



Southern Plains Network Vital Signs Monitoring Plan Phase 2 Report - Appendices

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Alibates Flint Quarries NM
Bent's Old Fort NHS
Capulin Volcano NM
Chickasaw NRA
Fort Larned NHS
Fort Union NM
Lake Meredith NRA
Lyndon. B. Johnson NHP
Pecos NHP
Sand Creek Massacre NHS
Washita Battlefield NHS

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APPENDIX A. PARK NATURAL RESOURCE SUMMARIES

A.1 ALIBATES FLINT QUARRIES NATIONAL MONUMENT (ALFL)

Alibates Flint Quarries National Monument (ALFL) is 1,371 acres (555 ha) in size, and is located adjacent to the boundaries of Lake Meredith National Recreation Area (LAMR), approximately 21 miles (34 km) North of Amarillo in the Panhandle of Texas. For thousands of years, people have come to these red bluffs above the Canadian River for Alibates Flint, distributing it through the Great Plains and beyond. The occurrence of extensive quarry pits at the Alibates Flint Quarries and caches of large, thin bifaces at the Alibates Ruin document the intensive prehistoric mining and manufacturing occurring during the Antelope Creek phase (A.D. 1200 – 1500). Numerous Panhandle Aspect village ruins and a series of petroglyphs are found within the national monument in association with the concentration of 734 flint quarry pits. ALFL was established in 1965 and is currently managed by the staff at Lake Meredith National Recreation Area. Public access at ALFL is only available by ranger-guided tours. There were 1,794 visitors in 2004.

A.1.1 Resource Overview

The land surface at ALFL is nearly flat and slopes to the southeast at approximately 8 to 10 feet (2.4 – 3 m) per mile. In the vicinity of Lake Meredith, this flat surface has been downcut by the Canadian River and its tributaries, causing canyons or “breaks”, some of which are now filled by Lake Meredith. The Alibates Dolomite is Permian in age and contains an abundance of flint, which was used by some of the earliest humans to make tools and points. The flint can often be found in alternating beds of gray and red.

The Canadian River Basin climate is characterized as semi-arid with an average annual rainfall of 20 inches (51 cm) per year. Seventy percent of the precipitation falls between April and September, which is the primary growing season. This area has hot summers and cold winters with strong winds that work to increase evaporation rates, which have been estimated to average 60-65% of the total precipitation. Elevation is approximately 3,200 feet (975 m).

A.1.2 Enabling Legislation / Management Documents

On August 21, 1965, by Public Law 89-154, Congress recognized the national significance of a unique segment of Lake Meredith Recreation Area by creating the Alibates Flint Quarries and Texas Panhandle Pueblo Culture National Monument, “to provide for the preservation and public use of a concentration of unique flint quarries, used as a source of raw materials for weapons and tools by High Plains prehistoric cultures spanning 12,000 years.” The mission is defined as “to preserve and present to the public in an acceptable manner the extensive flint quarries associated with prehistoric man and the ruins of several village sites of the Panhandle Aspect culture of the Plains Village Indians.” Congress amended the park’s enabling act on November 10, 1978, by Public Law 95-625, to redesignate the monument as the Alibates Flint Quarries National Monument. The original 91-acre (37 ha) monument area is listed in the National Register of Historic Places. There is no other archeological area in the National Park System has been used as long and as continuously by humans. Thus, the monument contributes significantly toward understanding Indian occupation in the Region that spanned over 12,000 years. The monument is important for providing an understanding of the techniques involved in making chipped-stone artifacts which is fundamental to the study of archeology and to understanding prehistoric cultures.

There has been no General Management Plan created for LAMR. The most recent Resource Management Plan was completed in 1996 (Lake Meredith National Recreation Area 1996). An oil and gas management plan was developed in 2002 (Lake Meredith National Recreation Area 2002).

A.1.3 Natural Resources

Valuable Resources / Species of Interest

The Texas horned lizard (*Phrynosoma cornutum*) and ferruginous hawk (*Buteo regalis*), listed by the States of Texas, have been documented as occurring at ALFL. Bald eagles (*Haliaeetus leucocephalus*) over winter at adjacent LAMR and likely uses ALFL for foraging. Bird surveys

conducted at LAMR/ALFL detected scaled quail (*Callipepla squamata*), scissor-tailed flycatcher (*Tyrnanus forficatus*) and Cassin's sparrow *Amiophila cassinii*) (Patrikeev and Gallyoun 2004), all on the Partners In Flight watch list for the Pecos and Staked Plains region.

Geology / Soils

The Quartermaster Formation is the principal formation at ALFL and is divided into three members – the Cloud Chief Gypsum, Whitehorse Sandstone and the locally mapped Alibates Dolomite. The ledges and cliffs that dominate the area are capped by the resistant Alibates Dolomite. The Alibates Dolomite is comprised of two dolomite layers 12-15 feet thick separated by a shale layer. Locally, the lower dolomite is replaced by silica that has formed chert lenses called the Alibates Chert. The chert has been used for the last 12,000 years by Native Americans. Soil series include Burson-Quinlan-Aspermont, Mobeetie-Tascosa, and Acuff-Palo Duro-Olton. In areas with steeper slopes, the soils tend to be shallow (10 to 20 inches [25 to 50 cm]), well drained, calcareous, loamy to gravelly soils with variable amounts of rock fragments. These soils are also associated with rock outcrops in the park. Soils on steep slopes are highly susceptible to water erosion and moderately susceptible to wind erosion. On the flat areas there are areas of dunes and other sandy deposits.

Land Use

Alibates Flint Quarries National Monument is located within the Panhandle Field which covers about 1,475,000 acres (596,911 ha), of which approximately 1,000,000 acres (404,685 ha) produces sweet gas and about 400,000 acres (161,874 ha) produces sour gas with hydrogen sulfide. This field also produces around 250,000 acres (101,171 ha) of crude oil (Thompson 1939). In the vicinity of the parks, the oil and gas producing area is called the Panhandle West Field. The adjacent LAMR is popular for water recreation, hunting, fishing, horseback riding, using motorcycles and dune buggies in the off-road vehicle areas, and camping. Ranching, extractive activities and vacation development are the current primary land uses in the area surrounding LAMR.

Hydrology

ALFL is located in the Canadian River Basin, within the Lake Meredith watershed. Water from Lake Meredith may fill the breaks in the ALFL terrain during seasons experiencing heavy rainfall. Beyond these ephemeral water bodies, no surface waters fall within the ALFL boundaries. Soil erosion and groundwater conditions are among the largest hydrological concerns for ALFL park managers. Another water resource concern is irrigation, which supports local

agriculture, in turn lowering the water table contributing to soil desiccation. Furthermore, agricultural practices, in addition to oil and gas operations, are introducing contaminants to the groundwater. ALFL was included in the study area of the basic water quality assessment for LAMR conducted by the Water Resource Division (WRD) of the NPS in 2000.

Air Quality

An air emissions inventory was completed in 2003 (National Park Service 2003). ALFL is designated as a Class II area under the Clean Air Act. Ambient (i.e., ground level) concentrations of sulfur dioxide, nitrogen oxides, ozone, and particulate matter are not routinely monitored but are presumed to be in compliance with the National Ambient Air Quality Standards. The only nearby ambient monitoring was conducted until 1996 in Amarillo, Texas for PM-10 (particles with an aerometric diameter of 10 microns or less). All monitored values indicated compliance with the PM-10 NAAQS standard (highest 24-hour measurement of 60 micrograms per cubic meter compared to the 150 ug/m³ standard). Ozone levels in the project area are unknown at this time. The potential addition of nitrates and volatile organic compounds, the primary precursors for ozone formation, to those already present in the area from existing oil and gas-related activities and energy production, may justify monitoring ozone levels to track the cumulative impact of these activities on ambient ozone levels (Lake Meredith National Recreation Area 2002). There is currently only a low risk of foliar ozone damage. Exposure to 80 ppb ozone is infrequent, and exposure to 100 ppb rare (National Park Service 2005).

Although neither LAMR nor ALFL is subject to the visibility protection provisions that apply to Prevention of Significant Deterioration Class I areas, they do experience the widespread visible haze affecting this region of the country and would benefit from any future regional strategies to reduce visibility impairing pollution. Some of those pollutants are emitted in the vicinity of the parks by existing sources. For instance, about a dozen major sources in the three county area of Hutchinson, Moore, and Potter Counties contribute over 64,000 tons per year of SO₂, a pollutant that is transformed in the atmosphere to fine sulfate particles which have a dramatic effect on visibility impairment caused by scattering and absorption of light. It is likely that additional industrial activity associated with oil and gas production will contribute to fine particle formation. Based on extrapolation of visibility data collected over the period from 1988-1997 by the IMPROVE (Interagency Monitoring of Protected Visual Environments) visibility monitoring network, the visual range experienced on average in this area is from 30 to 60 miles (48 to 96 km) or probably about half the distance

that would be visible under natural visibility conditions in the area (Lake Meredith National Recreation Area 2002).

Wildlife

There have been several inventory related research projects for vertebrates at LAMR and ALFL (Killebrew 1977, Phillips, 1989, Yancey et al. 1998, Patrikeev and Gallyoun 2004). Most of these inventories did not specifically state which park the species was recorded in. All species detected at LAMR with the exception of those associated with riparian areas are very likely to occur at ALFL.

Mammals: There have been 60 species of mammals detected at ALFL and LAMR. Bats are probably the most under recorded group of mammals at LAMR. Patrikeev and Gallyoun (2004) detected only one species of bat and Yancey et al. (1998) did not find any. Surveys are difficult to conduct at the park due to consistent high winds that make captures with mist nets problematic. Future surveys with bat detectors or a harp trap may yield additional species. Two potentially occurring rare mammals are the Townsend's big-eared bat (*Corynorhinus townsendii*) and swift fox (*Vulpes velox*). Black-tailed prairie dog towns have been recorded from LAMR as recently as 2001, but there are no known towns documented from ALFL.

Birds: In addition to 72 species of breeding birds detected by Patrikeev and Gallyoun (2004), an anonymous park bird lists 23 additional species as nesting or likely nesting in the park, but there is no evidence, or even an author, to substantiate the list. It has been speculated that the park may be a large-overwintering site for grassland birds.

Reptiles and Amphibians: There have been 32 reptile and 11 amphibian species recorded from LAMR and ALFL. The Texas horned lizard is a state listed species, but is relatively common at LAMR and ALFL (Patrikeev and Gallyoun 2004).

Invertebrates: Phillips (1990) states that there may be over 600 species of insects from LAMR. Identification of specimens has varied from getting to genus or species level. The giant mole cricket (*Gryllotalpa major*) was collected in McBride Canyon and is a rare species typical of high quality mixed-grass prairie.

Vegetation

A total of 486 species have been documented and supported by vouchers from ALFL and LAMR (Wright and Meador 1981, Nesom et al. 2005). Vegetation at ALFL is dominated by yucca grassland (36%), vegetated cliffs (34%), mixed-grassland (18%), mesquite grassland (8%), and mixed forest (3%) (Lake Meredith National Recreation Area 2002). Bell et al. (2000) also provides a list of plant species from ALFL but it is un-vouchered. Bell and Coffman

(2000) identified Russian olive (*Elaeagnus angustifolia*), field bindweed (*Convolvulus arvensis*), Russian thistle (*Salsola iberica*), Belvedere summer cypress (*Kochia scoparia*), Johnson grass (*Sorghum halpense*), King Ranch bluestem (*Borthriochloa ishaemum*) and yellow sweetclover (*Melilotus officinalis*) as the major introduced plant species at ALFL. They also identified the native honey mesquite (*Prosopis glandulosa*) as an invasive species on the monument. There are no known endangered or threatened plants within the boundaries of the parks. Potentially occurring rare plants at ALFL include Correll's Wild-Buckwheat (*Eriogonum correllii*), Tall Plains Spurge (*Euphorbia strictior*), Mexican Mud-Plantain (*Heteranthera mexicana*) and High Plains Goldenrod (*Solidago altiplanities*).

A.1.4 Management Issues

The grassland community, prairie restoration, the Texas horned lizard, night sky and soundscape, and water quality and quantity are the most important natural resource issues at ALFL. Woody species invasion, erosion, viewshed preservation and visitor carrying capacity are the biggest threats to natural resources at the park. Restoration and maintenance of the mixed-grass prairie enhances the habitat for both species of interest and native populations, while controlling the influx of woody and exotic plant species. Prairie restoration can lead to improved groundwater recharge and stewardship of upland wetlands and springs.

The quality and quantity of groundwater in the future is of major concern in this region. Continued pumping of the aquifer for agricultural purposes has the potential to lower the water table. The greatest potential for flood hazard to park visitors at ALFL is from isolated flash floods along side drainages. This also can cause erosion, negatively impacting the cultural resources in the area.

Human activity threatens both the natural and cultural resources of ALFL. Limiting public access to the site has limited the public impact. Continued development outside the park threatens the night sky while the soundscape is impacted by the engine sounds of personal watercraft, boats, motorcycles, off-road vehicles and well drilling and production. Off-road vehicle use, unauthorized in this area, has caused severe damage to soil, vegetation and cultural resources. Maintenance of boundary fence remains an essential means of controlling unauthorized use of parklands.

Oil and gas exploration and development has been actively pursued in the vicinity of LAMR and ALFL since the late 1920s, well before establishment of the parks. The earliest well on record within what later became LAMR was

completed on October 3, 1927. Many others followed. In the parks today, there are 170 active well sites, evidence of 15 abandoned (unreclaimed) operation sites, 64 km of active oil field access roads, 167 km of abandoned roads, and 6 km of existing oil and gas pipelines (Lake Meredith National Recreation Area 2002).

A.1.5 Partnering / Neighboring Agencies

Current Partners

Texas Parks and Wildlife, Bureau of Reclamation, National Wild Turkey Federation

Potential Partners

Quail Unlimited, US Forest Service, West Texas A+M, Texas Tech University, Amarillo College

Neighboring Land Management Agencies

Lake Meredith National Recreation Area, Palo Duro Canyon State Park, Playa Lakes Wildlife Management Area, Gene Howe Wildlife Management Area, Cross Bar (Bureau of Land Management), Buffalo Lake NWR, Muleshoe NWR, Optima NWR, McClellan Creek National Grasslands, Caprock Canyon State Park, Black Kettle National Grasslands, Four Canyon Preserve (The Nature Conservancy)

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A.2 BENT'S OLD FORT NATIONAL HISTORIC SITE (BEOL)

For much of its 16-year history, this fort was the only major permanent anglo settlement on the Santa Fe Trail between Missouri and the Mexican settlements. William and Charles Bent, along with Ceran St. Vrain, built the original adobe fort in 1833 to trade for buffalo robes from the Southern Cheyenne and Arapaho Indians. The fort became the center of a trading empire that included Fort St. Vrain to the north and Fort Adobe to the south,

along with stores at Taos and Santa Fe. The fort provided explorers, adventurers, and the U.S. Army a place to get needed supplies, wagon repairs, livestock, good food, water and company, rest and protection in this vast “Great American Desert.” During the war with Mexico in 1846, the fort became a staging area for Colonel Stephen Watts Kearny’s “Army of the West”. Disasters and disease caused the fort’s abandonment in 1849. At 799 acres (323 ha), Bent’s Old Fort National Historic Site received 30,889 visitors in 2004.

A.2.1 Resource Overview

Bent’s Old Fort National Historic Site is located in southeastern Colorado, in Otero County, northeast of La Junta. BEOL is situated on a series of low terraces along two miles of the Arkansas River, within the Great Plains-Palouse Steppe ecological province and the short-grass prairie ecoregion (Ladyman 2003). This part of the Central Short-grass physiographic region is dominated by Buffalo grass (*Buchloe dactyloides*) and blue grama grass (*Bouteloua gracilis*). In addition to the Arkansas River, a total of seven wetlands/ponds are found on the site – four on the north side of the river and three on the south side.

Temperature and rainfall reflect seasonal patterns at BEOL. The average maximum temperature from June to August is 91°F (32°C), while the average minimum temperature from December to February is 15°F (-9.5°C). Annual precipitation averages between 11 and 15 inches (28 to 38 cm). Approximately 70 percent of the precipitation falls in April through August and only about 10 percent falls in November through February.

A.2.2 Enabling Legislation / Management Documents

Bent’s Old Fort was established as a National Historic Site on June 3, 1960. The act stated the BEOL “shall be set aside as a public national memorial to commemorate the historic role played by such fort in the opening of the West.” On March 20, 1963, the federal register described and delineated the boundary of the park as 178 acres (72 ha). An act on November 10, 1978, revised the boundary to include approximately 622 additional acres (252 ha) for developing public access to the site from U.S. Highway 50 and for maintaining the historic setting.

Several management documents are in place to guide decision-making at BEOL. A general Management Plan and a Resource Management Plan were implemented in the early 1990s. The Resource Management Plan supports the objective to ensure that natural resources are in place that minimize impacts from twentieth-century influence. Native vegetation will be restored and exotic

plants controlled. (Bent’s Old Fort 1994). A Wildland Fire Management Plan was first developed in 1990 and updated in 2003. A Tamarisk Control Plan was developed in 1995, while a Vegetation Restoration Management Plan was completed prior to 2003, which prescribes restoration procedures, seed mixes, planting times, and a desired condition for degraded areas (Ladyman 2003).

A.2.3 Natural Resources

Valuable Resources / Species of Interest

The maintenance and enhancement of biotic integrity is of utmost importance to natural resource management at Bent’s Old Fort National Historic Site. The habitat along the Arkansas River is part of the globally rare cottonwood/willow riparian ecosystem. Both the river and seasonal wetlands found at BEOL provide a stopover site for migratory birds. The buffalo and blue grama grass of the short-grass prairie support a vital small mammal community that is the basis of the food chain. A small colony of black-tailed prairie dogs (*Cynomys ludovicianus*) is located in the southeastern corner of BEOL (Ladyman 2003). Several avian species of interest have been documented at the site: Ferruginous hawk (*Buteo regalis*) is listed in Colorado and Swainson’s hawk (*Buteo swainsoni*) is listed in neighboring Oklahoma. Texas horned lizard (*Phrynosoma cornutum*), listed in Colorado, has been observed at BEOL. Two fish species of interest may be present in the Arkansas River at Bent’s Old Fort. The Arkansas river shiner (*Notropis girardi*) is classified as threatened and is listed in all other states in the Southern Plains Network, while the Arkansas darter (*Etheostoma cragini*) is listed in Colorado, Kansas and Oklahoma, and is a candidate for federal listing.

Geology & Soils

According to a report by Koch & Santucci (2003), the Cretaceous bedrock at Bent’s Old Fort is the Bridge Creek Member of the Greenhorn Limestone Formation. Mammoth remains have been discovered in the Quaternary deposits at BEOL. Tusk fragments were found in a gravel bed by Jackson Moore, a NPS archeologist, between 1963 and 1966 (Moore 1973). Near the park boundaries (approximately 8 km northeast of La Junta), a collection of 28 fossil rudists (extinct bivalve) was made, and this fossil-bearing bed extends into the park (Cobban et al. 1985). River bottom soils at Bent’s Old Fort are predominately silty clay sand, with deep well-drained loam on the level upper terraces (Ladyman 2003).

Land Use

The majority of the land surrounding Bent’s Old Fort is classified as agricultural, with some portions rowcropped

and others grazed (Stubbendieck and Willson 1986). The eastern boundary of BEOL is shared with a 400 acre (162 ha) state wildlife area with seasonal hunts and low intensity rowcropping. County Road 194 forms a northern boundary to Bent's Old Fort, while CO 50 and a rail line form the southern boundary.

Hydrology

BEOL, containing 2.28 miles (3.67 km) of the Arkansas River, lies in the Upper Arkansas-John Martin Watershed. Seven small man-made ponds and a number of wetlands, one of which is the 55-acre (22 ha) Arch Wetland, are also present at BEOL. These ponds and wetlands help remediate heavy rainfall events and therefore protect BEOL from major flooding events. Another significant ecosystem at BEOL is the cottonwood/willow riparian area. BEOL Park managers are concerned about protecting these communities, particularly from invasion of exotic plants and erosion of the riparian substrate. The biggest potential threat facing the water resources at BEOL is point-source contaminants from nearby land practices such as agriculture and oil and gravel extractions. The State of Colorado has designated portions of the Arkansas River, including that which runs through BEOL, as impaired on its 2002 303(d) list, due to high levels of selenium. Groundwater and streamflow monitoring is currently occurring at BEOL. A basic water quality report by the WRD of the NPS was prepared in 1998.

Air Quality

BEOL is a Class II air quality area with a low risk for foliar ozone injury. Exposure to ozone concentrations greater than 80 ppb are known to occur only for a few hours each year, with exposures at or above 100 ppb very rare. One ozone-sensitive plant, Green Ash (*Fraxinus pennsylvanica*), is found at the site, but there are no known bioindicator species (National Park Service 2005).

Wildlife

Mammals: There are no federally threatened or endangered animals documented at Bent's Old Fort. A twelve-day survey was conducted in August of 2001 by the Colorado Natural Heritage Program, with a supplemental survey over six days the following spring. A total of 21 species (38%) were documented out of 55 expected species. Although no bats were documented, they surely forage and drink at BEOL and might possibly roost there as well (Gionfriddo et al. 2002; Gionfriddo and Stevens 2003). The use of mist nets for bat sampling at Bent's Old Fort were problematic and other survey methods are recommended in the future.

Birds: A twelve-day breeding bird survey was conducted in August 2001 by the Colorado Natural Heritage Program, followed by a six-day supplemental survey the following spring. Seventy-two species of birds (67%) were documented out of the 108 anticipated species (Gionfriddo et al. 2002; Gionfriddo and Stevens 2003). Four species of birds detected during this survey are on the Partners In Flight High Priority list for the Central Short-grass physiographic region: ferruginous hawk (*Buteo regalis*), northern harrier (*Circus cyaneus*), grasshopper sparrow (*Ammodramus savaanarrum*), and Lewis's woodpecker (*Melanerpes lewis*). The riparian habitat of the Arkansas River and surrounding wetlands provide a stopover for migratory birds.

Reptiles and Amphibians: A twelve-day survey was conducted in August 2001 under very dry conditions by the Colorado Natural Heritage Program, followed by a six-day supplemental survey the following spring. Each survey resulted in similar findings. Three species of amphibians (27%) were documented out of the 11 anticipated species. Seven species of reptiles (28%) were detected out of the 25 expected species, including the Texas horned lizard (Gionfriddo et al. 2002; Gionfriddo and Stevens 2003). The introduced bullfrog was detected and its colonization may have a negative impact on native anurans (Gionfriddo et al. 2002).

Fish: A twelve-day survey was conducted in August of 2001 by the Colorado Natural Heritage Program. Four species were documented at BEOL: common carp (*Cyprinus carpio*), plains killifish (*Fundulus zebrinus*), mosquitofish (*Gambusia affinis*) and green sunfish (*Lepomis cyanellus*). A better sampling technique might yield better results (Gionfriddo et al. 2002). A two-year fish-specific survey of the Arkansas River and the Arch Wetland was initiated in 2005 with the Bureau of Reclamation.

Vegetation

In a 1986 assessment of prairie, James Stubbendieck estimated that approximately 638 acres of Bent's Old Fort National Historic Site was in various successional stages leading to short-grass prairie. The dominant riparian species at the time were cottonwood (*Populus sargentii*), willow (*Salix interior*), and tamarisk (*Tamarix ramosissima*) (Stubbendieck and Willson 1986). Seventeen years later, some conditions had been altered. A 2003 restoration management plan determined that approximately 124 acres (50 ha) were upland prairie, 271 acres (110 ha) were riparian grassland, 300 acres (121 ha) were riparian shrub- and grasslands recovering from tamarisk invasion, 39 acres (16 ha) were river and bars, and 61 (25 ha) acres were wetlands. A wildfire had burned most of the

grassland south of the river and a portion of the north side in 2002. Tamarisk has been eradicated from the park but will require continued monitoring to ensure that it does not re-establish. The Arch wetland has expanded considerably due to the tamarisk removal. Grazing by livestock used in cultural interpretation still occurs (Ladyman 2003). Prairie restoration efforts continue at BEOL. The use of irrigation in recently reseeded sites has improved forb regeneration and the establishment of the desired buffalo grass and blue grama grass of the short-grass prairie.

A separate inventory of wetland vascular plants was taken over a 3 day period in August 2001 by the Colorado Natural Heritage Program. Two types of habitat seemed to dominate these wetlands. Those closest to the Arkansas River were dominated by cottonwood (*Populus deltoides* ssp. *monilifera*), with peach leaf willow (*Salix amygdaloides*) and coyote willow (*Salix exigua*) intermixed. The other wetlands contained stands of cattails (*Typha latifolia*) and bulrushes (*Schoenoplectus lacustris* ssp. *acutus*) (Gionfriddo et al. 2002). A follow-up inventory of the Arch Wetland vegetation was initiated by Bureau of Reclamation in 2005.

Ladyman's (2003) restoration plan states that all grasslands had varying amounts of the exotic plants, kochia (*Kochia scoparia*) and field bindweed (*Convolvulus arvensis*). Six species of exotic plants at BEOL are listed on Colorado's noxious plant list: Canada thistle (*Cirsium arvense*), hoary cress (*Cardaria draba*), perennial pepperweed (*Lepidium latifolium*), Russian knapweed (*Acroptilon repens*), field bindweed (*Convolvulus arvensis*), and jointed goat grass (*Aegilops repens*) (Ladyman 2003).

A.2.4 Management Issues

Natural resource issues regarding the biotic integrity of Bent's Old Fort receive the highest priority. A wildland fire in 2002 burned most of the grassland south of the Arkansas River, then jumped the river before being contained. A large section of the globally rare cottonwood-willow riparian habitat was severely burned, resulting in the death or disfiguration of scores of cottonwoods. The effects of the fire are still being measured in both the riparian areas and the grasslands. The park's fire management plan provides guidance for the use of prescribed burns to manage grasslands and assist with restoration efforts. The development of quality short-grass prairie and the elimination of invasive exotic plants will benefit the grassland community and provide suitable habitat for species of interest. Grassland birds and the small mammal community, black-tailed prairie dogs in particular, anchor this ecosystem.

The existence of a small prairie dog colony at the edge of the park brings its own set of management dilemmas. In addition to being a keystone species, black-tailed prairie dog is a candidate for federal listing and is listed by the state of Colorado. Prairie dogs are carriers of disease that threaten humans, specifically sylvatic plague. While the risk of transmission to humans is remote, there remains a concern in maintaining colonies near humans (Ladyman 2003).

Water resources have their own management issues. BEOL is fortunate to have seven wetlands in addition to two miles of Arkansas River. Consistent efforts at tamarisk removal have resulted in the expansion of Arch wetland, an important stopover for migrating birds. Many of the wetlands recharge their waters during flooding events along the river and would be negatively impacted by upstream dams. The disturbance regime of flooding can enrich the ecosystem, but also provides for invasion by exotic plants and animals. Finally, the issue of water use rights both within and outside of the park can have a profound effect on the ecosystems at Bent's Old Fort through impacts to both surface and groundwater levels.

Various human uses will continue to shape the natural resources at BEOL. The historic viewshed will continue to be threatened by surrounding land uses. While currently agricultural in nature, rowcropping and overgrazing can change the biotic community and encourage exotics. Feedlots in the vicinity would affect not only the view, but air and water quality as well. Gravel pits already exist in the area, as well as various levels of mineral, oil and gas extraction. There is a concern regarding hazardous spills associated with the highway and railway along the southern boundary of Bent's Old Fort. It must also be noted that the National Park Service does not own the mineral rights on the land south of the Arkansas River.

A.2.5 Partnering / Neighboring Agencies & Individuals:

Current Partners

CO Natural Heritage Program, CO Division of Wildlife, CO Department of Corrections, CO State Forest Service, CO Boys Ranch, La Junta City Golf Course, Fort Lyon Canal; Otero Junior College, NRCS, Adjacent landowners

Neighboring Land Management Agencies

Cimarron National Grassland, Comanche National Grassland, Fresh Tracks (Southern Plains Land Trust), Colorado Division of Wildlife Oxbow Unit, Ryan's Ponds in Rocky Ford

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A.3. CAPULIN VOLCANO NATIONAL MONUMENT (CAVO)

Capulin Volcano National Monument (CAVO) was established in 1916 to preserve a nearly perfectly shaped extinct volcanic cinder cone that stands more than 1200 feet (366 m) above the surrounding High Plains of northeastern New Mexico. A 2-mile (3.2 km) paved road spiraling to the volcano rim makes Capulin Volcano one of the most accessible volcanoes in the world. Trails leading around the rim and to the bottom of the crater allow a rare opportunity to easily explore a volcano. This 793-acre (321 ha) monument is located in Union County, New Mexico, approximately 20 miles (32 km) east of Raton and received 58,705 visitors in 2004.

A.3.1 Resource Overview

Reaching an elevation up to 8,182 feet (2,494 m), Capulin Volcano is a cinder cone primarily covered with piñon-juniper woodland and surrounded by short-grass prairie. The crater itself is approximately 400 feet (122 m) deep and the rim almost a mile in circumference, providing a panoramic view of the volcanic field, distant mountains and portions of four states.

While the cinder cone is undoubtedly the most significant natural resource of CAVO, maintenance of both the viewshed and air quality are vital to the visitor experience. Protecting the cinder cone from erosion is the major natural resource management challenge, followed closely by preventing the encroachment of woody plants into Alberta arctic butterfly habitat and invasive plants into the short-grass prairie. The recent efforts at CAVO to initiate a new GMP will help coordinate the management efforts.

CAVO receives 16–20 inches (41 – 51 cm) of rain annually. The average annual temperatures range from 35°F to 62°F (2 – 17°C). Average maximum temperatures for June to August is 78°F (25.5°C), while average minimum temperatures for December to February is 19°F (-7°C).

A.3.2 Enabling Legislation / Management Documents

Protection was first provided on January 16, 1891, when Capulin Mountain was "...Withdrawn from settlement, entry or other disposition under any of the public land laws, until such time as Congress may see fit to take action touching the same or until otherwise ordered by competent authority..." That authority came in the form of President Woodrow Wilson on August 9, 1916. He set Capulin aside as a national Monument by Presidential Proclamation No. 1340, to preserve "...a striking example of recent extinct volcanoes ..." which "...is of great scientific and especially geologic interest." Public Law 87-635 passed by the 87th Congress on September 5, 1962, amended the proclamation to "...preserve the scenic and scientific integrity of Capulin Mountain National Monument..." because of the significance of Capulin Volcano. Finally, on December 31, 1987, Congress changed the Monument's name from, "Capulin Mountain National Monument" to "Capulin Volcano National Monument," by Public Law 100-225 (101 Stat. 1547).

A Fire Management Plan (FMP) was recently completed that implements fire management objectives stated in the Capulin Volcano Resource Management Plan. These objectives are: 1.) Maintain the diversity of habitats in the Monument with particular attention to the remaining short-grass prairie; 2.) Reduce exotic vegetation; and

3.) Reduce fuel loading and the possibility of catastrophic fire that would damage resources and threaten visitors. The FMP proposes a long-range treatment schedule in which 70 to 400 acres (28 to 162 ha) are treated annually with combinations of fuel thinning and prescribed fire projects. This plan will be guided by weather and fuel conditions and measures to mitigate adverse effects on natural and cultural resources are proposed. Monitoring of fire effects, including the emergence of invasive plants, would occur after fire events. In addition to monitoring, the adaptive management approach taken with the fire management program would include ongoing consultation with stakeholders, and annual program reviews.

A.3.3 Natural Resources

Valuable Resources / Species of Interest

While no currently listed or category species of terrestrial mammals have been observed at CAVO, several species of interest have been documented. These include: Townsend's big-eared bat (*Plecotus townsendii*) (listed in New Mexico), and the Alberta arctic butterfly (*Oeneis alberta capulinensis*), endemic to a few isolated windblown grassy mesas in the Raton Mesa complex in northeastern New Mexico. This park is one of the eastern-most locations with grassland, montane and piñon/juniper habitat in close proximity.

Geology & Soils

A variety of volcanic features are enclosed by the CAVO boundaries. Capulin Volcano formed approximately 60,000 years ago, during the last active period in the Raton-Clayton volcanic field. The symmetry of the cinder cone was initially preserved because lava flowed only from vents located at the base of the volcano. The dry climate of northeastern New Mexico has contributed to its preservation. The surrounding lava flows cover the remainder of the monument. Capulin Volcano has been inactive for a period long enough that it is unlikely it will erupt again.

Harfert (n.d.) states that the southeast and north slopes of Capulin are covered with a cinder/soil mix almost a foot deep, but it may be the presence of caliche that allows the unusual growth of vegetation on the cinder cone. There are at least three zones of caliche layered concentrically around the cinder cone about two feet apart, extending throughout the cone except for the western breach area. Analysis of caliche samples displayed a composition of scoria, quartz or cristobalite, and a glassy black substance cemented together with calcium carbonate and containing a minor amount of clay minerals.

Land Use

Surrounding land use at CAVO has a major impact on the aesthetic quality of visitor satisfaction. The view from the rim of the volcano is quite comprehensive and would be diminished by incompatible development near the park. Most of the state-owned lands to the north, east and west of the monument are leased for grazing. There is private ranch land from the east to the south of Capulin. Surface mining is taking place to the east.

Hydrology

The only surface waters at CAVO are three sewage lagoons. The groundwater is at risk from surrounding anthropogenic sources of contamination such as municipal wastewater discharges, ranching operations, and mining and quarrying activities, as well as atmospheric deposition. A basic water quality assessment was completed in 1993 by the WRD of the NPS.

Air Quality

CAVO has been designated a Class II air quality area. According to the report, "Air Quality in the National Parks," which monitored selected parks from 1990 – 1999, the sulfate ion concentration and wet deposition is average for the National Park Service, with wet deposition showing an improving trend and concentration trend significantly improving. Nitrate concentration, however, was below average for national parks and continuing to degrade, while nitrogen wet deposition, average for national parks, showed a significant degradation. There is currently only a low risk of foliar ozone damage. Exposure to 80 ppb ozone is infrequent, and exposure to 100 ppb rare. Soil moisture serves to constrain the uptake of ozone at higher exposure levels, reducing the likelihood of foliar injury development (National Park Service 2005). Monitoring for acid deposition, as part of a national program, continues at Capulin. Twenty years of precipitation and pH records have been collected to aid in this effort.

Wildlife

Mammals: Biological surveys completed in 2002 by Natural Heritage New Mexico detected 28 mammal species (39%) of the 57 animals expected at CAVO. During this survey, a black bear (*Ursus americanus*) spent several nights on the monument. Rangers have reported seeing pronghorn and elk just outside of park boundaries (Johnson et al. 2003). While no listed or category species were observed, Parmenter et al. (2000) note that the swift fox (New Mexico state listed species) may wander through the monument property.

Birds: surveys conducted by Natural Heritage New Mexico in 2002, combined with observations by park staff, accounted for 56 (88.9%) of the 59 targeted species for CAVO. Twenty-seven species (45.8%) were found in grassland habitats, 46 species (78%) in piñon-juniper habitats, and 15 species (25.4%) in human-impacted areas (Johnson et al. 2003). Five species currently on the Partners in Flight high priority list for the Mesa and Plains Physiographic Region were detected: canyon towhee (*Pipilo fuscus*), Cassin's kingbird (*Tyrannus vociferans*), juniper titmouse (*Baeolophus griseus*), Cordilleran flycatcher (*Empidonax occidentalis*), and Virginia's warbler (*Vermivora virginiae*). A listed and category species inventory conducted in 2000 observed no qualifying birds, however loggerhead shrike has been previously recorded as a rare transient at the monument and adjacent prairie habitats may harbor Baird's sparrow during winter months (Parmenter et al. 2000). Natural Heritage New Mexico suggests that "the absence of livestock grazing on CAVO has apparently encouraged an increased diversity of grassland birds, especially ground- and shrub-nesting birds such as vesper sparrows (*Pooecetes gramineus*) and lark sparrows (*Chondestes grammacus*). At the same time, conifers appear to be invading several areas of grassland and potentially decreasing the area of habitat favored by grassland birds. Efforts to clear these areas, either mechanically or by prescribed fire, will help maintain grassland habitats should forest encroachment become severe" (Johnson et al. 2003). It should also be noted that playas located on adjacent land provide a major stopover for migratory birds.

Reptile and Amphibians: Drought affected the 2002 survey period for reptiles. Only 10 species (29%) of the anticipated 34 species were found at Capulin. Due to the unique presence of grassland, montane and piñon/juniper habitat in close proximity, other valuable resources of note are found in and adjacent to CAVO, including the eastern fence lizard, western prairie rattlesnake and Texas horned lizard.

Bats: Two species of bats (*Myotis thysanodes* and *Myotis ciliolabrum*) found at Capulin had been listed as Category 2 species in 1994. When the USF&WS dropped the category designation and created candidate species, the two bats were no longer classified (Parmenter et al. 2000). A third species, Townsend's big-eared bat (*Plecotus townsendii*), has been recently documented at CAVO (Johnson et al. 2003), and is listed by New Mexico.

Butterfly: A subspecies of the Alberta Arctic butterfly (*Oeneis alberta capulinensis*) was first discovered at CAVO (Brown 1970) and has been found to be endemic to a few wind-swept elevations in the area. Parmenter et al. (2000) consider this to be a genetically significant population with

a wider geographic distribution and suggest it should be protected as a species of special concern. Its larvae may feed on grasses of the genus *Festuca*, which are currently being impacted by woody encroachment, resulting in only a few hectares of sparse coverage. Fire or adverse weather can easily decimate such limited and small populations. Specific surveys for the Alberta arctic butterfly in 2002 and 2003 have failed to document this butterfly on Capulin volcano (Johnson et al. 2004).

Invertebrates: A list of beetle, grasshopper and cricket species found at CAVO has been compiled. Although no listed or category invertebrates were found, Parmenter et al. (2000) noted a number of rarely recorded species, resulting in range extensions. They suggest that "the probability is high that undescribed new species of arthropods may be found at Capulin Volcano, possibly representing endemic species [*Belotus abdominalis* (Soldier beetle), *Hyperaspis quadrivittata* (Ladybird beetle), *Sericoderus lateralis* (Minute fungus beetle), *Trox foveicollis* (Skin beetle)]." (Parmenter et al. 2000).

Vegetation

CAVO is located in the Arkansas Tablelands section of the Great Plains-Palouse Dry Steppe ecoregion. Three major habitat types are found within park boundaries: grasslands upon the lava flows, montane woodlands of ponderosa pine, and piñon/juniper forest on the cone itself. Six communities are identified by Natural Heritage New Mexico's (NHNM) Vegetation Community Classification system are crater grassland, disturbed grassland, piñon-juniper, lowland grassland, gamble oak and ponderosa (Johnson et al. 2003). Three major ecological processes identified as affecting the monument are fire, grazing and woody plant encroachment.

No threatened or endangered plants were located during the field survey conducted by NHNM in 2002. Two hundred and forty-three species (92%) of the 255 potential species were documented (Johnson et al. 2003). Existing pockets of native short-grass prairie vegetation do remain within CAVO (Parmenter et al. 2000) even though the cinder cone has become dominated by piñon/juniper forest. Harfert (n.d.) proposes that, unlike other unforested cinder cones in the area, the dense vegetation on Capulin is due to the atypical caliche soils found interspersed on the slopes. This reduction of grasslands may negatively affect the small population of endemic Alberta arctic butterfly.

Due to the unique presence of grassland, montane and piñon/juniper habitat in close proximity, other significant and valuable resources of note are found in and adjacent to CAVO, including ungrazed short-grass prairie, fringed sagewort (*Artemisia frigida*), piñon pine, gambell oak and ponderosa pine.

A.3.4 Management Issues

Erosion accelerated by human disturbance and control of exotic vegetation are two critical issues facing Capulin Volcano National Monument. Runoff from the Volcano Roadway continues to cause significant erosion at the drainage culverts. Unauthorized visitor trails inevitably cause erosion on slopes of the cinder cone from trampling of vegetation. An abandoned cinder pit located on the boundary of state land requires erosion control and revegetation. CAVO continues to try and acquire additional funding to address these erosion issues. An erosion mitigation plan needs to be developed for the Volcano Road at CAVO.

Control of exotic invasive plants is the second critical issue for CAVO. No federally listed noxious weeds have been found, although field bindweed (*Convolvulus arvensis*) is listed by the State of New Mexico as a Class C noxious weed (Johnson et al. 2003). These invasives cross park boundaries from adjacent lands and are introduced along roadsides by vehicles and the use of hay for erosion control. It is suspected that the effects of periodic drought combined with eighty years of fire suppression have exacerbated this situation. While exotics can be found at various construction and disturbance sites throughout the park, drastic control measures will be required along the fire road skirting the base of the cinder cone, and at selected sites below the Volcano Road. Past control efforts have targeted common mullein (*Verbascum thapsus*) and prickly Russian thistle (*Salsola tragus*) for removal.

An inventory of all vascular plants, including those introduced to the monument, was completed by Natural Heritage New Mexico in 2002. They noted that twenty-two introduced plant species had been previously detected at CAVO. Slim amaranth (*Amaranthus hybridus*) and prickly Russian thistle (*Salsola tragus*) were identified as the two most widespread introduced species within park boundaries. Eight species on the final plant list (*Bromus tectorum*, *Cichorium intybus*, *Chenopodium album*, *Cynoglossum officinale*, *Descurainia sophia*, *Kochia scoparia*, *Salsola tragus*, and *Verbascum thapsus*) are listed as noxious by other states (Johnson et al. 2003). Inventory and mapping of noxious weeds has been completed by the Great Plains Cooperative Ecosystems Studies Unit. Japanese brome (*Bromus japonicus*) and downy brome (*Bromus tectorum*) were identified as the most serious threats due to their difficulty to control. It is determined that these annual bromes inhabit 45 acres (18.1 ha). A medium urgency designation has been given to common horehound (*Marrubium vulgare*) due to its invasive potential, although it currently has low occurrence and small populations at CAVO (Natumilani et al. 2004). Eradication measures will continue as funding requests

are met. Local hay sources are being screened for the presence of noxious weeds in an effort to limit further introduction. Due to the suppression of wild fire, piñon pine and juniper are now invading grassland on the slopes of Capulin where the Alberta arctic butterfly was discovered. Recent surveys have failed to document the butterfly's presence, raising concern about the impact of this woody encroachment. Historic photos of the cinder cone readily show the increase in piñon-juniper vegetation over the past several decades.

An assessment of the condition of the prairie and recommendations given for management were completed by Stubbendieck (1986). Parmenter et al. (2000) stated that the grass habitats at CAVO "appear to be well preserved and protected." Maintaining these grassland habitats will be vital for the Alberta arctic butterfly and other dependant plant and animal species. At present, an estimated 100 acres (40 ha) are in need of restoration for a number of reasons – utility disturbance, roads, non-native invasives, woody encroachment, and exclusion of wild fire. The exclusion of grazing for several decades may also be impacting the health of these grasslands. A native plant propagation project has been approved for funding in FY05 and FY06 and includes a partnership with the NRCS Plant Materials Center in Las Lunas, New Mexico. There are pockets of native vegetation within CAVO for use as seed source.

Eighty years of fire suppression at CAVO has led to degradation of the short-grass prairie though encroachment of woody and exotic invasive species. Concerns have been raised regarding the catastrophic effect an uncontrolled wild fire and resultant conditions might have on the monument. A newly instituted Fire Management Plan has identified three objectives to restore balance: maintain habitat diversity, particularly the short-grass prairie; reduce exotic vegetation; and reduce fuel load that threatens resources and visitors. It is anticipated that these objectives can be reached through implementation of a multi-year fuel thinning/prescribed fire rotation, monitoring of fire effects after the event and an adaptive management approach involving stakeholders. Fire weather data is currently being collected and fire effects are being observed.

Unmanaged diseases and pests both to plants and wildlife are an ongoing threat in any protected area. Current monitoring continues at CAVO for the gypsy moth (*Lymantria dispar*).

There are several issues pertaining to human use that need to be addressed at CAVO. Park visitors can have a negative impact on the natural resources of the monument. As discussed earlier, unauthorized trails expose the cinder cone to accelerated erosion. The Volcano Road, used by visitors to access the volcano crater, also causes erosion

and allows for the introduction of invasive plants to the slopes of the cinder cone.

Changes associated with the land surrounding the park can affect air, water, scenic quality and can affect biological communities through fragmentation and isolation. The views from Capulin Volcano are one of the most important features and resources, yet regional haze slowly increases as air quality diminishes. The potential development of two new coal fired power plants in the area would likely bolster this negative trend. Development in the form of subdivision of neighboring ranches will not only affect the viewshed but further diminish the night sky resource through the addition of all-night illumination. Attempts in 2003 to monitor this important resource were unsuccessful.

Concerns regarding water quality issues and access continue to grow. CAVO has no water features other than a water treatment lagoon, but resolution of these matters will have an impact on the monument. The Raton Basin aquifer is undeclared, resulting in questions regarding water rights. The community of Folsom, north of CAVO, has contaminated ground water.

