation	don't know	Monitoring of the hydrologic functions –spring flow, critical to what is happening in the area; better climate monitoring, poor weather station coverage (evapo-transpiration, precip, temp, etc.); Monitoirng of certain indicator species; insect & bat population; pollinators, amphibians, ceratin veg communities or plants; understand these groups; why are these populations changing (ranges of bat species moving west)	* need assessment of the cottonwood – possible indicator of ecosystem health; * lichen flora & stresses on those systems, * Develop intact grasslands away from developed sites, will likely need to sustain with fire. Larger scale on TNC lands impt issue: Restoring forest health (via prescribed fire); reduce fuel load, restore ecosystem health by reducing competition, brush & woodland abatement on the savanna grasslands.	
14. If you could only have one long-term monitoring project in your park, what would it be, and why?	vegetation (historic scene)	don't know			

Questions/Respondents	A	B	C	D	D cont.
19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?	none noted	off-trail hiking			
20. Are there any real or perceived impacts due to routine maintenance activities or other NPS activities?	maintaining cultural landscape alters floodplain; artificial watering	mowing			

L.6. Guadalupe Mountains National Park (16-17 March 2005)

Summary of staff interviews for the Guadalupe Mountains National Park Vital Signs Phase I scoping meeting.

Question	A	B	C
1. What are the park's most valuable/important/significant species of concern?	NR	Guadalupe violet; Barbary sheep; Elk;	Guadalupe violet, McKittrick pennyroyal, Frijole chiquipin oak, Mex Spotted Owl
2. What are the park's species of concern?	NR	Mexican spotted owl; (also mt short horned lizard, tx horned lizard, black bear, mt. lion, montz quail, merriam's turkery, burrow owl, gypsum scale-broom, Guadalupe rabbitbrush, chaplain's columbine, yellow-billed cuckoo, gray-banded kingsnake; javelina	No additional species to add.
3. What are the park's most important natural resource management issues?	lack resource data management personnel; balance visitor use with protection; geology collecting	Lack of basic inventories; current veg map; exotics; Restoraton of extirpated species (desert big horn sheep, black-tailed prairie dog, American pronghorn); Highway corridor & wildlife mortality	Water-all facets (quality, quantity, etc.); Protection of scenic vistas; & Fire management

Question	A	B	C
4. What are the greatest current threats to significant park natural resources?	as in #3; ground water	Slow implementation of fire management; exotics	Water: water mining in West TX, esp in Dell Valley. Development includes desalination plant, groundwater mining, saline byproduct dumping & any associated contaminants. Scenic vistas: encroachment, human occupation, wind farms & associated impacts to desert big horn, migrating raptors & bats, etc. Fire managemetn: role in maintainng a balance in ecological processes.
5. What are the greatest potential threats to significant park resources?	air quality; brine disposal; encroachment	Slow implementation of fire management; exotics; encroachment; light pollution	No other, except potential from oil & gas exploration.
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?	water quality; air quality	riparian bird survey (I&M); paleontology inventory; water chemistry selected locations; airshed; Fire history	Tree ring studies by Penn State Univer, MSOW inventories, propagation of Guadalupe violet, I&M funded inventories
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?	water quality; spring discharge	15 yrs mtn. lion monitoring; deer pellet transects1974 browse survey map; McKit pennyroyal surveys	stream flow/discharge

Question	A	B	C
11. Which ecosystem components are most important to protect? Why?	surface water/springs; soil	riparian deciduous woodlands; Rocky Mt mixed-conifer zone; migration corridors for terrestrial organisms	all components are impt because of interrelations. All pieces necessary for functioning system.
12. In your opinion, which stressor is the most significant? Why?	drought; acid rain; visitors	Drought; Increased vehicle traffic	Drought
13. In your opinion, what are the park's top three monitoring questions?	grountwater quality/quantitye; air quality	air quality effects; water quantity-groundwater/surface water	1) How will introduction of millions of gallons of brine into the salt basin affect species, dune formation & microclimate? 2) Can the park sustain on a long-term basis a population of desert big horn sheep? 3) Is the "bowl" susceptible to a catastrophic wildlife?
14. If you could only have one long-term monitoring project in your park, what would it be, and why?	groundwater quality/quantity	see #13	Water quality, quantity, flow rates, etc.
19. Are there any real or perceived impacts directly due to visitors, visitor use or visitor activities?	vanadlism/theft to paleo resources; backcountry sanitation	Visitors are impacting park's resources; McKit Canyon corridor sensitive	introduction of exotics, imapcts due to human waste disposal in backcountry & MKCanyon

Question	A	B	C
20. Are there any real or perceived impacts due to routine maintenance activities or other NPS activities?	trail maint. Impacts to paleo resource	Need to systematically replace trails with a system that is more inert like textured concrete; trail maint can be a threat to paleontological specimens; Clean equipment to help reduce spread of exotic plants	mostly negligible, occasional trail & road maintainence & repair & effects on palenotological features
21. Are there other issues you would like considered? For example, interdisciplinary topics, landscape-level changes, or topics about which you think we need more information to help us further identify important monitoring needs?	NR	One of the elements to help us ID future monit needs, better effort of staff knowle & presence of park staff in the field, & getting those observation back to the program managers.	need a holistic perspective on how to deal with encroachment, preservation of wilderness values, importance of wildlife corridors form one sky island complex to another

L.7. White Sands National Monument (20 December 2004 & 12 April 2005)

Summary of staff interviews for the White Sands National Monument Vital Signs Phase I scoping meeting.

Question/Respondent	New Items	A	B	C	D	E
1. What are the park's most valuable/important/significant species of concern?		L: large animals movements restricted by fence	unknown (possibly food plants-U, insect pollinators-U, cryptobiotic species-M or H)	saltcedar-H; white species-scientific interest; not necessarily keystone species or T&E; desert grasslands-declining resources-M; cottonwoods-potential indicator species of ground water-M to H; Lake Lucero inverts/bacteria-U; cryptograms-M to H; gypsophilic plants-L to M	cryptograms; water-dependent species-L; gypsophiles; pedestal -forming plants-L; saltcedar (related to enhancing wildlife habitat); porcupine-U	all species; bats-L for park
2. What are the park's species of concern?		NR	pupfish-L; white species' those on official list	there is no formal SOC list; white species	Gambel's quail; scaled quail; cotton rats; hanta virus; cottonwood; pupfish; neotropical migrants; pronghorn	NA

Question/Respondent	New Items	A	B	C	D	E
3. What are the park's most important natural resource management issues?	High importance : hydrologic al function/gr oundwater; saltcedar; oryx (high maintenanc e issue)	need increased staff; air quality declining-; make visitors aware of diversity	saltcedar invasion-H; erosion	groundwater depth -H; saltcedar; potential hydrazine contamination (especially of Lake Lucero) from missle crash; air quality (impact cryptograms?)	groundwater hydrology and relation to plant communities	impact roads and accessibility into dunes; oryx
4. What are the greatest current threats to significant park natural resources?	High import: saltcedar, declining water tables/grou ndwater	lack grasslands; invasives; exotics	loss groundwater	saltcedar (playas at risk; relation between climate, groundwater, saltcedar); Lost River loss; soil erosion	exotic plants; water table	NA
5. What are the greatest potential threats to significant park resources?	see above, climate change-M	loss groundwater	loss groundwater; climate change; air quality	groundwater loss; brine discharge; climate change; hydrozine contamination; air quality; light pollution	groundwater loss & quality	NA
6. What are the park's most significant natural resources needs?	High importance : high resolution saltcedar map; understand groundwat er-dune formation	better understanding ecosystem function; should fire be introduced?	increased research	increased staffing; high resolution saltcedar map; geologic research (dune movement, groundwater/sand interaction)	NA	NA

Question/Respondent	New Items	A	B	C	D	E
	interactions					
7. Are there current research, inventory, or monitoring projects on natural resources being conducted in the park?		no	herp inventory; dune movement (UTEP); soil survey (NRCS); pollen/C14 on 10 pedestal hearth sites	7 active permits (2 geological, 5 biological); Rosenblum's project; Meyer riparian bird survey	NA	NA
8. Are there any historic research, inventory, or monitoring projects that you think are especially valuable in understanding the park's natural systems?		unknown	old herbarium; insect collection	Reid's grad student (UTEP) project from 70's & 80's; Fryburger's geology report; historic inventories back to 30's; past arieal photos	grazing & relation to vegetation; pre-European landscape	NA
9. Are you working with other agencies/land owners on any inventory, monitoring, research, or restoration projects? Please provide list & indicate in what capacity.		NA	soil survey?	HAFB, WSMR (saltcedar control); WS pupfish conservation team; NMDGF oryx removal; NRCS/DOD/NPS soil survey	NA	NA

Question/Respondent	New Items	A	B	C	D	E
10. Does climatological data (historic through present) exist in electronic format for your park?		yes	staff will make decision on who takes this over	Alamogordo airport (since 1916); WSMR & HAFB (since 1940's); park data at Santa Teresa NOAA office	as hard copy; records from 1990; NOAA wather station	hard copy (daily high and low temp, monthly & ytd precip); key punch data sent to Santa Teresa; designated national weather observer (e.g., storms, tornados, etc.)
11. What 3 GIS themes should have the highest priority for completion?	H importance : generate accurate saltcedar distributio n map; soil condition layer (level of erosion); shrub vs grassland cover (better veg map); military roads (could be impt for wilderness assessment)	exotics (including shrubs); archaeological sites; military roads	saltcedar; better soil; finer grained vegetation; plant/animal location; biotic soil; cottonwood monitoring	saltcedar map; disturbance (including military roads)	NA	NA

Question/Respondent	New Items	A	B	C	D	E
12. What 3 other important data layers should you have in your park's GIS database?	H import.: dune movement which is related to dune formation & hydrology/ groundwater	effects main road on dune dynamics	dune movement	park has good coverages; digital veg map	NA	NA
13. Which ecosystem components are most important to protect? Why?	H impt: groundwater; soil formation/ processes/ prevent further degradation to a less diverse state	water; air quality	possibly groundwater	Lake Lucero invertebrates; grassland ecosystem & shrub conversion (historic grazing); erosion	sand production at Lake Lucero (dune formation not continuous dependent on hydrology)	control non-natives
14. In your opinion, which stressor is the most significant? Why?	H: groundwater loss; saltcedar invasion	nothing imminent; exotic plants most visible	climate; groundwater loss	saltcedar; exotics; oryx exclusion; loss wetlands; groundwater loss; military contaminants; noise; Past stressors: grazing, loss Lost River	groundwater (greatest impact on geologic & biologic processes)	NA

Question/Respondent	New Items	A	B	C	D	E
15. In your opinion, what are the park's top three monitoring questions?	H impt: groundwater; dune movement/ formation monitored via aerial photos; saltcedar	animal populations (including reptiles)	groundwater; water quality; plant ecology (finer vegetation/habitat map)	saltcedar spread; grassland/shrubland ecotone; soil erosion; dune formation/movement; cottonwoods as indicators moisture [5 years groundwater depth/chemistry exists-no need to continue]	groundwater level; dune formation/movement (exisitng 1995-2004 dune edge monitoring)	parking accessibility at visitor station
16. If you could only have one long-term monitoring project in your park, what would it be, and why?	groundwater	groundwater	groundwater--relates to dune formation, movement, plant community	saltcedar invasion	groundwater (Fryberger for recommendations)	NA
17. We want information produced by the Inventory and Monitoring Program to be widely interpreted. What is the best way to make this information available to interpretive staff and the public & other park staff?		Interpretive staff should interact with research/resource staff and go in field; resource staff should participate in interp	need reports written for layperson	brochure produced through Harper's Ferry; site bulletins; use website	put on web site; brown bag lunch presentations to staff; rewrite reports for use by public; brochures; need real interpretive techniques	use electronic media and web site

Question/Respondent	New Items	A	B	C	D	E
18. Are there other issues you would like considered? For example, interdisciplinary topics, landscape-level changes, or topics about which you think we need more information to help us further identify important monitoring needs?		more staff or more research from outside; increase coop with military installations	understand historical ecological conditions and conversion grassland to shrubland; outside research; paleontological evaluation; writeup on human settlement	showcase white species and rapid evolution; Steve Hagarth thesis on behavior; Hagar 1998 dissertation on lesser earless lizard; too little info on grazing impacts; what were pre-Anglo plant communities?	evolutionary processes of white species	monitor other parks to look for issues overlooked
19. Are there problems perceived by the local govt officials/military as to management of the park?	No resource issues; primarily economic					
20. Perceived impacts due to visitors.	Where visitors go, the "sites" are durable; no real issues					

Question/Respondent	New Items	A	B	C	D	E
21. Perceived impacts due to maintenance?	Road maintenance activities is the prime activity; was analyzed via NEPA, & no significant impacts identified. Kit fox may be habituated to the garbage; no monitoring wells around the evaporation ponds, but the ponds are lined. This is primary sewage- Ford may need to be asked about this.					