A.3.5 Partnering / Neighboring Agencies & Individuals

Current Partners

Natural Heritage New Mexico, Natural Resource Conservation Service Plant Materials Center, New Mexico Department of Game and Fish, New Mexico Extension Service, neighboring NPS sites, USFS, Vermejo Park Ranch, Philmont Scout Ranch, 4H and FFA clubs at Des Moines School, Wildflower seed club, and local volunteers

Potential partners

Boy Scouts, Youth Conservation Corps, Raton Youth Organization

Neighboring Land Management Agencies

Maxwell NWR, Kiowa National Grassland, Rita Blanca National Grassland, Sugarite Canyon State Park

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A.4 CHICKASAW NATIONAL RECREATION AREA (CHIC)

Chickasaw National Recreation Area (CHIC) was the first national park established in the state of Oklahoma and the seventh in the National Park System. The park preserves cultural resources, lakes, streams, and springs on the edge of the Arbuckle Mountains, providing opportunity for aquatic activities. Originally part of the Choctaw Reservation, this land was first ceded to the Chickasaw Tribe, then sold to the federal government for a promise to protect the springs from private development. In the years following Oklahoma's statehood, Platt National Park was created and provided visitor access to the "healing" waters. In 1962, Arbuckle Reservoir was authorized to provide flood control and recreation opportunities, eventually inundating 2,340 acres (947 ha) south of Platt National Park. The two facilities and connecting riparian lands were joined in 1976 to form the 9,889-acre (4,002 ha) Chickasaw National Recreation Area, which received 1,277,753 visitors in 2004.

A.4.1 Resource Overview

The juncture of the southern Osage Plains and the Arbuckle Mountains in south-central Oklahoma is a transitional ecotone of Eastern deciduous forest and the Western

prairies. Although much of Chickasaw National Recreation Area is in the Arbuckle Mountains physiographic province, the northwestern portion of CHIC is a transitional area to the low rolling hills of the redbed plains (Hoagland and Johnson 1999). CHIC lies within the Arbuckle Mountains geographic region, within the Arbuckle Mountain Uplift geological province, and within the Red River drainage basin. The topography of the park is moderately rolling with several steep bluffs in the northern portion and level terrain on the upland areas in the southern portion. Arbuckle Reservoir is surrounded by steep valley walls with bluffs along lengthy sections, especially on the sides of the Rock Creek arm. Elevations range from 872 feet (266 m) of Lake Arbuckle to 1,082 feet (330 m) at Mount Airy (Chickasaw National Recreation Area 1999).

Chickasaw National Recreation Area is located in Murray County, approximately 90 miles (145 km) south of Oklahoma City. North-south U.S. Highway 177 bisects the Platt District (nee Platt National Park), while State Highway 7 runs along the northern park boundary with the adjoining town of Sulphur, Oklahoma. CHIC is divided into three management units. The 934-acre (378 ha) Platt District is the former Platt National Park and preserves the historical and designed cultural landscape of intact Civilian Conservation Corps park architecture, freshwater and mineral springs that have drawn people to the area for centuries, and the 67-acre (27 ha) Veteran's Lake. The Arbuckle District, at 6,656 acres (2,694 ha), is comprised of the 2,340-acre (947 ha) Arbuckle Reservoir and its surrounding recreational lands. The reservoir is fed by Rocky Creek and its tributaries – Guy Sandy Creek, Buckhorn Creek and Travertine Creek. The Rock Creek Corridor covers approximately 1,500 acres (607 ha) and connects the Platt District to the Arbuckle District (Chickasaw National Recreation Area 1999).

The park is located in the Subtropical Humid climate zone (Hoagland & Johnson 2001), resulting in a warm continental climate. Summers are hot and humid, with an average maximum temperature June–August of (91°F [33°C]) and prevailing winds from the southwest. Winters are mild with an average minimum temperature December–February of (28°F [-2°C]). Snowfall is light and lasts only a few days, resulting in a relatively dry season. Average annual precipitation is 38 inches (97 cm), with 70% falling during the warm months predominately from thunderstorms. Damaging hail is common and tornados not unusual (Chickasaw National Recreation Area 1997).

A.4.2 Enabling Legislation / Management Documents

Chickasaw National Recreation Area is the oldest park in the Southern Plains Network. The Sulphur Springs

Reservation was created on July 1, 1902. This legislation provided for the federal government to purchase 640 acres (259 ha) from the Chickasaw and Choctaw Indian Nation, Indian Territory, at their request "... for the proper utilization and control of said springs and waters of said creeks." 1904 legislation added 217 acres (88 ha) to the reservation and the name was changed on June 29, 1906, to Platt National Park. Under the auspices of the Bureau of Reclamation, the Arbuckle Federal Reclamation Project received authorization on August 23, 1962, for flood control, water supply and "...for the conservation and development of fish and wildlife, and the enhancement of recreation opportunities." March 17, 1976 legislation combined Platt National Park and Arbuckle Recreation Area with additional lands to form Chickasaw National Recreation Area "... to provide for public outdoor recreation use and enjoyment of Arbuckle Reservoir and land adjacent thereto, and to provide for more efficient administration of other adjacent area containing scenic, scientific, natural and historic values contributing to public enjoyment of the area and to designate the area in such a manner as will constitute a fitting memorialization of the Chickasaw Indian Nation ..." (Chickasaw National Recreation Area 1999).

According to the 1996 Strategic Plan, the stated Mission is "... to provide for the protection of Chickasaw National Recreation Area's unique resources, springs, streams, lakes, and other natural features, and its cultural history and structures, as well as its recreational resources and built facilities; and to provide for public education, appreciation and recreational use and enjoyment of these resources" (Wikle et. al. 1998). A Fire Management Plan was formulated in 1997 to provide the guidelines necessary for sound fire management practices used in prescribed burns to promote habitat health and to reduce fuel loads. In 1998, a Water Resource Management Plan to guide water resource-related planning activities at CHIC for the next decade was developed. The Resource Management Plan (Chickasaw National Recreation Area 1999) documents the natural and cultural resources at Chickasaw, describes and evaluates resource management activities, delineates resource problems and data deficiencies, and lays out a logical course for addressing them. The major objectives of the resource program are to protect the natural and physical resources within the park and to restore most of the park to approximate its resemblance when the first Chickasaw people arrived circa 1820 (Chickasaw National Recreation Area 1999).

A.4.3 Natural Resources

Valuable Resources / Species of Interest

While no federally threatened or endangered plants or animals have been documented at Chickasaw, several

animal species documented at Chickasaw are tracked by the Oklahoma Biological Inventory. Texas horned lizard (*Phrynosoma cornutum*) and Swainson's hawk (*Buteo swainsoni*) are of special interest to the State. Marsh rice rat (*Oryzomys palustris*) is also on the Oklahoma list and its discovery at CHIC provided the first record for Murray County.

Geology / Soils

According to the CHIC Resource Management Plan (1999), beneath Murray County are late Pennsylvania and Permian shales, with abundant marine fossils. Brachiopods, echinoderms, trilobites, pelycopods, bryozoans, graptolites, and ostracodes have all been discovered within the park (Koch and Santucci 2003). The recreation area lies within the Arbuckle Uplift, which formed the Arbuckle Mountains. The mountains eroded over eons, washing successive layers of sandstone, shales and conglomerates into the lower elevation of the park. These strata include Vanoss group and Ada Formation, with soils that are deep, gently to strongly sloping, moderately well-drained, and loamy or clayey. They are in the Clarita-Durant-Burleson, Shidler-Claremore-Clarita, and Chigley-Clarita general soil map units. The largest soil type in the Platt District is Rayford Cobble loam, a moderate to well-drained prairie soil found south of the streams and covering slopes of 5 to 20 percent grade. Bedrock along stream channels, such as Rock Creek and Guy Sandy Creek, consist of alluvium and terrace Quaternary deposits. These Garvin-Elandco soils are level to gently sloping, moderate to well drained, deep clay and loam. The conglomerate rock of CHIC is a characteristic feature of the Platt District, utilized in various ways within the cultural landscape.

Land Use

Chickasaw National Recreation Area is bordered on the north by the City of Sulphur, while the remainder of the park is surrounded by ranch land and residential developments (Chickasaw National Recreation Area 1999). Hay production is the primary agricultural enterprise (Stubbendieck and Willson 1986) on lands immediately bordering the park, but activities in Murray County have turned to poultry and dairy production, which produce concentrated wastes (Wikle et. al. 1998). Oil seeps on Rock Creek are evident but their cause is unknown – there are abandoned oil wells near the park but the seeps may be naturally occurring (Chickasaw National Recreation Area 1999). Several resorts and youth camps are also found in the area.

Land use and circulation patterns at the northern end of CHIC were established by the time the district became a reservation in 1902. The City of Sulphur and its residential

and commercial infrastructure are closely entwined with the Platt District. The city maintains some main water lines and main sewer lines within the district, as well as a 4.5 acre (1.8 ha) sewage treatment plant which also serves the historic district. Commercial land uses north of CHIC on Rock Creek include cement operations, milk production and construction. Approval has been given for construction of a water pipeline from Lake Arbuckle to serve Sulphur and perhaps alleviate the depletion of spring flow within the park, but has not been implemented (Wikle et. al. 1998).

Hydrology

Water resources are the largest asset to CHIC and account for a majority of the annual visitation. The two largest water bodies at CHIC are Lake of the Arbuckles and Veteran's Lake, both man-made reservoirs. These lakes serve a variety of functions including recreation, flood control, and a potential municipal water source. Lake of the Arbuckles is supported by five streams, Rock, Guy Sandy, Buckhorn, Wilson, and Travertine Creeks. Wilson Creek also supports Veteran's Lake. Aquifers at CHIC can experience large fluctuations in water levels. Agricultural and industrial practices, residential areas, recreational impacts, exotic plant invasions, lake eutrophication, and illegal disposal sites are all posing threats to aquatic resources at CHIC. A basic water quality assessment was completed in 1997 by the WRD of the NPS.

Air Quality

Chickasaw National Recreation Area is designated a Class II air quality area. Air monitoring studies have not been conducted, but because of the rural nature of the surrounding area, air quality is considered good. The natural sulphur gases produced by some water wells can result in disagreeable odors. The City of Sulphur, as well as distant metropolitan areas can potentially affect the air quality of CHIC (Chickasaw National Recreation Area 1999).

The risk of foliar ozone injury to plants at Chickasaw National Recreation Area is high. Since the site is subject to potentially harmful levels of ozone annually, the probability of foliar injury developing is greatest when ozone levels are somewhat reduced and moist soils do not constrain the uptake of ozone. Foliar ozone injury can be assessed using one or more bioindicator species: white ash (*Fraxinus americana*), American sycamore (*Platanus occidentalis*), and skunkbush (*Rhus trilobata*) (National Park Service 2005).

Wildlife

Mammals: The Oklahoma Biological Inventory conducted a survey of mammals May – August, 2003. They observed 22 species, of which 16 were on the predicted list of 25. Six new species records for Murray County were documented, including marsh rice rat (*Oryzomys palustris*), which is tracked by the Oklahoma Natural Heritage Inventory (Kelly et al. 2004). Since 1920, the park has maintained a small (3-7) historical herd of bison (*Bison bison*) within an 84-acre (34 ha) enclosure. Species extirpated from CHIC include the black capped vireo (*Vireo atricapillus*), elk (*Cervus elaphus*), black bears (*Ursus Americans*), gray wolf (*Canis lupus*) and river otter (*Ultra condenses*) (Chickasaw National Recreation Area 1999).

Birds: A survey conducted by the Oklahoma Biological Inventory from May to July, 2003 documented 85 species of birds. Species tracked by the Oklahoma Natural Heritage Inventory that were observed at CHIC include: Black Vulture (*Coragyps atratus*), Canada Goose (*Branta canadensis*), Cooper's Hawk (*Accipiter cooperii*), Swainson's Hawk (*Buteo Swansonii*), Spotted Sandpiper (*Actitis macularia*), and Yellow Warbler (*Dendroica petechia*) (Kelly et al. 2004). No federally threatened or endangered birds were detected. Historical sightings have been made of the endangered peregrine falcon, the least tern and the black-capped vireo, but not in recent years (Chickasaw National Recreation Area 1999). Six species of interest to Partners In Flight in the Oaks and Prairies physiographic region were detected: northern bobwhite (*Colinus virginianus*), scissor-tailed flycatcher (*Tyrannus forficatus*), Bewick's wren (*Thryomanes bewickii*), painted bunting (*Passerina ciris*), dickcissel (*Spiza americana*), field sparrow (*Spizella pusilla*).

Reptiles and Amphibians: A survey conducted by the Oklahoma Biological Inventory from May to August, 2003, documented 36 species of reptiles (17 snakes, 11 lizards, 8 turtles). A search for amphibians resulted in observation of 9 species (Kelly et al. 2004). No state or federal listed threatened or endangered species were detected during the survey.

Fish: A 1993 stream survey conducted by Tulane University's Museum of Natural History collected 21 species from 10 locations. No state or federally threatened or endangered species were found. Sites closer to the reservoir were found to have greater species diversity due to stream size and habitat overlap (the edge effect). Western mosquitofish (*Gambusia affinis*) were the most abundant fish documented, but only found in the Vendome Well run. Green sunfish (*Lepomis cyanellus*), orangethroat darter (*Etheostoma spectabile*) and central stoneroller (*Camptostoma anomalum*) were the next most abundant and were found throughout the study areas (Taylor 1993).

In 1995, fish population studies reported that approximately 22% of the gizzard shad (*Dorosoma cepedianum*) found in Arbuckle Reservoir had tumors near their dorsal fins. Subsequent investigations revealed that the appearance of these tumors dated back to the mid-70s and appeared on shad in other lakes within the same drainage as Arbuckle. Stocking of shad had occurred between these lakes in the past (Ostrander et. al. 1998). The cause of the tumors is unknown. Arbuckle Reservoir is relatively free of agents that have historically been associated with cancer in fish (Ostrander 2000).

Arthropods: Fifty taxa of arthropods were collected in Travertine Creek during 1968-1969. No long-lived species were collected, possibly due to the sporadic nature of water flow (McKinley et. al. 1972). No state listed species of concern have been documented in the park, but surveys should be conducted for the Oklahoma cave amphipod (*Allocrangonyx pellucidus*) and prairie mole cricket (*Gryllotalpa major*) (Chickasaw National Recreation Area 1999).

Vegetation

There are no federally threatened or endangered plant species known to exist in the recreation area (Chickasaw National Recreation Area 1999). Oklahoma Biological Survey documented 582 taxa during an inventory in 2000 and noted there was a floristic affinity with the Edwards Plateau. Ten species are tracked by the Oklahoma Natural Heritage Inventory: woodland sedge (*Carex cephalophora* var. *cephalophora*), whitesheath sedge (*Carex hyalina*), pincushion cactus (*Coryphantha vivipara*), black dalea (*Dalea frutescens*), echinacea (*Echinacea paradoxa* var. *neglecta*), lace cactus (*Echinocereus reichenbachii*), Oklahoma penstemon (*Penstemon oklahomensis*), scurphea (*Psoralea reverchonii*), shortlobe oak (*Quercus durandii* var. *breviloba*) and Ozark dropseed (*Sporobolus ozarkanus*). The *Quercus stellata*–*Q. marilandica* forest and woodland association was the most prevalent woody vegetation type. The most prevalent grassland vegetation is *Schizachyrium scoparium*–*Sorghastrum nutans*. They type specimen of *Echinacea paradoxa* var. *neglecta* was collected in 1968 at Platt National Park (Hoagland and Johnson 2001).

Chickasaw National Recreation Area lies in a transitional zone between the eastern deciduous forests and the mixed-grass prairie (Chickasaw National Recreation Area 1999) and is located in one of the more densely vegetated areas of the county (Hoagland and Johnson 2000). There is high habitat diversity in the Rocky Creek Corridor and Arbuckle District, while the original landscape in the Platt District is highly altered. The district is considered a naturalistic area rather than a natural one. The park is currently dominated

by oak-hickory forest (Chickasaw National Recreation Area 1999) and three types of grassland are present: the little bluestem (*Schizachyrium scoparium*) type occupies well drained mesic uplands; the hairy grama type occupies xeric uplands with thin, dry soils; and the reverchon muhly type occupies poorly drained, thin soils that are saturated in the spring and very dry in the late summer (Stubbendieck and Willson 1986). Grazing was allowed throughout much of the park until 1986 (Chickasaw National Recreation Area 1997) but continues today only within a fenced pasture containing reintroduced bison (Chickasaw National Recreation Area 1999).

Hoagland and Johnson (2000) conducted an analysis of historic vegetation at CHIC. According to 1871 surveys, only one residence was within park boundaries and road development was limited. The acreage of woody vegetation exceeded that of grassland and no agricultural fields were present. Tree ring data collected from Lower Rock Creek yielded post oaks 200 – 250 years old and a chinquapin oak aged 165. The oldest eastern red cedar in the area was an average estimate of 85 years old. The overall habitat was composed of trees growing in “islands” interspersed among grasslands of little bluestem and sideoats grama (*Bouteloua curtipendula*). First encountered in 1897, eastern red cedar (*Juniperus virginiana*) dominated the area in 1956 aerial photographs. This domination, currently estimated 36% of CHIC, was aided by Civilian Conservation Corps forestation efforts performed during the 1930s, when cedar was actively planted in the landscape of the Platt District (Chickasaw National Recreation Area 1999). Woody plant encroachment and the subsequent canopy cover has resulted in decreased species diversity (Hoagland and Johnson 1999). Vegetation management using prescribed fire began in 1998 in an effort to restore habitat health (Chickasaw National Recreation Area 1999).

A.4.4 Management Issues

The most significant natural resource at Chickasaw National Recreation Area is water – lakes, streams, creeks, springs and aquifers. Assuring that there will be continued flow of clean water from the springs will fulfill the original agreement with the Chickasaw Nation that brought the park into being. The establishment of clear water rights will assist in maintaining adequate groundwater levels and water quality. Encouraging the City of Sulphur to switch their public water supply to lake-based instead of relying on wells will also ensure more groundwater. Management of water level, flow and release at Arbuckle Reservoir falls to both the Corps of Engineers and the Bureau of Reclamation, while recreational opportunities and issues are overseen by the park service. This has recently included decisions on the appropriate use of

personal water craft and monitoring levels of *E. coli*. The Water Resource Management Plan (1998) presents a list of long-term monitoring needs that addresses ongoing water issues at CHIC, “levels of biological hazards (fecal coliform); spring and stream flow; groundwater levels and relationship to surface flow; domestic and commercial withdrawal rates; evaluation of effects of CHIC operations; baseline inventories describing surface waters and groundwater flow; land use changes; inventory of historic ponds and evaluation of earthen dams” (Wikle et al. 1998). In-depth studies of the relationship of surface/ground water are currently underway in the park that will assist in future management decisions.

The second major issue confronting decision-makers at Chickasaw is the maintenance of its biotic integrity, specifically vegetation management and control of exotic/invasive species. Efforts continue to control the spread of eastern red cedar throughout the grasslands and woodlands of the Platt District and upper Rocky Creek Corridor. The cedar displaces native plants and alters the invaded habitats and animal populations. Fire suppression supports the establishment of cedar, which in turn limits groundwater recharge. Loss of grassland to woody encroachment, the overabundance of raccoons and the invasion of red imported fire ants have been cited by park managers as reasons for the decrease in quail and reptile populations. Feral dogs and cats from surrounding communities negatively impact native fauna while feral hogs root up native plants and cause erosion in riparian zones. The unauthorized harvesting of desirable native species, such as echinacea and cacti, and the inadvertent introduction of alien aquatic species threaten to deplete the native diversity of CHIC. Oklahoma Natural Heritage Inventory tracks numerous species of flora and fauna found in the park and the presence of several more species of concern are suspected. It is imperative that the valuable natural resource that is biotic integrity be maintained and enhanced at Chickasaw.

Human use has been a historic factor in shaping the landscape of CHIC and continues to impact the park. The proximity of neighboring towns and communities affect water quality and supply, air quality, the soundscape and night sky. Boundary encroachment, hazardous spills on the highways and sewer spills from the system transversing the park are just a few examples of frequent management issues. The Platt District and its springs have been a long-standing cultural resource, providing a family gathering space for centuries. Construction and landscaping completed by the Civilian Conservation Corps in the 1930s resulted in classic “park architecture” in an area that currently receives up to 1.5 million visitors a year. These numbers of visitors and their recreational activities have a tremendous effect on natural resources,

providing vectors for the introduction of exotic species and increasing levels of air/water/noise pollution. Fishing is a major recreational activity at Arbuckle Reservoir but the demand for sport fish has resulted in introduced genetics from outside the watershed and diminished populations of native fish.

Adjacent land use affects the park in several ways. Agricultural rowcropping and haying, chicken farms and feedlots often result in increased nitrates in the waterways and contaminants in the fishery. Oil and gas exploration and extraction impact the natural soundscape and introduce the possibility for additional pollution. Near-neighbor communities can complicate the prescribed fire process, often requiring additional education, permitting and safeguards to insure minimal disruption to their daily routine. All of these land uses increase the possibility for the introduction and harboring of invasive and exotic species.

A.4.5 Partnering / Neighboring Agencies & Individuals

Current Partners

Current: Oklahoma Dept. of Wildlife Conservation; USGS; East Central University; Chickasaw Nation

Potential Partners

Noble Foundation, Lifestyle Center of America, Goddard Youth Camp, NRCS – RC+D, OK Cooperative. Extension, Arbuckle Master Conservancy, Sulphur Schools, Murray County, City of Sulphur, Boy Scouts, Oklahoma State University

Neighboring Land Management Agencies

Tishomingo NWR, Hagerman NWR, Wichita Mountains NWR, Caddo National Grassland, LBJ National Grassland, McGee State Park, Boggy Depot State Park, Lake Murray State Park, Blue River WMA, Texoma-Tishomingo WMA, Pontotoc Ridge Preserve (TNC), Tallgrass Prairie Preserve (TNC), Eisenhower State Park (TX).

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A.5 FORT LARNED NATIONAL HISTORIC SITE (FOLS)

Fort Larned was built in October of 1859 to protect traffic along the Santa Fe Trail. It served as an agency for the administration of Central Plains Indians by the Bureau of Indian Affairs under the terms of the Fort Wise Treaty of 1861 and later as a key military base during the Indian War of 1868-1869. Fort Larned began its final mission in 1872 guarding the construction workers on the Santa Fe

railroad. Fort Larned National Historic Site totals 718 acres (291 ha) including easements and is divided into two units. The Fort Larned unit survives as one of the best examples of Indian Wars period forts, containing nine restored buildings on 366 acres (148 ha). This unit is surrounded by an additional 308 acres (125 ha) of scenic easement leased to preserve the historic views. A second unit, the Santa Fe Trails Ruts site, comprises 44 acres (18 ha) of remnant prairie containing remnants of wagon ruts running its length. FOLS entertained 36,541 visitors in 2004.

A.5.1 Resource Overview

Fort Larned National Historic Site is located in the South-central Great Plains section of the Great Plains Steppe Ecological Province at an elevation of approximately 2000 feet (610 m). The Fort itself is situated in central Pawnee County, on the banks and in the floodplain of the Pawnee River, approximately 6 miles (10 km) from its confluence with the Arkansas River in Larned, Kansas. The detached Trail Ruts unit is found on gently rolling uplands 4.5 miles (7.2 km) southwest of the Fort unit. Both units lie on the western edge of the mixed-grass prairie region of Kansas, characterized by grama grasses (*Bouteloua spp.*), buffalograss (*Buchloe dactyloides*), big bluestem (*Andropogon gerardii*), indian grass (*Sorghastrum nutans*) and associated species (Choate et al. 1998). The Trail Ruts unit, while never plowed, has had its original prairie vegetation heavily impacted by grazing and prairie dogs. It is estimated that 76% of FOLS is formerly cropped grassland that has undergone continuing prairie restoration since 1964 (Delisle and Busby 2004). The riparian area of the Pawnee River is delineated by a narrow, meandering green swath through the prairie. Deforested during the occupation of the fort, this deciduous riparian woodland has regenerated and is now composed of cottonwood (*Populus deltoides*), ash (*Fraxinus spp.*), willow (*Salix spp.*), boxelder (*Acer negundo*) and other tree species (Choate et al. 1998). There are no known federally threatened or endangered plant or animal species at Fort Larned. Black-tailed prairie dog (*Cynomys ludovicianus*), a candidate for federal listing, have a long-standing colony at the Trail Ruts unit.

FOLS has a semi-arid continental climate, generally west of the flow of Gulf moisture and east of the Rocky Mountain rain shadow (Becker et al. 1986), with changeable temperatures and precipitation. The average maximum temperature of 89°F (31.5°C) June through August is made more bearable by a constant breeze and low humidity. The dry season of winter brings average minimum temperatures of 19°F (-7°C) December through February. Snowfall averages 20 inches (51 cm) annually and seldom persists longer than three days after a snow event (Becker et al. 1986). The

average annual precipitation nears 23 inches (58 cm), with most of the moisture falling from intense thunder storms August through October. Winds are constant with only rare periods of calm (National Park Service 1979).

A.5.2 Enabling Legislation / Management Documents

The National Park Service recommended that Fort Larned receive an historic site designation after a 1955 reconnaissance visit by Merrill Mattes. Fort Larned National Historic Site, through Public Law 88-541, was authorized by Congress on August 31, 1964 to “commemorate the significant role played by Fort Larned in the opening of the West.” Several Management Plans guide decision-making at FOLS, a 1994 General Management Plan Amendment, Developing Concept Plan and Interpretive Prospectus that updated a 1978 master plan; a 1986 Prairie Management Plan to guide prairie restoration efforts; and a 2001 Fire Management Plan that implements fire related management actions from other management documents.

A.5.3 Natural Resources

Valuable Resources / Species of Interest

The black-tailed prairie dog is the most significant species at Fort Larned National Historic Site. This species has been long established at the Santa Fe Trail Ruts unit and is impacting the cultural resource of remnant wagon ruts. This keystone species of the prairie is providing a documented home for the burrowing owl (*Athene cunicularia*), a species of concern in neighboring states, and is suspected of providing residence for several species of herptiles. All of the biota at Fort Larned is highly valued because so many species have been displaced and reduced by intensive agricultural activities, hunting and trapping in the area.

Geology & Soils

The Fort Larned area is primarily underlain by cretaceous sandstone deposits of the Dakota Formation within the Central Kansas Uplift (Evans 1999). Fort Larned also lies within the Arkansas River lowlands of the Upper Arkansas drainage basin (Evans 1999), with Post-Kansan sediment deposits (younger than 0.39 million years old) (Ross 1991). The soils of the region are chiefly silt and clay loams from Pawnee River stream and flood deposits and fine wind deposits of the Tertiary and Quarternary formation. These soils are generally fertile, but poor soil moisture limits plant growth. Five soil series are present: the Bridgeport series is the most abundant soil at FOLS, consisting of deep, well drained, moderately permeable soils on low, occasionally flooded terraces. Harney, Hord and Uly series are all deep,

well drained and moderately permeable soils, while the New Cambria series is slowly permeable (Stubbendieck et al. 1980). Soil at the Santa Fe Trail Ruts site is silty loam of the Harney series (Stubbendieck et al. 1980) compacted by years of intensive grazing. While erosion due to runoff is not a problem with sufficient root mass, silting from recently plowed agricultural fields is a threat to the wagon ruts (Evans 1999). Although no paleontological resources have been discovered, the potential to find fossils within the alluvium of FOLS does exist (Koch and Santucci 2003).

Land Use

The land at Fort Larned National Historic Site was heavily impacted during the fort's active period. Woodlands along the Pawnee River were decimated for firewood and the surrounding prairie was trampled and heavily grazed. The fort was decommissioned in 1978 and auctioned off in 1884 and was farmed until 1964. Row crop agriculture (wheat, alfalfa, sorghum) is still the predominate land use surrounding FOLS, with little surrounding land left uncultivated. Alternative agriculture uses such as feed lots are also found in Pawnee County, with a stock yard found to the north of the historic site. Petroleum production has gained in importance and there is activity within two miles of the fort. State highway 156 runs along the north side of the Fort. Land surrounding the Santa Fe Trail Ruts site is entirely row crop agriculture.

Hydrology

FOLS is located along the Pawnee River and most of the Park falls within the Pawnee River floodplain. The increased use of surface and ground waters for irrigation has decreased streamflow and complete drying of the streambed during the summer has become common in recent years. Furthermore, irrigation and other agricultural practices has facilitated soil erosion on the Pawnee River, which in turn has increased turbidity levels, and has eliminated much of the riparian vegetation. The overall deterioration of water quantity and quality has led to the decline of much of the resident aquatic life (Becker et al. 1986). The Kansas Geological Survey and the Kansas Water Resource Division are currently monitoring water quantity and quality at FOLS. A basic water quality assessment was completed in 2000 by the WRD of the NPS.

Air Quality

Fort Larned National Historic Site is a Class II air quality area. The rural location of the historic site places it at low risk for foliar ozone injury to plants. There are a few plant species at FOLS that are sensitive to ozone and

two bioindicator species: common milkweed (*Asclepias syriaca*), and redbud (*Cercis canadensis*) (National Park Service 2005).

Wildlife

Mammals: No federally threatened or endangered species have been documented at Fort Larned National Historic Site, nor are there listed species documented from Pawnee County (Delisle and Busby 2004). Several biological inventories have been performed for mammals. A 1989 study identified the deer mouse (*Peromyscus maniculatus*) and white footed mouse (*Peromyscus leucopus*) as the most common mammals found at FOLS. A second study conducted in mid-August 1998 by Fort Hays State University documented 17 species out of the 53 species expected. In addition to the two mice listed above, the big brown bat (*Eptesicus fuscus*) was added to the most common list (Choate et al. 1998). The most recent study from April-May 2001 by the Kansas Biological Survey observed 23 species of mammals, including four species not previously documented at Fort Larned: northern raccoon (*Procyon lotor*), eastern fox squirrel (*Sciurus niger*), Virginia opossum (*Didelphis virginiana*), and plains pocket gopher (*Geomys bursarius*). It is possible that the eastern spotted skunk (*Spilogale putorius interrupta*), a listed species, could inhabit the riparian area of the Pawnee River (Delisle and Busby 2004). The black-tailed prairie dog has maintained a healthy colony on the Santa Fe Trail Ruts unit. Prairie dogs were common along the trail and this colony was already established at the time the park service took possession of the site. This FOLS colony is one of only two populations on NPS land that is not threatened with sarcoptic (bubonic) plague (Plumb and Willson 1997). A keystone species of the short-grass prairie, prairie dogs and their colonies provide food and shelter for a number of animals, including the endangered black-footed ferret (*Mustella nigripes*). The colony has been inspected annually since 1981 for ferret, but none have been observed (Becker et al. 1986). It is speculated that the colony may be too small and isolated to support black-footed ferret (National Park Service 2001). Concern that the burrowing and foraging activities of prairie dogs are threatening the trail ruts has led to strategies for relocating the colony away from the ruts themselves. Similar burrowing activities of pocket gophers (*Geomys bursarius*) within the Fort Larned building area are not so well tolerated (Evans 1999). Mule deer and white-tailed deer are the largest mammals seen at FOLS.

Birds: No federally threatened or endangered birds have been documented at Fort Larned National Historic Site. A breeding bird survey was conducted by Kansas Biological Survey during May-June 2001. Of the 78 predicted species, 57 (73%) were documented. The riparian woodlands

provided the greatest species diversity, accounting for 48 (84%) of the documented species at FOLS, although the grassland species provided the greatest abundance of birds. Several new species for Pawnee County were identified: eastern screech owl (*Otus asio*), eastern wood-pewee (*Contopus virens*), eastern bluebird (*Sialia sialis*), gray catbird (*Dumetella carolinensis*), spotted towhee (*Pipilo maculatus*), and indigo bunting (*Passerina cyanea*). Fort Larned is located within the migratory path of several threatened or endangered species, including bald eagle (*Haliaeetus leucocephalus*), least tern (*Sterna antillarum*), piping plover (*Charadrius melodius*), snowy plover (*Charadrius alexandrinus*), and whooping crane (*Grus americana*) (Delisle and Busby 2004). Two avian species found on the Partners In Flight High Priority list for the Central Mixed-grass region have been documented at FOLS: Bell's vireo (*Vireo bellii*) and the dickcissel (*Spiza americana*).

Reptiles and Amphibians: A survey conducted in 1997 by Fort Hays State University documented 17 species of reptiles and amphibians. The most abundant amphibians found at Fort Union were the Great Plains toad (*Bufo cognatus*) and Woodhouse's toad (*Bufo woodhousii*). The painted turtle (*Chrysemys picta*) was the most abundant turtle found. Three new records for Pawnee County were discovered during this survey: slider turtle (*Trachemys scripta*), false map turtle (*Graptemys pseudogeographica*), and the secretive Great Plains narrowmouth toad (*Gastrophyrne olivacea*) (Choate et al. 1998). A second survey completed in June 2001 by Kansas Biological Survey also observed 17 (49%) of the 35 predicted species of reptiles and amphibians (Delisle and Busby 2004).

Fish: The 2001 biological survey conducted by Kansas Biological Survey identified 6 species of fish in the Pawnee River. As is often the case in summer, much of the streambed of deep muck was dry, resulting in shallow, isolated pools of highly turbid water. The dominant species were those tolerant of poor water quality: black bullhead (*Ameiurus melas*), common carp (*Cyprinus carpio*), and fathead minnow (*Pimephales promelas*) (Delisle and Busby 2004).

Vegetation

As early as 1827, historic accounts gleaned from diaries, reports and even sketches describe the historical landscape as being full of "good grass," with considerable tree cover along the riparian corridor of the Pawnee River. By 1867–1868, photographs show overgrazed and trampled prairie with hardly a tree in sight. One hundred years later, the vast majority of the prairie was turned into cropland while the perennial Pawnee River was reduced to dry streambed during the summer. Today, the story is one

of "rehabilitation" of the landscape to evoke the historic period of the fort, while restoring and maintaining vital habitats and ecological function (Evans 1999).

Fort Larned is located in the mixed-grass prairie of the Great Plains, a transition zone between the tall-grass prairies to the east and the western short-grass prairies. It is estimated that at least 400 acres (162 ha) (60%) of FOLS is considered grassland habitat (Becker et al. 1986). The 44-acre (18 ha) Santa Fe Trail Ruts unit is entirely native prairie, having never been plowed. It had, however been heavily grazed for many years, resulting in a lack of tall-grass species (Stubbendieck et al. 1980). A few other small relicts of native sod have been identified on the Fort unit. Prairie restoration at Fort Larned began in 1968 with the seeding of blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Short-grasses were chosen for fear that tall-grasses would pose a fire hazard (Stubbendieck and Willson 1986). Roger Landers from Iowa State University, in a 1975 report, assessed the initial restoration efforts, described the vegetation found, and gave specific recommendations for mowing, seeding and burning. This was followed by additional management recommendations in a 1980 report by Stubbendieck, Wiederspan and Kjar. The management tool of mowing was augmented in 1983 by the onset of prescribed burning (Stubbendieck and Willson 1986). Donald Becker, in his 1985 vegetation survey, stated that most plots had made "a small but significant increase" in tall-grass species and established permanent survey transects. Becker also voiced concern that exotic plants, dominated by downy brome, covered large portions of the restoration prairie. Stubbendieck and Willson revisited the prairies at FOLS in their 1986 report, reporting that mid-grass cover was increasing even as the short-grasses remained static. Cool season exotic grasses still dominated several restoration units. Restoration efforts continue to this day. A combined regimen of seeding, prescribed fire and haying moves the prairie slowly closer to its climax stage. Control of smooth brome (*Bromus inermis*) and other exotics may be possible by continuing with controlled burns.

The remnant prairie found at the Santa Fe Trail Ruts site suffers from overgrazing, first from livestock (excluded since 1975), and now from prairie dogs. No tall-grass species remain. A need exists to relocate the prairie dogs to the periphery of the ruts site to prevent further destruction of the ruts features. Debate currently focuses on reintroducing tall-grass species to the ruts while managing the periphery as short-grass (Evans 1999). Prairie dogs prefer short-grass for safety reasons, so it is hoped that this strategy might succeed where other methods have failed. Smooth brome (*Bromus inermis*) is invading the Trail Ruts site from the roadside, while kochia (*Kochia scoparia*) is attacking from the neighboring fields (Evans 1999).

Restoration of the riparian woodlands has been achieved naturally. Predominant trees in this community include black willow (*Salix nigra*), boxelder, cottonwood, green ash (*Fraxinus pennsylvanica*) and slippery elm (*Ulmus rubra*). American elm (*Ulmus americana*) had been a major component of these woodlands, but by 1968 most had been killed by Dutch elm disease (Evans 1999). Small fragments of original prairie sod exist along the banks of the Pawnee River (Stubbendieck and Willson 1986), while western wheat grass (*Agropyron smithii*) or herbaceous weeds have replaced much of the original woodland groundcover (Becker et al. 1986). Although this woodland did not exist during the period of Fort Larned, it will be retained as a visual barrier to the highway traffic and as a corridor of high biotic diversity (Choate et al. 1998).

A.5.4 Management Issues

Prairie restoration tops the list of management issues. The restored grasslands surrounding Fort Larned represent some of the earliest attempts at re-establishing prairie. Perhaps the greatest difficulty is the control of exotic invasive plants while perennial grasses gain hold. Over 100 acres (40 ha) are still in need of active management to remove smooth brome, kochia and poison hemlock (*Conium maculatum*). In areas where grasses have successfully established, a lack of diversity in forbs has been discovered. Reintroduction of several missing species will result in a healthier ecosystem.

Of similar concern is the impact the prairie dog colony is having on the wagon rut features at the Santa Fe Trail Ruts unit. While a valued species of concern, the colony covers three-quarters of the site and is obliterating the very elements that caused that area to first be preserved. Neighboring landowners are concerned with the colonies spread into their agricultural fields. While deemed too small to support black-footed ferret, the colony is occupied at times by burrowing owl. Monitoring of burrowing effects will continue while methods of controlling and managing the population are explored.

Restoration of displaced ecological patterns has met with mixed results. The long-term suppression of wildfire at FOLS requires the implementation of prescribed burns as a management tool for prairie restoration. Begun in 1999, there is evidence that properly timed fire has affected the seed production and vigor of the problem invasive, smooth brome. Study must continue to determine how fires timing affects species selection in restoration situations.

Seasonal flooding along the Pawnee River will likely never be restored. Irrigation drawdown and impoundment has changed the river from a perennial, clear-flowing stream to an intermittent, turbid imitation of itself. Sedimentation from

erosion of agricultural fields has covered the original sand bottom with 10 feet (3 m) or more of muck. Efforts continue to insure that FOLS acquire and maintain enough water rights to insure that the Pawnee River is replenished.

Preservation of the viewsheds at FOLS is vital to providing visitors a historic impression of life at the fort. This can be accomplished with continued landowner cooperation and scenic easements. While the view from south of the fort is evocative of the historic isolation, this is not the case of scenes from other directions (Evans 1999). Threat of unsuitable land use of surrounding properties will continue. Wind farms have been proposed to take advantage of the constant breeze and feedlots continue to be an ominous possibility.

A.5.5 Partnering / Neighboring Agencies

Current Partners

Fort Hays State University, Kansas State University, Kansas Ornithological Society, Kansas Biological Survey, NRCS

Neighboring Land Management Agencies

Quivira NWR, Cheyenne Bottoms Waterfowl Management Area, Sand Hills State Park, Cheney State Park, Kanopolis State Park, Smokey Valley Ranch (TNC), Cheyenne Bottoms Preserve (TNC); Konza Long Term Ecological Research

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A.6. FORT UNION NATIONAL MONUMENT (FOUN)

Fort Union National Monument is comprised of 721 acres (292 ha) of short-grass prairie contained within two separate units, located in northeastern New Mexico, approximately 10 miles (16 km) northwest of Watrous and Valmora in Mora County. Established in 1851, Fort Union served the region for forty years as a military supply depot, arsenal, and frontier military post protecting the Mountain Branch of the Santa Fe Trail. Three successive forts were constructed in the area, and the majority of the remains of each fort are contained within the monument boundaries, resulting in the largest grouping of adobe ruins in the United States (Johnson et al. 2003a). Wolf Creek divides the largest unit of 637 acres (258 ha), containing the remains of two forts, from the disjunct 84 acre (34 ha) second unit that contains remnants of the original fort (Muldavin et al. 2004). Of additional significance, the monument encloses the remnants of the largest accumulation of Santa Fe Trail ruts (Koch and Santucci 2003) in the US. FOUN continues to be surrounded by a 96,000-acre (38,850 ha) cattle ranch that pre-dates the 1891 closure of the fort (Johnson et al. 2003a).

A.6.1 Resource Overview

The monument, at an elevation of 6,800 feet (2,073 m), is located in a wide valley of Wolf Creek, on the southwestern fringe of the Great Plains. Annual precipitation is 16-20 inches (41 – 51 cm), with the majority of rain falling

from May to September, results in a semi-arid climate with notable periods of wind (Muldavin et al. 2004). Fort Union is in a region of the heaviest thunder and lightening regions in the nation (Fort Union National Monument 2000). Temperatures range from an average high of 80°F (27°C) from June to August to an average low of 14°F (-10°C) for December to February, with daily temperature fluctuations of 30°F (16.8°C) or more. Annual visitation at FOUN totaled 13,117 people in 2004.

A.6.2 Enabling Legislation / Management Documents

Fort Union National Monument was congressionally authorized by Public Law 83-429 on June 28, 1954, “to preserve and protect, in the public interest, the historic Old Fort Union, situated in the county of Mora, State of New Mexico, and to provide adequate public access thereto. . . .” The monument was formally established by the National Park Service on April 5, 1956. Additionally, under Public Law 100-35, the 100th United States Congress authorized the Santa Fe National Historic Trail on May 8, 1987 to commemorate the over 1,100 mile-long Santa Fe Trail from Old Franklin, Missouri to Santa Fe, New Mexico.

According to the Fort Union National Monument Resource Management Plan (2000), the “Mission of FOUN is to preserve the ruins of the historic fort, to provide for public access, and to educate the public about its significant role in the American Southwest, the Santa Fe Trail, and the development of United States rules in the Southwest.” The Resource Management Plan is a strategic planning document for management and conservation of the cultural and natural resources of Fort Union. Objectives of this planning document pertaining to natural resources include the desires to: “preserve and manage the resources, and to maintain and perpetuate the integrity of the historic remains of the three forts, the archeological resources, and the historic landscapes; ... increase knowledge, understanding, and appreciation of both the natural and cultural resources;” and “... instill an awareness and sensitivity toward the fragility of the resources and the need for continued preservation and protection.” These stated objectives are in keeping with those of the 1984 General Management Plan and Environmental Assessment, which included an additional objective “to seek a continuation of compatible activities on lands adjacent to the monument to protect the fort’s historic scene.”

A.6.3 Natural Resources

Valuable Resources / Species of Interest

The most significant natural resource at Fort Union National Monument is the native short-grass prairie community.

After bearing the brunt of tremendous historical use reflected in current vegetation patterns (Muldavin et al. 2004), the short-grass prairie has begun to tentatively restore itself after grazing was halted in 1956. There are no threatened or endangered species of plants or animals documented within the monument. Swainson's hawk (*Buteo swainsoni*) and Prairie falcon (*Falco mexicanus*) have both been observed at FOUN and are on neighboring Oklahoma's list. The adobe ruins may provide habitat for breeding and migrating birds, as well as roosts for bats and shelter for reptiles (Johnson et al. 2003a).

Geology & Soils

Fort Union is located on the east side of a southward trending valley of Wolf Creek, a tributary of the Mora River. The valley is bordered to the west by a prominent sandstone mesa and on the east and northeast by the Turkey Mountains (Fort Union National Monument 2000). The primary geologic formation exposed at FOUN is the Upper Cretaceous Graneros Shale. No fossils have been discovered within the park, although they have been found elsewhere in New Mexico from this same formation (Koch and Santucci 2003). Layers encountered in drilling the monument well were: top soil and gravel (first 7 feet [2 m]), black shale (7-140 feet [2-43 m]), white limestone (140-150 ft [43-46 m]), sandstone (150-300 ft [46-91 m]) and blue sandy shale (300-325 ft [91-99 m]) (Southwest Region 1984). Soils at FOUN are classified as Aridic Argiustolls, largely comprised of silt and stony (Partri) loams formed in alluvial material from the adjacent basalt formations and other eolian material, ranging in depth from very shallow to moderate, and unstable when devegetated (Freitag 1994).

Land Use

Fort Union is located in Mora County, an area of sparse population and low growth, where ranching is the predominant land use. The land immediately outside of the monument has been owned by the Fort Union Cattle Ranch since the early 1900's and has been grazed since that time (Fort Union National Monument 2000).

Hydrology

FOUN contains no surface water resources within its boundaries but Wolf Creek, adjacent to the Park, intermittently produces small springs and seepage areas within the Park. Drought is increasing the susceptibility of FOUN to exotic plant invasions, so insufficient water resources is a concern to Park managers. Another concern is the potential for anthropogenic sources of contaminants being introduced to the groundwater, particularly from nearby ranching operations, storm water runoff, recreational

use, and atmospheric deposition. FOUN personnel collect groundwater samples twice a month for bacteriological analyses and results have consistently complied with health standards. A basic water quality assessment has been completed (National Park Service 1998).

Air Quality

FOUN is a National Park Service Class II air quality area. No qualitative air data exists for the FOUN region and there are no air quality concerns at present (Fort Union National Monument 2000). The low levels of ozone exposure make the risk of foliar damage to plants negligible. While there are a few ozone-sensitive plants at FOUN, there are no bioindicator species at the site (National Park Service 2005).