M. Appendix - Result Matrix of Drivers and Stressors from CHDN Park Vital Sign Workshops

Category	Specific resources of concern	Stressors and Drivers											
		Air Quality	Climate	Altered Disturbance Patterns	Water Quality	Water Quantity	Land Use Change	Grazing	Resource Extract	Invasive species	Recreation	Disease	Soil Alteration
Air & Climate	Air quality	x	x	x		x	x	x	x		x	x	x
Air & Climate	Weather & climate	x	x			x							
Biota	Fish communities	x	x	x	x	x	x	x	x	x	x		x
Biota	Invasive/Exotic animal species		x	x	x	x	x	x	x	x	x	x	x
Biota	Invasive/Exotic plant species	x	x	x	x	x	x	x	x	x	x	x	x
Biota	Special plant communities			x		x	x	x		x	x	x	
Biota	Chisos Mountains Ecosystem	x	x	x	x		x	x		x	x	x	x
Biota	Desert communities, including grasslands	x	x	x		x	x	x	x	x	x		x
Biota	Freshwater communities-Rio Grande River		x	x	x	x	x	x	x	x	x		x
Biota	All Caves	x	x	x	x	x	x		x	x	x		
Biota	Big Horn Sheep						x	x		x		x	
Biota	Rattlesnake Springs		x	x	x	x	x	x	x	x	x	x	x
Biota	Special status species - plants	x	x	x	x	x	x	x	x	x	x	x	x
Biota	Special status species-Animals (incl inverts)		x	x	x	x	x	x	x	x	x	x	x
Biota	Focal communities-Riparian - Major Rivers (Rio Grande, Pecos, Devils)		x	x	x	x	x	x	x	x	x		x
Biota	Focal Community-Relic Plant Community	x	x	x		x	x			x		x	
Biota	Focal community -other riparian/cottonwoods		x	x		x	x	x	x			x	

		Stressors and Drivers											
Biota	Focal Community-foothill grasslands		x	x		x	x		x	x			
Biota	Desert grasslands & shrublands		x	x			x	x	x	x	x		x
Biota	Other taxa relevant to the Chihuahuan Desert												
Biota	Reptiles and Amphibians	x	x	x	x	x	x	x	x	x	x	x	x
Biota	Rocky Mt. mixed-conifer zone	x	x	x	x			x		x	x	x	x
Biota	Vegetation communities other than previously list												
Biota	Woodlands and forests		x	x			x	x	x	x	x	x	x
Ecosystem Pattern & Processes	Land Use & land cover	x	x	x	x	x	x	x	x	x	x	x	x
Ecosystem Pattern & Processes	Fire	x	x	x	x	x	x	x		x	x	x	x
Geology/Soils	Cave/Karst			x	x	x	x			x	x		
Geology/Soils	River channel		x	x		x	x	x	x	x			
Geology/Soils	Soil function and dynamics	x	x	x				x		x	x		x
Geology/Soils	Upland soils	x	x	x				x		x	x		x
Geology/Soils	Soils	x	x	x			x	x		x			
Geology/Soils	Subsurface geologic processes	x	x		x	x	x		x	x	x		
Geology/Soils	Geomorphologic processes	x	x		x	x	x	x	x		x		
Human Use	Point-Source Human Effects			x	x		x	x	x	x	x	x	
Human Use	Visitor usage	x			x	x	x			x	x		
Human Use	Visitor Satisfaction/Enjoyment	x	x	x	x	x	x	x	x	x	x	x	x
Human Use	Wilderness	x		x	x		x	x	x	x	x	x	
Human Use	Cultural Landscape		x	x		x	x		x	x		x	
Human Use	Light pollution	x					x	x			x		
Water	Groundwater dynamics	x	x		x	x	x	x	x		x		
Water	Reservoir hydrology/dynamics	x	x	x	x	x	x	x	x	x	x		x
Water	Springs and Seeps	x	x	x	x	x	x	x	x	x	x		x
Water	Water Quality	x		x	x	x	x	x	x		x		
Water	Regional groundwater flow system		x	x	x	x	x		x		x		x
Water	Rio Grande River	x	x	x	x	x	x	x	x	x	x		x

		Stressors and Drivers											
Water	Hydrology		x	x		x	x	x	x				
Water	Hydrology-ground water		x			x	x	x	x				

N. Appendix - Park Rankings of Complete List of Resource Issues and Potential Vital Signs Identified in Phase I Workshops

N.1. All Air & Climate Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - AIR & CLIMATE	PARK					
Resource Issue/Potential Vital Sign	**AMIS**	**BIBE**	**CAVE**	**FODA**	**GUMO**	**WHSA**
Air chemistry						
Historic vegetation data						
Ozone						
Particulate pollution/Visibility						
Pollinator distribution						
Weather & Climate						
Tree growth bands						
Vegetation communities						
Wet and dry deposition						

:low
:moderate
:high

N.2. All Biological Integrity Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - BIOLOGICAL INTEGRITY	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Algal communities						
Animals associated with special plant communities						
Aquatic communities						
Bats						
Black bear food supply						
Broad-ranging Species (mt. lion, mule deer)						
Burned areas						
Changes in habitat area						
Community structure						
Curly-leaf Muhly associated community						
Demographics of overstory species						
Desert community						
Desert surface crusts						
Development						
Distribution & diversity of bajada communities						
Distribution of exotics across the landscape						
Distribution of stream features/geomorphology						
Diversity of species within native and altered habitats						
Exotic animals & plants						
Fish communities, especially natives						
Flow regimes impacting aquatic organisms						
Fuel loads						
Grassland bird community						
Grassland vegetation						
Groundwater levels effecting species						
Historic cottonwood grove						
Hydrologic function						
Incidence of mutations						
Invertebrate communities						
Landscape-level changes in habitat quality						
Loss of critical food sources						
Meta-populations						
Mussels						
Native plant community composition						
Native species' response to exotics						

LEVEL I - BIOLOGICAL INTEGRITY	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Neotropical migrants						
Oak mott age structure & other special woodlands						
Poaching of special status species						
Population and distribution of "white-coloration" species						
Population monitoring						
Populations & distribution of special status species						
Reptiles & amphibians						
Riparian communities						
Small to moderate-sized carnivores						
Soil & sediment erosion						
Soil biota						
Soil chemistry						
Special plant communities						
Species composition (floral & faunal - native & exotic)						
Species of concern						
Spread of exotics within the range of special status species						
Stream channel characteristics						
Stream characteristics						
Structure and composition of native vegetation						
UV levels						
Visitor use patterns						
Water chemistry						
Water fluctuation regimes impacts to wildlife						
Wetlands						

:low
:moderate
:high

N.3. All Ecosystem Pattern and Process Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - ECOSYSTEM PATTERN & PROCESSES	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Elevational migration of plant communities						
Fire events						
Fuel dynamics (distribution & loading)						
Land cover, pattern and land use changes over time						
Night skies						
Soundscape						
Viewsheds						

:low
:moderate
:high

N.4. All Geology & Soil Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - GEOLOGY & SOILS	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Air pollution effecting soil chemistry						
Alluvial deposition						
Bat community structure						
Biological crusts						
Cave biota						
Cave floor chemistry						
Cave microclimate						
Cave/karst processes						
Caves/karst features						
Changes in dune stability						
Erosion						
Groundwater dynamics						
Infiltration and other soil characteristics						
Microbial functional diversity						
Migration of patch edges						
Physical disturbance of cave floors (natural & from visitors)						
Stream channel characteristics						
Visitor usage						
Water quality & quantity						
Waterflow in dry arroyos						

:low
:moderate
:high

N.5. All Human Use Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - HUMAN USE	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Air quality						
Algal blooms						
Backcountry campsite trampling & erosion						
Cultural landscape						
Decibel levels & frequency						
Feral cats						
Focal faunal & vegetation communities						
Grassland bird community effected by visitors						
Grassland vegetation effected by visitors						
Healthy ecosystems						
Human-caused fire						
Human-exotic interactions						
Integral vistas						
Invasive/Exotic plants						
Litter & waste density						
LM levels would give an indication of changes in night skies						
Night skies						
Number of human constructed elements						
Quantity of vandalism sites						
River campsite availability						
Social trails						
Soundscape						
Visitor statistics						
Visual resource integrity						
Water quality						

:low
:moderate
:high

N.6. All Water Resource Issue Rankings (Level of Concern) from Park Responses via the CHDN Intranet On-line Application

LEVEL I - WATER	PARK					
Resource Issue/Potential Vital Sign	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Animal utilization						
Aquatic macroinvertebrates						
Contaminant levels in fish						
Endemic spring species						
Exotic plants and animals in springs						
Flood events						
Groundwater chemistry in the unsaturated zone						
Groundwater dynamics						
Lake salinity						
Lake water levels						
Microorganisms						
Native fish communities & other key components						
Nutrient dynamics						
Persistence of the spring (flows) at a location						
Regional groundwater levels						
Relict communities						
River flow and quantity						
Siltation rates						
Spring dependent biota						
Spring flow and characteristics						
Spring-dependent species (i.e. aquatic macroinvertebrates)						
Surface water dynamics (hydroperiods, flow rates)						
Toxics						
Visitor use						
Water chemistry						

:low
:moderate
:high

O. Appendix - Regional or Adjacent Lands Monitoring Effects

O.1. Air Quality

O.1.1. National Atmospheric Deposition Program/National Trends Network

Operated by State Agricultural Experiment Station at University of Illinois (with USGS, USDA, others) this program was initiated in 1978. The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) monitors precipitation at a nationwide network of sites. Several groups cooperate to maintain the network, including the State Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and numerous other governmental and private entities. Data is collected on the chemistry of precipitation for monitoring of geographical and temporal long-term trends. Weekly precipitation samples are collected and then analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations, at the Central Analytical Laboratory.

O.2. Climate

O.2.1. National Oceanic and Atmospheric Administration, U.S. Climate Reference Network

The National Oceanic and Atmospheric Administration (NOAA) is establishing a network of climate stations (Climate Reference Network) with the help of the Western Regional Climate Center, as part of a NOAA initiative. The goal of this project is to monitor long-term precipitation and temperature observations to couple with past observations in order to investigate present and future climate change. If fully implemented, the network will have established about 250 stations nationwide.

O.2.2. U.S. Geological Survey (USGS), Earth Surface Dynamics Program, Southwest Climate Impacts Project

The Southwest Climate Impacts Project investigates how climate and human activities affect geologic processes (weathering, erosion, deposition) that change the landscape. The project involves the use of remotely placed CLIM-MET meteorological stations, which function for long periods of time, usually long enough to support a parent project that monitors surficial processes. This project is part of the USGS Earth Surface Dynamics Program, which is one of several areas of research the USGS leads as part of its participation in the larger U.S. Global Change Research Program.

O.3. Earth Sciences

O.3.1. Interpreting Indicators of Rangeland Health: Land Health Assessments

A collaboration among the U.S. Geological Survey, the USDA Agricultural Research Station, the Bureau of Land Management, and the NRCS, the Interpreting Indicators of Rangeland Health program is designed to provide a quick, qualitative assessment of rangeland health based on the functional status of 17 indicator variables. These indicators reflect three resource attributes of rangelands: soil stability, hydrologic function, and biotic integrity. The program is not a quantitative monitoring technique, but is designed to identify areas of concern, which would then need further quantitative assessment and/or monitoring.

O.4. Avian

O.4.1. Institute for Bird Populations, Monitoring Avian Productivity and Survivorship Program

The Institute for Bird Populations at Point Reyes Station, California, is a non-profit corporation focused on research and monitoring of avian populations at a global scale. In 1989, the Institute initiated the Monitoring Avian Productivity and Survivorship Program (MAPS) in cooperation with USGS, NPS, USFWS, state fish and wildlife agencies, and others to monitor avian productivity and survivorship at constant-effort mist net trapping and banding stations across the United States. Currently, data from over 500 MAPS stations have contributed to productivity indices and improving understanding of population trends, ranges and habitat of various species. MAPS stations can be run by any agency or organization, which follows the standard protocols, used by the IBP, and which contributes their data to the national MAPS database (http://www.birdpop.org/).

O.4.2. National Audubon Society, Christmas Bird Count

The National Audubon Society's Christmas Bird Count (CBC) is an annual 15-mile diameter circle Area Search for birds, conducted on one day in the winter by volunteers. Results from the CBC achieve the primary objective of monitoring the status and distribution of bird populations across the Western Hemisphere. The CBC has been conducted since 1900, and results are available from a national website sponsored by the National Audubon Society and the Cornell Lab of Ornithology (http://www.audubon.org/bird/cbc/index.html).

O.4.3. North American Breeding Bird Survey

Begun in 1966, the North American Breeding Bird Survey (BBS) was first administrated by the U.S. Fish and Wildlife Service, and is currently being administered by the U.S. Geological Survey, Patuxent Wildlife Research Center. The survey is conducted once in June across North America, at over 3500 routes. Routes are 24.5 miles long, with observers stopping every 0.5 miles to record all birds seen and heard during a 3-minute point count. Analysis of the data

results in continent-scale abundance maps, and trend information on individual species and groups such as neotropical migrants (http://www.mbr-pwrc.usgs.gov/bbs/bbs.html).

O.4.4. U.S. Geological Survey (USGS), Breeding Biology Research & Monitoring Database

A component of the USGS Global Change Research Program, the Breeding Biology Research and Monitoring Database (BBIRD) is a national program that uses standardized protocols to study bird nest success and nesting habitat requirements. Study sites consist of nest-finding plots, a minimum of 4 ha in size, which are intensively surveyed throughout the breeding season. Study sites often match unaltered with altered plots to examine how land use affects the ability of habitats to support source or sink populations of birds. Participants contribute their data to the national BBIRD database, which can then be used to identify large-scale patterns and trends. BBIRD sites on the Colorado Plateau do not appear to be common (http://pica.wru.umt.edu/BBIRD/info.htm).

O.4.5. Partners in Flight Program

Partners in Flight (PIF) began in 1989 as a national effort to document and reverse apparent declines in neotropical migratory birds. It is a cooperative effort with federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals. PIF is now international in scope, with PIF Mexico and PIF Canada (http://www.partnersinflight.org/).

O.5. Fish

O.5.1. Texas Department of Parks and Wildlife (TDPW) Sport and Native Fish Monitoring Programs

The TDPW conducts routine “creel” surveys of Amistad Reservoir for sports fisheries using standard protocols.

O.5.2. New Mexico Department of Game and Fish

In cooperation with Department of Defense, and National Park Service (when applicable) monitor White Sands Pupfish in the Tularosa Basin (where WHSA is located).

O.6. Mammals

O.6.1. U.S. Geological Survey (USGS), Bat Population Status in the United States and Territories

The USGS Bat Population Status project is intended to synthesize bat information from states,

conservation organizations, and Interior Department land managers that will then support hypothesis testing, developing monitoring protocols, and a summary of conservation needs. The initial phase of the project involved the creation of a Bat Population Database. This database will then be used for hypothesis testing, statistical analysis, and in the design of potential long-term monitoring programs.

O.7. Reptiles and Amphibians

O.7.1. U.S. Geological Survey (USGS), Amphibian Research and Monitoring Initiative

In response to growing awareness of amphibian declines and malformations, the USGS Amphibian Research and Monitoring Initiative (ARMI) program was initiated by the United States Congress in 2000 to monitor trends in amphibian populations on Department of Interior (DOI) lands, and to research the cause of amphibian declines. While intensive monitoring will be focused on DOI lands, ARMI will also provide a framework for incorporating amphibian monitoring data by other agencies outside of DOI lands. Partnerships with other DOI agencies include a nationwide survey by the Fish and Wildlife Service on 48 National Wildlife Refuges in 31 states for contaminants that may induce malformations in amphibians.

O.7.2. U.S. Geological Survey (USGS) Inventory, Monitoring, and Research Database for Reptiles

The USGS reptile database project originally aimed to collect information about reptile inventory, monitoring, and research projects on U.S. Department of Interior lands. It has expanded its scope to include all federal lands, as well as to include amphibian data. The database is intended to complement database work under the Amphibian Initiative, and will eventually become part of the PARC (Partners in Amphibian and Reptile Conservation) website and the USGS website.

O.8. Plants

O.8.1. New Mexico Rare Plant Technical Council

The New Mexico Rare Plant Technical Council is a volunteer organization that has developed and now maintains an internet database that contains information on biology and conservation status of the nearly 200 plant species found in New Mexico (http://nmrareplants.unm.edu/index.html).

O.8.2. USDA Forest Service, Forest Health Monitoring Program

USDA Forest Service, Forest Health Monitoring (FHM) is a component of the national Forest Inventory and Analysis program. Forest Health Monitoring is designed to determine status, changes, and trends in indicators of forest condition on an annual basis. Its focus is on forest

health issues that affect ecosystem sustainability. Intensive data are collected from a subset of plots already established by the FIA program. These data, identified as indicators of forest health, collect information about vegetation diversity, soils, lichens, downed woody debris, and tree crowns. They provide the basis for developing analytical approaches to addressing forest health issues (http://fhm.fs.fed.us/).

O.8.3. USDA Forest Service, Forest Inventory and Analysis Program

The Forest Inventory and Analysis Program (FIA) is a national USDA Forest Service program that provides a census of landscape level information about forestry resources since 1930. The FIA program inventories all forested lands, including federal, private and state lands. Access to the data is available through the National Forest Inventory and Analysis Geospatial Data Service Center, which can be accessed on the internet at: http://www.fs.fed.us/ne/fia/spatial/index_ss.html. FIA data is collected in 3 Phases, the third phase of which comprises the Forest Health Monitoring Program. Phase I data are collected at a coarse scale to make broad land cover classifications. Phase II data are collected at a fine scale on randomly selected plots located at the intersections of a 5000 m X 5000m grid. Phase II data collection requires a large data collection effort in the field. Together, Phase I and Phase III plots measure over 120 variables. Phase III intensive data collection, done on a subset of Phase II plots, is aimed towards indicators of forest health including vegetation, soils, lichens, downed woody debris and tree crowns.

O.9. Regional Research, Monitoring, and Database Programs

O.9.1. Jornada Experimental Range

Originally set aside in 1912, these lands are now operated by the USDA – Agricultural Research Service. Research projects cover a wide-range of topics from nutrient cycling, temporal changes in vegetation, rangeland health, key process and linkages in desert landscapes, and the role and impact of biota in ecosystems. Over 100 permanent quadrats were established in 1915 to monitor vegetation patterns. These were monitored annually until 1947 with a subset annually monitored until 1979. Many of these quadrats were relocated and measured in 1995 and 2001 (http://usda-ars.nmsu.edu/).

O.9.2. Jornada Basin Long-Term Ecological Research Project

The Jornada Basin Long-Term Ecological Research (LTER) site is comprised of the Chihuahuan Desert Rangeland Research Center operated by New Mexico State University and the USDA Jornada Experimental Range (see description in this section). The LTER covers approximately 100,000 ha in the Chihuahuan Desert of southern New Mexico. Research at the LTER focuses on five habitat types: black grama grassland (*Bouteloua eriopoda*), creosote bush scrub (*Larrea tridentata*), mesquite duneland (*Prosopis glandulosa*), tarbush shrublands (*Flourensia cernua*) and playa. Research focuses primarily on factors influencing desertification including animal-

induced soil disturbances, primary production, biodiversity and ecosystem function, soil microbial processes, and eolian processes (http://jornada-www.nmsu.edu/).

O.9.3. Natural Heritage New Mexico

The Arizona Natural Heritage Program is one of 86 primary data centers throughout the United States, Canada, Latin America, and the Caribbean countries, which uses the Natural Heritage Methodology for ranking and preserving species and communities. Its database contains scientific information on two elements: species, and subspecies. This allows the program to rank relative degree of imperilment of these elements, rank populations or occurrences of each according to their level of health or quality, and delineate and rank potential conservation areas (http://nhnm.unm.edu/).

O.9.4. Sevilleta Long Term Ecological Research Station (LTER)

The Sevilleta LTER is located near Albuquerque, New Mexico and is comprised mostly of the Sevilleta National Wildlife Refuge. Originally acquired by The Nature Conservancy, the refuge lands were turned over in 1973 to the U.S. Fish and Wildlife Service. In a cooperative effort with University of New Mexico the refuge became host to a LTER in 1988 – one of twenty-four nation-wide sites where research focuses on global warming trends and other environmental concerns. The LTER lands encompass subalpine mixed-conifer forest, riparian cottonwood communities, desert grasslands, mesquite and sand dunes, and Great Basin shrub and part of the Rio Grande river valley (http://sev.lternet.edu/).