Wildlife

Mammals: Natural Heritage New Mexico surveyed FOUN during 2001 and 2002. They documented 16 species of mammals. Bats were not surveyed but were observed and tentatively identified as Mexican free-tailed bats (*Tadarida brasiliensis*). Ord's kangaroo rat (*Dipodomys ordii*) was the most commonly caught species in the grassland. Two elk bulls (*Cervus elaphus*) and large herds of pronghorns (*Antilocapra americana*) have been observed near the park boundary (Johnson et al. 2003b).

Birds: Natural Heritage New Mexico surveyed FOUN during 2001 and 2002 and detected 52 species during the breeding season. Of these, 32 species (55.2%) were found in grassland habitats, 25 species (43.1%) were found in piñon-juniper habitats, and riparian habitats accounted for 20 species (34.5%). Brown-headed cowbird (*Molothrus ater*) was the most commonly detected bird, with 48.5% of detections. Cliff swallow (*Petrochelidon pyrrhonota*) and western meadowlark (*Sturnella neglecta*) were the second and third commonest species, with 13.3% and 12.2% of total detections, respectively (Johnson et al. 2003a). Six species of birds listed as high priority on the Partners In Flight Watch List for the "Physio 85 Mesa and Plains" region have been documented at Fort Union: Swainson's hawk (*Buteo swainsonii*), black-chinned hummingbird (*Archilochus alexandri*), canyon towhee (*Pipilo fuscus*), Cassin's sparrow (*Aimophila cassinii*), Cassin's kingbird (*Tyrannus vociferans*), and Virginia's warbler (*Vermivora virginiae*). As the short-grass prairie continues to improve, it may be possible to encourage the residence of several nearby species of interest – burrowing owl (*Athene cunicularia*) is known to inhabit the area, mountain plover (*Charadrius montanus*) might be found near, ferruginous hawk (*Buteo regalis*) and peregrine falcon (*Falco peregrinus*). The absence of livestock grazing on FOUN has apparently encouraged diversity of grassland

birds, especially ground- and shrub-nesting birds and has probably allowed the persistence of a small marshy area near the westernmost corner of the monument. The stabilization of historical structures has also allowed nesting by several species favoring cavities for nest placement. Clusters of planted and naturally-occurring deciduous trees have likely also encouraged canopy birds, while modern building structures provide nesting substrates for others (Johnson et al. 2003a).

Reptiles and Amphibians: Natural Heritage New Mexico surveyed FOUN during 2001 and 2002 and documented only 9 reptile and amphibian species. Severe drought during the survey period likely affected these results. Lack of habitat diversity, the small size of the park and its proximity to grazed rangeland may also reduce the number of species that permanently inhabit the monument (Johnson et al. 2003b).

Vegetation

FOUN is located in the southern parks and ranges section of the Southern Rocky Mountain Steppe ecoregion. An assessment of prairie carried out by Stubbendieck and Willson (1986) classified the majority of the monument as native prairie “in excellent condition,” with blue grama as the dominant grass. The Grama-Buffalograss groundcover was thought to be similar to that of 1884 (Stubbendieck and Willson 1986). A more recent survey of vegetation by Natural Heritage New Mexico in 2004 described the plant life at FOUN as relatively diverse, with the short-grass prairie still dominant yet reflecting the impacts of historic use. Drought was prevalent during the three summer seasons of this survey, resulting in the identification of 142 taxa, 16 plant associations and 11 alliances. The most abundant grass was blue grama (*Bouteloua gracilis*), the characteristic species of the short-grass prairie, and the most common associations were the Blue Grama/Fringed Sage Grassland (*Bouteloua gracilis*/*Artemisia frigida*) and the Blue Grama-Purple Threeawn (*Bouteloua gracilis*-*Aristida purpurea*), indicative of a long disturbance history. The remnants of the Santa Fe Trail have a different vegetation pattern – hairy grama (*Bouteloua hirsuta*) is associated with more compacted soils, while western wheatgrass (*Agropyron smithii*) and sleepygrass (*Achnatherum robustum*) reflect the concentration of water in the trails during rainfall events. The most diverse vegetation community at FOUN is found around the seeps and springs along the lower western slope of the monument (Muldavin et al. 2004).

There is little need for restoration efforts at FOUN, although management strategies need to be investigated. Lack of grazing on these prairies, while initially beneficial, may now limit range improvement. The reintroduction of fire,

of interest to the surrounding landowner, and should be explored.

The vegetation survey carried out by Natural Heritage New Mexico found only twelve species they considered “non-native alien introductions,” with none posing significant threats to native species (Muldavin et al. 2004). An earlier survey points out revegetation efforts on disturbed areas had been unsuccessful, allowing an influx of invasive species (Johnson et al. 2003a). A noxious weed inventory conducted March to August, 2003, determined that field bindweed (*Convolvulus arvensis*) was the only exotic species of concern, occupying an estimated 3.3 acres along the roadside and in the residence area. Many of the other exotic species identified at FOUN were only found in the low, wet area adjacent to Wolf Creek (Natumalani et al. 2004). In all cases, vigilance against infestation of disturbed areas was recommended as the major control method for Fort Union.

A.6.4 Management Issues

The most critical natural resource issue at Fort Union National Monument is “the need for effective means of dealing with unwanted vegetation and the problems of burrowing mammals” (Fort Union National Monument 2000). Botta’s pocket gophers (*Thomomys bottae*), rabbits and other rodents are excavating large patches of monument. Many soils in and around the ruins that have been recently deposited or dug up for other purposes have become ideal habitats for these animals (Muldavin et al. 2004). This small mammal community that includes mice, voles, shrews and moles also provides a possible vector for introduction of diseases such as hanta virus and bubonic plague. Efforts at revegetation with native grasses following disturbance has met with limited success, resulting in invasive species colonizing these areas. While invasive plant species are not welcome, the establishment of native vegetation within the perimeter of the stone foundations of the ruins is desired by the park management, but as yet unattained (Johnson et al. 2003a).

The expansive landscape surrounding Fort Union is an important part of the monument’s story, and preservation of the historic scene is a goal stated in the monument’s General Management Plan. Possible intrusions on the historic scene could include a variety of incompatible land uses: both mining and timber harvesting in the Turkey Mountains have been considered in the past. Power lines, road improvements and resort/retirement residential developments are examples of other activities that could intrude on the fort’s pristine setting. The National Park Service maintains a dialog with the owners of the surrounding range land, regional utilities, and transportation

agencies to encourage compatible uses of land within the Fort's viewshed (Fort Union National Monument 2000).

The drought/monsoon cycle is well documented in northeastern New Mexico, bringing its own unique set of stressors. The deep drought experienced from 2001 – 2004 may be broken in 2005 by an expected shift in the El Nino weather pattern. Periods of drought stress the prairie ecosystem and provide beneficial conditions for hanta virus. Fortunately, the historic dust storms from the days of "Fort Windy" are no longer a problem now that vegetation has been re-established, yet dust particles are still lifted into the atmosphere, affecting air quality.

The need to introduce fire as a management tool for the short-grass prairie has been discussed. While prairie fire is thought to increase biodiversity and reinvigorate ecosystem processes, the effects of various intensities and frequencies on more arid short-grass systems must be explored. Use of this management tool is limited by the size of the monument and the need to protect the cultural resources, but there are areas within the monument that may benefit from a prescribed burn (Muldavin et al. 2004).

The ruts of the Santa Fe Trail have either grown over with vegetation that threatens to obscure them or have eroded into active arroyos. Stabilizing erosion by revegetating affected areas runs the risk of obscuring the ruts with vegetation. It is hoped that a balance between erosion and vegetative deposition can be found to preserve these cultural relics (Muldavin et al. 2004).

A.6.5 Partnering / Neighboring Agencies

Current Partners

New Mexico Natural Heritage Program, Great Plains Cooperative Ecosystems Study Unit, USFWS, Soil Conservation Service.

Potential Partners

Highlands University; Weed Management organizations.

Neighboring Land Management Agencies

Coyote Creek State Park, Colin Neblitt Wildlife Area, Las Vegas NWR, Maxwell NWR; Area in Wagon Mound.

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A.7. LAKE MEREDITH NATIONAL RECREATION AREA (LAMR)

Lake Meredith National Recreation Area (LAMR) is located approximately 21 miles (34 km) North of Amarillo in the Panhandle of Texas. The park itself extends approximately 22 miles (35 km) across portions of Potter, Moore, and Hutchinson counties. Contrasting spectacularly with its surroundings, LAMR lies on the dry and windswept High Plains of the Texas Panhandle in a region known as Llano Estacado, or Staked Plain. The 46,349-acre (18,757 ha) national recreation area includes a 10,000-acre (4,047 ha) reservoir formed in the 1962 with the construction of Sanford Dam. Lake Meredith is the largest lake in the

Texas and Oklahoma panhandles and was constructed primarily to supply water to the surrounding communities, with recreation as a secondary use. LAMR contains valuable cultural and natural resources. The National Park Service has administered LAMR since 1965, initially called Sanford Recreation Area. In 1972, it was renamed Lake Meredith Recreation Area, and in 1990 it was renamed Lake Meredith National Recreation Area and officially became a unit of the NPS. The park hosted 806,481 visitors in 2004.

A.7.1 Resource Overview

LAMR is located on the High Plains of the Llano Estacado, specifically along the Breaks created by the Canadian River as it meanders west-east across the Texas Panhandle. Much of LAMR is in the category “Rough Broken Land” that can be divided into Mesa Top, Gravelly Slope, Steep Slope, and Bottomland. This area of Texas is comprised of gently rolling to moderately rough topography. Narrow, intermittent stream valleys flowing east to southeast dissect it. The Canadian River rises in the Sangre de Cristo Mountains of New Mexico and flows eastward across the semiarid Texas Panhandle and into Oklahoma, with a total watershed is approximately 13,000 square miles (33,670 km). The river has carved a narrow, steep-walled canyon from 197-295 feet (60-90 m) deep and up to 2 m (3.3 km) wide. Between this canyon and the surrounding caprock, many tributary streams have created a rough and broken topography, known as the Canadian River Breaks.

The Canadian River Basin climate is characterized as semi-arid with an average annual rainfall of 20 inches (51 cm) per year. Seventy percent of the precipitation falls between April and September, which is the primary growing season. This area has hot summers and cold winters with strong winds that work to increase evaporation rates, which have been estimated to average 60-65% of the total precipitation. The elevation ranges from 2800 to 3320 feet (853-1,012 m).

Sanford Dam is on the Canadian River about 38 miles (61 km) northeast of Amarillo. It is an earthfill structure 198 feet (60 m) high with a crest length of 6,380 feet (1,945 m) and a total volume of about 15,000 cubic yards. The dam impounds a reservoir with a capacity of 1,408,000 acre-feet. Lake Meredith provides an average of about 103,000 acre-feet annually for municipal and industrial uses to supplement existing ground-water supplied for eleven cities. The Canadian River is dry below the Sanford dam, which has not been opened in recent years to release water. Groundwater occurs primarily in the Ogallala aquifer, which lies uncomfortably above older rock units of the Cretaceous, Triassic, Jurassic and Permian formations. Substantial amounts of useable water

are found in the Cretaceous, Triassic, and Jurassic rocks; however, water within the Permian has been found to be saline and unusable.

A.7.2 Enabling Legislation / Management Documents

Lake Meredith National Recreation Area became a National Park System (NPS) unit by a series of agency actions between the NPS and the Bureau of Reclamation (BOR) spanning approximately four decades. The interaction between the BOR and the NPS began when Congress passed the Canadian River Reclamation Project Act of December 29, 1950, authorizing the BOR to design and construct the Sanford Dam and Reservoir (Public Law 81-898, 64 Stat. 1124). The dam's purposes included irrigating land, delivering water for industrial and municipal use, controlling floods, providing recreation and fish and wildlife benefits, and controlling and catching silt.

In 1953, the NPS determined that the reservoir would provide valuable recreational uses for Texas Panhandle residents. The NPS, however, found that the reservoir lacked national significance and suggested that the state or the neighboring cities administer the recreation area. Between 1953 and 1961 the Department of the Interior adopted policies requiring its agencies to evaluate federal reservoir projects for public benefits associated with recreation and wildlife. Consistent with this policy, the NPS and the BOR signed a Memorandum of Understanding and Agreement on June 26, 1961 that required the NPS to investigate, to plan, and to develop a recreation area at the Sanford Reservoir.

To insure that the reservoir would provide recreational uses for the public, Congress passed an Act in August 31, 1964 that authorized the Secretary of the Interior “[t]o provide for the establishment and [the] administration of public recreational facilities at the Sanford Reservoir area...” (78 Stat. 744). This act caused the Sanford Dam and Reservoir to be known as the Sanford Recreation Area. After Congress passed the act, the Canadian River Municipal Water Authority (CRMWA) and the BOR entered into an agreement allowing the CRMWA to administer the area or to recommend an agency to administer the area. The CRMWA suggested, and the BOR agreed, that the NPS should assume administration of the reservoir's public uses because the NPS had access to development capital and had experience at administering multipurpose reservoirs.

To transfer the administrative duties, the NPS and the BOR signed a Memorandum of Agreement on March 15, 1965. The agreement allowed the NPS to “establish policies, rules, and regulations relating to public outdoor recreational

use and occupancy of lands and water available for such use.” The agreement also divided Sanford Recreation Area into two segments for operation and for maintenance. The first segment, which the BOR administered, included land and water needed for the construction, the operation, and the maintenance of the dam. The NPS administered the second segment, which encompassed land and water used for recreation and for fish and wildlife enjoyment.

By Public Law 101-628 (16 U.S.C. § 460eee), on November 28, 1990, Congress renamed Lake Meredith Recreation Area as a National Recreation Area, “to provide for public outdoor recreation use and enjoyment of the lands and waters associated with Lake Meredith in the State of Texas, and to protect the scenic, scientific, cultural, and other values contributing to the public enjoyment of such lands and waters.” This change “codified the long-standing administrative arrangements between the BOR and the NPS” (136 Cong. Rec. 17,473), and made Lake Meredith National Recreation Area a National Park System unit emphasizing the importance of protecting and interpreting the natural and cultural resources of the park.

There has been no General Management Plan created for LAMR. The most recent Resource Management Plan was completed in 1996 (Lake Meredith National Recreation Area 1996). Other pertinent management documents include an oil and gas management plan developed in 2002 (Lake Meredith National Recreation Area 2002), a personal watercraft use assessment in 2003 (Lake Meredith National Recreation Area 2003), and an economic analysis of personal watercraft (National Park Service 2003a).

A.7.3 Natural Resources

Valuable Resources / Species of Interest

Federally listed species documented at LAMR are the Bald Eagle (*Haliaeetus leucocephalus*) and Arkansas River Shiner (*Notropis girardi*). The portion of the Canadian River from the boundary of the park to the confluence with Coetas creek was formally designated by US Fish and Wildlife Service as critical habitat for the shiner. Other documented state-listed species or species of concern include Texas Horned Lizard (*Phrynosoma cornutum*) and Ferruginous Hawk (*Buteo regalis*).

Geology / Soils

Five geologic formations outcrop in the vicinity of the parks, and from oldest to youngest include the Permian Quartermaster Formation, Triassic Dockum Group, Tertiary (Miocene-Pliocene) Ogallala Group, Pleistocene terrace deposits, and Holocene alluvium. Soil groups include Burson-Quinlan-Aspermont, Mobeetie-Tascosa, Acuff-Palo Duro-Olton, Tascosa Burson and Dumas-Dalhart.

The soils in the Lake Meredith area can be characterized as moderately deep to very deep, nearly level to strongly sloped, fine sandy loams to clay loams (USDA, SCS, Soil Surveys 1975, 1976, and 1980). In areas with steeper slopes, the soils tend to be shallow (10 to 20 inches [25-51 cm]), well drained, calcareous, loamy to gravelly soils with variable amounts of rock fragments. These soils are also associated with rock outcrops in the park. Soils on steep slopes are highly susceptible to water erosion and moderately susceptible to wind erosion. On the gentler slopes away from the reservoir, are very deep, well drained, calcareous clay loam soils. The hazard of water erosion is severe and the chance of wind erosion is moderate in these areas. On nearly level floodplain areas in the upper reaches of the reservoir, there are deep, calcareous soils that are subject to flooding about once every three to five years. Locally there may be hydric soils and wetlands in these floodplain areas. These soils are slightly susceptible to water erosion, but soil compaction may be a problem in these areas. On the flat areas above the reservoir, there are areas of dunes and other sandy deposits. These areas are highly susceptible to wind erosion. Problems associated with soils in the LAMR area are generally related to soil texture (grain size) and slope. Unprotected areas are subject to blowing soils and water erosion. In the parks, soil compaction, erosion, and slumping occurs along roads, drillpads, and flowlines, gathering lines and pipelines. Erosion tends to increase where vegetation has been removed and cut and fill activities have occurred. Accelerated erosion is more prevalent on steeper slopes and other disturbed areas in the parks.

The formation of the Canadian River Breaks was caused by several geologic processes. Recent research indicates that subsurface salt layers in Permian Formations about 2,000 feet (610 m) below the surface dissolved, collapsing the overlying deposits. Surface drainage concentrated in the lower areas and created the pathway for the present-day Canadian River. During wetter periods over the past several million years, the Canadian River eroded down through the Ogallala Formation, deepening the canyons or “breaks”. Further evidence of salt dissolution is obvious in the vicinity of the parks where subsurface salt deposits have dissolved leaving depressions on the surface. In addition, the salinity of the Canadian River (3,000 parts per million) suggests that salt dissolution is still occurring today near the Canadian River (Spearing 1991).

Land Use

Lake Meredith National Recreation Area is located within the Panhandle Field which covers about 1,475,000 acres (596,911 ha), of which approximately 1,000,000 acres (404,685 ha) produces sweet gas and about 400,000 acres (161,874 ha) produces sour gas with hydrogen

sulfide. This field also produces around 250,000 acres (101,171 ha) of crude oil (Thompson 1939). In the vicinity of the parks, the oil and gas producing area is called the Panhandle West Field.

Lake Meredith is the largest lake in the Texas and Oklahoma panhandles and is consistently, one of the top NPS Intermountain destinations in terms of visitation. In addition to water recreation, people come from a four-state area to hunt, fish, ride horseback, use motorcycles and dune buggies in the off-road vehicle areas, and to camp at numerous spots both near and away from the water. Ranching, extractive activities and vacation development are the current primary land uses in the area surrounding LAMR.

Hydrology

Lake Meredith was created when the Bureau of Reclamation constructed the Sanford Dam on the Canadian River. The reservoir was created to supply water to eleven surrounding communities, with recreational use a secondary purpose. Below the dam is a perennial stream that originates from two or more springs, but seldom flows more than 100 yards (91 m), except during periods of heavy rainfall. Also below the dam are several small artificial lakes and a large wetland, all of which are a result of the Sanford Dam. The largest of these artificial water bodies is the Stilling Basin, designed to still the water when it leaves the flood gates. This area is the most popular swimming area at LAMR. The Ogallala formation underlying LAMR is the most important aquifer to this area. It contributes to the water supply for farming, ranching, commercial and domestic uses. The heavy use of water from this aquifer is lowering the water table at a rate of 2-3 feet (61- 91 cm) per year. Ninety-nine percent of Lake Meredith is designated as impaired on the federal 303(d) list because of mercury contamination. Water quality and quantity are the most important natural resource concerns for LAMR. Erosion, exotic plant and animal invasions, non-point source pollution and recreational impacts are among the most significant factors affecting water quality. Reclamation of abandoned oil and gas and prairie restoration can lead to improved groundwater recharge of upland areas. A basic water quality assessment was completed in 2001 by the WRD of the NPS.

Air Quality

An air emissions inventory was completed in 2003 (National Park Service 2003b). LAMR is designated as a Class II area under the Clean Air Act. Ambient (i.e., ground level) concentrations of sulfur dioxide, nitrogen oxides, ozone, and particulate matter are not routinely monitored but are presumed to be in compliance with the National Ambient

Air Quality Standards. The only nearby ambient monitoring was conducted until 1996 in Amarillo, Texas for PM-10 (particles with an aerometric diameter of 10 microns or less). All monitored values indicated compliance with the PM-10 NAAQS standard (highest 24-hour measurement of 60 micrograms per cubic meter compared to the 150 ug/m³ standard). Ozone levels in the project area are unknown at this time. The potential addition of nitrates and volatile organic compounds, the primary precursors for ozone formation, to those already present in the area from existing oil and gas-related activities and energy production, may justify monitoring ozone levels to track the cumulative impact of these activities on ambient ozone levels (Lake Meredith National Recreation Area 2002). There is currently only a low risk of foliar ozone damage. Exposure to 80 ppb ozone is infrequent, and exposure to 100 ppb rare (National Park Service 2005).

Although neither LAMR nor ALFL is subject to the visibility protection provisions that apply to Prevention of Significant Deterioration Class I areas, they do experience the widespread visible haze affecting this region of the country and would benefit from any future regional strategies to reduce visibility impairing pollution. Some of those pollutants are emitted in the vicinity of the parks by existing sources. For instance, about a dozen major sources in the three county area of Hutchinson, Moore, and Potter Counties contribute over 64,000 tons per year of SO₂, a pollutant that is transformed in the atmosphere to fine sulfate particles which have a dramatic effect on visibility impairment caused by scattering and absorption of light. It is likely that additional industrial activity associated with oil and gas production will contribute to fine particle formation. Based on extrapolation of visibility data collected over the period from 1988-1997 by the IMPROVE (Interagency Monitoring of Protected Visual Environments) visibility monitoring network, the visual range experienced on average in this area is from 30-60 miles (48 to 96 km) or probably about half the distance that would be visible under natural visibility conditions in the area (Lake Meredith National Recreation Area 2002).

Wildlife

There have been several inventory related research projects for vertebrates at LAMR and ALFL (Killebrew 1977, Phillips, 1989, Yancey et al. 1998, Munger 2002, Patrikeev and Gallyoun 2004).

Mammals: There have been 60 species of mammals documented at LAMR and ALFL. There was a black-tailed prairie dog (*Cynomys ludovicianus*) town as recent as the 2001 but it was wiped out by plague. It is likely that prairie dogs will re-colonize LAMR in future years. Bats

are probably the most under recorded group of mammals at LAMR. Patrikeev and Gallyoun (2004) detected only one species of bat and Yancey et al. (1998) did not find any. Surveys are difficult to conduct at the park due to consistent high winds that make captures with mist nets problematic. Future surveys with bat detectors or a harp trap may yield additional species. Two potentially occurring rare mammals animals the Townsend's big-eared bat (*Corynorhinus townsendii*) and swift fox (*Vulpes velox*).

Birds: In addition to 72 species of breeding birds detected by Patrikeev and Gallyoun (2004), an anonymous park bird lists 23 additional species as nesting or likely nesting in the park, but there is no evidence, or even an author, to substantiate the list. LAMR has a high population of nesting Mississippi kites (*Ictinia mississippiensis*) along the riparian area and there is also a great blue heron (*Ardea herodias*) rookery (Lake Meredith National Recreation Area 2002). The park is located along the central flyway and has a high number of waterfowl during migration. LAMR has a large population of bald eagles (*Haliaeetus leucocephalus*) during the winter. It has been speculated that the park may be a large-overwintering site for grassland birds. Bird surveys conducted at LAMR/Alibates Flint Quarries National Monument detected scaled quail (*Callipepla squamata*), scissor-tailed flycatcher (*Tyrnanus forficatus*) and Cassin's sparrow (*Amiophila cassinii*), all on the Partners In Flight watch list for the Pecos and Staked Plains region. Three potentially rare species occurring at the park are snowy plover (*Charadrius alexandrinus*), piping plover (*Charadrius melodus*), and mountain plover (*Charadrius montanus*).

Reptiles and Amphibians: There have been 32 species of reptiles and 11 species of amphibians detected at LAMR and ALFL. The Texas horned lizard is a state listed species and is relatively common at LAMR (Patrikeev and Gallyoun 2004). The Colorado checkered whiptail (*Cnemidophorus neotesselatus*) may have been caught for the first time in Moore County by Patrikeev and Gallyoun (2004).

Fish: There have been 11 fish species detected from LAMR. The two rare species, Arkansas river shiners and peppered chubs (*Macrhybopsis tetranema*), present at LAMR are both threatened by impoundments and construction. The former has been found in the vicinity of Chicken and Bonita Creeks, and the latter in Chicken Creek (Patrikeev and Gallyoun 2004). A potential threat to the Arkansas River shiner at LAMR is the low water level caused by prolonged drought and extensive water retention upstream in New Mexico (Durham and Wilde, in press). Patrikeev and Gallyoun (1994) recorded the first river shiner (*Notropis blennioides*) in Texas, a likely introduction.

Invertebrates: Phillips (1990) states that there may be over 600 species of insects from LAMR. Identification of specimens has varied in getting to genus or species level. The giant mole cricket (*Gryllotalpa major*) was collected in McBride Canyon and is a rare species typical of high quality mixed-grass prairie.

Vegetation

A total of 486 species have been documented and supported by vouchers from the park (Wright and Meador 1981, Nesom et al. 2005). Much of the terrain surrounding the parks consists of flat grasslands. The predominant vegetative cover is comprised of blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), and buffalo grasses. Stands of cottonwood (*Populus deltoides*) and hackberry trees (*Celtis occidentalis*) are found in the side canyons along the lake. The varying lake levels have encouraged the encroachment of salt cedar in the floodplain areas. Nesom et al. (2005) detected 47 exotic species, from the park based on vouchered specimens. Two of the invasives, Russian olive (*Elaeagnus angustifolia*) and Siberian elm (*Ulmus pumila*) were identified by Nesom et al. (2005) as management priorities for the park. An earlier plant list by Phillips (1997) lists 516 species but there are no voucher specimens to support the list, and Nesom et al. (2005) estimated that 59 of these species were unlikely to occur at LAMR. Nesom et al. (2005) found four new state records, plains spring parsley (*Cymopterus acaulis*), slickseed fuzzybean (*Epilobium leptophyllum*), salt marsh goosegrass (*Puccinellia fasciculata*), and *Atriplex patula*, and six species with large range extensions at LAMR during their work in 2002. There are no known endangered or threatened plants within the boundaries of the parks. Off-road vehicle use has severely impacted vegetation along Rosita Creek, Blue Creek, and the Canadian River. Possibly occurring rare plants at LAMR include *Astragalus puniceus* var. *puniceus*, Correll's Wild-Buckwheat (*Eriogonum correllii*), Tall Plains Spurge (*Euphorbia strictior*), Mexican Mud-Plantain (*Heteranthera mexicana*) and High Plains Goldenrod (*Solidago altiplanities*).

A.7.4 Management Issues

The grassland community, prairie restoration, the Texas horned lizard and water quality and quantity are the most important natural resource issues at LAMR. Exotic species, erosion, air quality, non-source point pollution, off-road vehicle use, and the lack of long term management plan are the biggest threats to natural resources at the park. Prairie restoration can lead to improved groundwater recharge and stewardship of upland wetlands and springs. These improvements in turn will provide enhanced habitats

for many of the species of interest as well as resident communities.

Varying lake levels have encouraged the encroachment of salt cedar in floodplain areas. The tamarisk has out-competed native species and is likely contributing to the increasing salinity levels of the lake. Investigations are ongoing with the Bureau of Reclamation introducing insects to control tamarisk.

Erosion of the lake shore line is a major concern and has been studied and discussed in several documents (Lynn 1975, Etchieson and Couzzourt 1987, Bureau of Reclamation 1990). Some of these eroded areas could affect visitation by degrading boat ramps and the road to the Stilling Basin (Pranger 2000).

The quality and quantity of groundwater in the future is of major concern in this region. Continued pumping of the aquifer for agricultural purposes can potentially lower the water table. The water level of Lake Meredith fluctuates with floods and draw-downs and is subject to non-source point pollution (including erosion within park boundaries and elevated E. coli levels) that could contaminate the fishery.

Oil and gas exploration and development have been actively pursued in the vicinity of LAMR and ALFL since the late 1920s, well before establishment of the parks. The earliest well on record within what later became LAMR was completed on October 3, 1927. Many others followed. In the parks today, there are 170 active well sites, evidence of 15 abandoned (unreclaimed) operation sites, 40 miles (64 km) of active oil field access roads, 104 miles (167 km) of abandoned roads, and 3.7 miles (6 km) of existing oil and gas pipelines (Lake Meredith National Recreation Area 2002).

Human impact threatens both the natural and cultural resources of LAMR. High visitor attendance underscores the need to determine carrying capacity at various sites around the park. Off-road vehicle use in and out of permitted areas causes severe damage to soil, vegetation and cultural resources as well as use conflict among other visitors. Maintenance of boundary fence remains an essential means of controlling unauthorized use of parklands.

A.7.5 Partnering /Neighboring Agencies

Current Partners

Texas Parks and Wildlife, Bureau of Reclamation, Canadian River Water Management Authority, National Wild Turkey Federation, Bureau of Land Management

Potential Partners

Ducks Unlimited, Quail Unlimited, US Forest Service, West Texas A+M, Texas Tech University, Amarillo College.

Neighboring Land Management Agencies

Alibates Flint Quarries National Monument, Palo Duro Canyon State Park, Playa Lakes Wildlife Management Area, Gene Howe Wildlife Management Area, Cross Bar (Bureau of Land Management), Buffalo Lake NWR, Muleshoe NWR, Optima NWR, McClellan Creek National Grasslands, Caprock Canyon State Park, Black Kettle National Grasslands, Four Canyon Preserve (The Nature Conservancy)

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A.8 LYNDON B. JOHNSON NATIONAL HISTORICAL PARK (LYJO)

Lyndon B. Johnson National Historical Park (LYJO) preserves the settings and tells the story of our 36th President, from his ancestral heritage and boyhood home through his LBJ Ranch and final resting place, resulting in the most complete picture of any American president. The park consists of two units (Johnson City and LBJ Ranch districts) situated on the Llano uplift, in the Pedernales River Valley of the central Texas Hill Country, in Blanco and Gillespie counties, respectively. LYJO was originally established in 1969. The combined area of the two districts, which lie about 15 miles (24 km) from one another, is about 674 acres (270 ha). The park hosted 94,963 visitors in 2004.

A.8.1. Resource Overview

When this area of the Edwards Plateau was first settled in the mid-1800s, it contained oak savannah bisected by riparian woodland corridors and hillside slopes of Ashe juniper (*Juniperus asheii*). Presently, only tiny patches of semi-natural vegetation remain at LYJO: mostly at the prairie restoration site and along Town Creek in the Johnson Settlement, and along the Pedernales River at the LBJ Ranch District. The park is classified as southwest plateau and plains dry steppe and shrub according to Bailey (1994). Elevations range from 1190 to 1565 feet (363-477 m).

The Johnson City District is located in the southwest portion of Johnson City (Blanco County), and consists of the park headquarters and visitor center, the LBJ Boyhood Home, some adjacent homes, historic Johnson Settlement buildings and exhibits, a nature trail, semi-natural creek and prairie habitats, a demonstration herd of longhorn cattle and horses and associated pastures, volunteer camping sites, and maintenance sheds. The LBJ Ranch District stretches along the Pedernales River in eastern Gillespie County. It includes several historic buildings and cultural sites, ranch pastures, cultivated fields and pecan orchard. Adjacent to the LBJ Ranch District is the Lyndon B. Johnson State Park and Historic Site, from which the National Park Service operates its bus tours. Lyndon B. Johnson National Historical Park is located approximately 47 miles (76 km) west of Austin and 63 miles (101 km) north of San Antonio. State Highway 290 runs along the north edge of the Johnson City District and Ranch Road 1 and the Pedernales River run along the southern edge of the Ranch District.

The subtropical, sub-humid character of the Edwards Plateau results in a sunny, mild climate, except for summer's high humidity and 100°F (38°C) temperatures.

Winter temperatures are usually in the 50s°F (10°C); snow and ice are rare. Annual precipitation averages about 32 inches (81 cm), with May and September the wetter months and November, December and January the driest months.

A.8.2 Enabling Legislation / Management Documents

Lyndon B. Johnson National historical park was originally established by Public Law 91-14 on December 2, 1969, as a national historic site. The designation was changed to a national historical park on December 28, 1980. The enabling legislation states that the purpose of the park is “to preserve in public ownership historically significant properties associated with the life of Lyndon B. Johnson.” According to the General Management Plan (Lyndon B. Johnson National Historical Park 1999) the purpose is further defined “To research, preserve, and interpret significant resources and influences associated with the life and heritage of Lyndon B. Johnson”, and “To provide a variety of opportunities to experience the local and regional context that shaped the last frontier president, informed his policies and programs, and defined his legacy.” One of the mission goals for the park states, “the natural environment and cultural heritage of the Texas Hill Country are protected and maintained through a regional network of private and public stewardship.”

A resource management plan was completed in 1996 (Lyndon B. Johnson NHP 1996). This plan states that the plan must “give direction that will compliment, preserve, and/or restore the park’s natural resources as they appeared in the historic periods as defined in the area’s management objectives.” The plan focuses on live oak management, Hereford cattle, pasture management, pecan management, ball moss control, water resources management, rodent pest control, native grass restoration erosion control to stabilize Pedernales River bank, and insect pest management.

A fire management plan was completed in 2005 (Lyndon B. Johnson National Historical Park 2005) and an integrated pest management plan in 1999 (Baumann 1999).

A.8.3 Natural Resources

Valuable Resources / Species of Interest

Several species of concern have been documented at LYJO. Texas map turtle (*Graptemys versa*), Texas cooter (*Pseudemys texana*) and Guadalupe bass (*Micropterus treculii*) are all endemic to the Edwards Plateau. The American bald eagle (*Haliaeetus leucocephalus*) is federally listed as threatened and winters in the area. The

most valuable species for cultural reasons is the Hereford cow, a distinct strain is currently raised at the park that are descendents of the President’s herd.

Geology / Soils

Soils in the Johnson City District are shallow and underlain by limestone and marl, they are characterized as loamy, clayey, stony soils of the Brackett-Purves-Doss association (Lyndon B. Johnson National Historical Park 1999). Shallow rooting depth, rapid runoff, available water capacity, small stones, and steep slopes are limitations (SCS, USDA 1979). The soils of the LBJ Ranch District are sandy to loamy, gently sloping soils of the Lukenbach-Pedernales-Healty Association. These soils are moderately-well drained, permeability is moderately-slow, and runoff is moderate (Lyndon B. Johnson National Historical Park 1999). Soils of the Pedernales Riverbed contain recently deposited silty and sandy alluvium derived from upstream granites and sandstones, while bottomland terraces are covered with silty and sandy alluviums. Upslope outcrops of sandstone and marly limestone have weathered to pastures of sandy loams and deep redland clay loams. The river valley is surrounded by limestone hills. Sandy alluvial soils along the streams can be easily eroded during flash flood events.

Land Use

The Pedernales River valley has been and continues to be an area dominated by ranching activities and small orchards. The Johnson City District is surrounded by the Town of Johnson City and private ranch land. The LBJ Ranch District is bordered on the south by Lyndon B. Johnson State Park and Historic Site and the remainder by private ranch land, including some owned by the Johnson family.

Hydrology

The primary water bodies at LYJO are the Pedernales River and Town Creek. A few small streams and stock ponds are also present at LYJO. One of the most important aquatic resource concerns is the riparian ecosystems. The flood/drought cycle affects plant and animal presence and fecundity, in addition to water quality and quantity. The suppression of fire, which has allowed the encroachment of woody species into the riparian areas, has changed the groundwater recharge/discharge patterns. This may be contributing to the favorable conditions for the introduction and spread of plant and animal pathogens. LYJO is participating in the Lower Colorado River Authority (LCRA) River Watch Program, collecting data to be assessed by the LCRA and EPA. A basic water quality assessment was completed in 2000 by the WRD of the NPS.

Air Quality

The preservation of the night sky and the soundscape at LYJO directly impacts visitor satisfaction levels. Both districts are affected by light from San Antonio, Austin and smaller communities. The Pedernales River valley continues to succumb to a gradual change from agriculture to development and the onset of light and sound pollution. Erosion of the riverbank is also a concern, potentially occurring from the dams in the area. The Johnson City District is most affected by light as the surrounding town continues to grow, but the LBJ Ranch District is also affected by the growth and development of its neighboring community, Stonewall. US Highway 290 is near both units and as the traffic count grows, so does the ambient noise associated with high-speed roadways.

The risk of foliar ozone injury to plants at Lyndon B. Johnson National Historical Park is moderate. Concentrations frequently exceeded 60 and 80 ppb, and exceeded 100 ppb for a significant number of hours in several years. These levels of exposure can injure vegetation. While the levels of ozone exposure consistently create the potential for injury, periods of low soil moisture may reduce the likelihood of injury developing in particular years. Since LYJO is subject to potentially harmful levels of ozone annually, the probability of foliar injury developing may be greatest during years such as 1995 when ozone levels exceed the thresholds, and soil moisture levels are normal or under mild drought and do not significantly constrain the uptake of ozone. A program to assess the incidence of foliar ozone injury on plants at the site could use redbud (*Cercis canadensis*) (National Park Service 2005).

Wildlife

Mammals: Patrikeev and Gallyoun detected 17 species of mammals in 2002 and 2003. Patrikeev and Gallyoun (2004) recorded the first pygmy mouse (*Baiomys taylori*) for Blanco County. Nutria (*Myocastor coypus*) are an exotic species that are controlled on a semi-monthly basis.

Birds: Archer (1975) and Archer (1980) conducted bird surveys at Lyndon B. Johnson State Historical Park and documented 147 species. Patrikeev and Gallyoun (2004) did not specifically survey for birds due to the existing bird list, but documented 43 species during their work. There are 6 species that are documented at LYJO that are on Partners in Flight's watch list for the Edward's Plateau Region: black-chinned hummingbird (*Archilochus alexandri*), scissor-tailed flycatcher (*Tyrnanus forficatus*), northern bobwhite (*Colinus virginianus*), orchard oriole (*Icterus spurius*), Bell's vireo (*Vireo bellii*), and painted bunting (*Passerina ciris*).

Reptiles and Amphibians: Only 9 species of reptiles and 4 species of amphibians were documented during the 2002-03 inventory. There are as many as 58 species of reptiles and 17 species of amphibians known from Blanco and Gillespie counties (Dixon 2000). The low number of species may be due to a variety of factors. Patrikeev and Gallyoun (2004) speculated that it was due to the introduction of fire ants and the large percentage of exotic grasses at the park. In addition, the survey was completed towards the end of a drought when some of these species may have been at naturally low population levels. The Texas horned lizard (*Phrynosoma conatum*) is a state-listed species that is historically known to occur at LYJO. Patrikeev and Gallyoun (2004) did not detect the species and speculated that it may be due to the invasion by non-native fire ants.

Fish: Patrikeev and Gallyoun (2004) focused their efforts on shallow water areas with seining and detected 18 species. A supplemental survey was conducted in 2005 using electroshocking by the Lower Colorado River Authority that documented 4 additional species (Cook 2005). Both fish surveys detected the brook silverside (*Labidesthes sicculus*) that was a new record for the Colorado River watershed. The presence of this population is puzzling since they do not survive in bait buckets and the species is generally restricted to the Sabine and Red River watersheds (Hubbs et al. 1991).

Vegetation

The majority of the Ranch District is managed as improved range with exotic plant species. The Johnson City District has approximately 39 acres that can be classified as prairie or semi-natural prairie (Stubbendieck and Willson 1986), however these areas also contain a large number of exotic species. Portions of the Johnson City District in the immediate vicinity of the Johnson homestead are managed as overgrazed to depict the scene at the time of 1890's. The Johnson City District was probably historically planted in small grains or cotton prior to the 1920's, after this date it was converted to a pecan (*Carya illinoensis*) grove.

Two floristic inventories have documented 609 native and cultivated species (including distinct varieties, cultivars, and hybrids) present in the park, of these 471 are naturally occurring (Sanders and Gallyoun 2004, Sanders 2005). The first inventory was conducted in 2002 and was very intensive, but was completed at the end of a drought. The 2005 inventory was recommended by Dr. Sanders and was done in a year with normal or slightly above normal precipitation and documented 51 additional species. Sanders (2005) documented two new introduced naturalized species that had not been reported from Texas.

There are also two specimens of Eve's necklace (*Sophora affinis*) that may be close to champion tree status.

A.8.4 Management Issues

The issues of highest priority at LYJO deal with the restoration and maintenance of the grassland prairie and riverine ecological communities. LYJO currently has a cooperative agreement with the Ladybird Johnson Wildflower Center to study methods to control King Ranch bluestem (*Bothriochloa ischaemum*). Prairie restoration efforts are underway at the Johnson City District unit. Gabbard et al. (1997) and Smeins (2003) made several recommendations to restore the prairie in Johnson City, many of which are being implemented. Successful restoration and invasive control efforts should positively impact both the terrestrial vertebrate and the grassland bird diversity and populations.

The inventory results of Patrikeev and Gallyoun (2004) were lower than expected for terrestrial vertebrate fauna at LYJO. Presently, there are very few natural terrestrial habitats remaining in the park, a direct result of past ranch management objectives focused on cattle ranching. In addition, exotic fire ants (*Solenopsis invicta*) invaded around 1978 and may have caused irreversible damage to amphibian, reptile, and small mammal populations in the area, effectively driving some of those species to local extirpation.

Control and/or eradication of invasive and exotic species, both plants (Johnson grass [*Sorghum halapense*], woody succession) and animals (blackbuck antelope, nutria) are of major importance. The Gulf Coast Exotic Plant Management Team started work in 2005 to control exotic plants. A cooperative agreement with Texas A+M University was established to look at the native white-tailed deer and exotic blackbuck antelope populations. The suppression of fire has encouraged the encroachment of woody species, changing the nature of the habitat, affecting groundwater recharge and possibly allowing favorable conditions for the introduction and spread of plant and insect disease. A fire management plan has recently been completed and should help in restoring fire to the ecosystem.

Naturally occurring patterns and processes shape the ecosystem at LYJO. The flood/drought cycle of the Edwards Plateau affects the plant and animal species abundance as well as water quality and quantity – a major issue confronting the state of Texas. The park has recently started a sedimentation and erosion study of the river and the Jordan and Johnson dam with Intermountain Regional NPS staff.

Issues of additional concern that will need to be addressed include monitoring air quality, the compatibility of adjacent land use, the local tradition of hunting and wildlife management, and the ever present need for funding to be used for staff, maintenance and long-term planning.

A.8.5 Partnering /Neighboring Agencies

Current Partners

Lyndon B. Johnson State Park and Historic Site, Lower Colorado River Authority, Texas Forest Service, Balcones Canyonlands NWR, Ladybird Johnson Wildflower Center, Texas A+M University, Texas State University, Texas Master Naturalists, Texas Master Gardeners, Botanical Research Institute of Texas

Potential Partners

Selah Ranch, Natural Resources Conservation Service, Highland Lakes Audubon Society

Neighboring Land Management Agencies

Lyndon B. Johnson State Park and Historic Site, Pedernales Falls State Park, Enchanted Rock State Park, Blanco River State Park, Barton Creek Habitat Preserve (The Nature Conservancy), Camp Bullis (Department of Defense), Balcones Canyonlands NWR, Westcave Preserve (Lower Colorado River Authority)

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A.9 PECOS NATIONAL HISTORICAL PARK (PECO)

Pecos National Historical Park (PECO) was established in 1965 and preserves 12,000 years of human history within its two units. The 5,989 acre (2,424 ha) Pecos Unit preserves ancient Pecos Pueblo and other indigenous American structures, two Spanish colonial missions, a section of the Santa Fe Trail, the 20th century history of Forked Lightning Ranch, three miles of Glorieta Creek battlefield, approximately three miles of the Pecos River and Glorieta Creek. The 682 acre (276 ha) Glorieta unit is comprised of the two subunits. The Pidgeon's Ranch and Cañoncito subunits contain Mexican era homesteads and sites related to the Civil War Battle of Glorieta Pass. Approximately 1.5 miles of the Glorieta Creek lays within the Glorieta sub-unit. PECO received 33,691 visitors in 2004.

A.9.1. Resource Overview

Located in San Miguel County, 28 miles (45 km) southeast of Santa Fe, New Mexico, most of PECO lies in the upper Pecos River valley. This narrow valley is bordered by the 13,000-foot (3,962 m) Sangre de Cristo Mountains to the north, the rugged hills of the Tecolote Range to the east, and the steep Glorieta Mesa to the west. The 8,200-foot (2,499 m) Glorieta Mesa escarpment is the most prominent geologic feature in the area, rising abruptly above the 7,000-foot (2,134 m) valley floor. Glorieta Pass connects the Apache Canyon area and the northern Rio Grande Valley to the High Plains and short-grass prairie of New Mexico (Reed et al. 1999).

The southern Rocky Mountain Steppe geographic province, southern parks and ranges ecoregion gives way to the Mexican Highlands in this area, producing a climate and vegetation unique for this elevation. Major habitats found within PECO include riparian corridors, grasslands of old pastures, and predominant piñon/juniper (*Pinus edulis* / *Juniperus monosperma*) woodland (Parmenter and Lightfoot 1996). Annual precipitation varies from 16 to 20 inches (41-51 cm) per year, with the majority falling during the summer season. Temperatures range from an average high of 80°F (27°C) June to August to an average low of 15°F (-9°C) December through February. The spring season tends to be windy.

There are no threatened or endangered plants or animals documented at PECO. Dwarf milkweed (*Asclepias uncialis*), which has a State listing, has been documented in the park. Major management challenges include declining water quality from upstream activities in the Pecos River, resulting in contaminants in the fishery, and the influx of exotic plants and animals in the park.