O.9.5. Southwestern Museum of Biology, Curation of Biological Survey Collection

In 1994, United States Geological Survey (USGS) scientific collections of western vertebrates were moved from Fort Collins, CO, to Albuquerque, NM, where they joined a larger collection at the Museum of Southwestern Biology. This project creates and maintains electronic databases and curates the USGS collections, which consist of amphibians and reptiles, fishes, birds and mammals, mostly from the Rocky Mountains and Intermountain West. The collection is rich in bats and rodents, and a general research emphasis has been to document mammal species from public lands in the West. Vouchers from CHDN herpetological inventories are housed here.

O.10. Water Quality and Water Quantity Monitoring (other programs are described in Appendix I)

O.10.1. U.S. Geological Survey – Water Monitoring

The U.S. Geological Survey was created by an act of Congress in 1879 and has become the principal Federal agency providing water information needed to manage the Nation's water resources. In 1889, the U.S. Geological Survey established the first streamflow-gaging station on the Rio Grande River in New Mexico. The U.S. Geological Survey now operates and maintains a

network of about 7,000 streamflow-gaging stations nationwide and about 70% of these have real-time capabilities. The U.S. Geological Survey monitors the quantity and quality of water in many rivers, streams, lakes, and reservoirs. The monitoring program is a cooperative effort that is funded jointly by numerous Federal, State, and local agencies. Streamflow data collected as part of the monitoring program are used for hydrologic research, reservoir operations, forecasting floods and droughts, maintaining water quality, and monitoring water-quality conditions and trends (http://water.usgs.gov/).

P. Appendix - Chihuahuan Desert Network Prioritization Workshop Report

P.1. Overview

The CHDN Vital Signs Prioritization Workshop was held June 14–15, 2006 in El Paso, TX. This two-day workshop was attended by 64 people and continued the process of developing a long-term ecological monitoring program for natural resources in the Chihuahuan Desert Inventory and Monitoring Network (CHDN). This workshop was preceded in 2004 and 2005 by: 1) CHDN-held scoping sessions with park managers from each CHDN park, 2) review of peer-reviewed literature and gray literature, and 3) initiation of development of conceptual models for the three major terrestrial ecosystems in CHDN. In the fall of 2005, CHDN held one separate workshop, in Las Cruces, New Mexico, exclusively dealing with water-quality issues and potential aquatic resources vital signs as the network headed into development of its Phase II Water Quality Assessment report. This process resulted in a list of 35 potential vital signs for consideration in our water-quality and long-term monitoring programs (Table P.1).

Table P.1. Vital signs from Aquatic Resources & Water Quality Workshop, October 2005.

Vital Sign
Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)
Endemic spring species
Spring flow in regional groundwater flow system
Water quality in large rivers
Contaminants
Microorganisms
Water chemistry
Water quality of other large surface flows (rivers)
Persistence of the spring (flows) at a location
Spring dependent biota (i.e. aquatic macroinvertebrates, etc.)
Groundwater level (local & regional flow systems)
Surface water dynamics (hydroperiods, flow rates)
Water quality of springs
Water quality of springs
Cave groundwater dynamics
Relict communities
Water quality in cave systems
Native fish communities & other key components (mussels, amphibians, sliders)
Water quality in reservoir
Nutrient dynamics
Water quality of groundwater
Aquatic macroinvertebrates

Vital Sign
Streamflow, including arroyos
Contaminant levels in fish
Animal utilization
Exotic plants and animals in springs
Visitor use at springs & seeps
Water quanity of reservoir
Water quanity in cave systems
Siltation rates in reservoir
Extreme storm events
Water levels at Lake Lucero
Salinity levels at Lake Lucero
Groundwater chemistry in the unsaturated zone
Flood events on the Rio Grande

The goal of the prioritization workshop was to create a prioritized list of vital signs. Prior to the prioritization workshop, park superintendents, technical committee members, and all natural resource staff from each park scored the vital signs to be reviewed at the workshop (Table P.2) according to management significance. At the workshop, participants were divided into five workgroups: animals, aquatic resources, landscape- level issues, plants and soils, and unique (subterranean caves and dunes) (see Table P.3 for a complete list of participants and break-out group assignments). Each group reviewed a set of potential vital signs. Each vital sign that was retained was reviewed in four areas: 1) a justification source was indicated for each of seven major ecosystems, 2) ecological significance was scored, 3) potential partners were noted, and 4) potential measures were indicated. Following the workshop, a total score for each potential vital sign was calculated using ecological and management significance scores and a justification source weighting score (see Section 4). This process resulted in a prioritized list of vital signs for CHDN.

P.2. Workshop Objectives

- Review candidate vital signs.
- Identify justification sources for each vital sign by ecosystem.
- Score the Ecological Significance (ES) for each vital sign by ecosystem.
- Add new vital signs as appropriate.
- For the top 25% of vital signs, identify potential measures and monitoring partners.
- Develop a prioritized list of vital signs ranked according to ecological significance.

Table P.2. The 97 Vital Signs (Phase I) which made up the database for the VS Prioritization Workshop (Phase II).

Level 1	Level 2	Vital Sign
Air and Climate	Air Quality	Air quality in caves
		Atmospheric deposition of mercury
		Ozone
		Visibility and particulate matter
		Wet deposition chemistry (pH, NO3-, SO4=), cont sulfur dioxide (SO2)
	Weather and Climate	Carbon balance in soil
		Cave microclimate
		General meteorological conditions (precip, wind, RH, T, snow pack, soil moisture)
Geology and Soils	Geomorphology	Dune formation and stability
		Dune reactivation
		Geomorphology/channel characteristics of perennial rivers and streams
		Reservoir siltation
		Soil budget/movement (inflow/outflow)
		Soil erosion index
	Soil Quality	Cave floor chemistry
		Nutrient levels
		Soil chemistry
		Soil erosion index (wind and water)
		Soil health (stability, compaction, infiltration)
	Subsurface Geologic Processes	Cave/karst processes
		Caves/karst features
		Water volume of pools
		Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)
		Groundwater dynamics in cave systems
		Groundwater dynamics in dune systems
		Lake elevation for Amistad Reservoir - AMIS only
		Persistence of springs & seeps
		Regional groundwater flow systems
		Surface water dynamics (hydroperiods, flow rates and quantity) of rivers and other perennial waters

Level 1	Level 2	Vital Sign
		Water quantity and shoreline shape of Lake Lucero - WHSA only
		Water quantity of non-reservoir aquatic systems
		Waterflow in dry arroyos
	Water Quality	Contaminants in fish (primarily heavy metals)
		Core parameters (T, DO, conductivity, pH, turbidity, flow)
		Groundwater chemistry in the unsaturated zone
		Microbiotic components (esp. E. coli)
		Nutrient loading (ammonia, nitrites, nitrates, total P)
		Water chemistry (acidification)
		Water quality (core parameters: T, DO, cond, pH) of cave pools
		Water quality of regional groundwater systems
Biological Integrity	At-risk Biota	Collecting/poaching of species, esp. special concern
		Distribution & relative abundance of animal species of concern
		Distribution & reproduction of plant species of concern
	Focal Species or Communities	Animal communities in special/relic plant communities
		Biological soil crusts
		Black bear abundance & distribution
		Composition of algal communities
		Composition of wetland vegetation communities
		Distribution & composition of vegetation communities/ecosystems
		Distribution of broad-ranging species (mt. lion, mule deer)
		Distribution of oak motts & other special woodlands (dune field cottonwoods)
		Historic cottonwood grove - FODA only
		Mutation frequencies in amphibians
		Neotropical migrant bird communities
		Phenology (leaf out/drop, flowering)/Tree growth bands
		Relative abundance of bats
		Size & age structure of tournament caught fish - AMIS only
		Small to moderate-sized carnivores
		Soil microbes and other soil biota
		Species richness & diversity of amphibians
		Species richness & diversity of aquatic invertebrates in perennial streams & rivers
		Species richness & diversity of cave biota

Level 1	Level 2	Vital Sign
		Species richness & diversity of cave microbial communities
		Species richness & diversity of dune biota, esp. white-coloration species
		Species richness & diversity of native fish, mussels & turtles in perennial streams & rivers, esp. endemics
		Species richness & diversity of native species in reservoirs, esp. endemics
		Species richness & diversity of non-vascular plants
		Species richness & diversity of reptile community
		Species richness & diversity, composition of riparian vegetation communities
		Species richness & diversity, relative abundance of aquatic invertebrates of springs and seeps, esp. endemics
		Species richness & diversity-invertebrates, esp. endemics
		Species richness & diversity of cave pool biota
	Invasive Species	Distribution & composition of invasive/exotic plant associated with aquatic systems
		Distribution & abundance of invasive/non-native plants
		Distribution of hydrilla (recreation issue) - AMIS only
		Distribution of invasive/exotic aquatic invertebrates
		Distribution of non-native animals
		Distribution of non-native fish
		Feral cats
		Golden algae (Prymnesium parvum) distribution - exotic
Human Use	Consumptive Use	Distribution of mineral, oil and gas extraction sites
	Point Source Human Effects	Human-caused fire
		Visitor use at springs and seeps
	Visitor and Recreation Use	Effects of park visitors on natural resources
		Impacts of air quality on visitor satisfaction
		Visitor satisfaction relative to feature attractions (ie bats at the caverns)
Landscapes	Extreme Disturbance Events	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)
	Fire and Fuel Dynamics	Fire and fuel dynamics
	Landscape Dynamics	Degradation of desert ecosystems (including hydrologic function)
		Land use changes adjacent to parks
		Land use changes within Chihuahuan Desert
		Landscape dynamics (land cover, pattern & patch sizes changes) in parks-

Level 1	Level 2	Vital Sign
		Landscape fragmentation and connectivity
		Vegetation patch dynamics (microscale)
	Soundscape	Soundscape, especially in wilderness areas
	Viewscape	Night skies
		Viewsheds

Table P.3. List of Vital Signs Prioritization (Phase II) workshop participants.

Name	Organization	Position	Group/Function	NPS Participants
Animal Group				
Bustos, David	White Sands National Monument	Biologist	Animals	NPS
Foster, Danielle	Carlsbad Caverns National Park	Biologist	Animals	NPS
Goode, Matt	School of Natural Resources, University of Arizona	Assistant Research Scientist	Animals	
Harris, Art	Centennial Museum, Laboratory for Environmental Biology	Director	Animals	
Heiner, John	Fort Davis National Historic Site	Chief of Interpretation	Animals	NPS
Kelly, Jeff	Oklahoma Biological Survey, University of Oklahoma	Heritage Zoologist/Assistant Professor	Animals-Facilitator	
Mendez-Gonzalez, Cesar	New Mexico State University, Fishery & Wildlife Sciences	Doctoral Student	Animals	
Metzler, Eric	Research Associates	Entomologist	Animals	
Mueller, Jim	Tarleton State University, Department of Animal Sciences	Assistant Professor	Animals	
Skiles, Raymond	Big Bend National Park	Wildlife Biologist	Animals	NPS
Smith, Jackie	Natural Heritage Program, University of New Mexico	Assistant Zoologist	Note Taker	
West, Steve	Carlsbad, New Mexico	Biologist	Animals	
Wobbenhorst, Jan	Guadalupe Mountains National Park	Chief Ranger	Animals	NPS
Aquatic Resources and Water Quality Group				
Bennett, Jeff	Big Bend National Park	Physical Scientist	Aquatics	NPS
Briggs, Mark	Mark Briggs Consulting	Restoration Ecologist	Aquatics	
Huff, Rick	USGS, New Mexico Water Resources	Hydrologist	Aquatics	
Groeger, Al	Texas State University-San Marcos	Associate Professor, Dept. of Biology	Aquatics	

Name	Organization	Position	Group/Function	NPS Participants
Keeshen, Rebecca	Natural Heritage Program, University of New Mexico	Office Manager	Note Taker	
Lambert, Becky	US Geological Survey	Water Quality Coordinator	Aquatics	
Langman, Jeff	USGS, New Mexico Water Science Center	Hydrologist	Aquatics	
Longley, Glenn	Texas State University-San Marcos	Professor of Aquatic Biology	Aquatics	
Lougheed, Vanessa	University of Texas at El Paso	Aquatic Biologist	Aquatics	
Moring, Bruce	US Geological Survey, Research and Investigations Section	Senior Biologist	Aquatics	
Roemer, Dave	Carlsbad Caverns National Park	GIS Specialist/Biologist	Aquatics	NPS
Rosenlieb, Gary	I&M, Water Resources Division, National Park Service	Hydrologist	Aquatics	NPS, I&M
Shanks, W.C. "Pat"	US Geological Survey	Research Geologist	Aquatics	
Slade, Rick	Amistad National Recreation Area	Chief of Education and Resource Management	Aquatics-Facilitator	NPS
Walsh, Elizabeth "Liz"	University of Texas-El Paso	Assistant Professor, Dept. of Biology	Aquatics	
Landscape Issues Group				
Atchley-Montoya, Jennifer	World Wildlife Fund	Senior Program Officer	Landscape	
Bailey, Derek	Chihuahuan Desert Rangeland Research Center/NMSU Animal and Range Sciences	Director/Associate Professor	Landscape	
Davila, Vidal	Big Bend National Park	Chief of Science & Resource Management	Landscape	NPS
Gatewood, Richard	NPS, Chihuahuan Desert & Southern Plains Fire Program	Fire Ecologist	Landscape	NPS
Marin, Rebecca	University of Texas-El Paso	Doctoral Candidate	Landscape	

Name	Organization	Position	Group/Function	NPS Participants
Mills, Helen	Yale University	Doctoral Candidate	Landscape	
Neville, Teri	Natural Heritage Program, University of New Mexico	GIS Coordinator	Note Taker	
Noojibail, Gopaul	Carlsbad Caverns National Park	Chief of Resource Stewardship and Science	Landscape-Facilitator	NPS
Porter, Ellen	National Park Service, I&M Air Resources	Biologist	Landscape	NPS, I&M
Sikula, Nicole	The Nature Conservancy	Monitoring Coordinator	Landscape	
White, Joseph	Baylor University	Associate Professor of Biology	Landscape	
Whitford, Walt	USDA ARS, Jornada Experimental Range	Ecologist	Landscape	
Plants and Soil Resources Group				
Anderson, Dave	White Sands Missile Range	Botanist	Plants/Soil	
Armstrong, Fred	Guadalupe Mountains National Park	Resource Management Specialist	Plants/Soil	NPS
Biggam, Pete	NPS I&M Geological Resources Division	Soils Program Manager	Plants/Soil	NPS, I&M
Corral, Rafael	Fort Bliss	Botanist	Plants/Soil	
Florez, Lou	EPMT-CHDN & SOPN	Exotic Plant Management Specialist	Plants/Soil	NPS
Herrick, Jeff	USDA ARS, Jornada Experimental Range	Soil Scientist	Plants/Soil	
Hotchkin, Paul	University of Texas at El Paso	Doctoral Student	Plants/Soil	
Johnson, Kris	Natural Heritage Program, UNM	Director/Research Associate Professor	Plants/Soil-Facilitator	
McDaniel, Kirk	New Mexico State University	Professor of Range Science	Plants/Soil	
Monger, Curtis	New Mexico State University	Professor of Pedology/Environmental Science	Plants/Soil	

Name	Organization	Position	Group/Function	NPS Participants
Powell, Missy	I&M Chihuahuan Desert Network	Biological Science Technician	Note Taker	NPS, I&M
Rice, Kathleen "Kathy"	Desert Botanical Garden	Curator of Seeds	Plants/Soil	
Sirotnak, Joe	Big Bend National Park	Botanist/Ecologist	Plants/Soil	NPS
Sivinski, Bob	New Mexico Department of Forestry and Minerals	T&E Botanist	Plants/Soil	
Warnock, Bonnie	Sul Ross State University	Assistant Professor of Natural Resource Management	Plants/Soil	
West, Renee	Carlsbad Caverns National Park	Supervisory Biologist	Plants/Soil	NPS
Worthington, Richard	University of Texas-El Paso	Associate Professor of Biological Sciences	Plants/Soil	
Unique Systems Issues Group				
Barton, Hazel	Northern Kentucky University	Assistant Professor	Unique Systems	
Bell, Gorden	Guadalupe Mountains National Park	Geologist	Unique Systems	NPS
Gill, Tom	University of Texas-El Paso, Geological Sciences	Associate Professor	Unique Systems	
Langford, Rip	University of Texas-El Paso, Geological Sciences	Associate Professor	Unique Systems	
Hennrich, Marchelle	NMSU International Programs Office	Student Worker	Note Taker	
Pate, Dale	Carlsbad Caverns National Park	Supervisory Physical Scientist	Unique Systems	NPS
Perkins, Dusty	I&M Southern Plains Network	Network Program Coordinator	Unique Systems-Facilitator	NPS, I&M
White, Diane	White Sands National Monument	Resources Specialist	Unique Systems	NPS
Additional Participants				
Harris, Rick	Chamizal National Memorial	Superintendent	Rover – Day 2 only	NPS

Name	Organization	Position	Group/Function	NPS Participants
Lujan, John	Guadalupe Mountains National Park	Superintendent/Vice-Chair CHDN Board of Directors	Rover	NPS
Reiser, Hildy	I&M Chihuahuan Desert Network	Program Coordinator	Rover	NPS, I&M
Richie, Tom	I&M Chihuahuan Desert Network	Data Manager	Database/Equipment Management	NPS, I&M
Ward, Pat	USDA ARS, Jornada Experimental Range	Research Ecologist	Rover	

P.3. Prioritization Process

The workshop started with a welcome from John Lujan, Superintendent at Guadalupe Mountains National Park (Figure P.1). Hildy Reiser then presented an overview of the Inventory and Monitoring Program, the CHDN, and the workshop process (Table P.4). She emphasized that in ranking ecological significance the workgroups should stick to the pre-set criteria (See Section P.4). Each criterion and the scoring system were reviewed as a group to minimize differences in definitions and interpretations between groups. Pat Ward then presented an overview of CHDN Conceptual Modeling process. The workshop was then divided into five break-out groups, with a facilitator and note taker in each group (Figure P.2). The facilitators were familiar with the Inventory and Monitoring program and the vital signs process. All vital signs and scores were contained in an Access database.

Figure P.1. John Lujan welcomes workshop participants.

Figure P.2. Aquatics break-out group.

Table P.4. Vital Signs Prioritization (Phase II) Workshop agenda.

Wednesday June 14, 2006 – Camino Real Hotel, El Paso, Texas			
Time	Subject	Leader	Comments
7:45-8:30	Continental Breakfast		Kohlberg Room
8:30-8:40	Welcome	John Lujan	Kohlberg Room
8:40-8:50	Group Introductions	Hildy Reiser	Kohlberg Room
8:50-9:30	Overview of I&M and CHDN; and Workshop Objectives	Hildy Reiser	Kohlberg Room
9:30-10:30	Overview of CHDN Conceptual Modeling Process	Pat Ward	Kohlberg Room
10:30-10:50	Break		
10:50-11:10	Discussion - Conceptual Model and Potential Vital Signs	Participants	Kohlberg Room
11:10-12:30	Breakout Sessions – Evaluation of Potential Vital Signs	Facilitators	
	Landscape Level Issues	Gopaul Noojibail – Facilitator	Rio Grande Room
	Plants and Soils	Kris Johnson – Facilitator	Kohlberg Room
	Unique Systems	Dusty Perkins - Facilitator	Hereford A Room
	Aquatic Resources and Water Quality	Rick Slade – Facilitator	Santa Fe Room
	Animals	Jeff Kelly – Facilitator	Angus Room
12:30-1:30	Lunch		
1:30-3:00	Breakout Sessions – Evaluation of Potential Vital Signs	Facilitators	Assigned Rooms
3:00-3:20	Break		Kohlberg Room
3:20-5:00	Resume Breakout Sessions		Assigned Rooms
Thursday, June 15, 2006 – Camino Real Hotel, El Paso, TX			
7:45-8:30	Continental Breakfast		Kohlberg Room
8:30-8:45	Day's Objectives	Hildy Reiser	Kohlberg Room
8:45-12:00	Breakout Sessions – Evaluation of Potential Vital Signs and review of group list	Facilitators	Breaks as needed; See room assignments from June 14
12:00-1:00	Lunch		
1:00-2:00	Breakout Sessions Continue	Facilitators	Assigned Rooms
2:00-2:30	Presentation of Prioritized Vital Signs List + Discussion	Hildy Reiser	Kohlberg Room
2:30-3:00	Wrap-Up and Future Plans	Hildy Reiser	Kohlberg Room

Each break-out group worked through its list, one vital sign at a time, and reviewed fields containing information on justifications, potential measures,

and partners. Each break-out group participant was provided with a tally sheet that allowed each participant to track his or her scores by ecosystem for each vital sign. This allowed members to give full attention to the discussions and not worry about remembering scores. CHDN staff set up a spreadsheet ahead of time, whereby the note taker could quickly enter each group member's ecological significance score by ecosystem. The average, median, and mode were calculated for each vital sign by ecosystem. If the group felt the average value was not representative, a consensus score was provided via discussion. This was necessary when individual scores were bimodal. For example, if half indicated that the ecological significance score should be a 1 or 2, and the other half indicated 4 or 5, then the discrepancy was discussed before a final score was assigned. Median and modal values that were quite different from the average value provided a good indication that the mean value was not representative and that a refined score should be produced through consensus. Each break-out group was allowed to add vital signs to the list. Thirty-seven 'new' vital signs (generated by renaming of original vital signs, combining multiple vital signs into a newly titled vital sign, splitting original vital signs, and generating completely new vital signs) were added from the five break-out groups evaluating seven ecosystems. This data set was reduced to a total of 86 potential vital signs (Table P.5). Vital signs lists were also produced for each ecosystem (Tables P.6-P.12, see color key at the end of each table). The rankings of the vital signs in Tables P.6-P.12 are based on the rankings for only the ecosystem referenced in the table.

The break-out groups were also encouraged to write additional comments for each vital sign that pertained to scoring, justifications, monitoring objectives, measures, or other. All break-out groups also had suggestions for merging and combining vital signs (see the following links to the break-out group databases: Animals, Aquatics, Landscape, Plants and Soils, and Unique.

Table P.5. All CHDN vital signs ranked at the Vital Signs Prioritization Workshop (Phase II).