A.9.2 Enabling Legislation / Management Documents

Pecos National Monument was created on June 28, 1965 to "... set apart and preserve for the benefit and enjoyment of the American people a site of exceptional historic and archeological importance ... including the remains and artifacts of the seventeenth century Spanish missions and ancient Indian pueblo" (PL 89-54, June 28, 1965; 79 Stat. 195). The monument was expanded on June 27, 1990 to become Pecos National Historic Park, composed of Pecos National Monument and the Forked Lightning Ranch, in order to "... recognize the multi-theme history, including the cultural interaction among diverse groups of people of the Pecos area and its 'gateway' role between the Great Plains and the Rio Grande valley ... and to provide for the preservation and interpretation of the cultural and national resources of the Forked Lightning Ranch." (PL 101-313, June 27, 1990; 104 Stat. 279). On November 8, 1990, Congress once again expanded the park to include the 682-acre Glorieta unit. This unit was added to "... preserve and interpret the Battle of Glorieta Pass and to enhance visitor understanding of the Civil War and the Far West." (PL 101-536, November 8, 1990; 104 Stat. 2358).

The stated purpose of Pecos Unit is "to preserve and interpret an exceptional cultural and natural area that has had a long human history" while the purpose of the Glorieta Unit is "to preserve and interpret areas where the Civil War Battle of Glorieta Pass took place" (Pecos National Historical Park 1995). Several other management documents provide guidance for the stewardship of Pecos National Historic Park, including: the Natural and Cultural Resource Management Plan approved in 1999, which primarily addresses the Pecos Unit; The Pecos National Historic Park Land Protection Plan, approved in 1993, that describes land protection strategies for the Glorieta unit; and the Santa Fe National Historic Trail Comprehensive Management and Use Plan completed in 1990.

A.9.3 Natural Resources

Valuable Resources / Species of Interest

Landscape elements are among the parks valuable resources. Glorieta Pass has been a traditional link through the Sangre de Cristo Mountains between the Rio Grande valley and the Great Plains. For centuries, people have followed this common corridor. While the pass itself is not in the park, it can be seen from various vantage points within the park and provides an important historical context and connection. The Pecos River is one of only five year-round, free-flowing rivers in New Mexico and is one of the longest in the state. The Pecos River and the Glorieta Creek both sustain valuable riparian corridors that

support the greatest diversity (Pecos National Historical Park 1995).

A small population of dwarf milkweed (*Asclepias uncialis*), which has a State listing, was detected in the Pecos Unit in 1995 (Sivinski 1995), however additional searches have not detected the species and it is no longer present in the original location. Scientists have caught sight of flycatchers in the park but have been unable to determine if they may be the federally endangered Southwest willow flycatcher (*Empidonax traillii extimus*) (Pecos National Historical Park 1995).

Geology & Soils

The bedrock of the Pecos River valley floor consists of Pennsylvanian and early Permian soft shales, sandstones, siltstones, limestones and conglomerates of the Sangre de Cristo formation. Most of the formation is covered by alluvial fill and a mantle of thick soil derived from weathering and decomposition. The Magdalena group, consisting primarily of limestone, underlies the formation. Outcroppings are exposed on both sides of the Pecos River by the ranch house. Outcrops along Glorieta Creek are of igneous and metamorphosed Precambrian rocks, the Magdalena group and the Sangre de Cristo, Yeso and San Andres formations. Uplifting of the land and downcutting of the Pecos River during the Pleistocene are largely responsible for the area's present topography. Subsequent uplifting and downcutting shifted the river eastward to its present location. Deep alluvial gravel deposits and a series of terraces mark the former course of the river. Based on regional seismic and exploration activities, the formations in the park are not believed to have commercially exploitable mineral deposits, and the various strata are not associated with oil and gas producing beds (Pecos National Historical Park 1995). The federal government owns all of the mineral rights for lands within the park boundary that are under jurisdiction of the Park Service (Reed et al. 1999).

Petrified wood (Reed et al. 1999) and bi-valve fossils (NHNM, Y. Chauvin personal communication 2006) has been found on the eastern portion of the Pecos Unit. No additional fossils have been discovered from within the boundaries at PECO. However, two geologic units are exposed at the park that have been reported to have paleontological resources in other areas. The oldest formation exposed at Pecos is the Upper Pennsylvanian to Lower Permian Sangre de Cristo Formation. The other fossiliferous formation is the Upper Pennsylvanian Upper Member of the Madera Formation. Multiple reports of fossils from the Madera Formation suggest that there is a strong possibility of discovering specimens within PECO (Koch and Santucci 2003).

Soils of the Pecos Unit are identified as Vibo-Ribera and Ribera-Sombordoro-Vibo associations, and Tuluso-Sombordoro-Rock outcrop and Laporte-Rock outcrop complexes. On the Pecos River and Glorieta Creek floodplains there are frequently flooded soils. The upland soils vary from deep fine sandy loams on relatively flat slopes to very shallow stony loams on the ridges. Generally the park's soils are moderately to well drained, have moderate permeability and erosion hazards, and moderate to severe limitations for building. Soils of the Glorieta unit are identified as Cueva very stony clay, Capillo-Rock outcrop complex, Ortiz gravelly loam, Prewitt loam and Rednum loam. These soils generally have moderate to slow permeability, medium to very rapid runoff and severe to very severe erosion hazards. Soils in the Canoncito subunit were mapped as Pojoaque-Rough broken land complex, Travessilla-Rock outcrop, and Fivemile loam, potentially a prime agricultural soil. These soils have moderate permeability, medium to rapid runoff and moderate to severe erosion hazards (Pecos National Historical Park 1995).

Hydrology

Most of PECO lies in the Upper Pecos River Valley and contains three miles of the Pecos River. Additional surface waters include Glorieta Creek, a riparian restoration area, a pond, and several marshy habitats. Portions of the Pecos River, including the section that flows through PECO has been classified as impaired on the federal 303(d) list for inadequate temperatures and turbidity levels. The Pecos River is experiencing a decline in water quality and quantity because of drought conditions and from upstream activities outside of the Park. A basic water quality report was prepared by the WRD of the NPS in 1995.

Air Quality

Pecos National Historical Park is a Class II air quality area. Air quality is rated as better than required by the national ambient air quality standards. Air quality and visibility are usually excellent. However, in the winter air inversion periodically trap smoke from wood burning stoves, resulting in a haze (Pecos National Historical Park 1995; Reed et al. 1999). The Cañoncitos subunit is affected with visual and noise intrusions and air pollution from Interstate 25 (Pecos National Historical Park 1995). The low levels of ozone exposure at Pecos National Historic Park make the risk of foliar ozone injury to plants low. Scattered months of drought constrain the uptake of ozone and further reduce the likelihood of foliar injury. If the level of risk increases in the future, a program to assess the incidence of foliar ozone injury on plants at the site could use ponderosa pine (*Pinus ponderosa*) or skunkbush (*Rhus trilobata*) as bioindicators for ozone (National Park Service 2005).

Land Use

The Pecos Unit is bounded on the east by the Santa Fe National Forest, which is generally managed consistent to NPS management standards. However, some recreational uses in the Forest are not allowed in the park, so the boundaries need to be clearly marked. Both Glorieta Creek and the Pecos River are affected by the septic systems of private development upstream of the park. Both Pigeon's Ranch and Canoncito subunits are surrounded by private land and some Santa Fe National Forest land. Residential development continues to increase outside the boundaries and there are some agricultural uses nearby, primarily grazing. New Mexico State Road 50 runs through the Pigeon's Ranch unit and has a major negative effect on its natural and cultural resources and values. Interstate 25 also affects the Cañoncito subunit with visual and noise intrusions and air pollution (Pecos National Historical Park 1995).

Wildlife

Mammals: There are no known federally listed threatened or endangered animals in PECO. A complete faunal survey conducted by Parmenter and Lightfoot (1996) documented 25 mammal species. The list is dominated by rodents, with the deer mouse being the most common and widespread species in the park. Black bear tracks have been seen in the Pigeon's Ranch unit and the Pecos unit. Mountain lion tracks have also been seen in the Pecos unit. The riparian area was also historic habitat for river otter. There are several exotic species present in the park, including feral dogs and cats (Pecos National Historical Park 1995). Feral dogs (*Canis familiaris*) are trapped and removed from the park on a regular basis (Johnson et al. 2003).

Birds: There are no known federally listed threatened or endangered birds in PECO. The USF&WS has identified four listed species that may occur in the area: bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus anatum*), Mexican spotted owl (*Strix occidentalis lucida*) and Southwestern willow flycatcher (*Empidonax extremus*). A peregrine was observed flying down the Pecos River valley near the park in June 1988. The Mexican spotted owl has been recorded in the Santa Fe National Forest. In 1992, a pair of flycatchers were observed nesting 3 miles north of the park (Pecos National Historical Park 1995). In a 2002 breeding bird survey (Johnson et al. 2003) carried out by the New Mexico Natural Heritage Program:

"...one sex undetermined and two male willow flycatchers (Empidonax traillii) were detected on 4 and 5 June along the Pecos River. A visit by NMBBA staff on June 8 again detected willow flycatchers, but subsequent visits and

nest-searches by NMNHP and NMBBA staff detected none. Because habitat conditions at present do not appear suitable for breeding willow flycatchers (Sogge et al. 1997), these birds were very likely migrants. Willow flycatcher subspecies cannot be distinguished by observation; it is therefore unclear if these birds were the northern *E. t. adastus* subspecies or the endangered southwestern *E. t. extimus* subspecies. Breeding willow flycatchers are limited by impacts to vegetation by historical livestock grazing, small patch size of potentially suitable vegetation, and limited riparian regeneration due to lowered river levels from drought and upstream diversions.

This survey detected 79 bird species. Violet-green swallow (*Tachycineta thalassina*) was the most commonly detected bird, with Brewer's blackbird (*Euphagus cyanocephalus*), western wood-pewee (*Contopus sordidulus*), and yellow warbler (*Dendroica petechia*) also among the most commonly detected species (Johnson et al. 2003). Ten species of breeding birds on the Partners In Flight high priority list for the Mesa and Plains physiographic region were documented during this survey: black-chinned hummingbird (*Archilochus alexandri*), scaled quail (*Callipepla squamata*), canyon towhee (*Pipilo fuscus*), Cordilleran flycatcher (*Empidonax occidentalis*), gray flycatcher (*Empidonax wrightii*), Cassin's kingbird (*Tyrannus vociferans*), gray vireo (*Vireo vicinor*), juniper titmouse (*Baeolophus griseus*), Virginia's warbler (*Vermivora virginiae*), and Grace's warbler (*Dendroica graciae*). The Pecos River riparian area was observed to be the most important bird habitat in the ranch with the highest number of bird species and the greatest number of nest sights. The reproduction of six species were observed to be affected by brood parasitism of brown-headed cowbirds (*Molothrus ater*) (Pecos National Historical Park 1995).

Reptiles and Amphibians: Parmenter and Lightfoot (1996) documented 7 reptile species and 3 amphibian species. Eastern fence lizard (*Sceloporus undulatus*) and woodhouse toad (*Bufo woodhousei*) were the most common species found at that time. A subsequent survey during the summer of 2002 by New Mexico Natural Heritage Program documented 10 species (28.7%) on target list: 6 reptiles and 4 amphibians, including the tiger salamander (*Ambystoma tigrinum*). The number of species detected was probably strongly influenced by low rainfall in the months preceding the inventory. Monsoon rains were sporadic as well, which likely impacted amphibian activity patterns (Johnson et al. 2003).

Fish: The Rio Grande cutthroat trout may once have inhabited the park. According to the New Mexico Department of Game and Fish, the number and size of fish in the park in 1992 were average for the Pecos River and above average for statewide fish. There are several exotic species present in the park, including rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). In the summer of 1992, the NPS began testing the Pecos River for baseline water quality variables and contaminants. Preliminary results indicate elevated levels of heavy metals, including arsenic, chromium, lead, selenium and PCB in river fish. Levels flagged concerns for human health and fish and wildlife predators (Pecos National Historical Park 1995).

Arthropods: Parmenter and Lightfoot (1996) conducted an intensive survey for arthropods. 514 species were documented (407 had been identified at the time of the report). The most common and widespread terrestrial invertebrates included wolf spider, gnaphosid spider, camel cricket, grasshopper, western harvester ant and darkling beetles, among others. A comparison of grassland communities to woodland communities "... revealed that grassland sites support very different arthropod taxa and numbers of individuals when compared with piñon-juniper (sites), with species richness greatest in open grassland."

Vegetation

The Pecos River valley is in the Rocky Mountain conifer vegetation zone, within a transition zone between piñon/juniper and ponderosa pine (*Pinus ponderosa*), and some small Douglas fir (*Pseudotsuga menziesii*) stands in the eastern side of the park. The park is also close to the grasslands of the Great Plains. Naturally occurring fire has been suppressed for at least 50 years. According to the New Mexico Forestry Department, 41% of the Pecos unit is covered by piñon/juniper, interspersed with Ponderosa pine and Douglas fir. Another 26% is covered primarily with piñon/juniper, and 10% with a juniper/grassland cover. 3% is floodplain meadow, less than 1% has riparian deciduous forest dominated by cottonwoods and willows, 15% is pasture, and 5% is developed/altered/inundated. Small areas of old-growth piñon, which is an increasingly rare habitat type in New Mexico, are present. The Pecos River in the southern part of the Pecos Unit and Glorieta Creek on the northwestern portion support a rare cottonwood hybrid species, lance-leaf cottonwood (*Populus acuminata*). This species is believed to be a cross between narrow-leaf cottonwood (*P. angustifolia*) found at higher elevations and plains cottonwood (*P. deltoides*), found at lower elevations (Pecos National Historical Park 1995). Approximately 40 acres (of the original monument) is classified as Grama-Galleta Steppe prairie. Grazing generally ceased in June 1967 when the boundary fence was completed. The 64-

acre core of the monument has been closed to grazing since the 1940s, while the newest acreage was protected from grazing in 1978 (Stubendieck and Willson 1986).

There are no known federally listed threatened or endangered plants within PECO. The Holy Ghost ipomopsis (*Ipomopsis sancti-spiritus*) has been proposed for federal listing as an endangered species with critical habitat and has been identified in the mountains north of the park and could occur in the park. Two other rare species, Grama grass cactus (*Pediocactus papyriacanthus*) and Santa Fe cholla (*Opuntia viridiflora*) may occur on the ranch section (Pecos National Historical Park 1995).

A vegetation survey conducted by PECO between 1992 and 1994 resulted in 354 species of vascular plants, 57 of which were exotics (Reed et al. 1999). A study was done in 1999 by the New Mexico Natural Heritage Program to assess the riparian/wetland communities along Glorieta Creek in the Pecos unit prior to removal of two small dams and reservoirs. The creek was divided into upper, middle and lower segments. The upper and middle segments were dominated by rabbitbrush shrubland with some cottonwood forested wetland. The lower segment was dominated by coyote willow shrub wetland and was found to be in the best condition, with less fragmentation and fewer past impacts. The middle segment sustained the most impact with the reservoirs and levees. Natural recovery was occurring along Glorieta Creek and with careful management some degree of restoration was deemed possible (Muldavin et al. 1997). Park personnel have recently planted large numbers of cottonwood and willow trees as part of this riparian restoration project (Johnson et al. 2003).

There are several exotic species present in the park, including Russian thistle (*Salsola spp.*), Siberian elm (*Ulmus pumila*), and salt cedar (*Tamarix spp.*). The majority of the Pecos Pueblo ruins are covered by kochia (*Kochia scoparia*), which is damaging the ruins. (Pecos National Historical Park 1995). Apple trees (*Pyrus malus*) are present several locations, including an old orchard near the Pecos River (Pecos National Historical Park 1995), as well as the Headquarters building, the Mission Ruin and the Ranch House. Exotic trees are not presently abundant (Sivinski, 1995), but there is potential for invasion in wet areas (Johnson et al. 2003).

A.9.4 Management Issues

Maintaining the biotic integrity of Pecos National Historic Park takes the management issue with the highest priority. There are several exotic species present in the park, including rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), feral dogs and cats (*Felis domesticus*),

European clovers and grasses, Russian thistle, Siberian elm, and salt cedar. Kochia is growing on the pueblo ruins, and an old apple orchard is present near the Pecos River (Pecos National Historical Park 1995). The urban interface surrounding the park is a major source of feral dogs (*Canis familiaris*), which have been identified as potential disease vectors, are a danger to park visitors, and can decimate wildlife populations.

The water resources of Glorieta Creek and the Pecos River are another major focus for park managers. These riparian areas contain the highest biodiversity found at PECO and serve as vital corridors for species migration and dispersal. They also are integral to the cultural landscape. Visitors are drawn to these riparian areas, where use leads to soil compaction, vegetation trampling and disruption of wildlife behavior (Pecos National Historical Park 1995). Water quality of the Pecos River has been impacted by sources outside of the park. Contaminant levels in fish pose health hazards for both humans and wildlife. The sewage treatment plant for the city of Pecos discharges into the river 1 mile upstream of the park. There is also a practice of dumping untreated waste by private landowners into the Pecos River and Glorieta Creek. Staging for the widening and resurfacing of NM 50 was in a particularly vulnerable area of Glorieta Creek, just north of the park boundary, which included mining for soil and gravel. Because of these actions water quality has been impacted within the park due to the heavy erosion and ensuing sedimentation (Reed et al. 1999).

PECO was set aside partially to preserve scenic resources. Scenic elements remain from the time of the ancestral Pueblo Indian and Spanish occupation, but are affected by land use changes outside the park. Residential development continues to increase outside the park boundaries. New Mexico State Road 50 runs through the Pigeon's Ranch unit and has a major negative effect on its natural and cultural resources and values. Interstate 25 also affects the Cañoncito subunit with visual and noise intrusions and air pollution (Pecos National Historical Park 1995).

The Santa Fe National Forest adjoins several units of PECO, and piñon-juniper woodland comprises the majority of park habitat, requiring an emphasis on fire and forestry management. Grasslands in PECO continue to be encroached upon by woody vegetation. The Ips beetle causes die-off in patches of piñon pine, often stressed by drought. Previous decades of fire suppression has allowed for buildup of fuels. There is a need for a well-developed and coordinated fire plan in order to adequately manage this resource.

A.9.5 Partnering / Neighboring Agencies

Current Partners

New Mexico Natural Heritage Program

Neighboring Management Agencies

Las Vegas NWR, Santa Fe National Forest, Villaneuva State Park, Sevilleta LTER – Sevilleta NWR

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A.10 SAND CREEK MASSACRE NATIONAL HISTORIC SITE (SAND)

On November 29, 1864, Colonel John M. Chivington led approximately 700 U.S. volunteer soldiers to attack and kill about 150 Cheyenne and Arapaho people, mainly women, children, and the elderly, peacefully encamped along Big Sandy Creek. SAND will recognize the national significance of this massacre in American history, and its ongoing significance to the Cheyenne and Arapaho people and descendents of the massacre victims. While authorized, the proposed 12,480 acre (5,051 ha) historic site will not be established or open to the public until enough land is acquired to provide for the preservation, commemoration, and interpretation of the Sand Creek Massacre. To date, 920 acres (372 ha) have been purchased and an additional 1,465 acres (593 ha) is owned by the Cheyenne and Arapahoe tribes and managed by the NPS.

A.10.1 Resource Overview

SAND is located approximately 180 miles (290 km) southeast of Denver, in eastern Kiowa County, Colorado, within the High Plains section of the Great Plains-Palouse Dry Steppe Province ecoregion, at an elevation of approximately 4,000 feet (1,219 m). The site lies along a 5.5-mile (8.9 km) meandering stretch of intermittent Big Sandy Creek, through gently rolling prairie grassland with extensive viewsheds.

The climate at SAND is fairly typical of the eastern Colorado Plains – predominately clear and dry with moderate winds out of the southeast. Average annual precipitation is 13-14 inches (33-36 cm), falling fairly evenly throughout the year. Summer thunderstorms can bring heavy rains and hail, while winter snowfalls average 27 inches (69 cm) annually (Anderson et al. 1981). Temperatures range from an average of 87°F (31°C) from June through August, to an average minimum of 14°F (-10°C) December through February.

A.10.2 Enabling Legislation / Management Documents

On October 6, 1998 Congress authorized the SAND Site Study Act. This legislation (Public Law 105-243) mandated that the National Park Service identify the location and extent of the massacre area and determine its suitability and feasibility as a potential National Historic Site. Two years later, the Site Location Study and Special Resource Study/Environmental Assessment provided Congress with site boundaries and enough supporting information to move forward with the endeavor. SAND was therefore authorized by Public Law 106-465 on November 7, 2000. The purposes of the Act are to recognize the national

significance of the massacre in American history, and its ongoing significance to the Cheyenne and Arapaho people and descendants of the massacre victims. Establishment of the historic site will occur once an adequate amount of land has been secured from willing sellers. The park's authorizing legislation directs NPS to manage the site as close as practicable to the 1864 cultural landscape. On August 2, 2005, President Bush signed into law P.L. 109-45 which authorized the United States to take into trust 1,465 acres (565 ha) in the core area of the massacre site currently owned by the Cheyenne and Arapaho Tribes of Oklahoma.

A.10.3 Natural Resources

Valuable Resources / Species of Interest

The natural resources of SAND provide a fairly intact ecosystem. Work is being conducted to determine how the landscape has changed since 1864. Proper biotic inventories have yet to be completed, as most of the property within the proposed park boundaries remains in private hands. Black-tailed prairie dog (*Cynomys ludovicianus*), Arkansas darter (*Etheostoma cragini*), mountain plover (*Charadrius montanus*), and burrowing owl (*Athene cunicularia*) are state listed and/or federal candidate species that have been documented at SAND. Prairie dogs are a keystone species of the short-grass prairie that provides habitat for many other as-yet-undetected species of concern, such as the black-footed ferret (*Mustela nigripes*) and Swift fox (*Vulpes velox velox*). Of particular interest is the Lesser prairie chicken (*Tympanuchus pallidicinctus*), listed as threatened in Colorado and a federal candidate species. This dramatically declining bird has been historically documented within the authorized boundaries of SAND. Another significant bird species that may occur at SAND is the ferruginous hawk (*Buteo regalis*). Colorado bursage (*Ambrosia linearis*), is only found in Kiowa County and a few other areas in southeastern Colorado. The floodplain of Big Sandy Creek may provide ideal habitat for this highly endemic plant.

Geology & Soils

Big Sandy Creek drains the eastern side of a broad southeasterly trending valley composed largely of Quaternary wind-deposited sands from the Holocene and Pleistocene periods over sands, silt and gravel. The bluffs on the western side of the creek consist of non-calcareous, excessively drained Valent and Bijou-Valent loamy sands, while the terraces and eastern slopes contain deep, well-drained Kim-Harvey- Stoneham (KHS) loams derived from coarse, calcareous materials, to loess derived Wiley loam. Floodplain soils are level and poorly drained. The dune

and valley fill deposits average 20 to 50 feet (6-15 m) in depth above the chalky Smoky Hill Shale. Runoff erosion is not as problematic as wind erosion because of the high permeability of most of the soils at SAND (Sharps 1976; National Park Service 2000).

The Sand Creek Massacre National Historic Site sits along the center of the northeast-southwest trending axis of the Las Animas Arch 38. Gas was discovered in 1952 approximately 12 miles (20 km) southwest of SAND, while oil was discovered in 1964, northwest to east and closer to the historic site. Helium is being produced at a refinery northeast of Sand Creek in Cheyenne Wells. Most of the drilling for oil or gas near SAND has been unsuccessful. There are no known mineral extraction operations in the vicinity of Big Sandy Creek other than several oil/gas wells and subsurface mineral rights are held by individual landowners (National Park Service 2000).

Land Use

All surrounding land use at Sand Creek Massacre National Historic Site is agricultural – grazing, dry land farming, and land enrolled in the Conservation Reserve program. All but 920 acres (372 ha) of the land within the proposed boundaries is privately owned, divided among thirteen families and the Cheyenne and Arapaho tribes. County Road W cuts through three miles (5 km) of the southern edge of the massacre site, with a few secondary access roads within the park. Remnants of other man-made alterations include the crumbling Chivington canal, an abandoned ranch house and various fence lines, water tanks and windmills. There are various remnants of former ranch headquarters the original 12,480 acre (5,051 ha) authorized boundary. One major underground natural gas pipeline crosses SAND from the southwest to the northeast (National Park Service 2000).

Hydrology

SAND lies along an 5.5 miles (8.85 km) stretch of the Big Sandy Creek, also referred to as the Big Sandy Creek. Precipitation provides water for Big Sandy Creek, which intermittently flows based on rainfall events. During many years the creek does not have substantial enough water to reliably be used for potable or irrigation purposes. Several strips of wetlands are present at and around SAND. Groundwater at the site has been rated as fair to poor. These conditions are likely a result of ambient levels of minerals in the area. The biggest threat facing SAND water resources is erosion along the streambanks. Additionally, a wetland on the southern edge of SAND contains the federally listed Arkansas Darter. The only hydrological monitoring currently occurring is by Eads public works.

Air Quality

The study site and the entire Kiowa County area have generally excellent air quality and meet the “attainment” status for all required air pollutants monitored in the National Ambient Air Quality Standards. The area is a Class II airshed (National Park Service 2000).

Wildlife

Mammals: No formal surveys have been conducted for SAND. The black-tailed prairie dog is common on portions of SAND, so it is thought that the state and federally listed endangered black-footed ferret (*Mustela nigripes*) may also be a resident on and/or near the site. Free-ranging mule deer (*Odocoileus hemionus*), white-tail deer (*Odocoileus virginianus*), and pronghorn (*Antilocapra americana*) are present, as well as coyote (*Canis latrans*), raccoon (*Procyon lotor*), and badger (*Meles meles*) (National Park Service 2000).

Birds: A bird survey was initiated in 2005 by the Rocky Mountain Bird Observatory. The state and federally candidate species, mountain plover, as well as the state listed burrowing owl occurs at the park.

Fish: The Arkansas darter was found at SAND in 2005. This species is listed as a candidate species for federal listing and is listed by Kansas, Colorado, and Oklahoma. A more in-depth survey will begin in 2006.

Reptiles and Amphibians: There have been no formal surveys for reptiles and amphibians at SAND.

Vegetation

Consultations with the Cheyenne and Arapahoe tribes have identified protection of the landscape as one of the highest natural resource priorities at SAND. There are three types of habitat identified: riparian cottonwood along sections of the creek, short-grass prairie north of Big Sandy Creek; and the sand sage (*Artemisia filifolia*) community to the south. Within these grassland communities there are pockets of grasslands with tall-grass species due to the sandy soils. Over a long period of time, the intermittent flow and periodic flooding of Big Sandy Creek selects for largely dry prairie plant species through the riparian area, although mesic and wetland species are found around surface water or shallow groundwater. Eastern cottonwood (*Populus deltoides*) are the only trees at the site and are found in even-aged stands along seasonal stream traces. These trees are only successful in the presence of available water and minimal grazing pressures, so may have been historically limited by grazing bison (*Bison bison*) and firewood gathering by Indian tribes. The blue grama (*Bouteloua gracilis*) and buffalo grasses (*Buchloe dactyloides*) of the short-grass prairie dominate at SAND,

accompanied by some switchgrass (*Panicum virgatum*) and side-oats gramma (*Bouteloua curtipendula*). Sand sage has gained a foothold on drier slopes and where grazing has been excessive (National Park Service 2000). The rare showy prairie gentian (*Eustoma russellianum*) has been found at the park.

Exotic plants are not currently a large problem either along Big Sandy Creek or within the proposed park boundaries. Cheat grass (*Bromus tectorum*) and sand burr (*Cenchrus echinatus*) are the most common nuisance species, but Canada thistle (*Cirsium vulgare*) to the east and leafy spurge (*Euphorbia esula*) to the northwest will require vigilance to keep them from invading the park. Restoration of areas eroded from heavy foot and livestock traffic will continue to keep SAND relatively free of exotic vegetation (National Park Service 2000).

A.10.4 Management Issues

It has been a challenge for managers at SAND to develop a management plan because there is a dearth of baseline information available. With most of the proposed parkland still in private ownership, these inventories will develop slowly. It is fortunate that the site is in good shape, but efforts must be made to maintain its health. No one knows how the traditionally grazed grasslands will respond once they are taken out of grazing. Fire has long been excluded from the grasslands. The presence of healthy prairie dog colonies provides a strong basis for the possibility of many rare species. The existence of any small mammal community in the West brings the concern of disease transmission to humans – sylvatic plague in prairie dogs and hanta virus in deer mice are not easily passed on to humans, but care must be taken nonetheless. A looming management concern is the range expansion of feral hogs, a destructive invasive animal that brings destruction to riparian areas.

Sand Creek National Historic Site preserves approximately 5-1/2 miles of Big Sandy Creek. Maintenance of groundwater levels will be important to insure the continued flow of springs and seeps in the area, while water quality is important to wildlife and humans alike. Water rights, while not currently of major concern, should be addressed to insure an adequate supply of water for both the park and the wildlife in it. The flood process along Big Sandy Creek must also be maintained for the health of the natural resources within the boundaries of SAND. Erosion concerns, while minimal, do exist. Several small areas of bank erosion need to be restored before exotic plants gain a foothold.

The future effects of visitors must be taken into account, as hardscaping, foot traffic and vehicular traffic will impact the historic site. Air quality will be affected in the area with the

onslaught of visitors, roadways will impact the hydrology and the soundscape will be impacted. Boundary fencing must be in place to exclude activities such as hunting and off-road vehicle use. Surrounding land uses, while currently benign, could change with time, bringing their own alterations. Mineral, oil and gas extraction is carried on in Kiowa County. While no extractive activities are currently occurring along the proposed park boundary or within SAND, contingency plans should be developed for future use. The viewshed from the Sand Creek Massacre site extends for several miles to the north, east, and south, and still conveys a strong sense of its likely appearance at the time of the 1864 massacre. There is currently very little use of night lighting in a several mile radius area around the study site except for residential and agricultural operations (National Park Service 2000).

A.10.5 Partnering / Neighboring Agencies

Current Partners

Colorado Historical Society, the Cheyenne and Arapaho Tribes in Oklahoma, the Northern Cheyenne Tribe in Montana, the Northern Arapaho Tribe in Wyoming, NRCS, Colorado Division Of Wildlife, Kiowa County, Rocky Mountain Bird Observatory, Colorado Natural Heritage Program, The Conservation Fund, Colorado State Historical Fund, SAND property owners, Colorado Range Riders, Colorado State University.

Potential Partners

Colorado Native Plant Society, Volunteers for Outdoor Colorado.

Neighboring Land Management Agencies

Bohart Ranch (TNC); the Great Plains Reservoirs (Neenoshe, Neesopah, Neeskah, and Neegronda) and surrounding land owned by Colorado Division of Wildlife, Adobe Creek Reservoir (9,425 acres), Bureau of Land Management, and Small Chivington Reservoir.

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A.11 WASHITA BATTLEFIELD NATIONAL HISTORIC SITE (WABA)

Washita Battlefield National Historic Site (WABA) protects and interprets the site of the Southern Cheyenne village of Peace Chief Black Kettle that was attacked by the 7th U.S. Cavalry under Lt. Col. George A. Custer just before dawn on November 27, 1868. Hailed at the time as a significant victory, the battle of Washita remains controversial because many Indians and whites labeled Custer's attack a massacre. The site retains important cultural and historical value for the Cheyenne and other Southern Great Plains tribes, and its protection supports their on-going struggle to maintain control of their traditional homelands (Milner 2003). Black Kettle is still honored as a prominent leader who never ceased striving for peace even though it cost him his life. This 326-acre (132 ha) historic site received 14,215 visitors in 2004.

A.11.1 Resource Overview

WABA is in the Rolling Plains, near the western limit of the Redbed Plains physiographic region of the Great Plains Steppe and Shrub Province. The area was once continuous mixed and short-grass prairie amid red sandstone and gypsum outcroppings. Surrounded by parcels of the Black Kettle National Grasslands in west-central Oklahoma, WABA is less than a mile northwest of the town of Cheyenne, in Roger Mills County, Oklahoma. The Washita River winds west to northeast for 1.25 miles (2 km) across the park, dividing WABA into a floodplain bounded to the north and south by wooded "benches" at an approximate 2000 foot (610 m) elevation.

The climate at Washita Battlefield is sub-humid, temperate and continental. It is characterized by hot summers, mild winters, relatively high wind velocities and wide fluctuations in rainfall. Average maximum temperature June through August is 91°F (33°C), while average minimum temperatures December through February is 23°F (-5°C). Average annual precipitation is 25 inches (64 cm) with most of this falling between April and August. Severe thunderstorms are common and can produce tornados (National Park Service 2001).

A.11.2 Enabling Legislation / Management Documents

The Washita Battlefield was first named a National Historic Landmark in 1965. On November 12, 1996,

Washita Battlefield National Historic Site was established to “recognize the importance of the Battle of the Washita as a nationally significant element of frontier military history and as a symbol of the struggles of the Southern Great Plains tribes to maintain control of their traditional use areas.” (Public Law 104-333). The legislation also specifies that the park will work cooperatively with the Cheyenne-Arapaho Tribe in developing the management plan and in the preparation of educational programs for the public (Washita Battlefield National Historic Site 2001). Three purposes for WABA are identified as: 1) to recognize the attack by Lt. Col. George Armstrong Custer and the 7th U.S. Cavalry on the Cheyenne encampment of Chief Black Kettle as a nationally significant element of the United States government Indian policy; 2) to recognize the struggles of the Cheyenne and other Southern Great Plains tribes to maintain control of their traditional homelands; and 3) to protect, preserve and interpret the cultural and natural resources of the national historic site through the collaborative efforts of the United States government and the Cheyenne-Arapaho Tribe (National Park Service 2001).

Mission Goals have also been set for WABA. Those pertaining to natural resources include: Natural and cultural resources and associated values of WABA are protected, restored and maintained in good condition and managed within their broader ecosystem and cultural context; and WABA contributes to knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information (National Park Service 2001).

Several management documents guide staff in their efforts. A Strategic Plan was developed in 1998 to provide interim support until the General Management Plan was accepted in 2001. That same year, a specific Resource Management Plan was established and its recommendations are currently being implemented in the park. A Wildland Fire Management Plan was adopted in 2002 to assist with the implementation of prescribed burning used as a restoration tool.

A.11.3 Natural Resources

Valuable Resources / Species of Interest

There are two striking features of Washita Battlefield. The sweeping overlook vista of the floodplain campsite of Black Kettle and his people rises up in the distance to rose-colored gypsum outcrops, providing the visitor with a sense of space and reverence. The second thing a visitor might notice is the sound of quietness as the wind sighs across the prairie. These characteristics define WABA.

The short-grass/mixed-grass prairie ecosystem supports several species of interest at Washita. No federally threatened or endangered plant or animal species have been documented at the historic site. However, several animal species are found that are listed by the State of Oklahoma. Texas horned lizard (*Phrynosoma cornutum*) has been documented at WABA and is also listed by neighboring states of Texas and Colorado. The northern earless lizard (*Holbrookia maculata maculata*) has been observed, as well as Swainson’s hawk (*Buteo swainsoni*).

Geology & Soils

Washita Battleground National Historic Site is near the western limit of the Red Bed Plains physiographic zone, with exposure of the Cloud Chief Formation, which is composed primarily of Permian-aged red sandstones, siltstones, mudstones and impressive white gypsum (Neff 2002; Koch & Santucci 2003). Outcrops of gypsum, or alabaster, protrude from the ridge that divides the southern floodplain from the adjoining uplands. The Cloud Chief Formation has not been known to produce many fossils, although a few have been found just east of the park boundary (Brown 2001). WABA lies on the southern flank of the Anadarko Basin, a large, deep, sedimentary basin that is a major source of oil and gas. There is primarily deep gas production from Pennsylvanian age Cherokee, Atoka and Morrow Groups reservoirs near the historic site. Six wells within 1-1/2 miles of the site have tested these reservoirs and were unproductive, so perhaps future oil and gas drilling activities near WABA will be minimal. The previous landowner retained all the subsurface mineral rights at Washita (National Park Service 2001).

The Dust Bowl of the 1930s heavily impacted this part of Oklahoma, to the point that most of the original prairie topsoil is gone (Inglis 2001). The soil survey for Roger Mills County (USDA 1963) identifies 10 principal soil associations within WABA. Soils found on uplands and slopes include: Woodward (loam and fine sandy loam), Miles-Springer Complex (somewhat sandy), Miles-Nobscot complex (fine sandy loam to sand), hilly Springer loamy fine sand, and hilly Pratt loamy fine sand. Floodplain soils include: Spur and Port (silty-loam), hummocky Springer loamy fine sand, Yahola fine sandy loam, and Lincoln (National Park Service 2001).

Land Use

For the past one hundred years, land both in and around the Washita Battlefield National Historic Site has been used for farming and grazing. Land was cleared, fields were terraced and the Washita River was impounded and straightened in sections. A now-abandoned rail line was laid across the southern section of WABA in the 1920s,

involving cuts at the eastern end of the park and fill on the west end. An underground pipeline runs from the southwest corner of the park to the northeast.

Hydrology

WABA is located on the Washita River. The “Dust Bowl” of the 1930’s likely resulted in considerable changes to the local hydrology (Inglis 2001) and may be the cause of the stream characteristics that are discordant with its watershed conditions. Currently, the Washita River is considered an undersized stream with a wide valley-bottom floodplain (Inglis 2001). In addition to the drought conditions of the 1930’s, dams along the Washita River and irrigation of surface and ground waters have contributed to the current state of the river. Groundwater at WABA is generally hard and may contain excessive dissolved solids. Sulfate concentrations, in particular, are often above the recommended drinking limit. The greatest threats to the water resources at WABA include the silt build-up, dams, regional waste pits, invasive plant establishment in riparian areas, residential development, cattle ranching, and oil well operations. The USGS has gauged the Washita River at a station downstream from WABA for over 60 years. Additionally, they collected water quality data bi-annually from the 1930’s to the 1990’s. A functional evaluation of the Washita River was performed by the WRD in 2001 but no baseline water quality report has yet been completed.

Air Quality

There are no known point sources of air pollution currently visible from Washita Battleground National Historic Site (Washita Battlefield National Historic Site 2001). Current local sources of air pollution include particulate matter from agricultural practices, prescribed burning, and emissions associated with vehicle and farm usage. WABA is designated a Class II area (National Park Service 2001).

Wildlife

Mammals: A survey was conducted by Oklahoma Natural Heritage Inventory during 2000-2001. Twenty-one mammal species were detected, 10 of which were from the small mammal community. The most common mammal trapped was the hispid cotton rat (*Sigmodon hispidus*), only found south of the Washita River, followed by the white-footed mouse (*Peromyscus leucopus*). The most common species detected at tracking plates were raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*) and southern plains woodrat (*Neotoma micropus*) (Lomolino and Smith 2001).

Birds: No formal avian surveys have been completed at WABA, but an incidental list was compiled of observations by Oklahoma Natural Heritage during their 2000-2001

mammal survey. 45 bird species were recorded at this time (Lomolino and Smith 2001), including several on the Partners In Flight watch list for the Rolling Red Plains physiographic region: Swainson’s hawk (*Buteo swainsoni*), red-headed woodpecker (*Melanerpes erythrocephalus*), Cassin’s sparrow (*Aimophila cassinii*), and scissor-tailed flycatcher (*Tyrannus forficatus*). A baseline inventory of avian species is currently underway.

Reptiles and Amphibians: A survey was conducted by Oklahoma Natural Heritage Inventory during 2000-2001, documenting 11 reptiles and 4 amphibians. By far the most common reptile on site was the prairie racerunner (*Cnemidophorus sexlineatus*). Texas horned lizards (*Phrynosoma cornutum*), listed as a Category II species of concern by the state of Oklahoma, were also seen regularly. Along the river, Blanchard’s cricket frogs (*Acris crepitans*) were very common (Lomolino and Smith 2001). The northern earless lizard (*Holbrookia maculata maculata*) is another species listed by the State that has been documented at WABA.

Fish: Oklahoma Biological Survey conducted an inventory of fish found in the Washita River at WABA. Sampling was conducted three separate times during 2002-2003 and documented 16 species of fish. Mosquitofish (*Gambusia affinis*) and red shiners (*Cyprinella litrensis*) were extremely abundant. The moderately common fish species found are tolerant of siltation and turbidity (Bergey 2003).

Invertebrates: A survey for aquatic invertebrates in the Washita River at WABA was conducted by Oklahoma Biological Survey during 2002-2003. Three sampling resulted in 82 taxa of aquatic invertebrates and 26 taxa of aerial insects. Beetles, mayflies and dragonflies/damselflies were especially speciose. The river has a mosaic of different habitats which have characteristic associated invertebrates, resulting in a high diversity of invertebrate fauna (Bergey 2003).

Vegetation

Washita Battlefield National Historic Site is located at the juncture of several ecoregions. Moisture-loving eastern species overlap the more arid southwestern species, while tall-grass prairie gives way to short-grasses. The site itself can be divided into several clear habitats: upland forest, grasslands, old field, wetlands and riparian areas. It is estimated that historically, riparian areas covered 19 acres (8 ha) of park, while grassland dominated 316 acres (128 ha) (Hoagland et al. 2005). Baseline vegetation data was collected under drought conditions by Stotts and DuBey (1998). Their analysis suggested that the southern riparian area was the most “pristine,” the upland prairie in the southeast sector was the most ecologically healthy, and that the wooded “bench” to the north, although heavily

grazed, had never been plowed (Stotts and DuBey 1998; Milner 2003). The Oklahoma Biological Survey conducted a vascular flora inventory in 2002, collecting over eight months. They documented 272 species of vascular plants, 32 of which were trees, shrubs or vines. Five species tracked by the Oklahoma Natural Heritage Inventory were found: low silverbush (*Argythamnia humilis*), plains beeblossom (*Gaura brachycarpa*), cutleaf nightshade (*Solanum triflorum*), giant dropseed (*Sporobolus giganteus*), and prairie zinnia (*Zinnia grandiflora*) (Hoagland et al. 2005).

Thirty-two exotic species were documented, representing 11.8% of the flora collected at Washita Battlefield (Hoagland et al. 2005), several of which are listed by the State of Oklahoma as noxious weeds: Johnson grass (*Sorghum halepense*), white and yellow sweet clover (*Melilotus alba* and *M. officinale*), field bindweed (*Convolvulus arvensis*), bermuda grass (*Cynodon dactylon*), and downy brome (*Bromus mollis*). Control of exotic species is on-going at Washita and several areas are in need of restoration. The floodplain, once mid-grass prairie, has been plowed for decades and is now invaded by kochia (*Kochia scoparia*) and scotch thistle (*Onopordum acanthium*). Research is being done to assess the effectiveness of RoundUp™ on eradication of thistle. Successful efforts to remove tamarisk (*Tamarix chinensis*), once estimated to comprise 80% of the riparian cover, began in 1999 (Milner 2003). Four acres of black locust (*Robinia pseudoacacia*), invading from neighboring fields, were cleared from the eastern boundary in 2000 (Washita Battlefield National Historic Site 2001).

A.11.4 Management Issues

The most critical management issues at Washita Battlefield National Historic Site deal with biotic integrity. A portion of the parks enabling legislation reads, “to protect and preserve....the visual scene as closely as possible as it was at the time of the battle” – a tall order for an area that has been under agricultural management for a century. The grasslands of WABA, especially those in the floodplain, have been heavily altered by the plow. Minimal regard for soil conservation practices resulted in fertile prairie topsoil being blown away during the Dust Bowl. Those grasslands not plowed were heavily grazed, permanently changing the prairie plant communities. Exotic and native invasive plants quickly colonized disturbed areas. Western red cedar and mesquite began to invade overgrazed pasture. The suppression of wildland fire has encouraged this woody succession while enabling exotic plants to gain a foothold. The decline in habitat in conjunction with fragmentation,

has doubtless affected wildlife composition. The Washita River underwent failed attempts to straighten its meander. Somewhere along its course, tamarisk was planted to control the resulting erosion, only to dominate the riparian vegetation to the exclusion of other native species. Efforts aimed at controlling exotic species began shortly after the formation of WABA in 1996. The need to follow control efforts with the reintroduction of desired species is apparent. Fire, in the form of prescribed burns, must be reinstated in the management regime, both to encourage prairie health and to reduce potentially dangerous fuel loads. The role of grazing must also be evaluated as a management tool for Washita.

The protection of the viewsheds and the soundscape are among the most important issues at Washita. An effort is being made to establish a baseline sound measurement so that change can be monitored. Noise generated by park management activities will be minimized and purchased equipment will take decibel levels into account, all with a goal of preserving the all too rare silence. The nightsky feature, currently unpolluted by surrounding lights, contributes greatly to the visitor experience. The vistas at Washita Battlefield have been little altered and are generally evocative of the 1868 view. The skyline to the north is dominated by a series of deep red shale outcroppings. It is desired that all of these sensory experiences can be preserved through landowner cooperation and judicious easements, but adjacent land use can be difficult to control. Development of subdivisions, industry and extractive activities can all impact the sights and sounds at Washita (National Park Service 2001).

The management of the limited water resources will be vital to assuring that there will be water available for Washita Battlefield. Upstream impoundments and agricultural drawdown have altered the renewing floods and depleted the stream flow. Contamination from industrial activities is a dire threat, as is siltation from runoff erosion of agricultural fields. Groundwater level and quality, while possibly unsuitable for human consumption, remains important for the health of the ecosystem.