Graph of ranking of all vital signs

Final ID	Level 1	Level 2	Level 3	Vital Sign	Ranked Score
86	Water	Hydrology	Groundwater Dynamics	Groundwater dynamics in dune systems	8
84	Water	Hydrology	Groundwater Dynamics	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.53
129	New-Water	New-Hydrology	New-Surface Water Dynamics	Watershed hydrology	7.44
56	Geology and Soils	Geomorphology	Windblown Features and Processes	Dune reactivation	7.2
122	New-Water	New-Water Quality	New-Water Quality	Water quality (surface and groundwater)	7.129
112	Biological Integrity	Invasive Species	Invasive/Exotic Animals	Distribution of non-native animals	6.87
78	Landscapes	Landscape Dynamics	Land Cover and Use	Landscape dynamics (land cover, pattern & patch sizes changes)	6.8
114	New-Biological Integrity	New-Focal Species or Communities	New-Cave Communities	Microbial biofilm formation	6.765
110	Biological Integrity	Invasive Species	Invasive/Exotic Plants	Distribution & abundance of invasive/non-native plants	6.71
55	Geology and Soils	Geomorphology	Windblown Features and Processes	Dune formation and stability	6.67
126	New-Biological Integrity	New-Focal Species or Communities	New-Soil Communities	Lichen/mosses as biomonitors	6.67
111	Biological Integrity	Focal Species or Communities	Terrestrial Complex	Phenology (leaf out/drop, flowering)/tree growth bands	6.656
7	Air and Climate	Weather and Climate	Weather and Climate	General meteorological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.64
105	Water	Hydrology	Surface Water Dynamics	Lake elevation for Amistad Reservoir	6.64
75	Landscapes	Extreme Disturbance Events	Extreme Disturbance Events	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.6
28	Biological Integrity	Focal Species or Communities	Riparian communities	Bird communities	6.555
115	New-Water	New-Water Quality	New-Water Chemistry	Sediment quality	6.52
79	Landscapes	Landscape Dynamics	Land Cover and Use	Vegetation patch dynamics (microscale)	6.5

Final ID	Level 1	Level 2	Level 3	Vital Sign	Ranked Score
116	New-Air and Climate	New-Air Quality	New-Visibility and Particulate Matter	Visibility	6.5
24	Biological Integrity	Focal Species or Communities	Mammals	Relative abundance of bats	6.465
107	Landscapes	Landscape Dynamics	Land Cover and Use	Landscape fragmentation and connectivity	6.4
108	Landscapes	Landscape Dynamics	Land Cover and Use	Land use changes within Chihuahuan Desert	6.4
139	New-Water	New-Hydrology	New-Surface Water Dynamics	Surface water dynamics (hydroperiods, flow rates and quantity)	6.376
119	New-Biological Integrity	New-Focal Species or Communities	New-Vegetation Complex	Plant community composition	6.36
132	New-Biological Integrity	New-Focal Species or Communities	New-Freshwater Invertebrates	Invertebrates in aquatic systems	6.34
135	New-Biological Integrity	New-Focal Species or Communities	New-Sparsely Vegetated Communities	Bare ground	6.24
10	Biological Integrity	At-risk Biota	T&E Species and Communities	Distribution & relative abundance of animal species of concern	6.215
103	Water	Hydrology	Surface Water Dynamics	Persistence of springs & seeps	6.215
123	New-Air and Climate	New-Air Quality	New-Wet and dry Deposition	Atmospheric wet/dry deposition	6.181
120	New-Air and Climate	New-Air Quality	New-Visibility and Particulate Matter	Particulate matter	6.18
130	New-Biological Integrity	New-Focal Species or Communities	New-Fishes	Native and non-native fish in aquatic systems	6.142
76	Landscapes	Fire and Fuel Dynamics	Fire and Fuel Dynamics	Fire and fuel dynamics	6.073
137	New-Geology and Soils	New-Soil Quality	New-Soil Function and Dynamics	Soil erosion (wind and water)	5.993
16	Biological Integrity	Focal Species or Communities	Dune Communities	Species richness & diversity of dune biota, esp. white-coloration species	5.865
102	Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	Species richness & diversity of amphibians	5.845
62	Water	Water Quality	Water Chemistry	Water quality (core parameters: T, DO, cond, pH) of cave pools	5.8

Final ID	Level 1	Level 2	Level 3	Vital Sign	Ranked Score
54	Geology and Soils	Geomorphology	Stream/River Channel Characteristics	Geomorphology/channel characteristics of perennial rivers and streams	5.793
133	New-Biological Integrity	Focal Species or Communities	New-Vegetation Complex	Elevational/latitudinal shifts in plant distribution	5.75
35	Biological Integrity	Focal Species or Communities	Desert Community	Biological soil crusts	5.745
65	Air and Climate	Weather and Climate	Weather and Climate	Cave microclimate	5.7
127	New-Biological Integrity	New-Focal Species or Communities	New-Freshwater Communities	Vertebrates other than fish in aquatic systems	5.696
117	New-Biological Integrity	New-Focal Species or Communities	New-Vegetation Complex	Plant community distribution	5.695
134	New-Geology and Soils	New-Geomorphology	New-Soil Function and Dynamics	Sedimentation alluvial and aeolian	5.615
136	New-Biological Integrity	New-Focal Species or Communities	New-Riparian Communities	Riparian vegetation communities	5.585
80	Geology and Soils	Soil Quality	Soil Function and Dynamics	Nutrient levels	5.576
124	New-Biological Integrity	New-Invasive Species	New-Invasive/Exotic Animals	Distribution of non-native terrestrial insects	5.57
3	Air and Climate	Air Quality	Ozone	Ozone	5.5
138	New-Biological Integrity	New-Focal Species or Communities	New-Freshwater Communities	Algal communities	5.5
26	Biological Integrity	Focal Species or Communities	Mammals	Distribution of broad-ranging species (black bears, mt. lion, mule deer)	5.455
95	Water	Water Quality	Microorganisms	Microbiotic components (esp. E. coli)	5.43
128	New-Landscapes	New-Landscape Dynamics	New-Land Cover and Use	Animal metapopulations and movement	5.38
125	New-Biological Integrity	New-Focal Species or Communities	New-Vegetation Complex	Plant species richness	5.36
60	Geology and Soils	Soil Quality	Soil Function and Dynamics	Soil health (stability, compaction, infiltration)	5.3
118	New-Biological Integrity	New-Focal Species or Communities	New-Terrestrial Invertebrates	Richness and diversity of terrestrial insects esp. endemics	5.23

Final ID	Level 1	Level 2	Level 3	Vital Sign	Ranked Score
131	New-Biological Integrity	New-Focal Species or Communities	New-Desert Communities	Pollinator-mediated plant reproductive success	5.205
14	Biological Integrity	Focal Species or Communities	Cave Communities	Species richness & diversity of cave pool biota	5.2
140	New-Biological Integrity	New-At-risk Biota	New-Freshwater Invertebrates	Contaminants in aquatic or semi-aquatic vertebrates	5.079
85	Water	Hydrology	Groundwater Dynamics	Groundwater dynamics in cave systems	4.946
33	Biological Integrity	Focal Species or Communities	Soil Communities	Soil microbes and other soil biota	4.945
59	Geology and Soils	Soil Quality	Soil Function and Dynamics	Soil chemistry	4.935
1	Air and Climate	Air Quality	Air contaminants	Atmospheric deposition of mercury	4.884
15	Biological Integrity	Focal Species or Communities	Cave Communities	Species richness & diversity of cave microbial communities	4.83
121	New-Biological Integrity	New-Focal Species or Communities	New-Cave Communities	Cave invertebrate populations	4.7
71	Human Use	Visitor and Recreation Use	Visitor use	Effects of park visitors on natural resources	4.613
6	Air and Climate	Weather and Climate	Weather and Climate	Carbon balance in soil	4.535
12	Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	Species richness & diversity of reptile community	4.43
13	Biological Integrity	Focal Species or Communities	Cave Communities	Species richness & diversity of cave biota	4.2
8	Biological Integrity	At-risk Biota	T&E Species and Communities	Collecting/poaching of species, esp. special concern	4.051
42	Biological Integrity	Focal Species or Communities	Terrestrial Complex	Animal communities in special/relic habitats	4
69	Human Use	Point Source Human Effects	Point Source Human Effects	Visitor use at springs and seeps	3.935
9	Biological Integrity	At-risk Biota	T&E Species and Communities	Distribution & reproduction of plant species of concern	3.73
53	Geology and Soils	Geomorphology	Lake Features and Processes	Reservoir siltation	3.283

Final ID	Level 1	Level 2	Level 3	Vital Sign	Ranked Score
74	Human Use	Visitor and Recreation Use	Visitor Use	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.15
11	Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	Mutation (=malformation) frequencies in amphibians	2.8
27	Biological Integrity	Focal Species or Communities	Mammals	Small to moderate-sized carnivores	2.3
51	Biological Integrity	Invasive Species	Invasive/Exotic Plants	Distribution of hydrilla (recreation issue)	1.836
82	Landscapes	Viewscape	Viewscape/Dark Night Sky	Night skies	1.796
63	Geology and Soils	Subsurface Geologic Processes	Cave/Karst	Water volume of pools	1.68
70	Human Use	Point Source Human Effects	Point-Source Human Effects	Human-caused fire	1.6
67	Geology and Soils	Subsurface Geologic Processes	Cave/Karst Features and Processes	Caves/karst features	1.48
2	Air and Climate	Air Quality	Air contaminants	Air quality in caves	1.468
104	Water	Hydrology	Surface Water Dynamics	Water quantity and shoreline shape of Lake Lucero	1.424
81	Landscapes	Soundscape	Soundscape	Soundscape, especially in wilderness areas	1.36
50	Biological Integrity	Invasive Species	Invasive/Exotic Plants	Golden algae (Parmesium parvum) distribution - exotic	1.352
29	Biological Integrity	Focal Species or Communities	Terrestrial Invertebrates	Terrestrial non-insect invertebrates	1.286
40	Biological Integrity	Focal Species or Communities	Riparian Community	Historic cottonwood grove	1.2

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

Table P.6. CHDN vital signs for the Desert ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Desert Vital Signs

Final ID	Network Vital Sign	Ranked Score
84	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.530
129	Watershed hydrology	7.440
121	Water quality (surface and groundwater)	7.195
111	Phenology (leaf out/drop, flowering)/tree growth bands	6.875
112	Distribution of non-native animals	6.870
78	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
126	Lichen/mosses as biomonitors	6.670
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
115	Sediment quality	6.520
79	Vegetation patch dynamics (microscale)	6.500
116	Visibility	6.500
107	Landscape fragmentation and connectivity	6.400
108	Land use changes within Chihuahuan Desert	6.400
24	Relative abundance of bats	6.385
139	Surface water dynamics (hydroperiods, flow rates and quantity)	6.375
119	Plant community composition	6.360
132	Invertebrates in aquatic systems	6.318
122	Atmospheric wet/dry deposition	6.278
135	Bare ground	6.240
10	Distribution & relative abundance of animal species of concern	6.215
103	Persistence of springs & seeps	6.215
120	Particulate matter	6.180
137	Soil erosion (wind and water)	6.010
54	Geomorphology/channel characteristics of perennial rivers and streams	5.910
130	Native and non-native fish in aquatic systems	5.858
102	Species richness & diversity of amphibians	5.845
133	Elevational/latitudinal shifts in plant distribution	5.750
35	Biological soil crusts	5.745
127	Vertebrates other than fish in aquatic systems	5.695
76	Fire and fuel dynamics	5.640
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
136	Riparian vegetation communities	5.585
124	Distribution of non-native terrestrial insects	5.570
138	Algal communities	5.500

Final ID	Network Vital Sign	Ranked Score
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
3	Ozone	5.300
60	Soil health (stability, compaction, infiltration)	5.300
118	Richness and diversity of terrestrial insects esp. endemics	5.230
80	Nutrient levels	5.220
131	Pollinator-mediated plant reproductive success	5.205
33	Soil microbes and other soil biota	4.945
59	Soil chemistry	4.935
1	Atmospheric deposition of mercury	4.765
26	Distribution of broad-ranging species (mt. lion, mule deer)	4.610
71	Effects of park visitors on natural resources	4.555
6	Carbon balance in soil	4.535
12	Species richness & diversity of reptile community	4.430
8	Collecting/poaching of species, esp. special concern	4.420
140	Contaminants in aquatic or semi-aquatic vertebrates	4.256
42	Animal communities in special/relic habitats	4.000
69	Visitor use at springs and seeps	3.935
9	Distribution & reproduction of plant species of concern	3.730
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
27	Small to moderate-sized carnivores	2.300
82	Night skies	1.796
70	Human-caused fire	1.600
104	Water quantity and shoreline shape of Lake Lucero - WHSA only	1.424
81	Soundscape, especially in wilderness areas	1.360
29	Terrestrial non-insect invertebrates	1.286

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

Table P.7. CHDN vital signs for the Foothills ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Foothills Vital Signs

Final ID	Network Vital Sign	Ranked Score
84	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.530
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	7.195
111	Phenology (leaf out/drop, flowering)/tree growth bands	6.875
112	Distribution of non-native animals	6.870
78	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
126	Lichen/mosses as biomonitors	6.670
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
115	Sediment quality	6.520
79	Vegetation patch dynamics (microscale)	6.500
116	Visibility	6.500
107	Landscape fragmentation and connectivity	6.400
108	Land use changes within Chihuahuan Desert	6.400
24	Relative abundance of bats	6.385
139	Surface water dynamics (hydroperiods, flow rates and quantity)	6.375
119	Plant community composition	6.360
132	Invertebrates in aquatic systems	6.318
25	Black bear abundance & distribution	6.300
123	Atmospheric wet/dry deposition	6.278
135	Bare ground	6.240
10	Distribution & relative abundance of animal species of concern	6.215
103	Persistence of springs & seeps	6.215
76	Fire and fuel dynamics	6.190
120	Particulate matter	6.180
35	Biological soil crusts	6.025
137	Soil erosion (wind and water)	6.010
54	Geomorphology/channel characteristics of perennial rivers and streams	5.910
130	Native and non-native fish in aquatic systems	5.858
102	Species richness & diversity of amphibians	5.845
133	Elevational/latitudinal shifts in plant distribution	5.750
127	Vertebrates other than fish in aquatic systems	5.698
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
136	Riparian vegetation communities	5.585

Final ID	Network Vital Sign	Ranked Score
124	Distribution of non-native terrestrial insects	5.570
138	Algal communities	5.500
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
3	Ozone	5.300
60	Soil health (stability, compaction, infiltration)	5.300
118	Richness and diversity of terrestrial insects esp. endemics	5.230
80	Nutrient levels	5.220
131	Pollinator-mediated plant reproductive success	5.205
33	Soil microbes and other soil biota	4.945
59	Soil chemistry	4.935
1	Atmospheric deposition of mercury	4.815
26	Distribution of broad-ranging species (mt. lion, mule deer)	4.610
71	Effects of park visitors on natural resources	4.555
6	Carbon balance in soil	4.535
12	Species richness & diversity of reptile community	4.430
8	Collecting/poaching of species, esp. special concern	4.420
140	Contaminants in aquatic or semi-aquatic vertebrates	4.256
42	Animal communities in special/relic habitats	4.000
69	Visitor use at springs and seeps	3.935
9	Distribution & reproduction of plant species of concern	3.730
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
27	Small to moderate-sized carnivores	2.300
82	Night skies	1.796
70	Human-caused fire	1.600
81	Soundscape, especially in wilderness areas	1.360
29	Terrestrial non-insect invertebrates	1.286
40	Historic cottonwood grove	1.200

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

Table P.8. CHDN vital signs for the Mountain ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Mountain Vital Signs

Final ID	Network Vital Sign	Ranked Score
84	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.530
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	7.195
112	Distribution of non-native animals	6.870
78	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
126	Lichen/mosses as biomonitors	6.670
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
115	Sediment quality	6.520
79	Vegetation patch dynamics (microscale)	6.500
116	Visibility	6.500
107	Landscape fragmentation and connectivity	6.400
108	Land use changes within Chihuahuan Desert	6.400
76	Fire and fuel dynamics	6.390
24	Relative abundance of bats	6.385
139	Surface water dynamics (hydroperiods, flow rates and quantity)	6.375
119	Plant community composition	6.360
25	Black bear abundance & distribution	6.300
123	Atmospheric wet/dry deposition	6.278
132	Invertebrates in aquatic systems	6.278
135	Bare ground	6.240
10	Distribution & relative abundance of animal species of concern	6.215
103	Persistence of springs & seeps	6.215
120	Particulate matter	6.180
3	Ozone	6.100
35	Biological soil crusts	6.025
137	Soil erosion (wind and water)	6.010
111	Phenology (leaf out/drop, flowering)/tree growth bands	6.000
102	Species richness & diversity of amphibians	5.845
133	Elevational/latitudinal shifts in plant distribution	5.750
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
124	Distribution of non-native terrestrial insects	5.570
138	Algal communities	5.500
127	Vertebrates other than fish in aquatic systems	5.475

Final ID	Network Vital Sign	Ranked Score
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
60	Soil health (stability, compaction, infiltration)	5.300
118	Richness and diversity of terrestrial insects esp. endemics	5.230
80	Nutrient levels	5.220
131	Pollinator-mediated plant reproductive success	5.205
33	Soil microbes and other soil biota	4.945
59	Soil chemistry	4.935
1	Atmospheric deposition of mercury	4.815
26	Distribution of broad-ranging species (mt. lion, mule deer)	4.610
71	Effects of park visitors on natural resources	4.555
6	Carbon balance in soil	4.535
12	Species richness & diversity of reptile community	4.430
8	Collecting/poaching of species, esp. special concern	4.085
42	Animal communities in special/relic habitats	4.000
69	Visitor use at springs and seeps	3.935
9	Distribution & reproduction of plant species of concern	3.730
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
27	Small to moderate-sized carnivores	2.300
82	Night skies	1.796
70	Human-caused fire	1.600
81	Soundscape, especially in wilderness areas	1.360
29	Terrestrial non-insect invertebrates	1.286

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

Table P.9. CHDN vital signs for the Reservoir ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Reservoir Vital Signs

Final ID	Network Vital Sign	Ranked Score
84	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.530
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	6.925
112	Distribution of non-native animals	6.870
76	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
24	Relative abundance of bats	6.665
105	Lake elevation for Amistad Reservoir - AMIS only	6.640
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
115	Sediment quality	6.520
132	Invertebrates in aquatic systems	6.515
116	Visibility	6.500
108	Land use changes within Chihuahuan Desert	6.400
107	Landscape fragmentation and connectivity	6.400
119	Plant community composition	6.360
103	Persistence of springs & seeps	6.215
10	Distribution & relative abundance of animal species of concern	6.215
120	Particulate matter	6.180
78	Nutrient levels	6.050
123	Atmospheric wet/dry deposition	5.940
137	Soil erosion (wind and water)	5.910
130	Native and non-native fish in aquatic systems	5.858
102	Species richness & diversity of amphibians	5.845
127	Vertebrates other than fish in aquatic systems	5.695
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
138	Algal communities	5.500
95	Microbiotic components (esp. E. coli)	5.430
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
140	Contaminants in aquatic or semi-aquatic vertebrates	5.078
1	Atmospheric deposition of mercury	5.065
12	Species richness & diversity of reptile community	4.430
71	Effects of park visitors on natural resources	4.368
69	Visitor use at springs and seeps	3.935

Final ID	Network Vital Sign	Ranked Score
53	Reservoir siltation	3.283
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
51	Distribution of hydrilla (recreation issue) - AMIS only	1.836
82	Night skies	1.796
81	Soundscape, especially in wilderness areas	1.360
50	Golden algae (Parmesium parvum) distribution - exotic	1.352

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

Table P.10. CHDN vital signs for the River ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of River Vital Signs

Final ID	Network Vital Sign	Ranked Score
84	Groundwater dynamics (flow patterns, rates, levels, groundwater interaction with surface water)	7.530
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	6.925
112	Distribution of non-native animals	6.870
78	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
105	Lake elevation for Amistad Reservoir - AMIS only	6.640
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
115	Sediment quality	6.520
116	Visibility	6.500
108	Land use changes within Chihuahuan Desert	6.400
107	Landscape fragmentation and connectivity	6.400
24	Relative abundance of bats	6.385
139	Surface water dynamics (hydroperiods, flow rates and quantity)	6.375
119	Plant community composition	6.360
132	Invertebrates in aquatic systems	6.343
25	Black bear abundance & distribution	6.300
123	Atmospheric wet/dry deposition	6.278
103	Persistence of springs & seeps	6.215
10	Distribution & relative abundance of animal species of concern	6.215
120	Particulate matter	6.180
80	Nutrient levels	6.050
137	Soil erosion (wind and water)	6.010
54	Geomorphology/channel characteristics of perennial rivers and streams	5.910
130	Native and non-native fish in aquatic systems	5.858
102	Species richness & diversity of amphibians	5.845
127	Vertebrates other than fish in aquatic systems	5.695
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
136	Riparian vegetation communities	5.585
138	Algal communities	5.500
95	Microbiotic components (esp. E. coli)	5.430
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
140	Contaminants in aquatic or semi-aquatic vertebrates	5.078

Final ID	Network Vital Sign	Ranked Score
1	Atmospheric deposition of mercury	5.065
71	Effects of park visitors on natural resources	4.555
12	Species richness & diversity of reptile community	4.430
69	Visitor use at springs and seeps	3.935
9	Distribution & reproduction of plant species of concern	3.730
53	Reservoir siltation	3.283
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
51	Distribution of hydrilla (recreation issue) - AMIS only	1.836
82	Night skies	1.796
81	Soundscape, especially in wilderness areas	1.360
50	Golden algae (Parmesium parvum) distribution - exotic	1.352
	Top ranked VS group	
	VS in group after top ranked VS (1st break)	
	VS in group after 2nd major break	
	VS in group after 3rd or "sharpest" break	
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.	