Visitor use at WABA will be closely monitored to prevent additional degradation to sensitive natural resources. Barriers and erosion control measures will be used to control compaction and trampling caused by trail erosion and unauthorized trails. This is particularly critical in the riparian area, where controlled crossing and access points will be developed. Visitor education and the presence of ranger patrols will also reduce unintentional visitor impacts (National Park Service 2001).

A.11.5 Partnering / Neighboring Agencies & Individuals

Current Partners

USFWS – Washita NWR, USFS Black Kettle Grasslands,; Oklahoma Historical Society, Southern Cheyenne–Arapahoe Tribes

Neighboring Land Management Agencies

Washita NWR, Black Kettle National Grasslands, Foss State Park

A.11.6 Literature Cited

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APPENDIX B. SUMMARY OF FEDERAL LEGISLATION AND POLICY RELATED TO INVENTORY AND MONITORING

PUBLIC LAWS

National Park Service Organic Act (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.”

General Authorities Act of 1970 (16 USC 1a-1—1a-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...”

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 research on NPS resources. Section 5939 states that the purpose of legislation is to:

1. 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;

2. Ensure appropriate documentation of resource conditions in the National Park System;
3. Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value; and
4. Encourage the publication and dissemination of information derived from studies in the NPS.

Redwood National Park Act (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 park’s enabling legislation allow park managers to permit activities such as hunting and grazing.

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 history, architecture, archeology, engineering, and culture.’ NHPA requires federal agencies to account for effects of actions on historic (state and federal) properties.

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.

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 (some 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. 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.

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 ‘[e]ach 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 effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the USFWS (non-marine species) or the National Marine Fisheries Service (all marine species) as appropriate.

Wilderness Act of 1964 (16 USC 1131 et seq.)

Establishes the National Wilderness Preservation System. Wilderness Areas designated by Congress are made 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.

Federal Advisory Committee Act

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.

Government Performance and Results Act (GPRA)

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 all focused on measurable outcomes.

American Indian Religious Freedom Act of 1978

This Act ensures the freedom of Native Americans to practice the religion of their choosing, including the use of sacred lands. “It shall be the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites.”

Archaeological Resources Protection Act of 1979

This Act protects archaeological resources found on public and Indian lands and ensures cooperation between government agencies with respect to these resources. “The purpose of this chapter is to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands, and to foster increased cooperation and exchange of information between government authorities, the professional archaeological community, and private individuals having collections of archaeological resources and data...”

Federal Water Pollution Control Act (Clean Water Act) of 1972

This Act protects the biological, chemical, and physical nature of the Nation's waters through the elimination of pollutants and the creation of wastewater treatment plants.

"It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources..."

Fish and Wildlife Coordination Act of 1958 and 1980

"The FWCA, as amended, proposes to assure that fish and wildlife resources receive equal consideration with other values during the planning of water resources development projects. The Act was passed because the goals of water-related projects (e.g., flood control, irrigation, navigation, hydroelectric power) may conflict with the goal of conserving fish and wildlife resources. Conversely, developers can design water development projects to enhance the quality and enjoyment of fish and wildlife resources if such goals are incorporated into project plans."

Migratory Bird Treaty Act of 1974

This Act prohibits the hunting or collection of migratory bird species and is an agreement between the U.S. and the following countries: Canada, Mexico, Japan and Russia. "Establishment of a Federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this Convention . . . for the protection of migratory birds . . . or any part, nest, or egg of any such bird."

Mining in the Parks Act of 1976

This Act regulates the operation of mining claims within the National Park System in order to protect landmarks and resources. "Congress finds: that continued application of U.S. mining laws to National Park System lands conflicts with the purposes for which they were established; all mining operations on National Park System lands should be conducted to prevent or minimize damage to the environment and other resource values; surface disturbance from mineral development should be halted temporarily in certain National Park System areas while Congress determines whether to acquire valid mineral rights in these areas."

Taylor Grazing Act of 1934

This Act manages grazing on public lands through the use of districts and permitting schedules. "The Secretary must: provide for the protection, administration, regulation and improvement of the grazing districts; adopt regulations and enter into cooperative agreements necessary to accomplish the purposes of the Act; regulate occupancy and use; preserve the land and resources from destruction or unnecessary injury; provide for orderly improvement and development of the range. The Secretary may continue the study of erosion and flood control and perform work to protect and rehabilitate areas subject to the Act."

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.

Surface Mining Control and Reclamation Act of 1977

The Surface Mining Control and Reclamation Act was enacted in 1977. It establishes a nationwide program to protect the environment from adverse effects of surface coal mining operations, establishes minimum national standards for regulating surface coal mining, assists states in developing and implementing regulatory programs, and promotes reclamation of previously mined areas with inadequate reclamation. Under the Act, the Secretary of the Interior is directed to regulate the conduct of surface coal mining throughout the United States for both federally and non-federally owned rights. The Act establishes the Abandoned Mine Reclamation Fund, which is for the reclamation of land and water affected by coal mining. Eligibility for reclamation under this program requires that the land or water had been mined for coal, or affected by coal mining, and had been inadequately reclaimed prior to the enactment of this act in 1977. Both public and private lands are eligible for funding. Sections 522(e)(1) and 533(e)(3) of the act specifically prohibit surface mining within the National Park Service, National Wildlife Refuge System, National System of Trails, National Wilderness Preservation System, or Wild and Scenic Rivers System. The act also prohibits surface mining that adversely impacts any publicly-owned park or place included in the National Register of Historic Sites. These prohibitions are subject to valid existing rights at the time of the Act, the exact definition of which remains the subject of administrative and legal action. How valid existing rights are ultimately defined will affect the ability of mineral owners to mine in the Recreation Area.

EXECUTIVE ORDERS

Off-Road Vehicle Use (Executive Orders 11644 and 11989)

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)

Executive 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.’ To the extent possible, park facilities, such as campgrounds and rest areas, should be located outside floodplain areas. Executive Order 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; and, 4) encourage nonstructural over structural methods of flood hazard mitigation.

Protection of Wetlands (Executive Order 11990)

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)

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 cause. Among other things, this Executive Order 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)

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

Management Policies – 2001 (NPS Directives System)

This is the basic NPS service wide policy document. The Directives System is designed to provide NPS management and staffs 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

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

These documents are issued by Associate Directors and 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://www.nature.nps.gov/im/monitor>

APPENDIX C. GPRA GOALS SUMMARY FROM SOPN PARKS THAT MAY PERTAIN TO SOPN ACTIVITIES (PLANNED OR IN PROGRESS)

GPRA Goal	Park Specific Activities	Parks with this Goal
Ia01A - Disturbed Lands Restored	Restore land disturbed by agriculture, floods, fire, and tamarisk removal	BEOL
	Restore lands disturbed by development or agriculture	CAVO, CHIC, LYJO
	Restore land disturbed by oil and gas activities	LAMR
	Restore lands disturbed by development and implement monitoring for plant regeneration and exotics	PECO
Ia01B – Disturbed Lands – Other	Restore area invaded by eastern red cedar and ashe juniper	CHIC
Ia01C - Wetlands	Inventory park wetlands and conditions identified	BEOL, CHIC, LYJO, PECO, SAND
Ia01D - Riparian	Inventory riparian areas and conditions identified	BEOL, CHIC, FOLS, LAMR, LYJO, SAND
Ia01E - Uplands	Assess condition of uplands and desired conditions identified	ALFL, BEOL, CHIC, FOLS, FOUN, LAMR, LYJO, PECO, SAND, WABA
	Maintain short-grass prairie	CAVO
Ia01G - Mined Lands	Restore disturbed lands	LAMR
Ia02B - Species of Concern	Bison herd in good condition	CHIC
	Native plant and animal species that are damaging resources are controlled	FOUN
Ia1B - Exotic Vegetation Contained	Control exotic plants	ALFL, BEOL, CAVO, CHIC, FOUN, LAMR, SAND, WABA
	Scotch thistle and other alien plants are controlled	PECO
Ia2A - T&E Listed Species	Stable population status	LAMR, LYJO, PECO
Ia2C - Invasive Animals	Remove fire ants, feral pigs, and feral cats	CHIC
	Animal and insect populations controlled	LYJO, WABA
	Feral dog population controlled	PECO
Ia3 - Air Quality	Improve or maintain air quality	CAVO
Ia4a - Surface Water Quality, Rivers and Streams	Meet water quality standards	BEOL, LYJO, PECO, SAND, WABA
	Monitor perennial streams for bacteria	CHIC
Ia4b – Water Quality, Reservoirs	Meet water quality standards	CHIC, LAMR, LYJO
Ia4c – Water Quantity	Protect water quantity conditions	CHIC
IVb1A - Park Partnerships	Work with Bureau of Reclamation on inventory project	BEOL
	Manage park resources	ALFL, CAVO, CHIC, FOLS, FOUN, LAMR, PECO

APPENDIX D. NATIONAL PARK SERVICE DESIGNATION GLOSSARY

SOPN PARK DESIGNATIONS

National Monument

The Antiquities Act of 1906 authorized the President to declare by public proclamation landmarks, structures, and other objects of historic or scientific interest situated on lands owned or controlled by the government to be national monuments. SOPN Monuments: Alibates Flint Quarries, Capulin Volcano and Fort Union.

National Historic Site

Usually, a national historic site contains a single historical feature that was directly associated with its subject. Derived from the Historic Sites Act of 1935, a number of historic sites were established by secretaries of the Interior, but most have been authorized by acts of Congress. SOPN Historic Sites: Bent's Old Fort, Fort Larned, Sand Creek Massacre, and Washita Battlefield.

National Historical Park

This designation generally applies to historic parks that extend beyond single properties or buildings. SOPN Historical Parks: Lyndon B. Johnson and Pecos.

National Recreation Area

Twelve NRAs in the system are centered on large reservoirs and emphasize water-based recreation. Five other NRAs are located near major population centers. Such urban parks combine scarce open spaces with the preservation of significant historic resources and important natural areas in location that can provide outdoor recreation for large numbers of people. SOPN Recreation Areas: Chickasaw and Lake Meredith.

assets. Hunting, mining and consumptive activities are not authorized.

National Preserve

National preserves are areas having characteristics associated with national parks, but in which Congress has permitted continued public hunting, trapping, oil/gas exploration and extraction. Many existing national preserves, without sport hunting, would qualify for national park designation.

National Memorial

A national memorial is commemorative of a historic person or episode; it need not occupy a site historically connected with its subject.

National Battlefield

This general title includes national battlefield, national battlefield park, national battlefield site, and national military park. In 1958, an NPS committee recommended national battlefield as the single title for all such park lands.

National Cemetery

There are presently 14 national cemeteries in the National Park System, all of which are administered in conjunction with an associated unit and are not accounted for separately.

National Seashore

Ten national seashores have been established on the Atlantic, Gulf and Pacific coasts; some are developed and some relatively primitive. Hunting is allowed at many of these sites.

OTHER PARK DESIGNATIONS

National Park

These are generally large natural places having a wide variety of attributes, at times including significant historic

National Lakeshore

National lakeshores, all on the Great Lakes, closely parallel the seashores in character and use.

National River

There are several variations to this category: national river and recreation area, national scenic river, wild river, etc. The first was authorized in 1964 and others were established following passage of the Wild and Scenic Rivers Act of 1968.

National Parkway

The title parkway refers to a roadway and the parkland paralleling the roadway. All were intended for scenic motoring along a protected corridor and often connect cultural sites.

National Trail

National scenic trails and national historic trails are the titles given to these linear parklands (over 3,600 miles) authorized under the National Trails System Act of 1968.

Affiliated Areas

In an Act of August 18, 1970, the National Park System was defined in law as, “any area of land and water now or hereafter administered by the Secretary of the Interior through the National Park Service for park, monument, historic, parkway, recreational or other purposes.” The Affiliated Areas comprise a variety of locations in the United States and Canada that preserve significant properties outside the National Park System. Some of these have been recognized by Acts of Congress, others have been designated national historic sites by the Secretary of the Interior under authority of the Historic Sites Act of 1935. All draw on technical or financial aid from the National Park Service.

Other Designations

Some units of the National Park System bear unique titles or combinations of titles, like the White House and Prince William Forest Park.

APPENDIX E. SOUTHERN PLAINS NETWORK AND INDIVIDUAL PARK MAPS



Figure E.1 SOPN Annual Precipitation

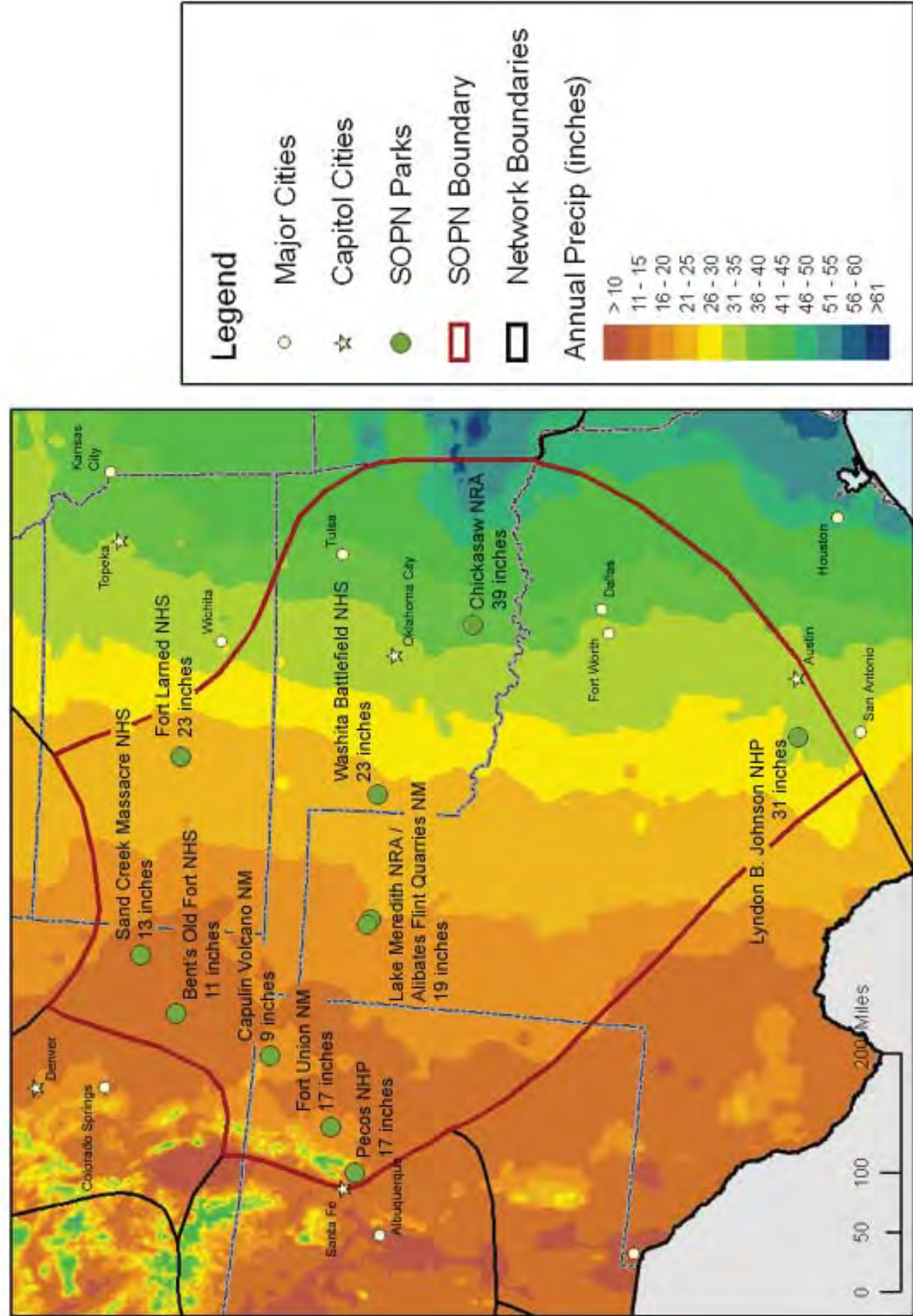
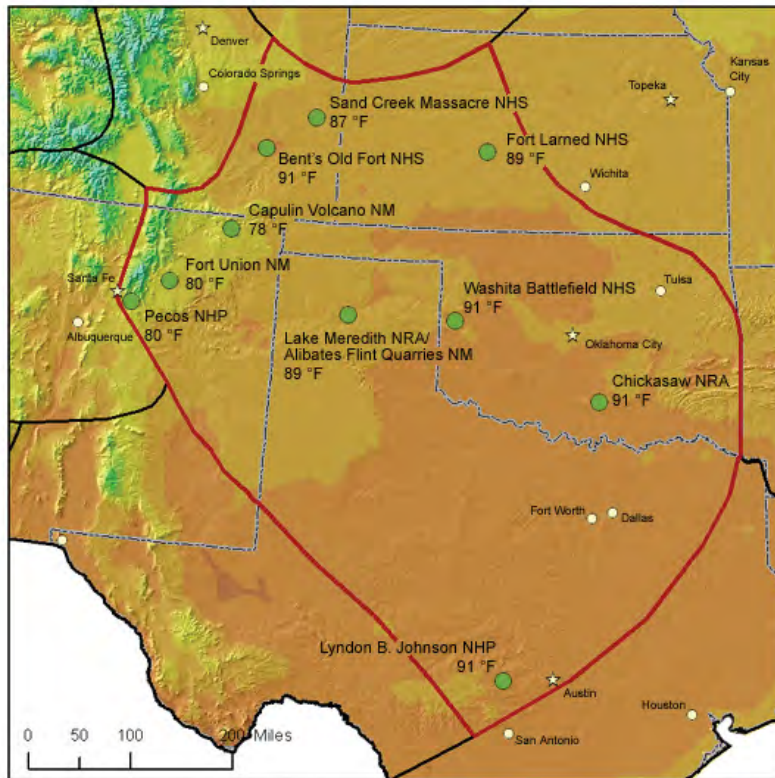
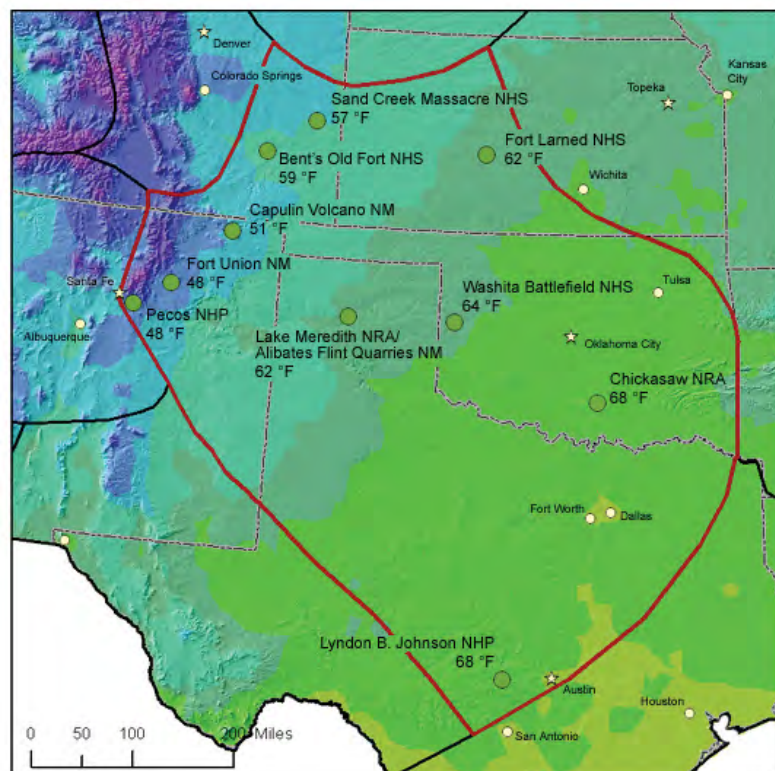


Figure E.2 SOPN Average Summer Temperatures (°F - June to August)



(a) Maximum Temperature



(b) Minimum Temperature

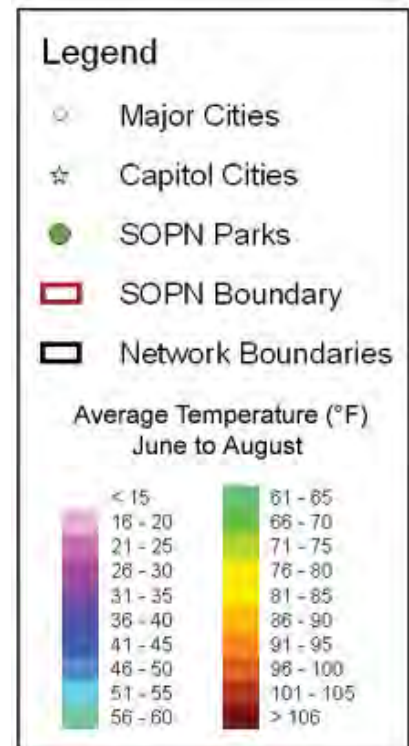
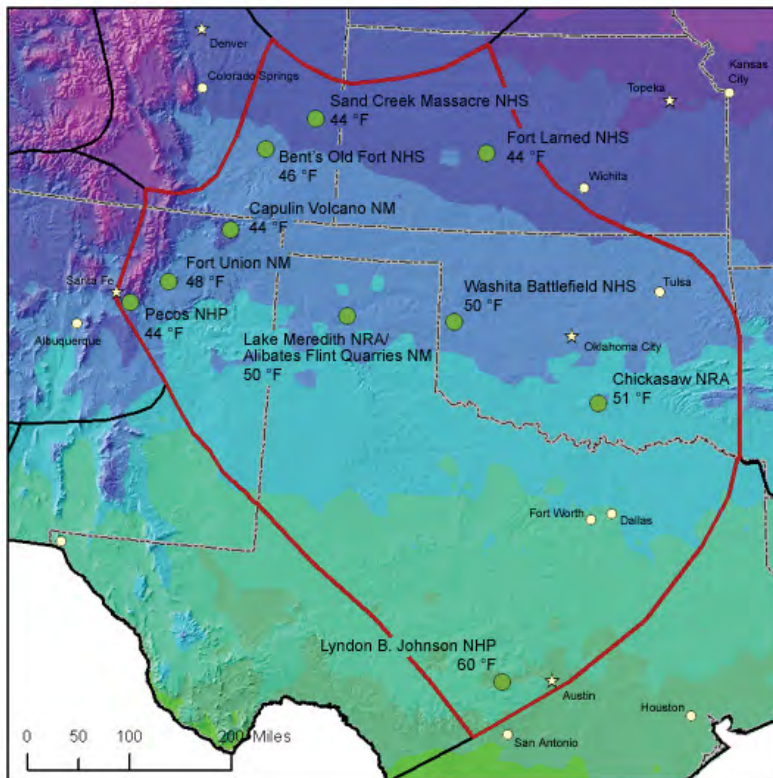
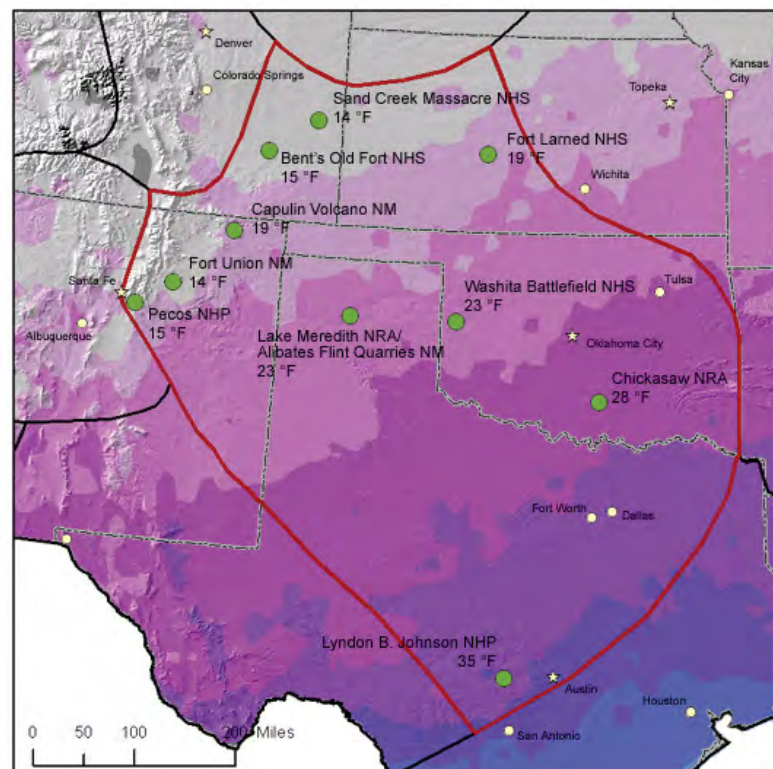


Figure E.3 SOPN Average Winter Temperatures (°F - December to February)



(a) Maximum Temperature



(b) Minimum Temperature

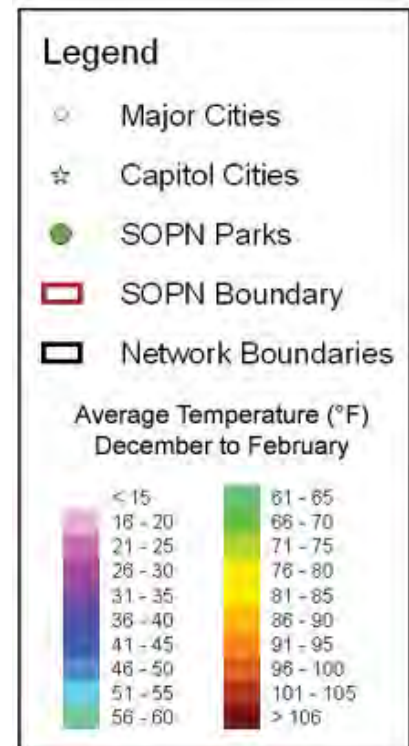


Figure E.4 Bent's Old Fort National Historic Site

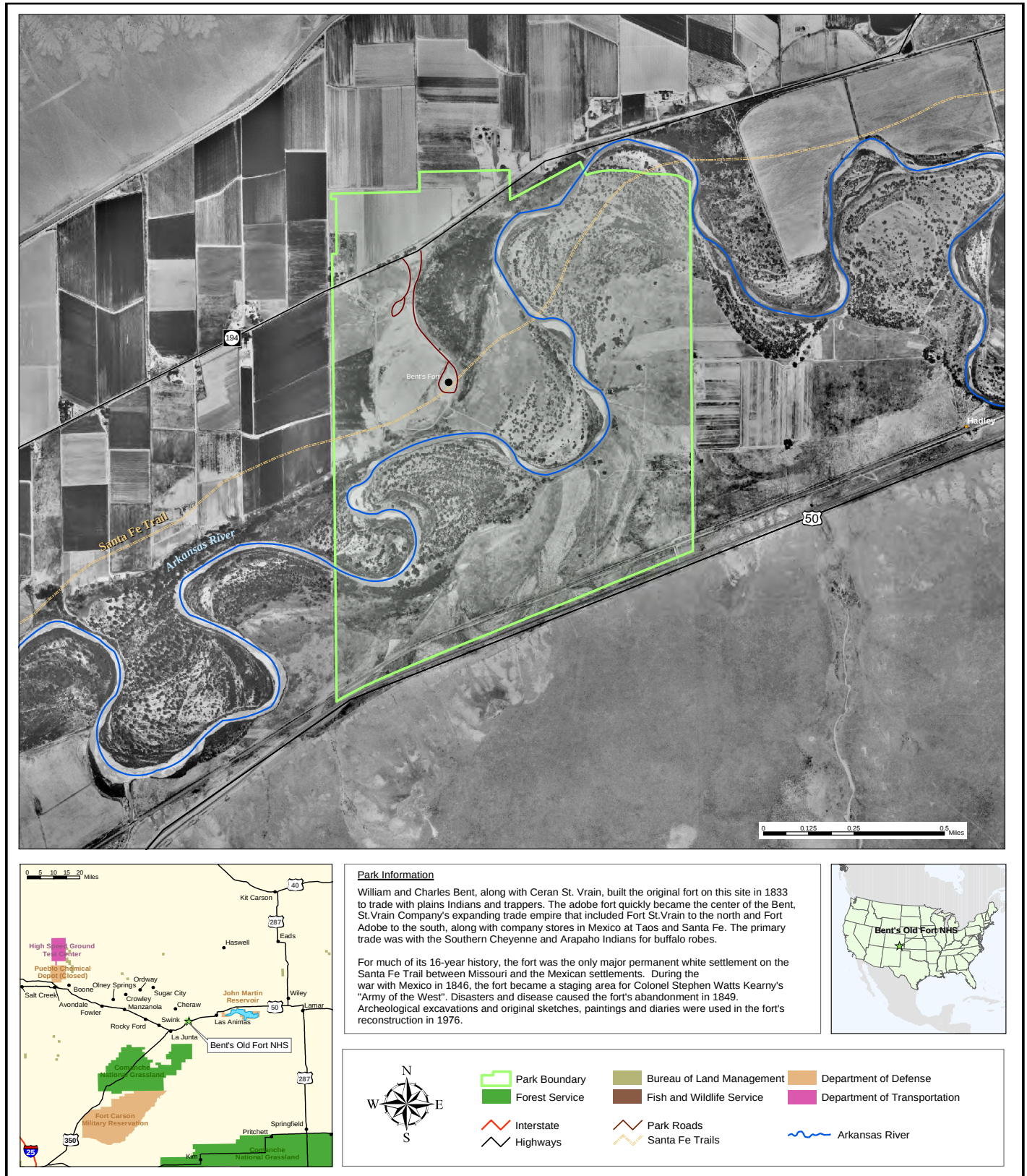


Figure E.5 Capulin Volcano National Monument

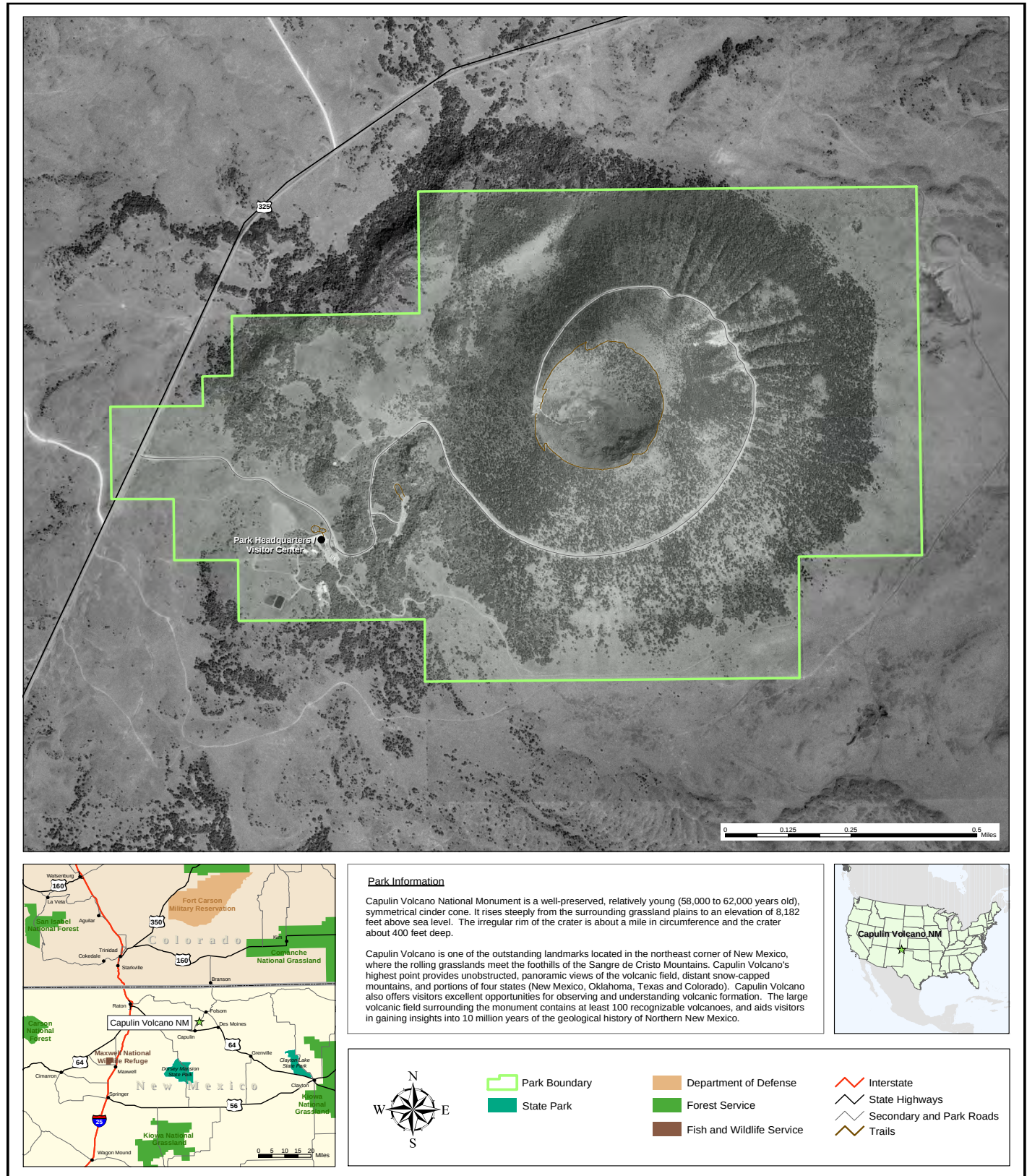


Figure E.6 Chickasaw National Recreation Area

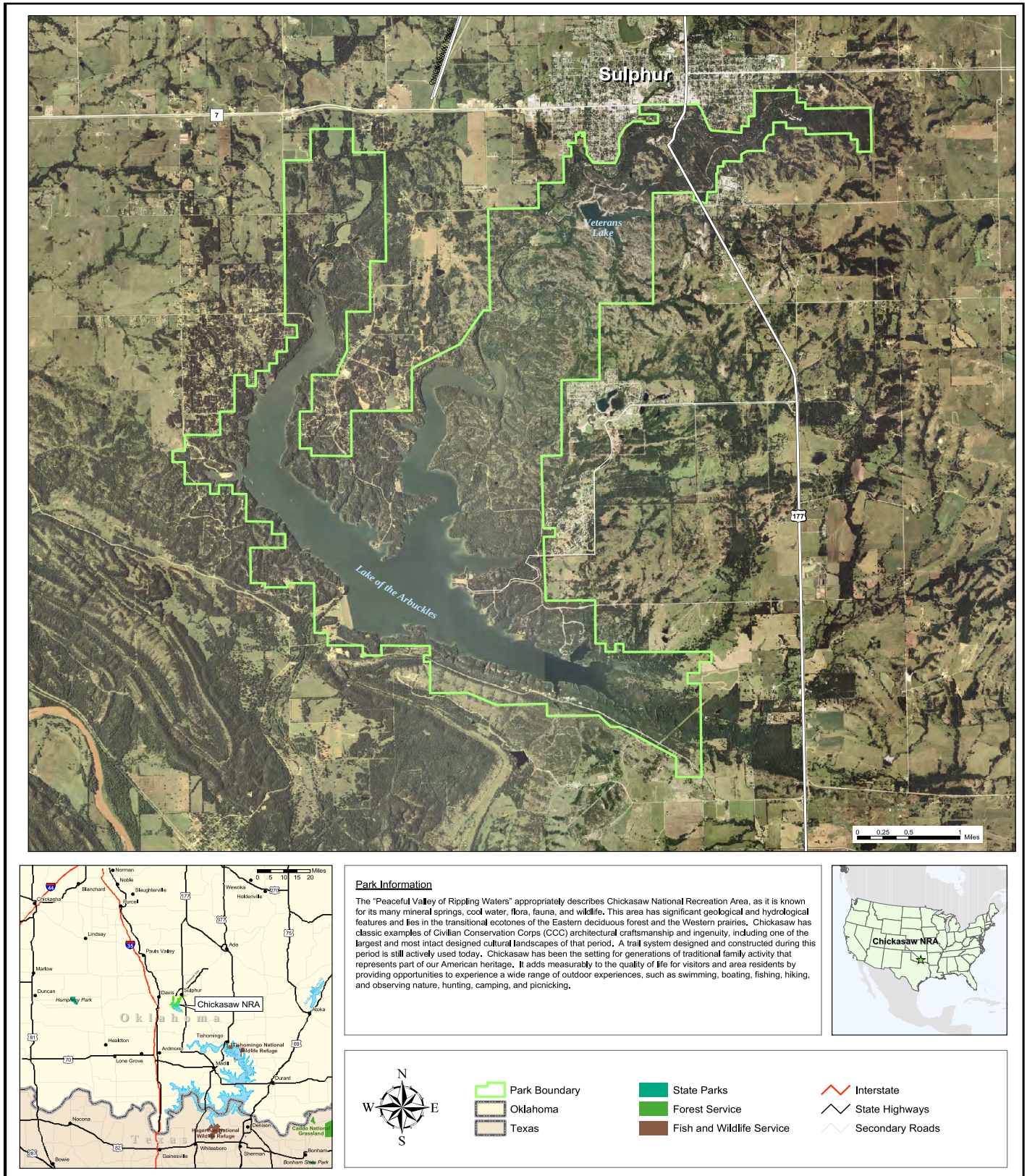


Figure E.7 Fort Larned National Historic Site

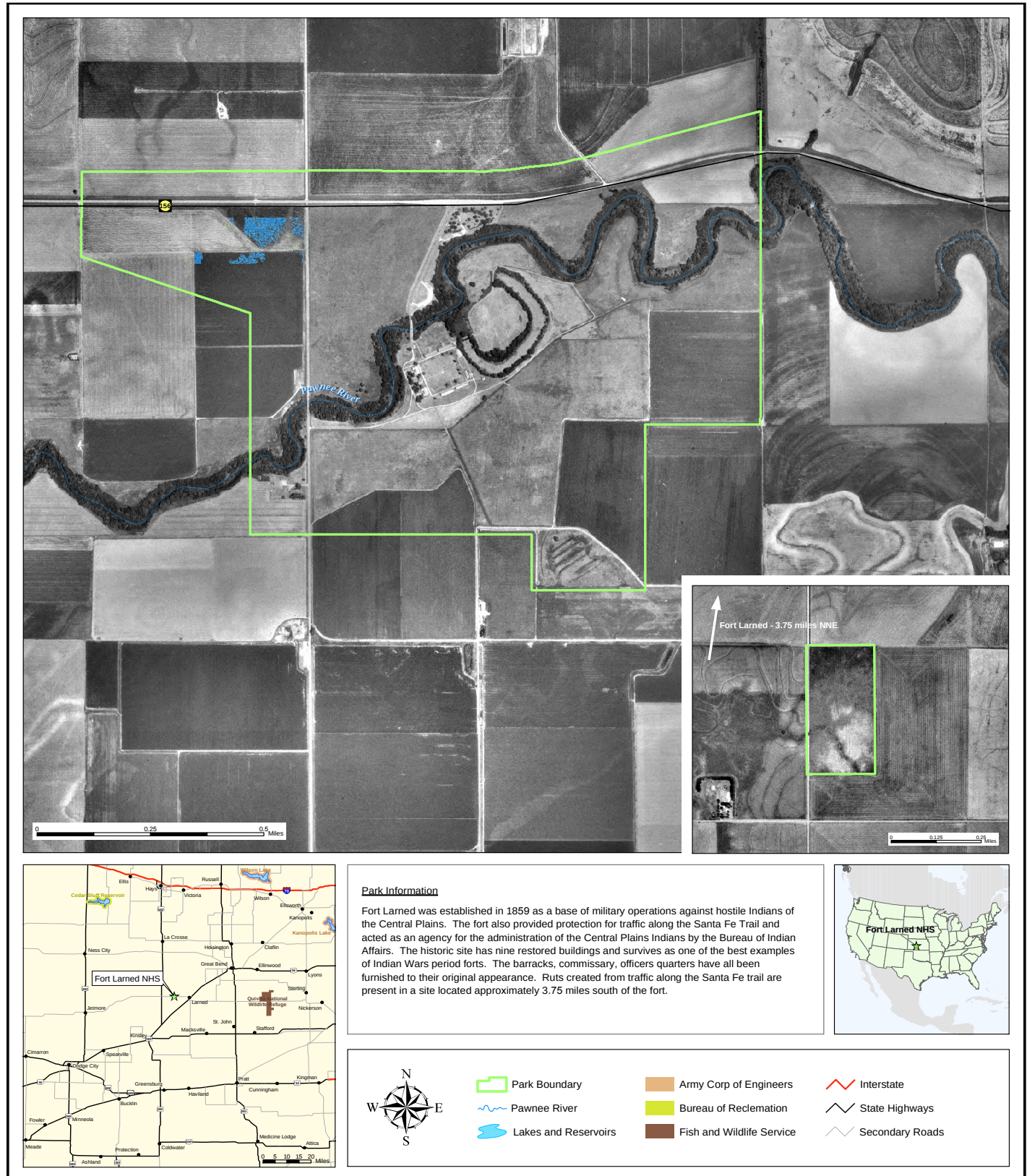


Figure E.8 Fort Union National Monument

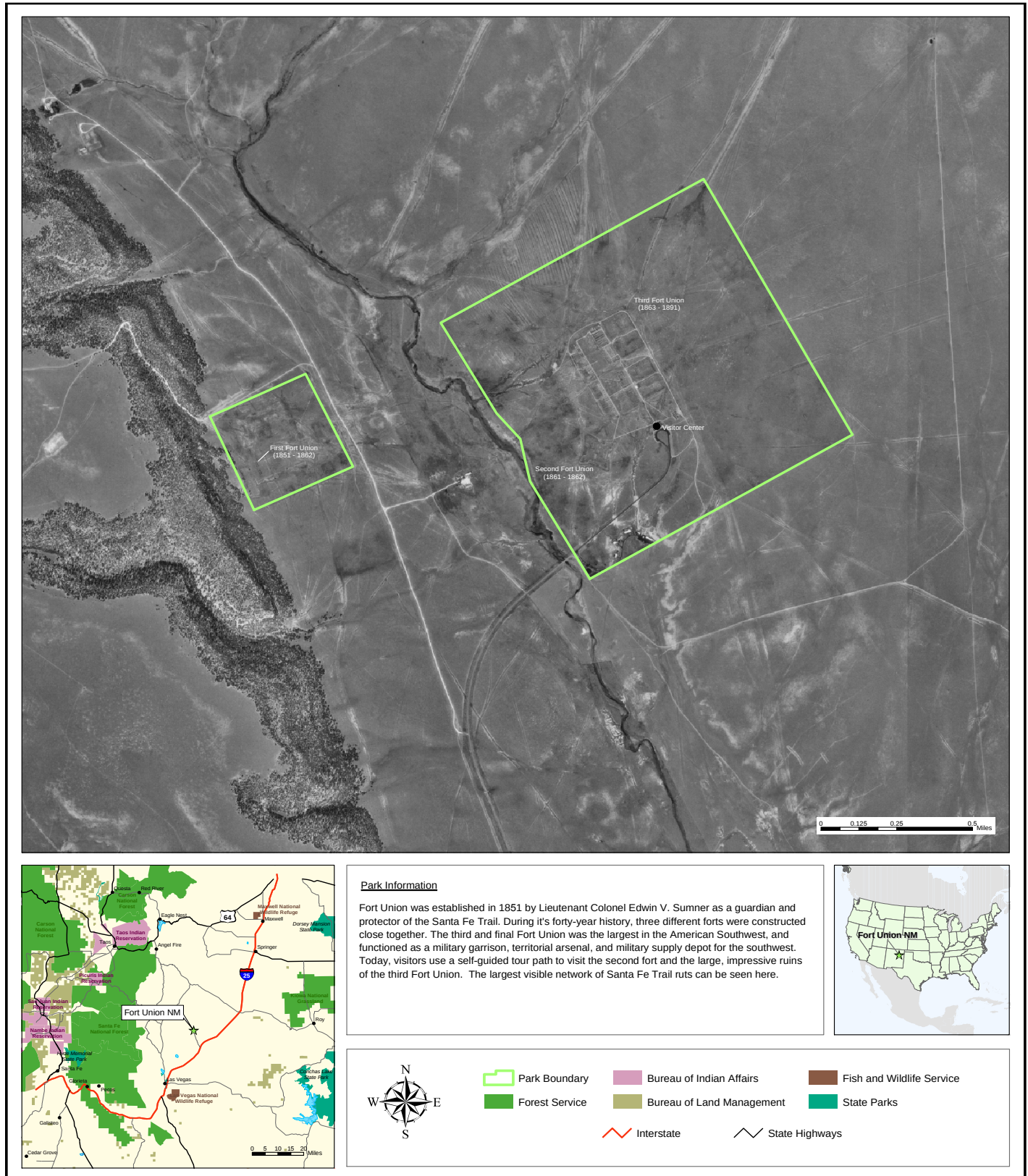


Figure E.9 Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument

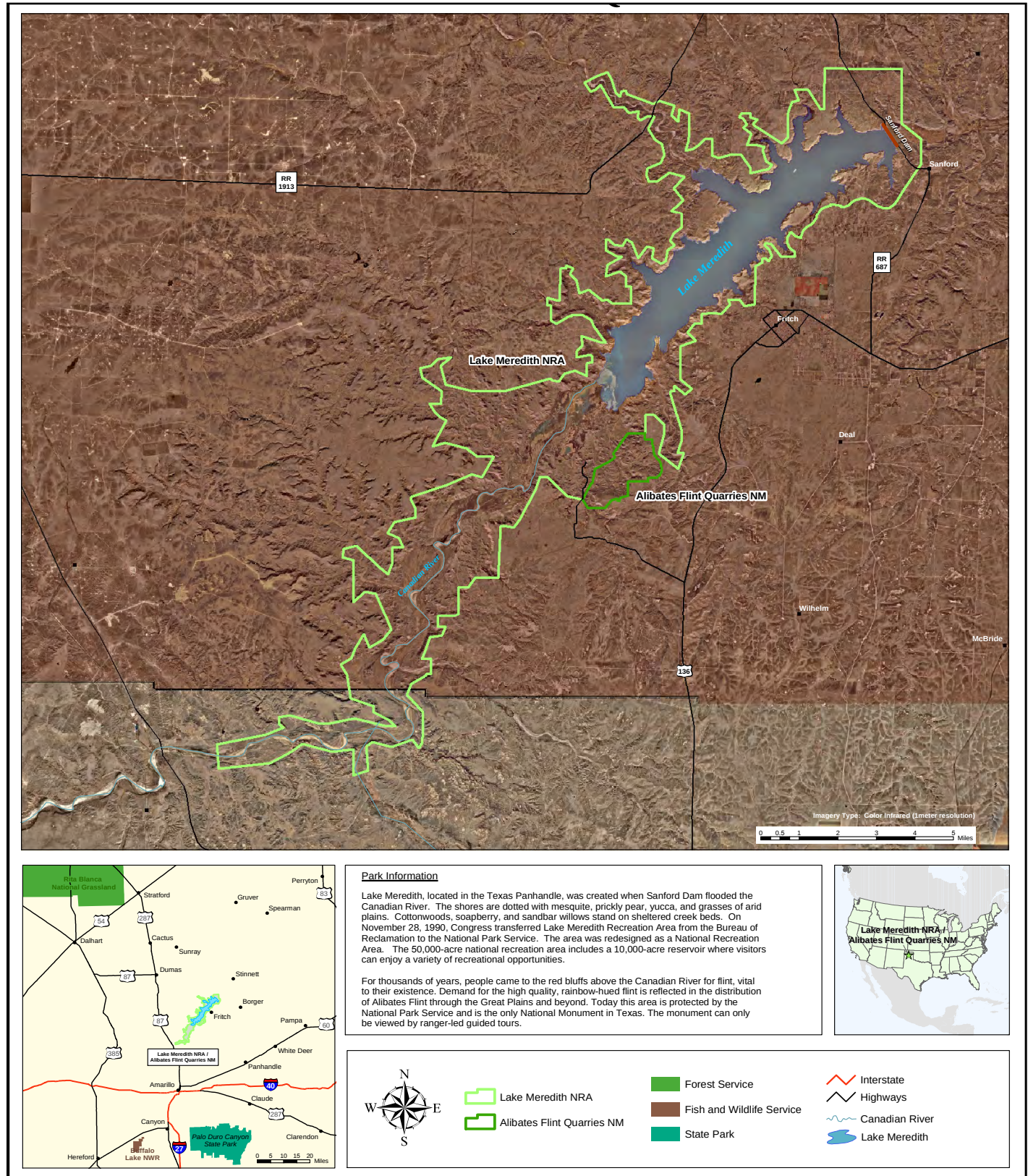


Figure E.10 Lyndon B. Johnson National Historical Park

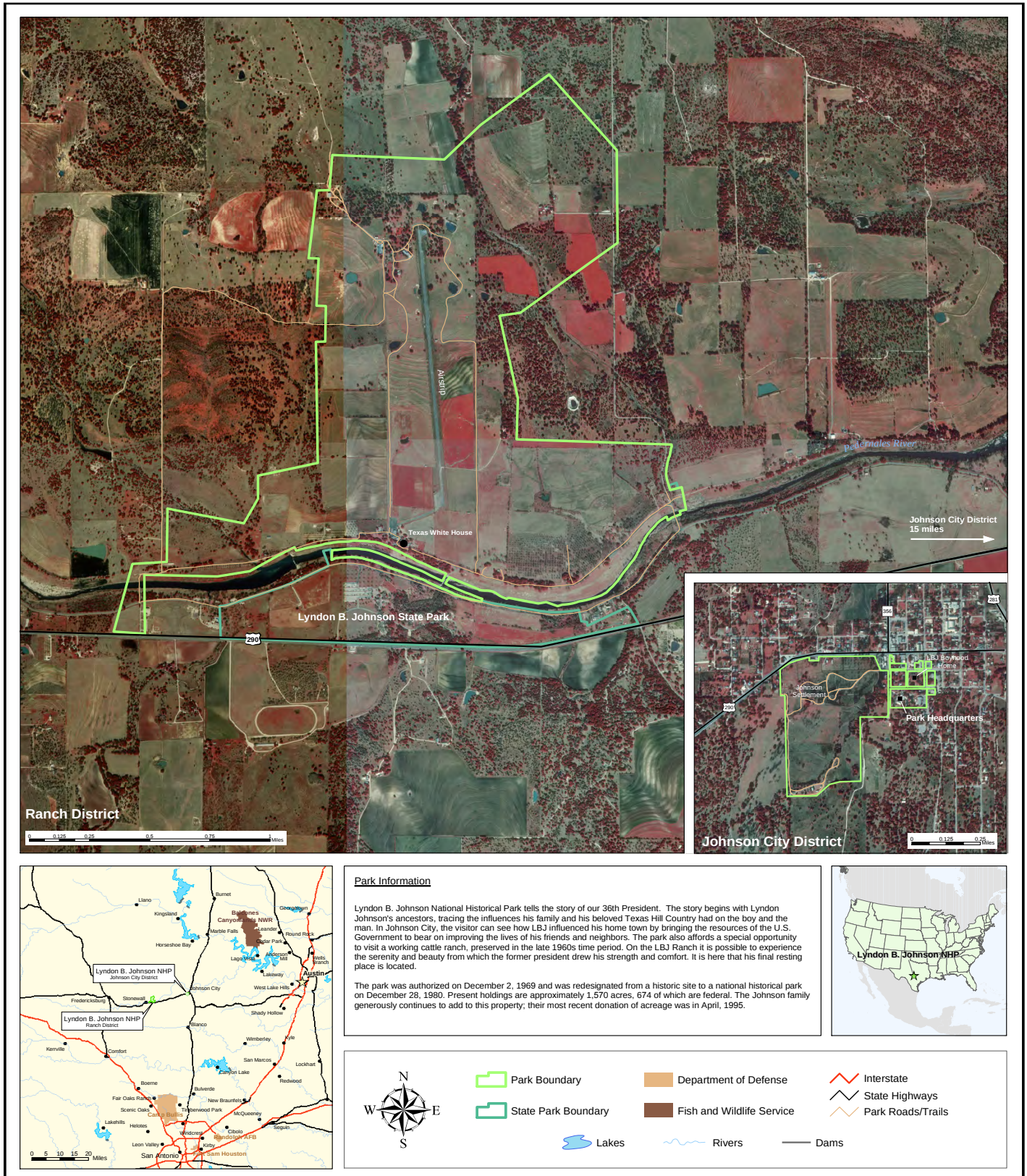


Figure E.11 Pecos National Historical Park

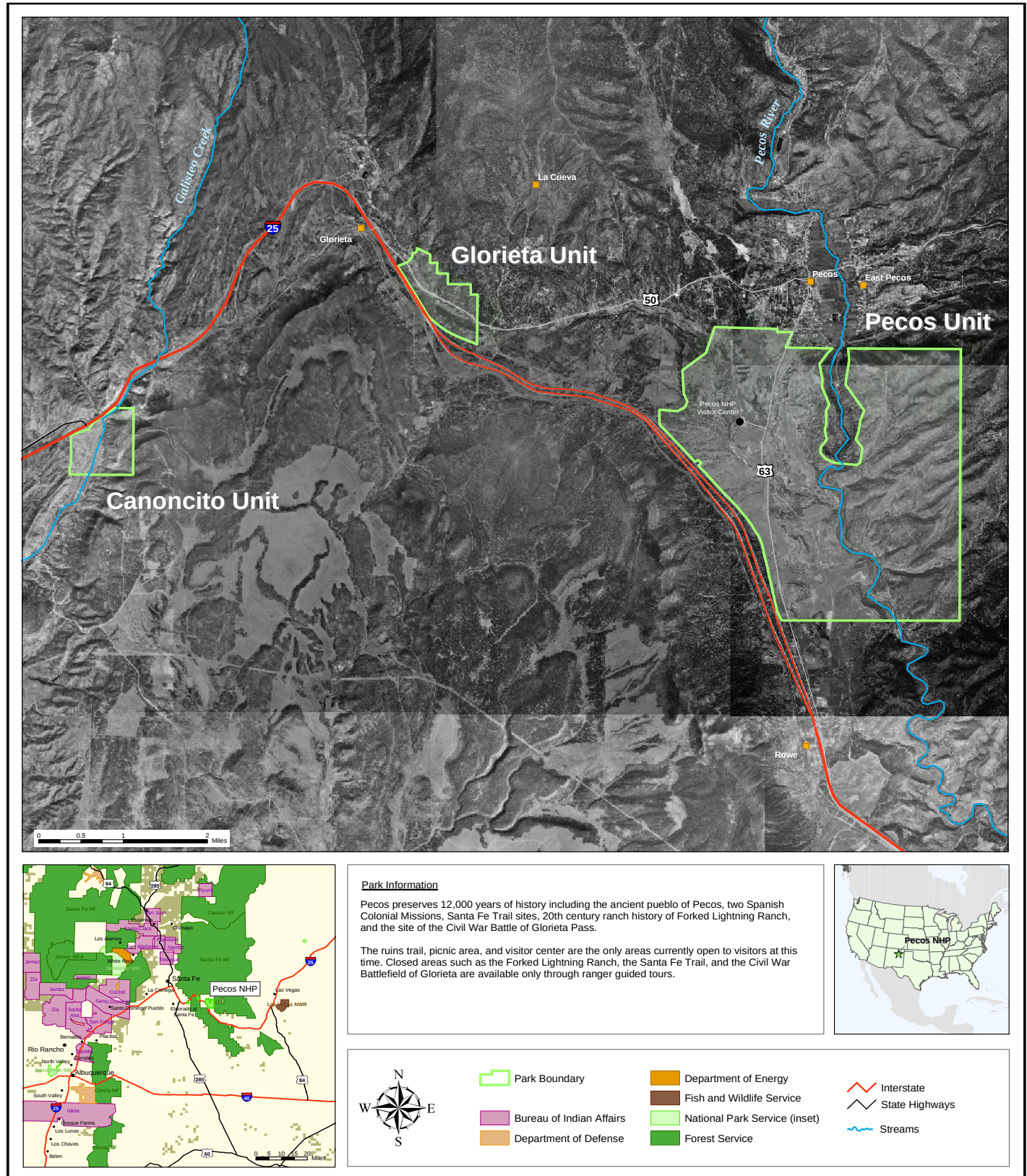


Figure E.12 Sand Creek Massacre National Historic Site

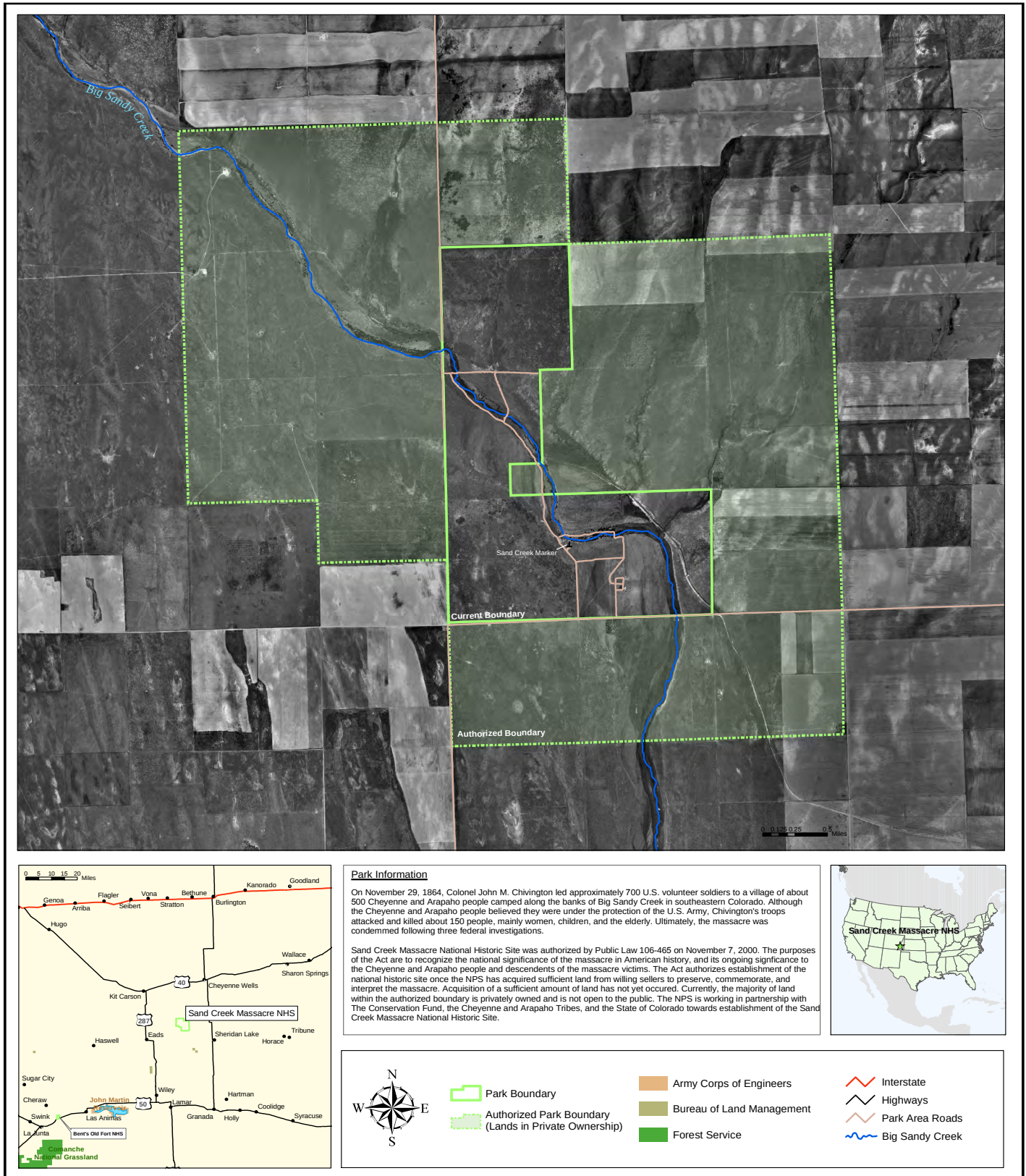
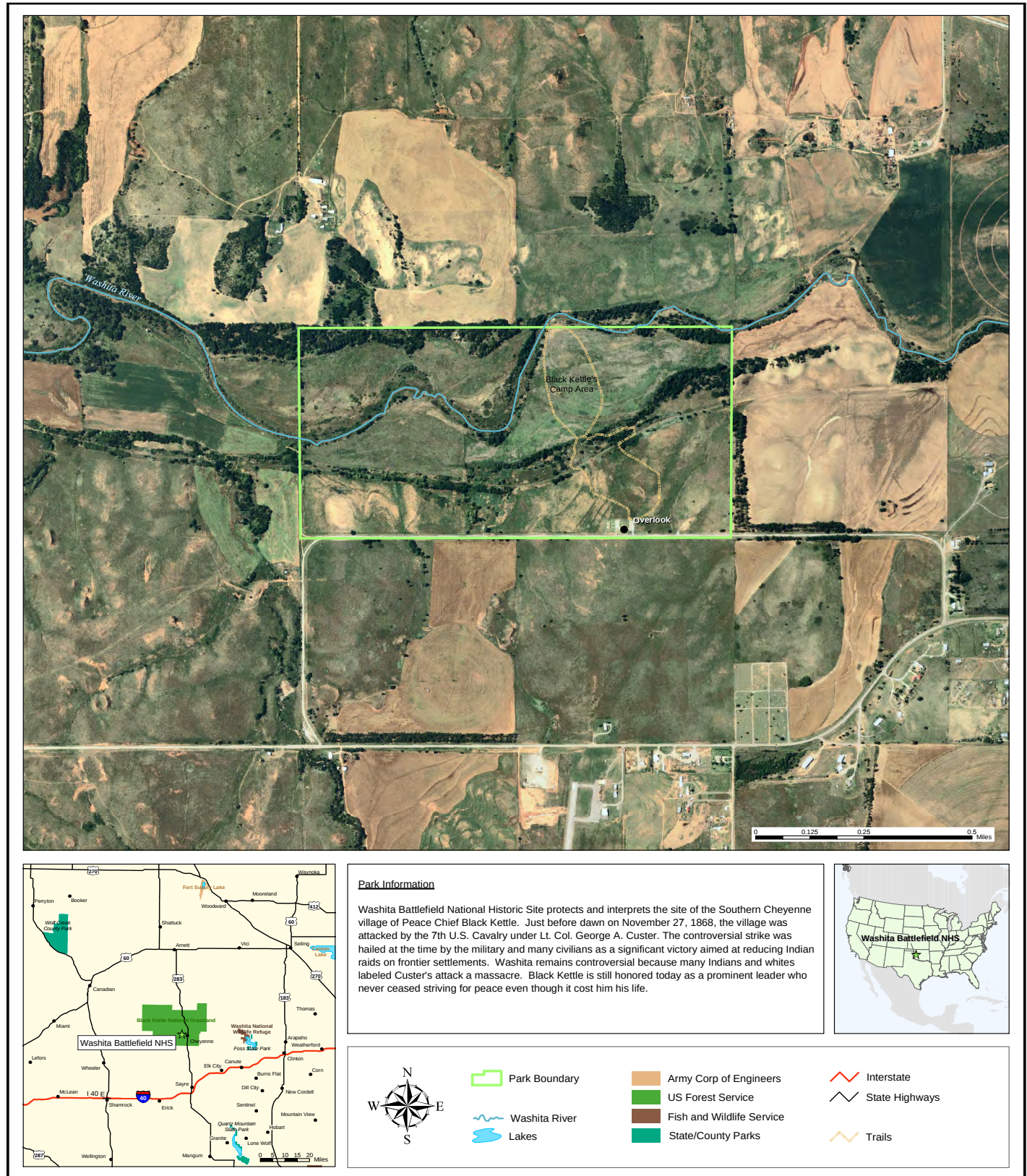


Figure E.13 Washita Battlefield National Historic Site



APPENIDIX F. STATE AND FEDERALLY LISTED SPECIES AND ENDEMIC SPECIES (PRESENT AND POSSIBLY PRESENT)



Phrynosoma cornutum – Texas Horned Lizard
Lake Meredith National Recreation Area, May 7, 2003
Photo by Michael Patrikeev

Common Name	Scientific Name	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Federal Status	States Listed	Endemic To
Reptiles															
Northern earless lizard	Holbrookia maculata maculata											●		OK	
Texas horned lizard	Phrynosoma cornutum	●	●		●			●	○			●		CO, OK, TX	
Texas map turtle	Graptemys versa								●					Endemic	Edwards Plateau
Mammals															
Black-tailed prairie dog	Cynomys ludovicianus		●			●		●			●			NM	
Marsh rice rat	Orzomys palustris				●									OK	
Mountain lion	Puma concolor							○				○		OK	
Palo Duro Canyon mouse	Peromyscus truei comanche							○						TX, Endemic	Texas Panhandle
Swift fox	Vulpes velox			○				○			○			CO, OK, NM	
Townsend's big eared bat	Corynorhinus townsendii			●										NM	
Birds															
Bald eagle	Haliaeetus leucocephalus							●	●				Threatened	CO, KS, OK, NM, TX	
Burrowing owl	Athene cunicularia		○			●					●			CO, OK	
Ferruginous hawk	Buteo regalis		●								○			CO, OK	
Lesser prairie chicken	Tympanuchus pallidicinctus							○			○		Candidate	CO, OK, NM	
Mountain plover	Charadrius montanus										●		Proposed and removed	CO, OK, NM	
Southwestern willow flycatcher	Empidonax traillii extimus									○			Endangered	TX, CO, NM	
Swainson's hawk	Buteo swainsonii				●		●					●		OK	
Fish															
Arkansas darter	Etheostoma cragini		○								●		Candidate	KS, CO, OK	
Arkansas river shiner	Notropis girardi							●					Threatened	KS, OK, NM, TX	

● – Species Present in SOPN ○ – Species Possibly Present in SOPN

Common Name	Scientific Name	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Federal Status	States Listed	Endemic To
Guadalupe bass	Micropterus treculi								●					Endemic	Edwards Plateau
Invertebrates															
Alberta arctic butterfly	Oeneis alberta capulinensis			●										Endemic	Northeastern New Mexico Mountains
Giant mole cricket	Gryllotalpa major							●						OK	
Plants															
Dwarf Milkweed	Asclepias uncialis									○				Endemic	Northern New Mexico
Streaked Ragweed	Ambrosia linearis										○			Endemic	Southeastern Colorado

● – Species Present in SOPN ○ – Species Possibly Present in SOPN

APPENDIX G. EXOTIC PLANTS FOUND IN SOUTHERN PLAINS NETWORK PARKS

(WITH APPLICABLE NOXIOUS WEED DESIGNATIONS)



Tragopogon dubius - Salsify
Photo by Heidi Sosinski, NPS

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Abutilon theophrasti</i> Medik.	velvetleaf	CO		•		•	•							
<i>Acroptilon repens</i> (L.) DC.	knapweed, Russian	CO, KS, NM		•										
<i>Aegilops cylindrica</i> Host	goatgrass, jointed	CO, NM		•		•	•		•					
<i>Agropyron cristatum</i> (L.) Gaertn.	wheatgrass, crested				•						•			
<i>Agrostis gigantea</i> Roth	bentgrass, redtop or water							•	•		•			
<i>Albizia julibrissin</i> Durazz.	mimosa					•								may be escaped
<i>Alyssum minus</i> (L.) Rothm.	alyssum, European										•			
<i>Amaranthus blitoides</i> S. Wats	amaranth, prostrate								•					
<i>Amaranthus retroflexus</i> L.	amaranth, redroot		•	•		•			•					
<i>Arctium minus</i> Bernh.	burdock	CO									•			
<i>Arenaria serpyllifolia</i> L.	sandwort, thyme-leaf					•				•			•	
<i>Arundo donax</i> L.	reed, giant	TX								•				
<i>Asparagus officinalis</i> L.	asparagus, garden			•		•				•	•			
<i>Atriplex rosea</i> L.	saltbush, redscale										•			
<i>Bothriochloa bladhii</i> (Retz.) S.T. Blake	beardgrass, Australian						•							
<i>Bothriochloa ischaemum</i> var. <i>songarica</i> (Rupr. ex Fisch. & C.A. Mey.) Celarier & Harlan	bluestem, King Ranch					•			•	•			•	
<i>Brassica nigra</i> (L.) Koch	mustard, black									•				
<i>Bromus catharticus</i> Vahl	rescue-grass					•		•	•	•	•			
<i>Bromus commutatus</i> Schrad.	brome, meadow			•			•							

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Bromus hordeaceus</i> ssp. <i>hordeaceus</i> L.	brome, soft												•	syn: Bromus mollis
<i>Bromus inermis</i> Leyss.	brome, smooth			•	•		•		•		•			
<i>Bromus japonicus</i> Thunb. ex Murr.	brome, Japanese			•	•	•	•	•	•	•	•		•	
<i>Bromus lanceolatus</i> Roth	brome, big-spike									•				syn: Bromus macrostachys
<i>Bromus tectorum</i> L.	cheatgrass	CO		•	•	•	•	•			•	•		
<i>Broussonetia papyrifera</i> (L.) L'Her. Ex Vent.	mulberry, paper					•								
<i>Buglossoides arvensis</i> (L.) I.M. Johnston	bugloss, false					•				•				
<i>Capsella bursa-pastoris</i> (L.) Medik.	shepherd's purse	CO				•	•			•	•		•	
<i>Cardaria draba</i> (L.) Desv.	hoary cress	CO, KS, NM		•							•			
<i>Carduus nutans</i> L.	musk thistle, nodding	CO, KS, NM, OK								•				
<i>Carduus tenuiflorus</i> W. Curtis	thistle, slenderflower									•				
<i>Centaurea melitensis</i> L.	star-thistle, short-spine	NM								•				
<i>Cerastium glomeratum</i> Thuill.	chickweed, bunch-flower					•				•				
<i>Chenopodium ambrosioides</i> L.	wormseed					•				•				
<i>Chenopodium glaucum</i> L.	goosefoot, oakleaf								•					
<i>Chorisporea tenella</i> (Pallas) DC.	mustard, purple	CO		•							•			
<i>Cichorium intybus</i> L.	chicory	CO			•									
<i>Cirsium arvense</i> (L.) Scop.	thistle, Canada	CO, KS, NM, OK		•								•		
<i>Conium maculatum</i> L.	poison-hemlock	CO, NM		•			•			•	•			

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Facelis retusa</i> (Lam.) Schultz-Bip.	trampweed, annual									•				
<i>Fatoua villosa</i> (Thunb.) Nakei	crabweed, hairy									•				
<i>Geranium pusillum</i> L.	geranium, small												•	
<i>Hibiscus trionum</i> L.	flower of an hour	CO		•			•						•	
<i>Hordeum murinum</i> L.	barley, mouse									•				
<i>Hordeum vulgare</i> L.	barley, common									•				
<i>Kochia scoparia</i> (L.) Schrad.	kochia, common	CO		•	•		•	•			•		•	
<i>Kummerowia stipulacea</i> (Maxim.) Makino	clover, Korean					•								escaped cultivation?
<i>Lactuca serriola</i> L.	lettuce, prickly wild			•		•	•	•	•	•	•		•	
<i>Lamium amplexicaule</i> L.	henbit					•	•		•	•			•	
<i>Lathyrus hirsutus</i> L.	pea-vine, rough					•				•				
<i>Lepidium latifolium</i> L.	pepperweed, broadleaf	CO, NM		•										
<i>Lespedeza cuneata</i> (Dum.-Cours.) G. Don	lespedeza, Chinese	CO, KS				•								
<i>Ligustrum sinense</i> Lour.	privet, Chinese									•				
<i>Ligustrum vulgare</i> L.	privet, European					•								
<i>Lolium arundinaceum</i> (Schreb.) S.J. Darbyshire	fescue, tall									•	•			syn = Festuca arundinacea
<i>Lolium perenne</i> L.	ryegrass, perennial					•	•		•	•	•		•	
<i>Lolium pratense</i> (Huds.) S.J. Darbyshire	ryegrass, meadow					•								
<i>Lolium temulentum</i> L.	ryegrass, darnel								•					
<i>Lonicera japonica</i> Thunb.	honeysuckle, Japanese					•				•				

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Lonicera maackii</i> (Rupr.) Herder	honeysuckle, Amur					•								
<i>Malva neglecta</i> Wallr.	common mallow										•			
<i>Malva parviflora</i> L.	mallow, little or cheeseweed									•				
<i>Marrubium vulgare</i> L.	horehound				•	•		•		•	•			
<i>Medicago lupulina</i> L.	medic, black					•	•			•	•			
<i>Medicago minima</i> (L.) L.	medic, burclover					•			•	•			•	
<i>Medicago polymorpha</i> L.	bur-clover, California				•					•				
<i>Medicago sativa</i> L.	alfalfa					•	•	•	•		•			
<i>Melia azedarach</i> L.	chinaberry					•				•				cultivated escapee?
<i>Melilotus alba</i> Medikus	sweetclover, white				•		•		•	•			•	
<i>Melilotus lupulina</i>						•		•						cultivated?
<i>Melilotus officinalis</i> (L.) Lam.	sweetclover, yellow				•	•	•	•	•		•		•	
<i>Mollucella laevis</i>									•					
<i>Morus alba</i> L.	mulberry, white						•		•	•			•	
<i>Myriophyllum spicatum</i> L.	watermilfoil, Eurasian	CO, NM, TX							•					
<i>Nepeta cataria</i> L.	catnip					•	•				•			escapee?
<i>Onopordum acanthium</i> L.	thistle, Scotch	CO, NM, OK									•			
<i>Panicum coloratum</i> L.	Klein grass									•				
<i>Panicum miliaceum</i> L.	millet, wild proso	CO							•					
<i>Parthenium hysterophorus</i> L.	whiteweed					•								

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Paspalum dilatatum</i> Poir.	Dallis-grass					•				•				
<i>Paspalum urvillei</i> Steud	Vasey grass									•				
<i>Pennisetum glaucum</i> (L.) R. Br.	millet, pearl	CO				•								
<i>Phleum pratense</i> L.	timothy										•			
<i>Plantago lanceolata</i> L.	plantain, narrowleaf					•		•			•			
<i>Poa annua</i> L.	bluegrass, annual	OK				•				•				
<i>Poa compressa</i> L.	bluegrass, Canada										•			
<i>Polygonum arenastrum</i> Jord. Ex Boreau	knotweed, ovalleaf						•		•				•	
<i>Polygonum aviculare</i> L.	knotweed, prostrate										•		•	
<i>Polygonum convolvulus</i> L.	bindweed, black				•	•					•			
<i>Polypogon monspeliensis</i> (L.) Desf.	grass, rabbit's-foot			•					•	•				
<i>Potentilla recta</i> L.	cinquefoil, sulfur	CO				•								
<i>Psathyrostachys juncea</i> (Fisch.) Nevski	wildrye, Russian										•			
<i>Rumex crispus</i> L.	dock, curly					•	•		•		•		•	
<i>Rumex obtusifolius</i> L.	dock, bluntleaf			•										
<i>Rumex patientia</i> L.	dock, patience						•							
<i>Rumex pulcher</i> L.	dock, fiddle					•								cultivated?
<i>Rumex stenophyllus</i> Ledeb.	dock, narrowleaf						•		•					
<i>Salsola collina</i> Pallas	Russian thistle, slender	CO							•					
<i>Salsola kali</i> L.	Russian thistle, prickly			•			•							

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Salsola tragus</i> L.	Russian thistle, prickly	CO	•	•	•			•	•		•		•	syn = <i>Salsola iberica</i>
<i>Saponaria officinalis</i> L.	bouncingbet	CO				•								
<i>Scorzonera laciniata</i> L.	vipergrass, cutleaf								•		•			
<i>Setaria pumila</i> (Poir.) Roemer & J.A. Schultes	bristleglass, yellow	FED			•		•		•					
<i>Setaria viridis</i> (L.) Beauv.	bristleglass, green	CO		•	•		•				•		•	
<i>Sherardia arvensis</i> L.	fieldmadder, blue									•				
<i>Sinapis arvensis</i> L.	mustard, charlock					•								
<i>Sisymbrium altissimum</i> L.	mustard, tumble					•					•			
<i>Sisymbrium irio</i> L.	mustard, London rocket									•				
<i>Sonchus asper</i> (L.) Hill	sowthistle, prickly or spiny					•	•	•	•	•	•		•	
<i>Sonchus oleraceus</i> L.	sowthistle, common									•				
<i>Sorghum alnum</i> Parodi	sorghum, perennial								•					
<i>Sorghum halapense</i> (L.) Pers.	Johnson-grass	CO, KS	•	•		•	•		•	•			•	
<i>Stellaria media</i> (L.) Vill.	chickweed, common					•	•			•			•	
<i>Tamarix chinensis</i> Lour.	tamarisk, fivestamen	NM, TX				•			•					
<i>Tamarix ramosissima</i> Ledeb.	tamarick, saltcedar	CO, NM, TX		•					•		•		•	
<i>Taraxacum laevigatum</i> (Willd.) DC.	dandelion, rock					•								
<i>Thinopyrum ponticum</i> (Podp.) Z.-W. Liu & R.-C. Wang	wheatgrass, tall										•			syn = <i>Elymus elongatus</i>
<i>Thlaspi arvense</i> L.	pennycress, field						•						•	
<i>Torilis arvensis</i> (Huds.) Link	hedgепarsley, beggerlice					•				•				

Scientific Name	Common Name	Noxious Weed	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA	Comment
<i>Torilis nodosa</i> (L.) Gaertn.	hedgearsley, knotted									•				
<i>Tragopogon dubius</i> Scop.	salsify, yellow or western			•	•	•	•	•	•		•		•	
<i>Tragopogon pratensis</i> L.	salsify, meadow				•			•						
<i>Triadica sebiferum</i> (L.) Small	tallow-tree, Chinese	TX								•				syn = Sapium sebiferum
<i>Tribulus terrestris</i> L.	puncturevine, goathead	CO		•		•	•		•		•		•	
<i>Trifolium campestre</i> Schreb.	hop clover, large					•								
<i>Trifolium dubium</i> Sibthorp	hop clover, small					•								
<i>Trifolium pratense</i> L.	clover, red										•			
<i>Trifolium repens</i> L.	clover, white										•			
<i>Triticum aestivum</i> L.	wheat, common					•	•						•	
<i>Ulmus pumila</i> L.	elm, Siberian	NM		•			•	•	•		•		•	
<i>Verbascum thapsus</i> L.	mullein, common	CO		•	•	•		•		•	•			
<i>Verbena brasiliensis</i> Vell.	vervain, Brazilian									•				
<i>Veronica agrestis</i> L.	speedwell, field					•								
<i>Veronica arvensis</i> L.	speedwell, common or corn									•			•	
<i>Vicia sativa</i> L.	vetch, narrowleaf					•				•				
<i>Vicia villosa</i> Roth	vetch, winter or hairy									•				

APPENDIX H. EXOTIC ANIMALS FOUND IN SOUTHERN PLAINS NETWORK PARKS



Rana catesbeiana – Bullfrog
Lake Meredith National Recreation Area, May 7, 2003.
Photo by Katherine B. Castro

Common Name	Scientific Name	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Fish (continued)												
Black crappie	<i>Pomoxis nigromaculatus</i>		•									
Walleye	<i>Stizostedion vitreum</i>								•			
Brook silverside	<i>Labidesthes sicculus</i>								•			
Warmouth	<i>Lepomis gulosus</i>								•			
Bluegill	<i>Lepomis macrochirus</i>		•									
Longear sunfish	<i>Lepomis megalotis</i>							•				
American gizzard shad	<i>Dorosoma cepedianum</i>							•				
Mosquitofish	<i>Gambusia affinis</i>		•									
Common carp	<i>Cyprinus carpio</i>		•			•		•	•			•
Longnose sucker	<i>Catostomus catostomus</i>		•									
Rio Grande perch	<i>Cichlasoma cyanoguttatum</i>								•			
Pirate perch	<i>Aphredoderus sayanus</i>								•			

APPENDIX I. SOUTHERN PLAINS NETWORK WATER RESOURCES REPORT

Prepared by Karie Cherwin and Dusty Perkins

"Of all our natural resources, water has become the most precious... In an age when man has forgotten his origins and is blind even to his most essential needs for survival, water along with other resources has become the victim of his indifference."

-Rachel Carson, Silent Spring

I.1 ABSTRACT

This document facilitates the development of a water quality monitoring plan for the Southern Plains Network (SOPN) Vital Signs Inventory and Monitoring Program by describing the status of water resources within each of the eleven network parks. Furthermore, this report discusses existing data, data gaps, water legislation, and management issues for SOPN Park water resources. The two most significant concerns for SOPN water resources are pollution, primarily from point sources, and insufficient water quantity. Primary network needs include data collection, analysis, and feedback, as well as the prioritization of management strategies. SOPN will fully incorporate the funding and monitoring plan given by the Water Resources Division with the broader Vital Signs Inventory and Monitoring Program to more efficiently track the progress of the NPS long term strategic goal of improving Park water quality and quantity.

I.2 INTRODUCTION

The National Park Service (NPS) has long recognized that protection and restoration of national park waters, watersheds, and aquatic life is critical for maintaining the integrity of all the resources and visitor experiences within the park system. In particular, the Water Resource Division (WRD) is funding water quality monitoring in the national parks through the Inventory and Monitoring Program to track the progress of the NPS long-term strategic goal of significantly reducing the amount of water pollution in park water bodies. Furthermore, the NPS is committed to preserving pristine water quality in parks where it now exists, including waters classified as Outstanding National Resource Waters (ONRW) or state-equivalent listed waters. As part of this initiative, in FY2005 the WRD began to provide \$29,000 per year to the SOPN for water resource monitoring.

The purpose for water quality and quantity monitoring arises from several overarching needs:

- documentation of water quality parameters that are vulnerable to alteration from various sources of contamination or land use practices

- protection of designated waters
- establishment of water quality parameters useful for indicating ecosystem integrity of particular water resources
- establishment of baseline conditions
- provide park managers with science to guide decision making

To fulfill the obligations and reach the goals of the water resource monitoring initiative and address legal mandates under the Clean Water Act (CWA), SOPN will provide data to:

- support management of SOPN water resources
- support management in relation to 303(d) listed waters, designation of ONRW, and to protect designated waters
- assess the status and trend in selected indicators of the condition of aquatic/riparian/wetland ecosystems
- indicate early warning of water resource decline to direct management in the mitigation improvement of these conditions

The water quality monitoring initiative, funded by the WRD, will be fully integrated into the broader SOPN Vital Signs Inventory and Monitoring Program. Incorporating the two monitoring programs will benefit the SOPN in several ways. For example, water quantity is an important hydrological concern for the SOPN, but is not discretely emphasized in the WRD monitoring plan. Because water quantity plays a role in shaping and maintaining landscape features and ecological habitats, SOPN will likely include appropriate monitoring program. Other advantages for incorporating the WRD monitoring plan with the general vital signs monitoring plan include streamlining operations, synthesizing data, and increasing partnership opportunities.

I.3 OVERVIEW OF WATER RESOURCES WITHIN SOUTHERN PLAINS NETWORK

Water resources are relatively scarce in the Great Plains, including the SOPN (Figure I.1). However, due in large part

Table I.1 Major water bodies found within Southern Plains Network parks.

Park Name	Code	Water Bodies
Alibates Flint Quarries National Monument	ALFL	None
Bent's Old Fort National Historic Site	BEOL	Arkansas River, Arch Wetland, several small ponds
Capulin Volcano National Monument	CAVO	None
Chickasaw National Recreation Area	CHIC	Lake of the Arbuckles, Veterans Lake, several streams & ponds
Fort Larned National Historic Site	FOLS	Pawnee River
Fort Union National Monument	FOUN	None within the park (Wolf Creek is adjacent to park)
Lake Meredith National Recreation Area	LAMR	Lake Meredith, Canadian River, several streams & creeks
Lyndon B. Johnson National Historical Park	LYJO	Pedernales River, Town Creek and stock ponds
Pecos National Historical Park	PECO	Pecos River, restored wetland, Glorieta Creek, Pecos tributaries
Sand Creek Massacre National Historic Site	SAND	Big Sandy Creek and wetland
Washita Battlefield National Historic Site	WABA	Washita River

to the cultural reasons that the parks were established, eight of the eleven SOPN parks contain significant water bodies (Tables I-1 and I-2).

Rivers in the SOPN generally flow eastward and are characterized by extreme turbidity, high evaporation rates, moderate flow velocity and dynamic channels. Great Plains streams fall into three categories: the shallow stream with shifting sand beds; clear brooks, ponds, and marshes supported by seeps and springs; and residual pools of intermittent streams (Cross and Moss 1987). In general, streams in the southern Great Plains are characterized by irregular flows, small-particle substrates, and distinct wet-dry cycles.

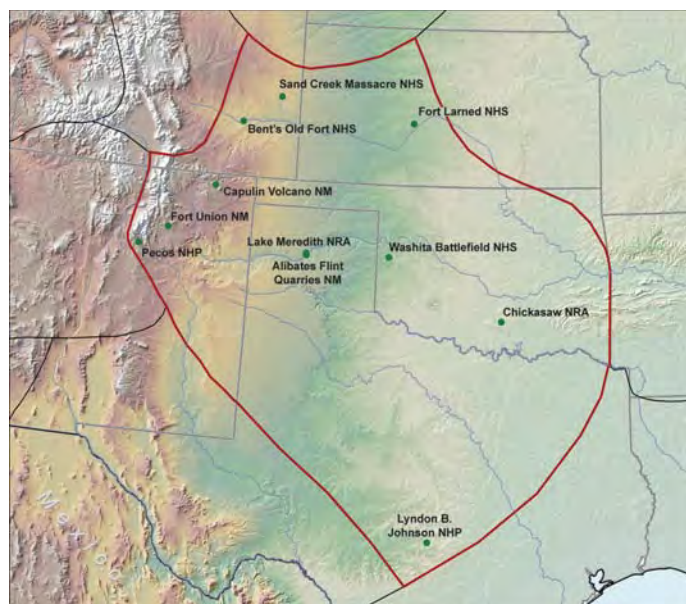


Figure I.1 Southern Plains Inventory and Monitoring Network

Much of the water originates from the western mountains while many sediments originate from thunderstorm runoff on the Great Plains, often causing extreme turbidity during low flows. High salinity levels are also characteristic of rivers in the Great Plains due to salt- and gypsum-laden groundwaters. Like the plains themselves, river temperatures can fluctuate widely with summer, open-river water temperatures exceeding 86°F (30°C).

The water table is high in many areas of this region, producing poor drainage conditions and in some areas, a high proportion of ephemeral-perennial wetlands (Bailey 2001). The Ogallala Aquifer consists of one or more geological units connected belowground under the central Great Plains, and is essential to agricultural, urban, and environmental resources. This aquifer contains about 20% of the irrigated farmland in the High Plains and about 30% of the water used for irrigation (Huntzinger 1996). Precipitation is the principal source of natural groundwater recharge, but recharge can also result from seepage loss from streams and lakes. Natural discharge occurs as evaporation from plants and soils where the water table is near the surface or as seepage to springs.

There have been significant changes in the amount and permanency of surface and ground water since pre-Columbian times as a result of ranching (e.g., stock ponds), irrigation, flood control, and other anthropogenic changes. Few major rivers in the Great Plains still exhibit the conditions evident before agricultural development and water management had occurred. Altered river hydrographs from dams, irrigation and municipal withdrawals, groundwater depletion, and other land use changes are a significant impact to aquatic systems in the Great Plains (Cross and Moss 1987, Longo and Yoskowitz

2002). The reservoir at LAMR has dramatically altered the fish community upstream and downstream of the dam (Bonner and Wilde 2000). Sediment deposition is part of reservoir design but remains a maintenance concern. In virtually all the river systems, dewatering has altered the timing and extent of flows, downstream temperatures, levels of dissolved nutrients, sediment transport and deposition, and the structure of plant and animal communities. Dams exist at three SOPN parks, LAMR, CHIC, and LYJO, and aquatic resources at other parks are affected by altered flows, primarily from agriculture and development.

Water quality throughout the Great Plains has been affected by herbicides and other pollutants, and SOPN parks are no exception. Agricultural use of nitrogen fertilizers is the largest source of nitrates in near-surface aquifers in the mid-continent (Koplin et al. 1994). A report summarizing data from 1991 indicated over 100,000 metric tons of pesticides (herbicides, insecticides, and fungicides) were applied in the mid-continent often to control non-indigenous plants and animals. Effects of these pollutants on the quality of human life and on the integrity of the ecological community are still largely unknown. The U.S. Environmental Protection Agency (EPA) has initiated an effort to develop stressor information to help recognize areas where urban development, agricultural non-point pollution (pesticides, toxic chemicals, nutrient pollution), and agricultural development may exacerbate

ecological decline. Elevated *E. coli* levels, indicators of fecal contamination, are also a concern at CHIC.

Groundwater depletion is of regional concern for both Great Plains ecology and society. Kromm and White (1992) observed that groundwater depletion has destroyed much of the water-supported habitat for fish and mammals in parts of the Great Plains. They reported that more than 700 miles (1,127 km) of once permanently flowing rivers in Kansas no longer flow year round. The Ogallala aquifer has declined from 1940 to 1980 by an average area-weighted, water-level decline of 10 feet (3 m) (3 inches [7 cm] per year; Dugan et al. 1994). Local area declines have varied, exceeding 98 feet (30 m) in some parts of the central and southern High Plains; 20 feet (6 m) in southwestern Kansas, east-central New Mexico, and the Oklahoma and Texas panhandles (Dugan et al. 1994). Subsurface water quantity and quality is an important resource and management issue at CHIC, FOLS, and BEOL due to groundwater depletion from neighboring lands (primarily for irrigation and development).