Table P.11. CHDN vital signs for the Caves ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Caves Vital Signs

Final ID	Network Vital Sign	Ranked Score
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	7.235
114	Microbial biofilm formation	6.765
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
108	Land use changes within Chihuahuan Desert	6.400
24	Relative abundance of bats	6.385
123	Atmospheric wet/dry deposition	6.278
85	Groundwater dynamics in cave systems	6.238
103	Persistence of springs & seeps	6.215
9	Distribution & relative abundance of animal species of concern	6.215
120	Particulate matter	6.180
80	Nutrient levels	6.050
62	Water quality (core parameters: T, DO, cond, pH) of cave pools	5.800
65	Cave microclimate	5.700
134	Sedimentation alluvial and aeolian	5.615
95	Microbiotic components (esp. E. coli)	5.430
128	Animal metapopulations and movement	5.380
14	Species richness & diversity of cave pool biota	5.200
71	Effects of park visitors on natural resources	5.050
15	Species richness & diversity of cave microbial communities	4.830
1	Atmospheric deposition of mercury	4.830
121	Cave invertebrate populations	4.700
13	Species richness & diversity of cave biota	4.200
8	Collecting/poaching of species, esp. special concern	3.665
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
27	Small to moderate-sized carnivores	2.300
63	Water volume of pools	1.680
70	Human-caused fire	1.600
67	Caves/karst features	1.480
2	Air quality in caves	1.468
81	Soundscape, especially in wilderness areas	1.360
	Top ranked VS group	
	VS in group after top ranked VS (1st break)	
	VS in group after 2nd major break	
	VS in group after 3rd or "sharpest" break	

Final ID	Network Vital Sign	Ranked Score
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.	

Table P.12. CHDN vital signs for the Dunes ecosystem ranked at the vital signs prioritization workshop.

Graph of ranking of Dunes Vital Signs

Final ID	Network Vital Sign	Ranked Score
86	Groundwater dynamics in dune systems	8.000
129	Watershed hydrology	7.440
122	Water quality (surface and groundwater)	7.235
56	Dune reactivation	7.200
111	Phenology (leaf out/drop, flowering)/tree growth bands	6.875
112	Distribution of non-native animals	6.870
78	Landscape dynamics (land cover, pattern & patch sizes changes)	6.800
110	Distribution & abundance of invasive/non-native plants	6.710
126	Lichen/mosses as biomonitors	6.670
55	Dune formation and stability	6.670
24	Relative abundance of bats	6.665
7	General meterological conditions (precip, wind, RH, T, snow pack, soil moisture)	6.640
75	Distribution & characterization of extreme disturbance events (fire, insect/pathogen outbreaks, floods)	6.600
28	Bird communities	6.555
116	Visibility	6.500
79	Vegetation patch dynamics (microscale)	6.500
108	Land use changes within Chihuahuan Desert	6.400
107	Landscape fragmentation and connectivity	6.400
119	Plant community composition	6.360
132	Invertebrates in aquatic systems	6.270
135	Bare ground	6.240
103	Persistence of springs & seeps	6.215
10	Distribution & relative abundance of animal species of concern	6.215
120	Particulate matter	6.180
137	Soil erosion (wind and water)	6.010
123	Atmospheric wet/dry deposition	5.940
16	Species richness & diversity of dune biota, esp. white-coloration species	5.865
102	Species richness & diversity of amphibians	5.845
133	Elevational/latitudinal shifts in plant distribution	5.750
35	Biological soil crusts	5.745
117	Plant community distribution	5.640
134	Sedimentation alluvial and aeolian	5.615
124	Distribution of non-native terrestrial insects	5.570
128	Animal metapopulations and movement	5.380
125	Plant species richness	5.360
60	Soil health (stability, compaction, infiltration)	5.300
3	Ozone	5.300
118	Richness and diversity of terrestrial insects esp. endemics	5.230
80	Nutrient levels	5.220

Final ID	Network Vital Sign	Ranked Score
131	Pollinator-mediated plant reproductive success	5.205
33	Soil microbes and other soil biota	4.945
59	Soil chemistry	4.935
1	Atmospheric deposition of mercury	4.830
71	Effects of park visitors on natural resources	4.653
26	Distribution of broad-ranging species (mt. lion, mule deer)	4.610
12	Species richness & diversity of reptile community	4.430
42	Animal communities in special/relic habitats	4.000
9	Distribution & reproduction of plant species of concern	3.730
8	Collecting/poaching of species, esp. special concern	3.665
74	Visitor satisfaction relative to feature attractions (ie bats at the caverns)	3.150
11	Mutation (=malformation) frequencies in amphibians	2.800
27	Small to moderate-sized carnivores	2.300
82	Night skies	1.796
81	Soundscape, especially in wilderness areas	1.360
29	Terrestrial non-insect invertebrates	1.286

	Top ranked VS group
	VS in group after top ranked VS (1st break)
	VS in group after 2nd major break
	VS in group after 3rd or "sharpest" break
	New VS identified by the 5 Break Out Groups from Vital Signs Workshop. In most cases the new VS combined one or more original VSs, or renamed an original VS. The renamed VS was considered a more appropriate description of the intent of the VS.

P.4. Vital Signs Prioritization Workshop – Scoring Criteria

The following subsections provide the documentation for the vital signs scoring process.

P.4.1. Ranked Scores For Vital Signs

The rank score for each of the 86 unique vital signs was calculated using the formula:

$$(ES + [1/2 * MS]) \times JS_{max}$$

where ES was the Ecological Significance Score provided at the prioritization workshop (possible value range 1-5), the MS was the Management Significance Score value provided prior to the prioritization workshop (possible value range 1-6), and JS was the Justification Score which was a weight assigned according to the type of source used to justify the vital sign's ecological or management significance (values: 0.4, 0.7, or 1.0). The maximum JS was applied for each ecosystem. This allowed for a range of Rank Scores of 0.6 to 8.0. See Sections 4.2, 4.3 and 4.4 for the specific criteria.

As previously stated, the consolidated list included some newly titled vital signs per the recommendations of the group participants at the prioritization workshop. If more than one group ranked an existing or related new vital sign, those scores were averaged to produce the rank score given in the consolidated list. Likewise, if a vital sign was considered applicable to more than one ecosystem, then the rank score given in the consolidated list is an average score among the ecosystems.

For each list of vital signs and associated rank scores (consolidated and by ecosystem), a graph shows the descending order of ranks. These graphs provided a means for visualizing natural breaks in the rank scores and hence a means for grouping the highest ranked vital signs. Groupings of the vital signs in all lists have been color-coded. These groupings and represented prioritization provided a template for discussing the important vital signs that may eventually be monitored.

P.4.2. Justification Sources

In order to justify the selection of all vital signs that are ultimately monitored, it was important for us to know *why* any given vital sign was suggested and the *source* of information that provided the explanation (see Table P.13). To facilitate compilation of potential vital signs, justifications, and associated sources during these two days, participants were asked to prepare prior to attending the workshop. They were asked to develop their own top list of vital signs from the unique vital signs produced from the Phase I process. They were also asked to provide a list of references that would help justify the selection of those vital signs, and they were asked to bring supporting information for those vital signs.

Table P.13. Justification sources for use in the Chihuahuan Desert Network Prioritization Workshop.

Class Name	Definition and Examples	Citation
Legally Mandated	A vital sign that should be monitored because of an existing or legal mandate from Congress. For example, monitoring of a Threatened or Endangered Species. The name of the act or regulation identifier could be given.	ESA (1974; Fed. Reg. (1993:pp)
Management Priority	Chosen because there is a non-legally binding management need to understand trends in this vital sign. NPS or acronym of a particular unit could be used along with a year or date of established policy (if present) to identify this source.	NPS (2002); CAVE
Personal Observation	Recommended vital sign based on personal observations, professional judgment, or unpublished data analysis. Patterns that have been established through repeated or occasional, casual observation. Last name of observer and abbreviation for personal observation should be used to identify this source.	Davila (pers. obs.)
Non-peer Reviewed Literature	Information that has not undergone specific review for scientific process or content accuracy. This category can include reports, models, articles, and books. Cite according to last name(s) of author(s) and year produced.	Reiser et al. (2006)
Peer-reviewed	Information that has undergone specific review for scientific process or content accuracy. This category can include journal articles, edited books, and published models.	Havstad et al. (2002)

Weightings of justification sources were not revealed to participants at the time of the workshop in order to avoid bias in their responses. The weightings were applied after the workshop, and the data were exported into MSQL for data analysis. Justification source scores were applied as the maximum score for each vital sign by each ecosystem. The weightings were broken down as follows:

- 1.0– Peer-reviewed Literature or Legally Mandated
- 0.7 – Non-peer Reviewed Literature or Management Priority
- 0.4 – Personal Observation

P.4.3. Ecological Significance Scores

Each vital sign was also ranked according to possible influence on the function of a given ecosystem (Ecological Significance). Seven ranking criteria were used to by each participant determine the scoring. The note taker entered a number (with up to 1 decimal place) for the ecological significance score.

The ranking questions were as follows:

For this potential vital sign, how many of the following statements do you STRONGLY AGREE with?

- There is a strong, defensible linkage between the vital sign and the ecological function or critical resource it is intended to represent (supported by ecological literature or knowledge of system).
- The vital sign provides an early warning of changes to ecosystems or signifies an impending change in the ecological system. [Note: replace the term ecosystem with landscape or population, as appropriate.]
- The vital sign responds to change in a predictable and explainable matter.
- The vital sign has low natural variability (high signal to noise ratio).
- There are reference conditions that exist within the region and/or threshold values that could be determined to assess deviance from a natural condition.
- The vital sign reflects the capacity of key ecosystem processes to resist or recover from change induced by exposure to natural disturbances and/or anthropogenic stressors. [Note: replace the term ecosystem with landscape or population, as appropriate.]
- The vital sign represents a resource or function of high ecological importance based on the supporting ecological literature and knowledge of the system.

The final score was tabulated based on total number of statements the reviewer agreed with. Scores were broken down as follows:

Scores:

- **5** = Participant agrees that 6-7 statements apply to proposed vital sign
- **4** = Participant agrees that 4-5 statements apply to proposed vital sign
- **3** = Participant agrees that 3 statements apply to proposed vital sign
- **2** = Participant agrees that 2 statements apply to proposed vital sign
- **1** = Participant agrees that 1 statement apply to proposed vital sign
- **0** = Participant agrees that none of these statements apply

P.4.4. Management Significance Scores

The final score was the average of all respondents' scores for a particular vital sign. For 'new' vital signs generated from the workshop, only the technical committee members provided management significance scores, but they were allowed to discuss their scores with other park staff. The final management significance score was an average for all six parks.

The eight ranking criteria for management concern score (MC) were included in a handout that was used by park staff and the Technical Committee for scoring original and 'new' vital signs:

For this potential vital sign, how many of the following statements do you STRONGLY AGREE with?

- There is an obvious, direct application of the data to a key management decision, or for evaluating the effectiveness of past management decisions.
- The vital sign will produce results that are clearly understood and accepted by park managers, other policy makers, research scientists, and the general public.
- Monitoring results are likely to provide early warning of resource impairment, and will save park resources and money if a problem is discovered early.
- In cases where data will be used primarily to influence external decisions, the decisions will affect key resources in the park, and there is a great potential for the park to influence the external decisions.
- Data are of high interest to the public.
- For species-level monitoring, involves species that are harvested, endemic, invasive, or at-risk biota.
- There is an obvious, direct application of the data to performance (GPRA) goals.
- Contributes to increased understanding that ultimately leads to better management.

The final score was tabulated based on the number of statements the reviewer agreed with. Scores were broken down as follows:

Scores:

- **6** = Participants agree that 7-8 statements apply to proposed vital sign
- **5** = Participants agree that 5-6 statements apply to proposed vital sign
- **4** = Participants agree that 4 statements apply to proposed vital sign

- **3** = Participants agree that 3 statements apply to proposed vital sign
- **2** = Participants agree that 2 statement apply to proposed vital sign
- **1** = Participants agree that 1 statement applies to proposed vital sign
- **0** = Participants agree that none of these statements apply