Table I.2 Water resources within Southern Plains Network parks

Park	Perennial Rivers		Intermittent Rivers		Adjacent Perennial Rivers		Lakes / Reservoirs		Lake / Reservoir Shoreline		Canal	
	Length (Miles)	Impaired Length (Miles)	Length (Miles)	Impaired Length (Miles)	Length (Miles)	Impaired Length (Miles)	Length (Acres)	Impaired Length (Acres)	Length (Miles)	Impaired Length (Miles)	Length (Miles)	Impaired Length (Miles)
ALFL			3.6	0								
BEOL	2.3	2.3										
CAVO												
CHIC	7.0	0	5.8	0			2503	0	36.8	0		
FOLS	2.0	0	2.7	0								
FOUN												
LAMR	17.9	0	24.7	0			16242	16219	109	108		
LYJO	0.1	0	2.5	0	4.9	0	13	0	2.7	0		
PECO	6.2	2.86	12.1	0.1								
SAND	2.7	0	11.4	0							3.1	0
WABA	0.9	0										
TOTAL	39.1	5.1	62.7	0.1	4.9	0	18758	16219	148.4	107.7	3.1	0

I.4 RESOURCE LEGISLATION APPLICABLE TO SOPN PARKS

I.4.1 Federal Legislation

The Clean Water Act

The Clean Water Act, adopted by Congress in 1972, required that states, territories, and authorized tribes develop water quality standards for the protection and restoration of waters within their jurisdictions. Section 305(b) of the Clean Water Act requires that states assess the health of their waters and the extent to which water quality standards are being met (Table I.3). To satisfy this requirement each state must submit a water quality inventory report, the 305(b) Water Quality Report, every two years to the EPA. This report provides descriptions of the water quality of all navigable waters within the state to the extent that these waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities. Each state must also determine the extent of pollutant discharge elimination required and the level of water quality required for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows for recreational activities. Each state will also provide estimates of environmental impacts, economic and social costs necessary to achieve these objectives, the economic and social benefits of such achievements, and an estimate of the date these achievements will be met. Finally, each state must describe the nature and extent of non-point source pollutants and recommendations as to the programs to control these sources, including an estimate of the costs of implementing these programs. The water quality report submitted by the state to the EPA is referred to as the 305(b) Water Quality Report and identifies the impairments, if existing, for waters within that state. Waters listed in the 305(b) report are referred to as 305(b) listed waters and can be found on the EPA's Water Quality Inventory Electronic 305(b) Report website (<http://www.epa.gov/waters/305b/index.html>). This list includes the attainment status (whether or not the waterbody is supporting designated uses) for designated uses (e.g. aquatic life support, fish consumption, primary contact recreation) for specific waterbodies.

In addition to the 305(b) Water Quality Report, The Clean Water Act, Section 303(d), requires that states develop an Impaired Waterbodies List for waterbodies that do not meet the water quality standards that the states have set. States must establish priority ranking for these waters and develop Total Maximum Daily Load (TMDL) programs for these waters. A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet

water quality standards, and allocates pollutant loadings among point and non-point sources. The EPA must approve the TMDL (EPA 2002). While TMDLs have been required by the Clean Water Act since 1972, many states, territories, or authorized tribes have not developed them until recently, a result of recent legal action against the EPA by citizens groups seeking the listing of waters and development of TMDLs. States, territories, or authorized tribes are required to submit their list of 303(d) waters in every even numbered year (referred to as the 2-year listing cycle). The 303(d) list is referred to as the 303(d) Impaired Waterbodies List and must be based on documented methodology that includes an evaluation of existing and readily available data. Waterbodies that have been identified as impaired and have a scheduled development for, or existing TMDL are then added to the 303(d) Impaired Waters List for that state. Waterbodies continue to be included on subsequent Impaired Waterbodies Lists until TMDLs are completed, applicable criteria are met, or the original basis for the listing is shown to be flawed.

There are several designated uses of water quality for which the states are required to monitor. Each designated use has a unique set of water quality criteria, set individually by each state that must be met for the designated use to be realized. In the 305(b) Water Quality Report, the state must identify the type of assessment (monitored or evaluated) that was used to make each designated support determination. Monitored assessments are based on data collected within the past 5 years. Evaluated assessments are based on qualitative information (if no monitoring data are available) or on monitoring data that are more than 5 years old (EPA 2000). If available, specific water quality, biological and physical data can be obtained from STORET (short for STOrage and RETrieval): <http://www.epa.gov/STORET/index.html>

The 305(b) Designated Uses are as follows (EPA 2000):

Aquatic Life Support: The water body provides for suitable habitat for protection and propagation of desirable fish, shellfish, and other aquatic organisms.

Drinking Water Supply: The water body can supply safe drinking water with conventional treatment.

Fish Consumption: The water body supports fish free from contamination that could pose a significant human health risk to consumers.

Shellfish Harvesting: The water body supports a population of shellfish free from toxicants and pathogens that could pose a significant human health risk to consumers.

Table I.3 Summary of designated uses for the major water bodies in the Southern Plains Network (derived from 305(b) Water Quality Reports)

Park	State	Waterbody	WBID ¹	Designated Use Category	State Designated Use	Attainment of Use
BEOL	CO	Arkansas River	COARLA01B_3700*	Fish, Shellfish, and Wildlife Aquatic Life Harvesting Recreation Public Water Supply Agricultural	Aquatic Life Warm Fish Consumption Primary Contact (Recreation) Drinking Water Supply Agriculture	Not Supporting Not Assessed Fully Supported Not Supporting Fully Supported
CHIC	OK	Lake of the Arbuckles	OK310800020100_00	Fish, Shellfish, and Wildlife Recreation Public Water Supply Aesthetic Value Agricultural Value Public Water Supply Industrial	Warm water aquatic community Primary Contact (Recreation) Public/Private Water Supply Aesthetics Agriculture SWS-Sensitive Water Supply Industry	Insufficient information Insufficient information Insufficient information Fully Supporting Insufficient information Not Assessed Insufficient information
CHIC	OK	Veterans Lake	OK310800020120_00	Fish, Shellfish, and Wildlife Recreation Aesthetic Value Agricultural Industrial	Warm water aquatic community Primary Contact (Recreation) Aesthetics Agriculture Industry	Not Assessed Not Assessed Not Assessed Not Assessed Not Assessed
FOLS	KS	Pawnee River	KS110300052585	Recreation Fish, Shellfish, Wildlife Public Water Supply Agricultural Agricultural	Non-contact Recreation Acute Aquatic Life Domestic Water Supply Irrigation Water Use Livestock Watering Use	Fully Supporting Not Supporting Fully Supporting Fully Supporting Fully Supporting
LAMR	TX	Lake Meredith	TX0102_01*	Fish, Shellfish, Wildlife Recreation Fish, Shellfish, Wildlife Aquatic Life Harvesting Public Water Supply Fish, Shellfish, Wildlife	Aquatic Life Use Contact Recreation Use General Use Fish Consumption Use Public Water Supply Use Overall Use Support	Fully Supporting Fully Supporting Fully Supporting Partial Support Fully Supporting Partial Support
LAMR	TX	Lake Meredith	TX0102_02*	Fish, Shellfish, Wildlife Recreation Fish, Shellfish, Wildlife Aquatic Life Harvesting Public Water Supply Fish, Shellfish, Wildlife	Aquatic Life Use Contact Recreation Use General Use Fish Consumption Use Public Water Supply Use Overall Use Support	Not Assessed Fully Supporting Fully Supporting Partial Support Fully Supporting Partial Support

* Water Unit is listed as "impaired" under section 303(d) of the Federal Clean Water Act

¹ Every State must assign a Water Body Identification (WBID) code to each body of water listed on their 305 and 303(d) lists.

Table I.3 Summary of designated uses for the major water bodies in the Southern Plains (continued)

Park	State	Waterbody	WBID ¹	Designated Use Category	State Designated Use	Attainment of Use
LYJO	TX	Pedernales River	TX1414_04	Fish, Shellfish, Wildlife Recreation Fish, Shellfish, Wildlife Aquatic Life Harvesting Public Water Supply Fish, Shellfish, Wildlife	Aquatic Life Use Contact Recreation Use General Use Fish Consumption Use Public Water Supply Use Overall Use Support	Fully Supporting Fully Supporting Fully Supporting Not Assessed Fully Supporting Fully Supporting
PECO	NM	Pecos River	NM-2214.A_002*	Fish, Shellfish, Wildlife Fish, Shellfish, Wildlife Aquatic Life Harvesting Recreation Public Water Supply Agricultural Agricultural	Wildlife Habitat High Quality Coldwater Fishery Fish Culture Secondary Contact Domestic Water Supply Livestock Watering Irrigation	Fully Supporting Partial Support Fully Supporting Fully Supporting Fully Supporting Fully Supporting Fully Supporting
SAND	CO	Big Sandy Creek	COARLA02_4300	Fish, Shellfish, Wildlife Recreation Agricultural	Aquatic Life Warm 2 Secondary Contact (Recreation) Agriculture	Fully Supporting Fully Supporting Fully Supporting
WABA	OK	Washita River	OK310840020010_00	Fish, Shellfish, and Wildlife Recreation Public Water Supply Aesthetic Value Agricultural Industrial	Warm water aquatic community Primary Contact (Recreation) Public/Private Water Supply Aesthetics Agriculture Industry	Not Supporting Insufficient information Not Assessed Insufficient information Fully Supporting Fully Supporting

* Water Unit is listed as "impaired" under section 303(d) of the Federal Clean Water Act

¹ Every State must assign a Water Body Identification (WBID) code to each body of water listed on their 305 and 303(d) lists.

Table I.4 303(d) Listed Waters in the Southern Plains Network

Park	State	WBID ³	Water Body	Portion Impaired	Impairment
BEOL	CO	COARLA01B	Arkansas River	From above Fountain Creek to Stateline (problems increase downstream); 2.27 miles	Selenium
LAMR	TX	TX-0102	Lake Meredith	Nearly all of lake; 16,218.84 acres	Mercury in Fish Tissue
PECO	NM	NM-2214.A_003	Pecos River	From Canon de Manzanita to Alamitos Canyon; 2.86 miles	Temperature & Turbidity

³Every State must assign a Water Body Identification (WBID) code to each body of water listed on their 305 and 303(d) lists.

Primary Contact Recreation – Swimming: People can swim in the water body without risk of adverse human health effects (such as catching waterborne diseases from raw sewage contamination).

Secondary Contact Recreation: People can perform activities on the water (such as boating) without risk of adverse human health effects from incidental ingestion or contact with the water.

Agriculture: The water quality is suitable for irrigating fields or watering livestock.

Many states designate their waters for additional uses such as:

Ground Water Recharge: The surface water body plays a significant role in replenishing ground water; surface water supply and quality are adequate to protect existing or potential uses of ground water.

Wildlife Habitat: Water quality supports the water body's role in providing habitat and resources for land-based wildlife as well as aquatic life.

Culture: Water quality supports the water body's role in tribal culture and preserves the water body's religious, ceremonial, or subsistence significance.

Since each state sets its own water quality standards, the definition of attainment of the EPA Designated Use Support (*i.e.* fully supporting, fully supporting but threatened, partially supporting, not supporting, not assessed) is slightly different for each state. Prior to 2002, data collection and interpretation efforts under the Clean Water Act were not always coordinated. The EPA is now recommending that states submit an Integrated Water Quality Monitoring and Assessment Report (EPA 2002) to satisfy the requirements for both Sections 305(b) and 303(d) of the Clean Water Act (EPA 2000). The Integrated Report will combine the non-regulatory requirements of the 305(b) Water Quality Report with the regulation driven (mandated TMDL development) 303(d) Impaired Waterbodies List. The EPA has established several basic categories for an Integrated List.

Information for the 305(b) and 303(d) summary tables can be obtained from the Environmental Protection Agency (EPA) Waters website <http://www.epa.gov/waters/> which provides both 305(b) and 303(d) information and state issued 305(b) Water Quality Reports and 303(d) Impaired Lists. For the majority

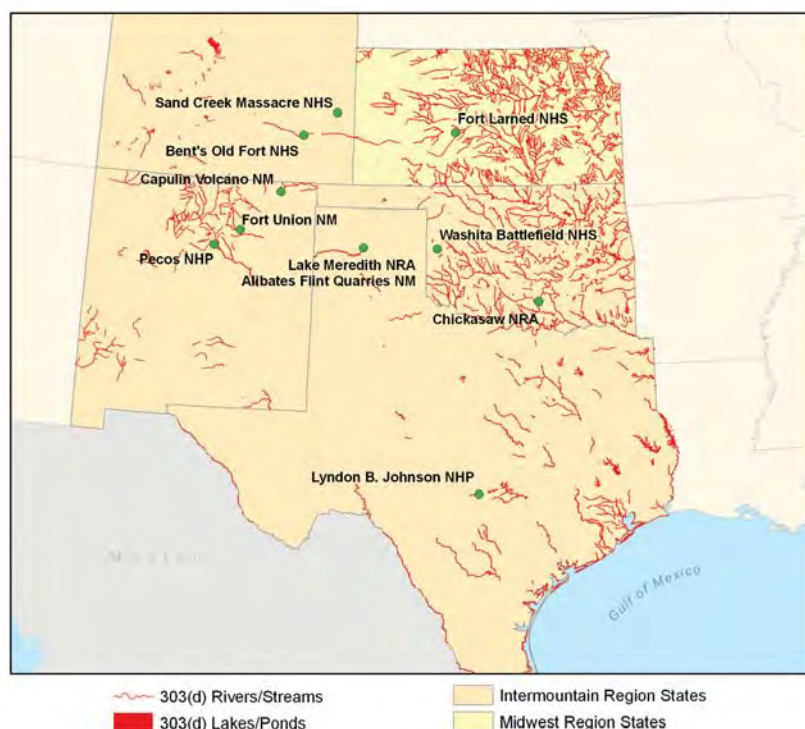


Figure I.2 Map of 303(d) waters in Colorado, Kansas, New Mexico, Oklahoma, and Texas, the states in which the SOPN lies. 303(d) bodies of water are colored red. Three 303(d) listed waters fall within park boundaries.

of waterbodies the EPA Water Quality Inventory website (<http://www.epa.gov/waters/305b/index.html>) had the most current and complete information for 305(b) assessment and attainment status (whether or not the water quality for a specific waterbody was supporting its designated use). Information for 303(d) Impaired Waterbodies Lists was summarized from both the EPA Total Maximum Daily Load (TMDL) Reports (<http://www.epa.gov/waters/tmdl/index.html>) and state issued 303(d) Impaired Waters Lists (from individual state websites).

Applicability to SOPN: SOPN has three waterbodies that are designated as 303(d) impaired (Table I.4 and Figure I.2). These waters are the Arkansas River at Bent's Old Fort NHS, Lake Meredith at Lake Meredith NRA, and the Pecos River at Pecos NHP. Once a waterbody is listed, the state must bring it into compliance with water quality standards by developing a Total Maximum Daily Load (TMDL) for the pollutant(s) of concern. TMDLs are designed to restore the health of waters and to establish acceptable levels of point and non-point inputs. Pollution controls prescribed by the TMDLs are implemented through the National Pollution Discharge Elimination System (NPDES) for point sources and through Best Management Practices (BMPs) for non-point sources.

The Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was passed in 1974 and amended in 1986 and 1996. This act directs the U.S. Environmental Protection Agency to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. Primary enforcement responsibilities lie with the states. The act also protects underground sources of drinking water with primary enforcement responsibilities again resting with the states. Federal agencies having jurisdiction over public water systems must comply with all requirements to the same extent as any non-governmental entity. Source water protection means preventing contamination and reducing the need for treatment of drinking water supplies. Source water protection also means taking positive steps to manage potential sources of contaminants and contingency planning for the future by determining alternative sources of drinking water.

Applicability to SOPN: The SDWA protects rivers, lakes, reservoirs, springs, and ground water wells (if they serve more than 25 people) that serve as drinking water sources. SOPN parks that are affected by this legislation are Lake Meredith National Recreation Area, which provides drinking water to 11 surrounding communities, and Chickasaw National Recreation Area, which was originally established with the intent of providing drinking water to local areas.

I.4.2 State Legislation

The NPS is required to comply with state laws for water quality standards and management, regardless of other jurisdictional status or landownership. The following describes legislation of each of the five states that the SOPN covers (Colorado, Kansas, Oklahoma, New Mexico, and Texas).

Colorado

SOPN parks in Colorado are Bent's Old Fort National Historic Site and Sand Creek Massacre National Historical Site.

State Agencies Responsible for Water Management: The Colorado Department of Public Health and Environment oversees the protection of the state's waters, and is charged with conserving the state's waters and protecting, maintaining, and improving the their quality for the wildlife and aquatic life, for domestic, agricultural, industrial, recreational and other beneficial uses. The Water Quality Control Commission (WQCC) is the administrative agency responsible for developing specific state water quality policies. The WQCC adopts water quality classifications and standards for surface and ground waters of the state, as well as various regulations aimed at achieving compliance with those classifications and standards. The Water Quality Division serves as staff to the commission and provides them with recommendations based on assessment of the state's waters. Within the Department of Natural Resources, the Division of Water Resources, headed by the State Engineer, ensures the competent distribution of water, and administers water rights through the appropriation doctrine. This division also controls permits for ground water wells, provides water supply statistics, and surface flow data. The Colorado Water Conservation Board ensures the development, protection, and management of Colorado's waters. It is the only entity that can hold an instream water right.

Primary Pieces of State Water Legislation: The state notes nine designated uses of water including 2 levels each for Aquatic Cold Water and Warm waters, domestic water supply, three different uses for Recreation and Agriculture. Their anti-degradation relates to those waters where existing water quality shall remain the same, and discharges to the waters will not cause impairment unless economic and social needs outweigh the benefits of maintaining the existing water quality. Colorado does not have a list of Tier III waters, but instead refers to them as Outstanding Waters. The State of Colorado has no streamflow or biological criteria or guidance with which to protect existing uses.

State Surface Water Quality Standards: Colorado fulfills its obligation to the federal CWA by assessing and reporting on the quality of its waters in the report, "Status of Water Quality in Colorado". This report details the water quality within the watersheds that make up the four major river systems, the Arkansas River, Colorado River, Platte River, and the Rio Grande, all of which originate within the state. The Water Quality Control Division (WQCD) is responsible for monitoring, assessing, and managing the waters based on the state's water quality standards.

Surface water quality standards are established to protect classified uses. In Colorado, waterbodies may be assigned any of four categories of classification: aquatic life, water supply, recreation, and agriculture. In the latest biennium, Colorado made changes in the use classifications of many streams.

The causes and sources of impairment to CO water bodies were also reported in the latest report. The most important pollutant for Colorado surface waters is metals and pH. Other major pollutants include nitrate and sulfate. The major sources of these pollutants have not been identified in most cases, and are therefore classified as "unknown".

Kansas

The SOPN Park in Kansas is Fort Larned National Historical Site.

State Agencies Responsible for Water Management: Several state agencies are responsible for managing and monitoring water quality within Kansas. The Kansas Water Office (KWO) is the water planning agency for the state. The Kansas Water Authority is within the KWO and is responsible for advising the Governor, the Legislature, and the Director of the KWO on issues of water policy. Other agencies that cooperate in water quality management are the Kansas Department of Agriculture (KDA), Kansas Department of Health and Environment (KDHE), State Conservation Commission (SCC), and Kansas Department of Wildlife and Parks (KDWP).

Primary Pieces of State Water Legislation: The Kansas Water Plan was completed in 1999 and is one of the primary tools used by the state to coordinate development, conservation, and management of its water resources.

State Surface Water Quality Standards: Kansas Surface Water Quality Standards are incorporated in Kansas administrative Regulations KAR 28-16-28b through 28-16-28f. The official regulations are published by the Kansas Secretary of State. However, the official publication of the Kansas Regulations only takes place once per year and lags behind official adoption of new regulations by as much as a year. Since parts of the Kansas Surface Water Quality Standards have been amended annually, an up-

to-date official version of the Standards is rarely available in a single publication. To obtain a complete set of the official Standards one must access to the official Kansas Administrative Regulations, the annual Supplement to the Kansas Administrative Regulations, and the most recent year's *Kansas Register*. The Kansas Surface Water Quality Standard, K.A.R. 28-16-28g, was adopted by Secretary Roderick L. Bremby, Kansas Dept. of Health and Environment, on April 25, 2005. The Kansas Surface Water Register (dated November 5, 2004) is adopted by reference in K.A.R. 28-16-28g. Copies of the regulation, the register and the 2003 stream and lake recreational UAAs were submitted to U.S. EPA on May 26, 2005. By regulation, the U.S. EPA has 60 days to approve the regulation and 90 days to disapprove.

New Mexico

SOPN Parks in New Mexico are Capulin Volcano National Monument, Fort Union National Monument, and Pecos National Historical Park.

State Agencies Responsible for Water Management: The Water Quality Control Commission (WQCC) is the state water pollution control agency that oversees all actions relating to the federal CWA and Safe Drinking Water Act (SWDA).

Primary Pieces of State Water Legislation: The State Water Quality Act provides the main authority for water quality management in New Mexico, in addition to federal legislation. This law establishes the Water Quality Control Commission (WQCC) and specifies its duties and powers.

State Surface Water Quality Standards: New Mexico's Surface Water Quality Standards (WQS) define water quality goals by designating uses for waterbodies, setting criteria to protect those uses, and establishing provisions to preserve water quality. To meet the requirements of Section 303 (c) of the federal Clean Water Act, the WQS are examined for changes on a 3-year rotating basis in a process known as the Triennial Review.

On April 12, 2005, the WQCC adopted its Statement of Reasons and final revisions to the WQS. The WQCC filed the amendments to the WQS with the New Mexico State Records Center on April 21, 2005. The final amendments to the WQS were published in the May 13, 2005 New Mexico Register and became effective on May 23, 2005 (consistent with the New Mexico Water Quality Act requirement at 74-6-6(E)). The WQCC filed a corrections notice with the New Mexico State Records Center on June 15, 2005. The corrections were published in the June 30, 2005 New Mexico Register and are effective on July 17, 2005.

The integrated revision of the WQS incorporates changes through July 17, 2005 were included in the New Mexico Administrative Code on August 1, 2005. The United States Environmental Protection Agency (EPA) provides approval, policy and guidance for New Mexico's WQS. As required by federal regulation, New Mexico submitted the revised WQS and supporting documentation to EPA on July 7, 2005. According to 40 CFR 131.21(a), EPA is required to approve the WQS revisions within 60 days or disapprove the WQS revisions within 90 days of receipt.

Oklahoma

SOPN Parks in Oklahoma are Chickasaw National Recreation Area and Washita Battlefield National Historic Site.

State Agencies Responsible for Water Management: The Water Quality Division develops and maintains Oklahoma's Water Quality Standards and routinely collects physical, chemical and biological data to support the document. The Division directs Oklahoma's Beneficial Use Monitoring Program (BUMP) to document beneficial use impairments, identify impairment sources (if possible), detect water quality trends, provide needed information for the Water Quality Standards and facilitate the prioritization of pollution control activities. The Tribal Nations claim ownership and sovereign authority to regulate all water (surface water and groundwater) within their original tribal boundaries (all or parts of 22 counties in southeast Oklahoma).

Primary Pieces of State Water Legislation: The State/ Tribal Water Compact, which is the predominant legislation guiding water resource management, addresses three major subjects: (1) water rights administration, (2) water quality standards administration, and (3) economic development.

State Surface Water Quality Standards: The Oklahoma Water Resources Board's statutory authority and responsibility concerning establishment of state water quality standards are provided under 82 O.S., §1085.30. Under this statute the Oklahoma Water Resources Board is authorized to promulgate rules

which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters [82:1085.30(A)].

These Standards are designed to maintain and protect the quality of the waters of the state. The standards specify numerical and narrative criteria to protect beneficial uses designated for certain waters of the State. The purpose of the Standards is to promote and protect as many beneficial

uses as are attainable and to assure that degradation of existing quality of waters of the State does not occur.

Texas

SOPN Parks in Texas are Alibates Flint Quarries National Monument, Lake Meredith National Recreation Area, and Lyndon B. Johnson National Historical Park.

State Agencies Responsible for Water Management: There are many organizations within Texas that monitor the state's water resources. The Texas Natural Resource Conservation Commission (TNRCC) oversees the state's air, water, and waste management. Texas Water Conservation Association the leading organization in Texas devoted to conserving, developing, protecting, and using the water resources of the state for all beneficial purposes. The Lower Colorado River Authority (LCRA) is responsible for overseeing the lower Colorado River basin region in which LYJO lies. The Canadian River Municipal Water Authority manages the basin in which LAMR lies.

Primary Pieces of State Water Legislation: Current water laws for the state of Texas are the result of over 200 years of legislation and litigation. Overall, the state of Texas divides its water policies into two categories: groundwater and surface water. Groundwater laws are more limited, as this type of water is typically considered the property of the owner of the surface property from which it is pumped. Surface water on the other hand, is generally owned by the state.

State Surface Water Quality Standards: The state of Texas has established standards that protect the purposes for which the water bodies in the state will be used, and defined measurements that will assure the water quality is acceptable to attain those uses. Based on the standards, the Texas Commission on Environmental Quality (TCEQ), along with other federal, regional, and local agencies, carries out a regular program of monitoring and assessment to determine which water bodies are meeting the standards set for their use, and which are not. The state produces a periodic report, the "Texas Water Quality Inventory and 303(d) List," that compares water quality conditions to established standards, as required by federal Clean Water Act (CWA) Sections 305(b) and 303(d).

Texas Surface Water Quality Standards (WQS) have established the designated uses, or purposes, for which the state's water bodies should be suitable. Furthermore, they have provided numerical and narrative goals for water quality throughout the state. Also, the Texas Surface WQS provides a basis upon which regulatory programs may be developed.

Four major water use categories are defined by the Texas State WQS: aquatic life use; contact recreation

(swimming); public water supply; and fish and shellfish (oyster) consumption. A variety of other general uses are also explained such as, navigation, water supply for agriculture and industry, and wetland functions.

I.4.3 National Park Service

Government Performance and Results Act (GPRA)

Established in 1993 (Public Law 103-62), this Act requires parks to have means of measuring or quantifying results of management activities, including those in relation to water resources. In particular, the GPRA goal for water resources requires parks to report impaired waters as defined by Section 303(d) of the Clean Water Act.

Applicability to SOPN: All parks within the SOPN are required to follow the regulations mandated by GPA. Three parks have 303(d) listed waters: BEOL, LAMR, and PECO (see 303(d) information above).

I.5 SOPN PARK NARRATIVES

I.5.1 Alibates Flint Quarries National Monument (ALFL)

Background

Alibates Flint Quarries National Monument (ALFL) encompasses 1,371 acres (555 ha) adjacent to Lake Meredith National Recreation Area (LAMR) (Figure I.3). ALFL falls within the semi-arid steppe climate in the Steppe ecoregion of the high plains and plateaus (Bailey 1995). The average annual rainfall at ALFL is 20 inches (51 cm), 60-65% of which is lost through evaporation/evapotranspiration. Seventy percent of the precipitation falls during the primary growing season. The terrain is characterized as rough and broken as it has been cut by the Canadian River. Soils in the area range from very fine sandy loams to silty clay loams.

Primary Water Resources

ALFL is situated in the Canadian River Basin and within the Lake Meredith watershed. Water from Lake Meredith seasonally fills the breaks created by the Canadian River breaks; however, other than these, no surface water resources fall within the ALFL boundaries.

Management and Scientific Issues

Soil erosion and groundwater conditions are the largest concerns for ALFL park managers. Irrigation that supports nearby agriculture is lowering the water table thereby contributing to soil desertification. Agricultural land use

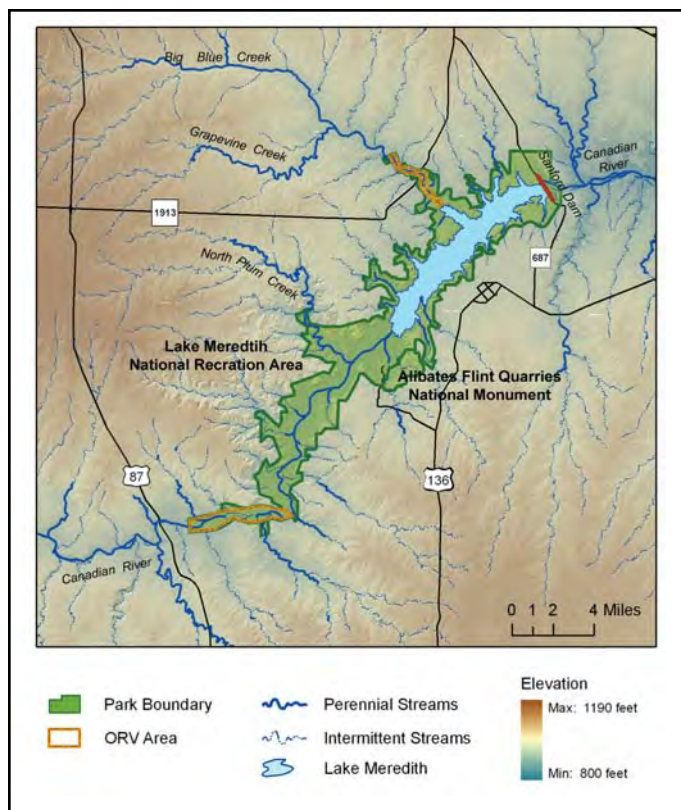


Figure I.3 Map of Alibates Flint Quarries National Monument with water bodies highlighted.

and oil and gas operations are introducing contaminants to the groundwater.

Past and Present Monitoring

ALFL has not conducted any independent monitoring projects, although LAMR has included ALFL in some of its monitoring projects. For example, the basic water quality assessment completed by the Water Resources Division included ALFL in its study area as part of the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 2000a).

I.5.2 Bent's Old Fort National Historical Site (BEOL)

Background

Bent's Old Fort National Historic Site (BEOL), 799-acres (323 ha) in size (Figure I.4), is located on the Arkansas River. BEOL is primarily underlain by bedrock comprised of Bridge Creek Limestone (Ladyman 2003). Silty clay loams to sandy loams comprise the soils for the bottomland areas of SAND; well-drained loamy soils are found in the upland areas. BEOL receives approximately 12 inches (30 cm) of annual precipitation.

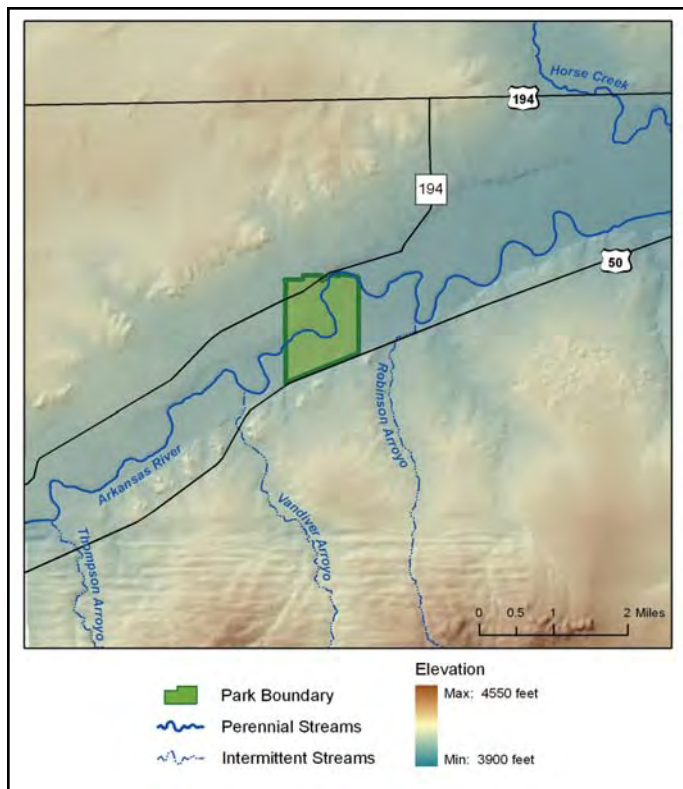


Figure I.4 Map of Bent's Old Fort National Historic Site with water bodies highlighted.

Primary Water Resources

BEOL falls within the Upper Arkansas-John Martin Watershed. Based on the National Hydrography Dataset (NHD), a total of 2.28 miles (3.67 km) of perennial streams are within or adjacent to the BEOL park boundary. Seven small man-made ponds and one 55-acre (22 ha) wetland are also located at this park. State-designated uses for classified waterbodies within or adjacent to the BEOL park boundary include: agriculture, aquatic life warm water – class 2, domestic water source, and recreation primary contact.

BEOL also has a number of wetland sites. Arch wetland is the largest and is located between the river and the fort. River overflow and leakage from Fort Lyon irrigation canal appear to provide water for this area. Case Bolt wetland is less than one-half acre (0.2 ha) of shallow open water south of the fort that is permanently inundated. The water source may be from irrigation overflow or seepage from other man-made ponds. To the south of the river, the abandoned slough receives overflow from the Arkansas River during very large flooding events, with no evidence of prolonged inundation. Cattail Pond also receives water from large flooding events and runoff from summer thunderstorms. Three other wetland areas appear to be

man-made depressions that collect runoff (Gionfriddo et al. 2002).

Management and Scientific Issues

Maintaining the wetland areas and riparian zones are the primary aquatic concerns for BEOL. The cottonwood (*Populus deltoides*) / riparian habitats, in particular, receive special attention as they are considered to be a globally rare ecosystem-type. Exotic plants and flooding processes are two of the biggest threats related to water resource concerns at this park. The flooding events can cause erosion, opening an avenue for invasive species and the wet/dry cycles affect both surface water levels and groundwater recharge. Neighboring land uses can impact both water quality, due to potential point-sources, and quantity due to unresolved water rights issues. In addition, nearby extractive activities pose difficulties for water quality through hazardous spills both on-site and on the roadway adjacent to the park.

BEOL listed its most significant natural resource issue as being value/function of the Arch Wetland. Other important natural resource issues are water drainage, hydrology, water effects on adobe forts, upstream dams, and flooding. Of these, floods are the greatest threat facing BEOL.

The State of Colorado designated a portion of the Arkansas River, including the section that runs through BEOL, on its 2002 303(d) list as quality impaired for aquatic life warm water – class 2 and domestic water source. The pollutant responsible for the impairment of the Arkansas River is identified as selenium (Se). For some time iron (Fe) was also listed as a pollutant to the Arkansas River. However, the Environmental Protection Agency (EPA) recently removed this designation as ambient-based conditions of iron in this region are naturally high (Hegeman, personal communication). Standards for acceptable iron levels were set according to existing levels at the time the original pollutant-designation was removed.

Past and Present Monitoring

Current research is being conducted by the park on the local water table. Also, USGS is currently monitoring river flows near the park. Historically, circa 1968, there was research done on tamarisks (*Tamarix spp.*) on the south side of river.

A report compiled in by the NPS Water Resources Division retrieved water quality data for the Bent's Old Fort area collected between 1961 and 1994 (NPS 1998a). Within the study area, which included Fort Lyons Canal headgates above La Junta and the La Junta Sewage Treatment plant upstream of BEOL, five industrial/municipal dischargers and ten active or inactive USGS water gauges were found. No stations were located within park boundaries. The

most problematic readings with the highest contaminant levels occurred during the 1970s, with scattered reports for various heavy metals. Copper and lead often exceeded limits throughout the study area, while chloride, chlorine and sulfates also had frequent elevated levels. It was concluded that human activities, such as industrial and municipal wastewater discharge, agricultural and mining operations, stormwater runoff and atmospheric deposition all negatively impact the water quality of the Arkansas River as it runs through Bent's Old Fort National Historic Site.

I.5.3 Capulin Volcano National Monument (CAVO)

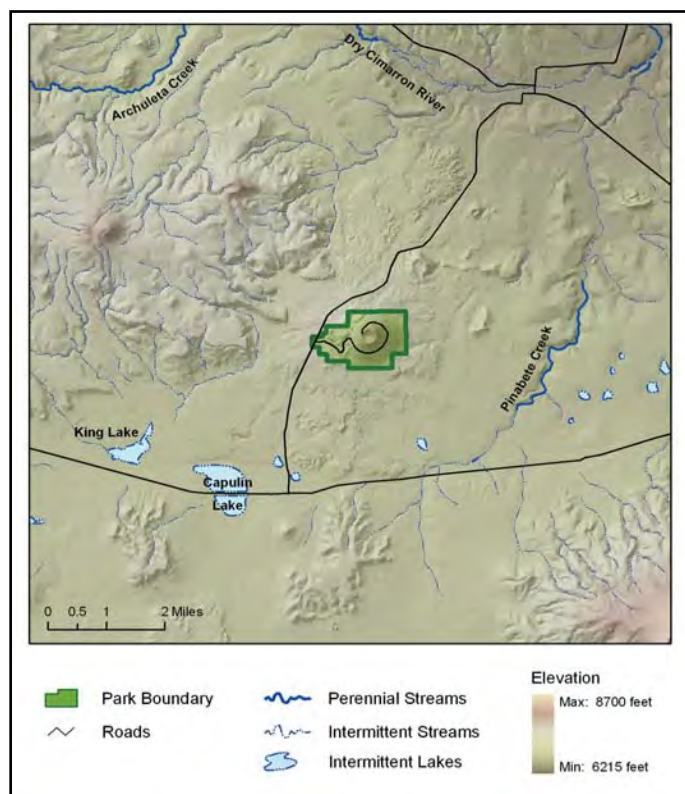


Figure I.5 Map of Capulin Volcano National Monument with water bodies highlighted.

Background

Capulin Volcano National Monument (CAVO) is a 793-acre (321 ha) site in Northeastern New Mexico (Figure I.5). Capulin Volcano was formed during its last period of activity, approximately 60,000 years ago. After eruptions ceased and substrate cooled, vegetation began to establish on the volcano and surrounding area. The root matter of the plants helped stabilize the erodible volcano; however erosion still remains a concern. There are three predominant ecosystems that comprise CAVO: piñon-juniper woodlands, which cover most of the volcano;

short-grass prairies; and scrublands (Johnson et al. 2003). CAVO falls within the Great Plains-Palouse Dry Steppe ecoregion (Bailey 1995). CAVO receives 16–20 inches (41 - 51 cm) of rain annually.

Primary Water Resources

Surface waters within the boundaries of CAVO include only three sewage lagoons (NPS 1999).

Management and Scientific Issues

The most significant water resource issue at Capulin Volcano National Monument is the lack of water. Drought conditions over the past several years have stressed the plant and animal communities. For example, drought, which can serve as a disturbance mechanism, has contributed to exotic plant invasions. Groundwater at CAVO is facing anthropogenic threats, with potential sources being municipal wastewater discharges, ranching operations, mining and quarrying activities, stormwater runoff, recreational use, and atmospheric deposition.

Past and Present Monitoring

A basic water quality assessment was completed by the Water Resources Division of the National Park Service in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park. The Baseline Water Quality Data Inventory and Analysis Report based on this water quality assessment revealed that data is completely lacking for any hydrologic-related parameters, such as groundwater quantity and quality, within CAVO boundaries (NPS 1999).

I.5.4 Chickasaw National Recreation Area (CHIC)

Background

Chickasaw National Recreation Area (CHIC) covers 9,889 acres (4,002 ha) in south-central Oklahoma (Figure I.6). In the late 1800's the Chickasaw and Choctaw Native American tribal units recognized threats to the freshwater and mineral springs and therefore requested that the federal government establish sustainable management practices (Wikle et al. 1998). This request ultimately led to the establishment of CHIC. Today, water-based recreation, such as fishing, boating, and water skiing account for the largest portion of visitation.

CHIC has a moist sub-humid climate, characterized by long warm summers and fairly short and mild winters (Wikle et al. 1998). Average annual precipitation is 38 inches (97 cm). The landscape of CHIC ranges from steep ridges to valley floors.

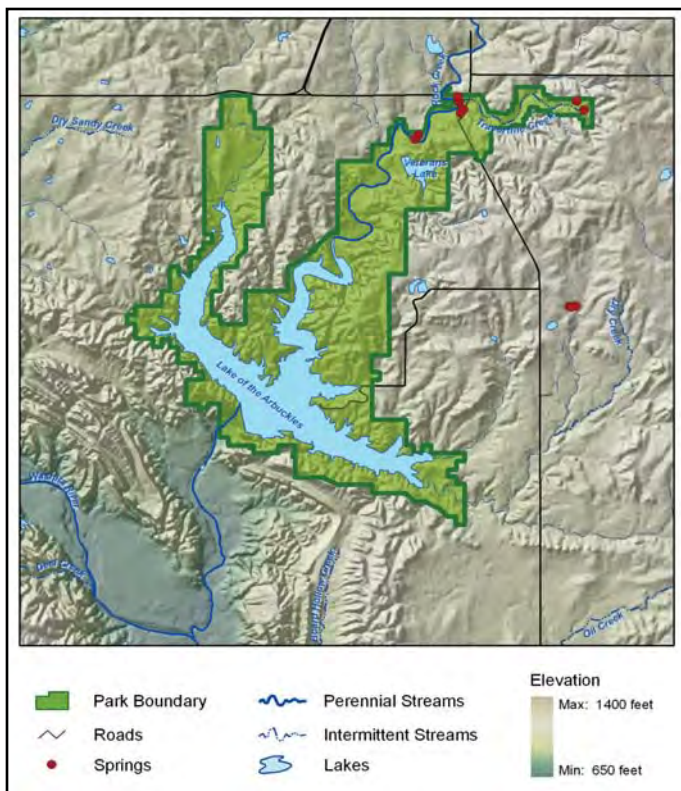


Figure I.6 Map of Chickasaw National Recreation Area with water bodies highlighted.

Primary Water Resources

The two largest surface water resources at CHIC are Lake of the Arbuckles, covering approximately 3,127 acres (1,265 ha), and Veteran's Lake, spanning an average of 67 acres (27 ha); both are man-made reservoirs. Lake of the Arbuckles was constructed in 1966 by the US Bureau of Reclamation (BOR). This lake serves recreational needs, facilitates flood control, and serves as a potential water source for local communities. Lake of the Arbuckles is supported by Rock, Guy Sandy, Buckhorn, Wilson, and Travertine Creeks, the five largest streams in CHIC. Wilson Creek, a tributary of Rock Creek, also supplies Veteran's Lake.

Dry periods are significant because of the aquifer's dependence on precipitation for recharge. It has been shown that during and after these dry periods, aquifer water levels experience a decline (Hanson and Cates 1994). It is presumed the drop in the water table has caused some of the springs in CHIC to go through prolonged no-flow periods.

Management and Scientific Issues

Impacts from agricultural, residential, and industrial, as well as transportation of hazardous wastes on nearby highways, and problems associated with illegal disposal

sites are posing serious threats to the water quality of CHIC. Internal issues include recreational impacts, exotic plant management, and especially the importance of maintaining groundwater quality and quantity. Eutrophication is also occurring in park waters. Lake of the Arbuckles had only been in existence for ten years when it first started showing signs of eutrophication.

Present and Past Monitoring

There are currently several aquatic monitoring projects occurring at CHIC: waterflow, fish surveys, aquatic invertebrate, water quality, lake levels, spring levels, and flow. In addition, a basic water quality assessment was completed in by the Water Resources Division in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 1997).

I.5.5 Fort Larned National Historical Site (FOLS)

Background

Fort Larned National Historical Site (FOLS) encompasses 718 acres (291 ha) (Figure I.7). FOLS is primarily underlain by sandstone and lies within the Central Kansas Uplift. Soils on the site belong to the Harney series, which are moderately erodible. Prior to European settlement, the landscape at FOLS was covered with mixed-grass prairie and some woodland areas, particularly in the riparian areas of the Pawnee River. With the agricultural development of the area, many changes occurred, such as the conversion of prairie to cropland, the destruction of woodlands, and more. The consequences of these changes are still a concern for Park managers today. The climate at FOLS is semi-arid with average annual precipitation of 23 inches (58 cm). Thunderstorms during the growing season contribute most of the moisture. Due to low humidity and a continual breeze, temperatures are typically moderate.

Primary Water Resources

FOLS is located along the banks of the Pawnee River and most of the lands occupying the Park are in the Pawnee River floodplain. Historically, this river was a shifting, sand-bottom stream with permanent flow (Delisle and Busby 2004). The increased use of surface and ground waters for irrigation purposes has decreased river flow; complete drying of the streambed in the summer has become common in recent years. The wet/dry climate cycle, which produces large variation in water quantity, has an effect on both the Pawnee River and groundwater recharge, which in turn affects water quality. The conversion of native grasslands to cropland increased soil erosion on the Pawnee River banks and increasing water turbidity. Installation of

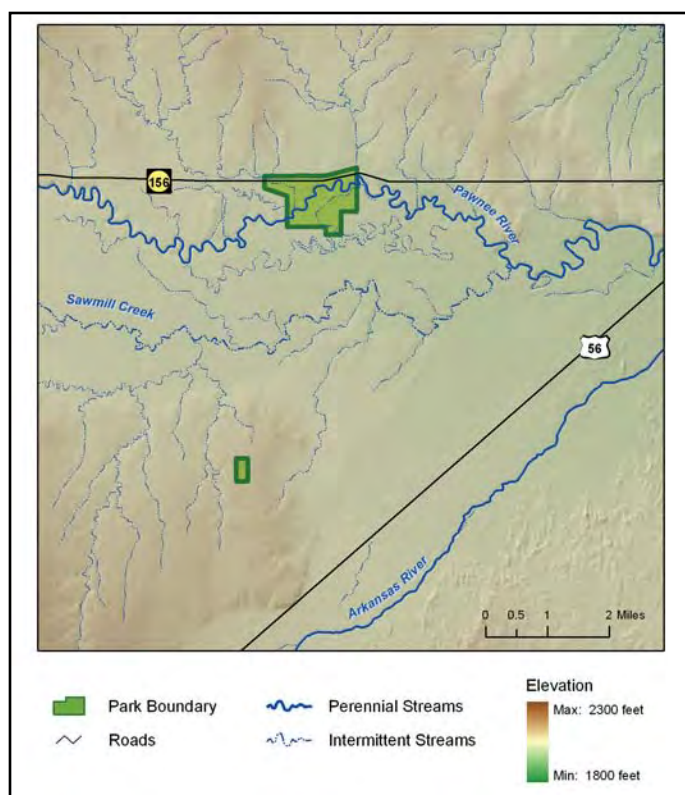


Figure I.7 Map of Fort Larned National Historic Site with water bodies highlighted.

impoundments along the Pawnee decreased the gradient of the river and left many impounded sections.

When the fort was constructed in the 1800's, water wells were sulphurous and had a high mineral content; consequently, the Pawnee River was the primary source for drinking water. The oxbow just to the east of the fort still functioned as a wetland, capturing floodwaters and providing filtration services. In 1938, a concrete dam was constructed just downstream from the fort, impounding six miles of stream water for agricultural use. This impounded the river within park boundaries creating a lacustrine (or ponded) environment in the river. The decreased flow of the river combined with erosion of plowed fields resulted in a silted streambed now 12 to 14 feet (3-4 m) higher than in 1860 (Fort Larned National Historic Site 1979).

A flood levee was constructed along the south side of the Pawnee River, isolating the oxbow lake from its floodplain and wetland functions. Water was then pumped into the oxbow to provide water for livestock, altering the wetland ecosystem. The oxbow lake has not been filled since 1974 (Fort Larned National Historic Site 1979) and remains cut off from the Pawnee River. As a consequence, most of the wetland vegetation has been lost (Becker et al. 1986).

Changes in stream gradient and impoundment have led to infrequent flooding, less diversity of substrates and decreased support of floodplain wetlands (Delisle and Busby 2004). These flow alterations, increased stream turbidity, increased toxin and nutrient loads and overall deterioration of water quality has led to several decades of decline in aquatic life (Becker et al. 1986).

Management and Scientific Issues

The highest priority aquatic resource issues at FOLS are water levels in the Pawnee River, the forested riparian community, and erosion. Groundwater contamination from faulty septic systems is also a concern. Flooding events can cause erosion, opening an avenue for invasive species. Neighboring land uses can impact both water quality and availability through water rights.

Past and Present Monitoring

Current monitoring projects at FOLS are being conducted by the Kansas Geological Survey and the Kansas Water Resource Division. A basic water quality assessment was completed by the Water Resources Division in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 2000b).

I.5.6 Fort Union National Monument (FOUN)

Background

Fort Union National Monument (FOUN) encompasses 721 acres (292 ha) of land in two disjunct parcels of northeastern New Mexico (Figure I.8). The large parcel of 637 acres (258 ha) is separated from the small parcel of 84 acres (34 ha), by a corridor of privately-owned land. This corridor, traversed by Wolf Creek, is a valley that is bounded by a 150-200 foot (46-61 m) sandstone mesa to the West and by the Turkey Mountains to the East. The small portion of the park is west of Wolf Creek while the large unit lies east of the creek, all falling within the Mora watershed district. The western-most edge of the large park unit falls within the Wolf Creek floodplain. A 96,000-acre (38,850 ha) cattle ranch that pre-dates the abandonment of the post in 1891 surrounds FOUN, however the monument has been fenced from grazing since its establishment in 1956. The climate at FOUN is semi-arid with approximately 18 inches (46 cm) of average annual precipitation, the majority of which falls during the summer monsoon season. Wind speeds in this area are often extremely high, which at times may cause soil erosion and elevated levels of aerial dust (Freitag 1994).

FOUN falls within three ecoregion-types: Southern Rocky Mountain Steppe, Open Woodland, and Coniferous Forest (Bailey 1995). The primary ecosystem present at

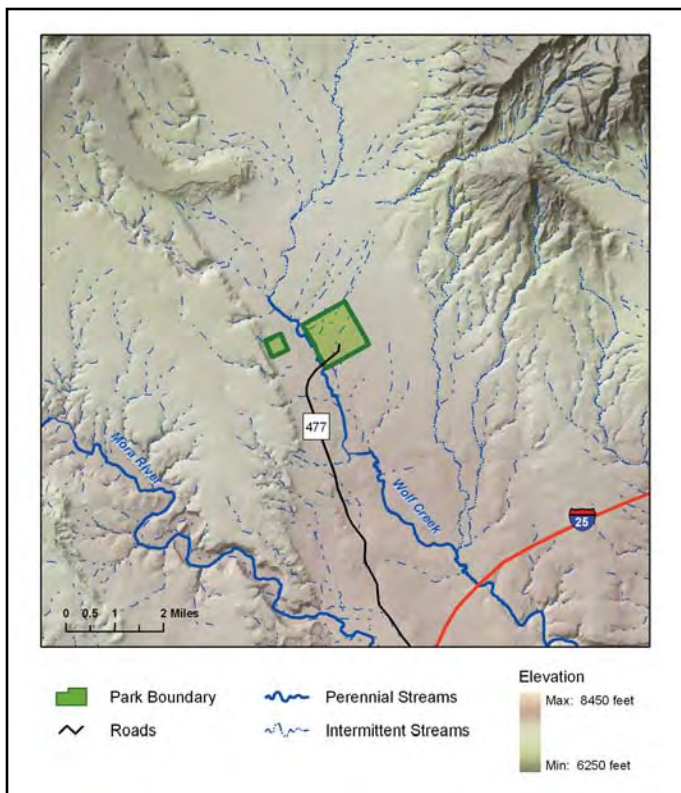


Figure I.8. Map of Fort Union National Monument with water bodies highlighted.

FOUN is short-grass prairie. Soils at FOUN consist of a well-drained loam with gentle slopes (1-5%), which was derived limestone, sandstone, and basalt (Southwest Region 1984). Generally, the soils can be classified as aridic argiustols, comprised of silt and stony loams (Freitag 1994).

Primary Water Resources

Fort Union National Monument contains no surface water resources within its boundaries. However, Wolf Creek will occasionally produce small springs and seepage areas within the park. The quality of groundwater at Fort Union is within the recommended limits set by the 1962 Public Health Service Drinking Water standards as adopted by the EPA. Analyses are made every three years by a state approved laboratory. The Park Staff collects water samples twice a month for bacteriological analyses by a state-approved laboratory. Results are consistently in compliance with health standards.

There are no permanent streams or water bodies with the boundaries of Fort Union National Monument. The small riparian area that is Wolf Creek is the principal drainage for the area. Three intermittent drainages crossing the main unit are the result of erosion of old trail ruts (Southwest Region 1984). Spring seeps occur at the western edge

of the main unit, above Wolf Creek. These wetlands may likely be categorized as jurisdictional wetlands under US Army Corps of Engineers rules, both as function of species composition and soils conditions (Muldivin et. al. 2004).

Management and Scientific Issues

Potential anthropogenic sources of contaminants include ranching operations; recreational use; storm water runoff; and atmospheric deposition. (NPS 1998b). An additional issue that needs to be addressed is the lack of adequate baseline information on the natural resources at FOUN

Past and Present Monitoring

A basic water quality assessment was completed in 1998 by the Water Resources Division of in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 1998b).

I.5.7 Lake Meredith National Recreation Area (LAMR)

Background

Lake Meredith was formed in the 1962 when the Bureau of Reclamation constructed the Sanford Dam on the Canadian River (Figure I.9). It was designated as a National Recreation Area in 1990 and the ownership transferred from the BLM to the NPS. The park is 46,349 acres (18,757 ha) in size. The lake was constructed to supply water to eleven surrounding communities, with recreational use of the area as a secondary purpose. The landscape at LAMR is characterized as rough and broken that can be divided into two distinct areas: the upland area including the mesa top with a steep, gravelly slope, and the bottomland area surrounding the reservoir. Soil groups at this site include Burson-Quinlan-Aspermont, Mobeetie-Tascosa, Acuff-Palo Duro-Olton, Tascosa Burson and Dumas-Dalhart. There are four formations of varying geologic ages that outcrop in the immediate vicinity of the recreation area – the Permian Quartermaster Formation; the Tertiary, Pliocene, Ogallala Formation; the quaternary, Pleistocene, Fluvatile terrace deposits; and the Quaternary Holocene Alluvium. The climate at LAMR is semi-arid with an average annual rainfall 20 inches (51 cm), 70% of which falls between April and September.

Primary Water Resources

Lake Meredith lies behind a 228-foot (69 m) earthfill dam built on the Canadian River. Approximately 10,000 acres (4,047 ha) in size, it is the largest lake in the Texas and Oklahoma panhandles. In addition to water recreation, visitors utilize LAMR for hunting, fishing, horseback

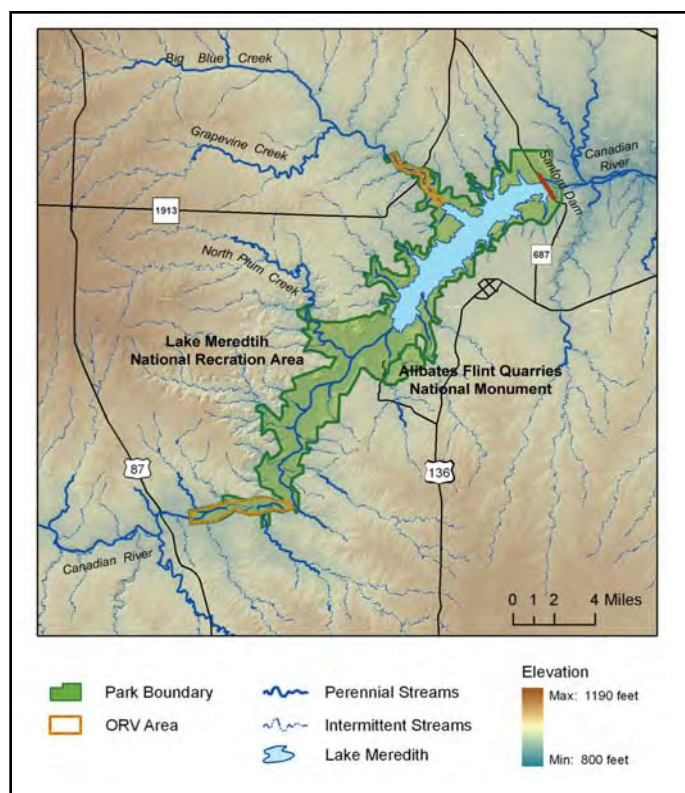


Figure I.9 Map of Lake Meredith National Recreation Area with water bodies highlighted.

riding, camping and more. The Canadian River flows south and southeast across the Texas panhandle. Below the dam is a perennial stream from two or more springs, but seldom flows more than 100 yards (91 m), except in periods of heavy rainfall. The dam has resulted in mean annual discharge being reduced by 76% and the historic mainstem fish assemblage in the Canadian River has been almost completely replaced by species that were formerly restricted to tributary streams (Bonner and Wilde 2000). In the Spring Canyon area below the dam are several other small artificial lakes and a large wetland area created by seepage through Sanford Dam. The largest of these reservoirs is the Stilling Basin, which was designed to still the water when it leaves the flood gates to prevent turbulence and severe erosion downstream. This area is considered the best swimming beach at LAMR.

The Ogallala formation is the most important water-bearing strata to LAMR and the surrounding area. This stratum supplies the region with water for farming, ranching, commercial, and domestic uses. The Ogallala is being pumped at a rate in excess of its recharge in most years, so the water table is lowered by an average rate of 2-3 feet (61-91 cm) per year. Flood hazards at Lake Meredith and Alibates include the entire peripheral area of Lake Meredith; however, the greatest potential for flood hazard to park visitors is from isolated flash floods along side

drainages or from flooding on the Canadian River above Lake Meredith. Rising lake levels present little hazard as rises occur slowly. Stands of cottonwood and hackberry trees (*Celtis occidentalis*) are found in the side canyons along the lake. The varying lake levels have encouraged the encroachment of salt cedar in the floodplain areas. LAMR supports a large number of plant and animal species, including two federally listed species: the Bald Eagle (*Haliaeetus leucocephalus*) and Arkansas River Shiner (*Notropis girardi*).

Management and Scientific Issues

Ninety-nine percent of Lake Meredith is designated as impaired on the federal 303(d) list because of mercury contamination. Water quality and quantity are the most important concerns at LAMR. The federally listed Arkansas River shiner occurs in the Canadian River. Erosion, the invasion of exotics such as tamarisk, non-point source pollution and visitor carrying capacity are the biggest threats to water resources at the park. Reclamation of abandoned oil and gas infrastructure sites and prairie restoration can lead to improved groundwater recharge and stewardship of upland areas. These improvements in turn will provide enhanced habitats for many of the species of interest as well as resident communities. Continued pumping of the aquifer for agricultural purposes can potentially lower the water table. The water level of Lake Meredith fluctuates with floods and draw-downs and is subject to non-source point pollution (including erosion within park boundaries and elevated *E. coli* levels) that could contaminate the fishery.

Past and Present Monitoring

A basic water quality assessment was completed by the Water Resources Division in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 2000a). The park is in need of a heavy metals water quality assessment.

I.5.8 Lyndon B. Johnson National Historical Park (LYJO)

Background

The park consists of two units (districts), which lie about 15 miles (24 km) from one another, situated on the Llano uplift, in the Pedernales River Valley of the central Texas Hill Country, in Blanco and Gillespie counties, respectively (Figure I.10). LYJO was originally established in 1969 with a combined area of the two districts of 674 acres (270 ha). When this area of the Edwards Plateau was first settled in the mid-1800s, it contained oak savannah bisected by riparian woodland corridors and hillside slopes of ashe

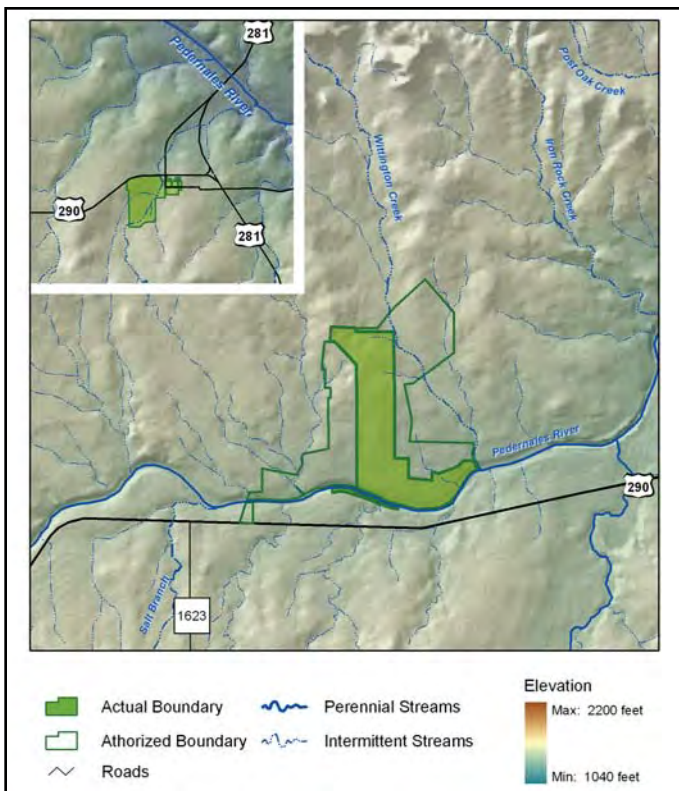


Figure I.10 Map of Lyndon B. Johnson National Historical Park with water bodies highlighted.

juniper (*Juniperus asheii*). Presently, only tiny patches of semi-natural vegetation remain at LYJO: mostly at the prairie restoration site and along Town Creek in the Johnson City District, and along the Pedernales River at the LBJ Ranch District.

The subtropical, sub-humid character of the Edwards Plateau results in a sunny, mild climate, except for summer's high humidity and 100°F (38°C) temperatures. Winter temperatures are usually in the 50s°F (10°C); snow and ice are rare. Annual precipitation averages 32 inches (81 cm), with May and September the wetter months and November, December and January the driest months.

Soils of the Pedernales riverbed contain recently deposited silty and sandy alluvium derived from upstream granites and sandstones, while bottomland terraces are covered with silty and sandy alluviums. Upslope outcrops of sandstone and marly limestone have weathered to pastures of sandy loams and deep redland clay loams. The river valley is surrounded by limestone hills.

Primary Water Resources

The primary water bodies at LYJO are the Pedernales River and Town Creek. There are also a few small streams and stock ponds. Flooding along the Pedernales is an annual threat to the park. At times, the area experiences storms

that result in some of the highest precipitation rates in the US. This contributes to the severe erosion present along the river as well as flash floods that are not uncommon.

Management and Scientific Issues

One of the most important concerns for LYJO Park managers is the riverine ecosystems. Several aquatic species of concern have been documented at LYJO. Texas map turtle (*Graptemys versa*) and Guadalupe bass (*Micropterus treculii*) are both endemic to the Edwards Plateau. The American bald eagle is federally listed as threatened and is a part-time winter resident. The flood/drought cycle of the Edwards Plateau affects the plant and animal species abundance as well as water quality and quantity. Sandy alluvial soils along the streams can be easily eroded during flash flood events. The suppression of fire has encouraged the encroachment of woody species, changing the nature of the habitat, affecting groundwater recharge and possibly allowing favorable conditions for the introduction and spread of plant and insect disease. The Pedernales River valley continues to succumb to a gradual change from agriculture to development and the onset of light and sound pollution.

Past and Present Monitoring

The park has monitored water quality at two sites on the Pedernales River since 1996. The monitoring began due to concerns of high nutrient and bacteria contamination from livestock grazing on lands upstream from the ranch. The monitoring is conducted by park staff as part of the Lower Colorado River Authority (LCRA) River Watch Program. Monitoring has also been implemented on Town Creek in the Johnson City District unit in 2004. Additionally, a hydromet is being installed at the LBJ Ranch unit. A basic water quality assessment was completed by the Water Resources Division in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 2001).

I.5.9 Pecos National Historic Park (PECO)

Background

Pecos National Historic Park (PECO) was designated in 1965. The 6,670-acre (2,699 ha) park is located in New Mexico, on the southern edge of the Sangre de Cristo Mountains (Figure I.11). Most of the park lies in the Upper Pecos River Valley at an elevation of approximately 7,000 feet (2,134 m). Annual precipitation varies from 16 to 20 inches (41-51 cm) per year, with the majority falling during the summer season. The park's predominant vegetation is piñon-juniper woodland. Neighboring conserved lands

include Las Vegas NWR, Santa Fe National Forest, and Villaneuva State Park.

Primary Water Resources

Four miles of the Pecos River flows through the park. Additional surface hydrology features include Glorieta Creek, a riparian restoration area, a pond, and marshy habitats.

Water quality and availability will continue to grow in importance in the arid southwest. While the ecosystem has developed with the wet/dry climatic cycle, the capture rate of groundwater is critical.

Management and Scientific Issues

The highest priority water resource issues for PECO are reptile community, large carnivores, riparian community, and a migratory songbird stopover point. The Pecos River is experiencing declining water quality from upstream activities beyond the park boundary, resulting in contaminants in the fishery. Parts of the Pecos River that flow through PECO are listed on New Mexico's 303(d) list due to elevated turbidity and temperature levels. The maintenance of minimum flows and continued exclusion of livestock in both Glorieta Creek and the Pecos River will ensure the persistence of riparian vegetation necessary to many breeding birds.

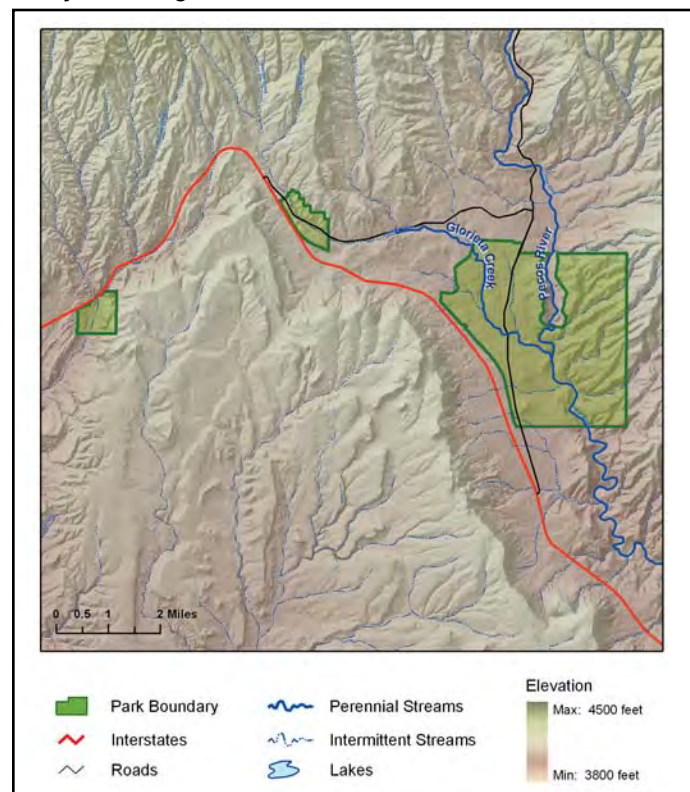


Figure I.11 Map of Pecos National Historic Park with water bodies highlighted.

Past and Present Monitoring

A basic water quality assessment was completed by the Water Resources Division in accordance with the Servicewide initiative to obtain baseline data on water resources of every Park (NPS 1995).

I.5.10 Sand Creek Massacre National Historic Site (SAND)

Background

Sand Creek Massacre National Historic Site (SAND) is a 2,400-acre (971 ha) site that lies along a 5.5 mile (8.9 km) stretch of Big Sandy Creek in southeastern Colorado (Figure I.12). The climate at SAND is dry and clear with average annual precipitation of 13-14 inches (33-36 cm). The landscape of SAND is largely short-grass prairies. Trees on the site are eastern cottonwood, found in even-aged groves close to Big Sandy Creek.

Primary Water Resources

Big Sandy Creek is the primary water body found within SAND. Big Sandy Creek is an intermittently flowing stream derived from infrequent large spring/summer rainfall events. During normal and dry years, the creek does not substantially flow and has not been reliably used for potable or irrigation use. Recent observations of the creek and associated plant communities suggests that the only water normally found on the site is in creek-scoured depressions that intercept groundwater, several minor seeps, and one major perennial spring.

A narrow strip containing two types of wetlands shown on National Wetlands Inventory map borders Big Sandy Creek throughout the length of the site. A third type of wetland classification is found along the creek bed where more flow character is maintained. Four small pockets or strips of wetland are also indicated on spring and seep areas. Big Sandy Creek water quality varies throughout the year and through particular storm events because of the creek's intermittent character. It is generally of good quality although it has limitations as potable water due to high alkalinity and periodic high-suspended sediments. Groundwater quality in the area of the creek has generally been rated as fair to poor. Few water rights have been established for the surface water of Big Sandy Creek, and none within SAND. Big Sandy Creek drains the eastern side of a broad southeasterly trending valley composed largely of Quaternary eolian sands overlaying complex and discontinuous Pleistocene sands, silts, and gravels above the chalky Smoky Hill Shale (part of the Niobrara Formation). Dune sands make up the bluffs along and extending back from the western side of the creek, while

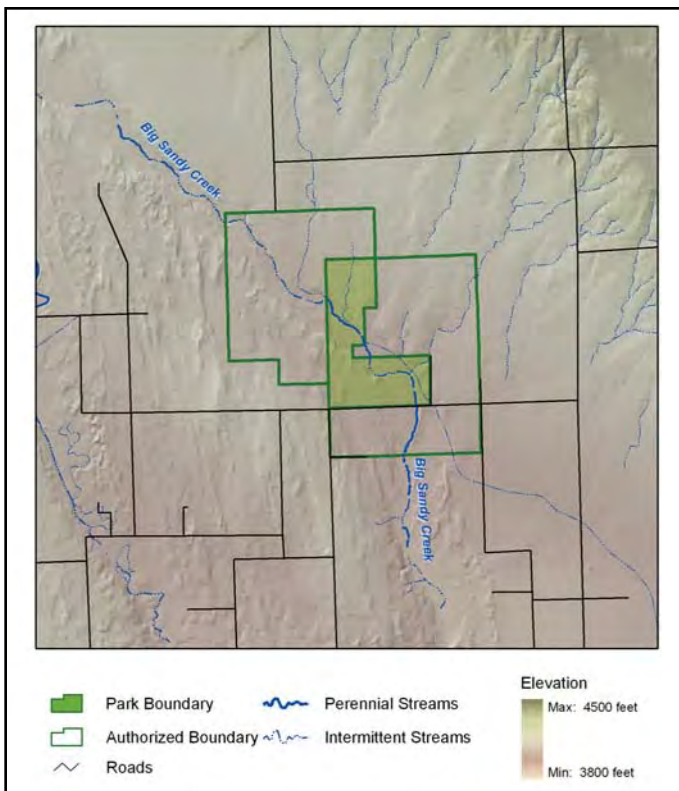


Figure I.12 Map of Sand Creek Massacre National Historic Site with water bodies highlighted.

coarser (and including more silt) valley fill and slopewash materials blanket the terraces and slopes extending eastward. Along Big Sandy Creek, just south of the Dawson South Bend are deep dune and valley fill deposits. Soils along Big Sandy Creek within the floodplain are nearly level and poorly drained.

Management and Scientific Issues

The largest threat currently facing water resources at SAND is erosion along the streambanks. Another significant issue for SAND is the permanent wetland located on the southern edge of the park that contains the federally listed Arkansas Darter (*Etheostoma cragini*). Water resources must be monitored to preserve the upland springs, wetlands and ponds and insure water quality. The wet/dry climate cycle, which produces large variation in water quantity, has an effect on both ponds and groundwater recharge. Flooding events can cause erosion, opening an avenue for invasive species. Neighboring land uses can impact both water quality and availability through water rights. The acquisition of water and mineral rights during land purchase is of major importance. While no extractive activities are currently occurring along the proposed park boundary or within SAND, contingency plans should be developed for future use. Great Plains Reservoirs is a nearby public conservation area.

Past and Present Monitoring

Currently, Eads public works is monitoring water flow. Additional water monitoring projects have not occurred as of yet. However, with additional funding, a baseline water quality report, among other monitoring projects, shall be initiated.

I.5.11 Washita Battlefield National Historic Site (WABA)

Background

Washita Battlefield National Historic Site (WABA) is a 326-acre (132 ha) site located on the banks of the Washita River (Figure I.13). The climate at WABA is temperate and characterized by hot, humid summers, mild winters, relatively high wind velocities, and wide fluctuations in rainfall. Average annual precipitation is 25 inches (64 cm) with most of this occurring between April and August. The surrounding landscape is classified as dry plains, steppe with moderate valley slopes (2-20%) and a gently rolling topography (Bergey 2003). Ten distinct soil types occur within the park boundaries; in general, ranging from sands to loams. This site was drastically affected by the "Dust Bowl" in the 1930's (Inglis 2001), which likely caused changes in the local hydrology. The water resources at WABA are important to both the natural environment and the cultural landscape (Reber et al. 1999)

Primary Water Resources

The Washita River is the primary water body found within WABA. This eastward-flowing river originates in the high plains of the eastern panhandle of Texas and is a tributary to the Red River (Reber et al. 1999). It is a single-thread sand channel with moderate entrenchment, width/depth ratio, and sinuosity (Inglis 2001). Water depth of the Washita River typically ranges between 4-6 inches (10-15.5 cm) and the channel width is 8-10 feet (2.4-3 m). WABA falls within the Washita Headwaters Watershed, a catchment that is predominantly covered by agricultural land (Andrews 1998).

Currently, the Washita River is considered an undersized stream having a wide valley-bottom floodplain (Inglis 2001) and stream characteristics discordant with its watershed conditions. The unbalanced river conditions today are likely a result of the landscape desertification that occurred in the 1930s' "Dust Bowl". Soil dessication during that time caused high amounts of sedimentary wash-out to the Washita River. Further affecting the river, in the 1950's, numerous flood control/water conservation structures were designed on tributaries of the Washita. These dams have decreased peak flows along the river. Other contributing

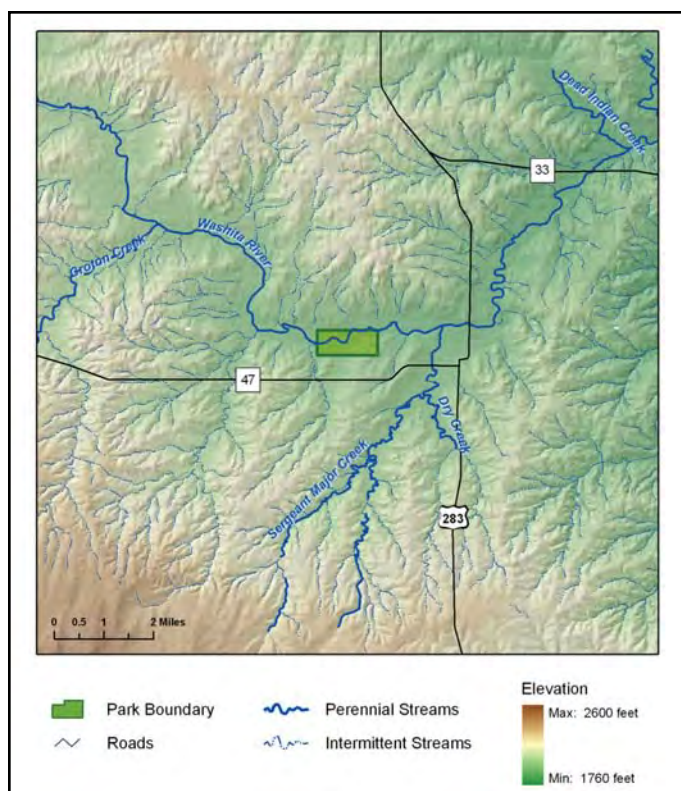


Figure I.13 Map of Washita Battlefield National Historic Site with water bodies highlighted.

factors to the current state of the Washita River are the cultivation and irrigation of croplands, the construction and use of paved roads, the building of residential homes, the introduction of cattle ranching, and the process of oil well operations (Andrews 1998). An on-going goal of WABA is to restore this site to its natural conditions (pre-1860's).

A beaver pond on the western edge of the park has served as a sediment settling pond, resulting in a sandy river bed below the beaver dam. Water salinity is elevated, particularly during the low flow periods of summer. All pools lack the coarser gravels and aquatic plants necessary for a ranking above suboptimal in a recent bioassessment (Bergey 2003).

Groundwater in the vicinity of WABA is generally hard and may contain excessive dissolved solids. Sulfate concentrations are often above the recommended drinking limit and in some cases chloride concentrations may also be high (Washita Battlefield National Historic Site 2001). Groundwater depth varied within the boundaries of WABA, from an average of 18 feet (5 m) below the upland prairie to only 5 feet (2 m) deep on the floodplain.

Management and Scientific Issues

The greatest threats to the water resources at WABA include the effects of dams and silt build-up in the Washita

River, both of which decrease the river flow, and water contamination. There are several potential pollutants to the Washita River and the alluvial aquifer in which the river lies (e.g., nutrients, pesticides, petroleum hydrocarbons, bacteria, and metals). An additional concern to WABA is the waste pit facility located 2 miles (1.2 km) west of the park. Until recently, the facility consisted of a commercial saltwater disposal well, primarily used for the injection of saline wastes produced by oil and gas mining. This facility is currently expanding its operations and will add waste fields as close as ¼ mile (0.4 km) up slope from the Washita River (Bergey 2003).

Surrounding land use presents challenges to WABA as the potentially negative effects of these practices are largely beyond the control of park managers (Inglis 2001). However, the park is taking measures to restore the area to the most natural state as possible. The park has removed irrigation wells, replaced cropland with native mixed-grass prairie vegetation, and removed invasive shrubs along the river (Andrews 1998).

Invasive non-native plant species are becoming a problem in the riparian zone of the Washita River are affecting water quality and quantity. Some of the invaders are upland species that consume large amounts of soil water. The invasion of tamarisk, in particular, is drastically reducing the soil water content. This lowers the river flow and creates river bank instability (Inglis 2001).

The Washita Battlefield National Historic Site has riparian water rights for domestic use, not to exceed five acre-feet per year. The park has appropriated all existing groundwater rights that were formerly held by the previous owners. Seven permits for the appropriation rights of groundwater are held by upstream and downstream owners (Washita Battlefield National Historic Site 2001). Results of the recent hydrological assessments at WABA imply that the water resources within the park are sub-par. A baseline water quality report is needed for managers to have data on which to base their restoration and management plans.

Past and Present Monitoring

The USGS has gauged the Washita River at a station approximately 2 miles (1.2 km) downstream from WABA for over 60 years. In addition, they collected water-quality samples at the gauging station twice a year from the mid 1930's until 1990. Furthermore, a water quality assessment was performed by the USGS in 1998, in which the Washita River was sampled. An evaluation of the functional condition of the Washita River was performed in 2001 by the Water Operations Branch (WOB) of the Water Resource Division (WRD).

I.6 ACKNOWLEDGEMENTS

We would like to thank the Southern Plains Network Technical Committee for their cooperation in the scoping interviews. Much of the information provided in the park narratives of this appendix was derived from the scoping interviews. Also, we would like to thank Dr. Timothy Seastedt for his helpful comments during the development of this document. Furthermore, we would like to recognize that portions of this appendix were adapted from water quality reports from other networks such as SCPN, NCCN, NCBN, and SODN.

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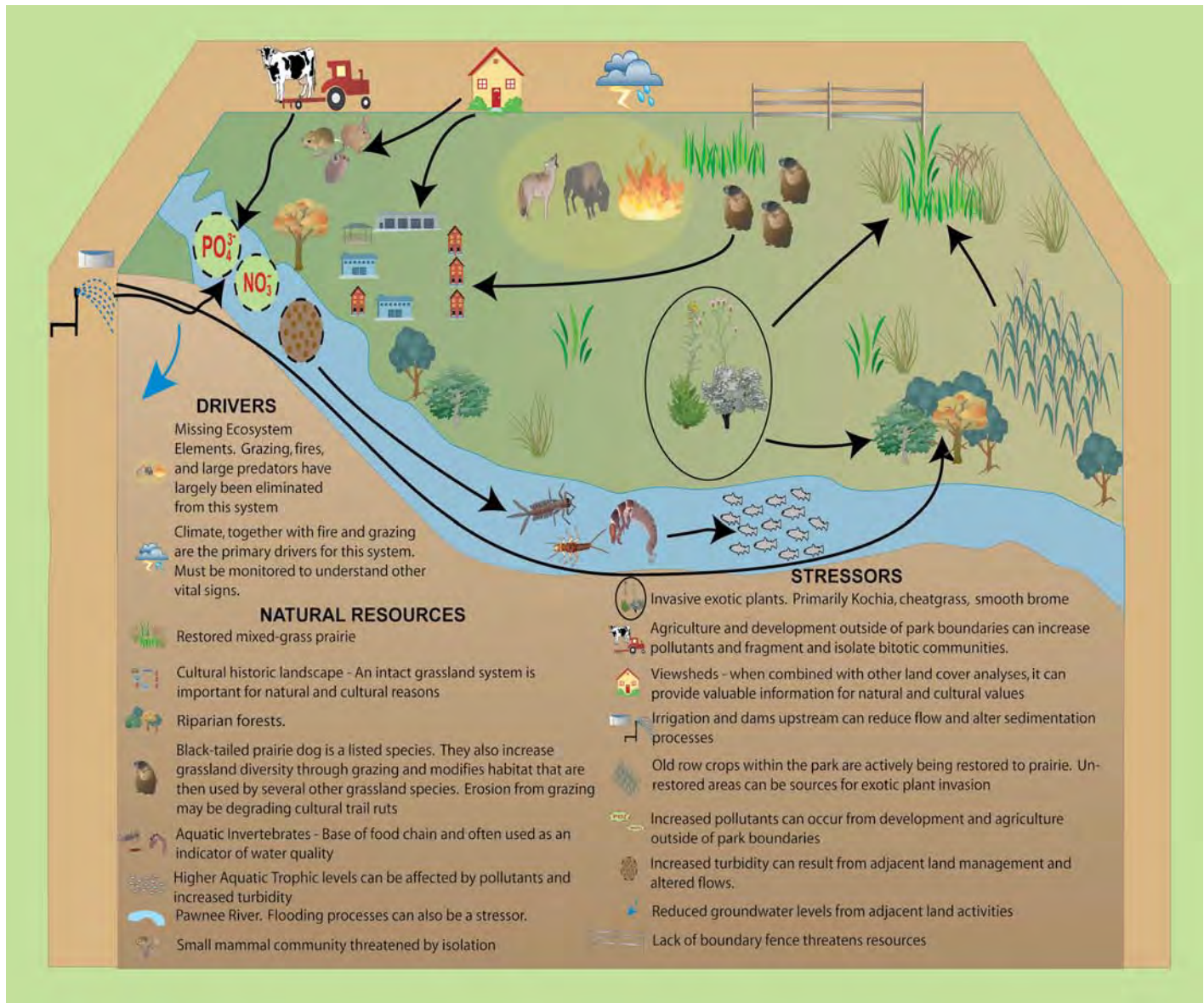
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APPENDIX J. NATURAL RESOURCES AND STRESSORS

(DERIVED FROM SCOPING SESSIONS AND RANKED BY PARK STAFF)



All issues were ranked by assigning an issue a point value. High priority issues were assigned 4 points; medium priority issues were assigned 3 points, low priority issues were assigned 2 points, and non-issues were assigned 1 point. All scores were averaged to arrive at an overall score for the issue.

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Exotic Plants (Kochia, tamarisk, cheatgrass etc.)	3.64	Medium	High	High	Medium	High	Low	High	High	High	High	High
Grassland community	3.45	High	High	High	Medium	Medium	Low	High	High	Low	High	High
Prairie Restoration	3.36	High	High	High	Medium	High	Not An Issue	High	High	Not An Issue	High	High
Viewshed	3.18	High	Medium	Medium	Medium	High	Medium	Medium	Medium	Low	Medium	High
Erosion - Slopes, lakeshores, banks	3.09	High	Low	High	High	High	Low	High	High	Not An Issue	Medium	Low
Funding (lack of money and staff)	3.09	High	Medium	Medium	High	High	Low	High	Medium	Low	Medium	Low
Adjacent Land Use (mining, feedlots, agriculture, grazing, fire, development, etc.)	2.91	Medium	Medium	Medium	Medium	Medium	Not An Issue	Medium	Medium	Low	High	High
Fire (lack of, frequency, effects of, prevention, etc.)	2.91	Not An Issue	High	High	Medium	Medium	Low	Not An Issue	Medium	High	High	Medium
Water Quantity	2.91	High	Low	Not An Issue	High	High	Not An Issue	High	Medium	Medium	Medium	Medium
Water Quality	2.82	High	Low	Not An Issue	High	Medium	Not An Issue	High	Medium	Medium	Medium	Medium
Cottonwood Riparian Community	2.73	Medium	High	Not An Issue	Low	High	Not An Issue	Medium	Not An Issue	High	High	Medium
Riverine community (River, stream)	2.73	Not An Issue	Medium	Not An Issue	High	Medium	Not An Issue	Not An Issue	High	High	High	High
Wildlife Diseases effects on staff and visitors (west nile,hantavirus)	2.73	Low	High	Low	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
Grassland/Succession to more woody vegetation	2.64	Medium	Not An Issue	High	Medium	Low	Not An Issue	Medium	Medium	High	Not An Issue	High
Lack of long-term management plan	2.64	Low	Not An Issue	Medium	Low	High	Low	High	Medium	Medium	High	Not An Issue

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Night sky	2.64	High	Low	Medium	Low	Low	Low	Medium	Medium	Low	Medium	Medium
Soundscape	2.64	High	Low	Low	Medium	Low	Not An Issue	Medium	Medium	Low	Medium	High
Weather patterns (drought, wet periods)	2.64	Low	Medium	Low	Low	Medium	Medium	Low	High	Medium	Medium	Low
Woody Invasive Species (Mesquite, Cedar, PJ, shrubs, etc.)	2.64	High	Not An Issue	High	High	Not An Issue	Not An Issue	Medium	Medium	Medium	Not An Issue	High
Air Quality	2.55	Medium	Low	Low	Medium	Low	Low	Medium	Medium	Medium	Medium	Low
Big Game (Deer, pronghorn antelope)	2.55	Low	Low	Low	Medium	Low	Not An Issue	Medium	High	High	Medium	Low
Grassland birds	2.55	Medium	Medium	Medium	Medium	Low	Not An Issue	Medium	Medium	Low	Medium	Low
Groundwater levels	2.55	Not An Issue	Medium	Low	High	Medium	Not An Issue	Low	Medium	Medium	Medium	Medium
Reptile Community	2.55	Medium	Low	Low	Medium	Low	Not An Issue	Medium	Medium	High	Medium	Low
Small mammal community (mice, voles, shrews, moles)	2.55	Low	Medium	Low	Medium	High	Medium	Low	Medium	Low	Low	Low
Wetlands in upland systems (prairie wetlands, ponds)	2.55	Medium	High	Not An Issue	Medium	Low	Not An Issue	Medium	Low	Low	Medium	High
Flooding process along river/stream/lake	2.45	Medium	High	Not An Issue	Medium	Medium	Not An Issue	Low	Medium	Low	Medium	Low
Bald Eagle	2.36	Medium	Low	Low	Medium	Not An Issue	Not An Issue	Medium	Low	High	Medium	Low
Boundary survey/fencing	2.36	Medium	Medium	Not An Issue	Medium	Medium	Not An Issue	Medium	Low	Low	Medium	Low
Migratory songbird stopover area	2.36	Medium	Low	Low	Medium	Low	Not An Issue	Medium	Low	High	Low	Low
Effects of Park visitors on natural resources (Trails, camping, fishing, hunting, unauthorized, authorized, etc)	2.27	High	Not An Issue	Medium	Medium	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	High	Low

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Pollution from non-park sources	2.27	Medium	Medium	Low	Medium	Low	Not An Issue	Medium	Low	Low	Low	Low
Texas horned lizard	2.27	High	Not An Issue	Low	Medium	Not An Issue	Not An Issue	High	Medium	Low	Low	Low
Insect diseases on ecosystem (Ips beetle, Armillaria)	2.18	Low	Not An Issue	Medium	Low	Not An Issue	Not An Issue	Low	Medium	High	Medium	Low
Water use (rights within park, rights of others outside the park, aquifers)	2.18	Not An Issue	Medium	Not An Issue	High	Medium	Not An Issue	Not An Issue	Medium	Low	Medium	Low
Mineral, Oil, and Gas Extraction	2.09	Medium	Medium	Not An Issue	Low	Low	Not An Issue	Medium	Not An Issue	Not An Issue	Medium	Medium
Upland Springs	2.09	Medium	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Medium	Not An Issue	Low	Medium	Medium
Black-tailed prairie dogs	2.00	Low	Medium	Not An Issue	Not An Issue	High	Not An Issue	Low	Not An Issue	Low	Medium	Low
Hunting	2.00	Low	Low	Not An Issue	Medium	Low	Not An Issue	Medium	Medium	Not An Issue	Medium	Not An Issue
Small game (rabbits, squirrels)	2.00	Low	Low	Low	Medium	Low	Not An Issue	Low	Low	Low	Low	Low
Contamination of Water Supply (from sewer, oil spill, feedlots etc.)	1.91	Not An Issue	Not An Issue	Not An Issue	High	Medium	Not An Issue	Medium	Low	Low	Not An Issue	Low
Game birds (quail, ducks, turkey)	1.91	Not An Issue	Low	Low	Medium	Low	Not An Issue	Low	Low	Low	Medium	Not An Issue
Off-road vehicle use	1.91	Medium	Low	Not An Issue	Low	Not An Issue	Not An Issue	Medium	Not An Issue	Low	Medium	Low
Effects of Grazing (overgrazing, lack of grazing, etc.)	1.82	Low	Not An Issue	Low	Low	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	High	Medium
Hazardous spill on adjacent highway, railroad	1.82	Not An Issue	Medium	Not An Issue	Medium	Low	Not An Issue	Medium	Low	Low	Not An Issue	Not An Issue
Burrowing owl	1.73	Low	Low	Not An Issue	Low	Medium	Not An Issue	Low	Not An Issue	Low	Low	Not An Issue
Feral Dogs	1.73	Not An Issue	Low	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Low	High	Not An Issue	Low

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Contaminants in Fishery	1.64	Not An Issue	Low	Not An Issue	Medium	Not An Issue	Not An Issue	Medium	Not An Issue	Medium	Not An Issue	Not An Issue
E.coli levels	1.64	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Medium	Low	Low	Not An Issue	Low
Fishing	1.64	Not An Issue	Not An Issue	Not An Issue	Medium	Low	Not An Issue	Medium	Not An Issue	Medium	Not An Issue	Not An Issue
Game Fish	1.64	Not An Issue	Not An Issue	Not An Issue	Medium	Low	Not An Issue	Medium	Not An Issue	Low	Not An Issue	Low
Large Carnivores (bear, mountain lion, jagarundi)	1.64	Not An Issue	Not An Issue	Low	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	High	Not An Issue	Medium
Lesser Prairie Chicken	1.64	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Low	High	Low
Swift fox	1.64	Low	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Low	Not An Issue	Low	Medium	Low
Exotic Game (axis deer, blackbuck antelope, fallow deer)	1.55	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Low
Feral Cats	1.55	Not An Issue	Low	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Low	Low	Not An Issue	Low
Feral Hogs	1.55	Low	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Medium	Not An Issue
Fire Ants	1.55	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Low
Montane/grassland/desert interface (easternmost location)	1.55	Not An Issue	Not An Issue	High	Medium	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue
Raccoons	1.55	Not An Issue	Not An Issue	Not An Issue	Medium	Low	Not An Issue	Not An Issue	Low	Low	Not An Issue	Low
Endemic invertebrates	1.45	Not An Issue	Not An Issue	Low	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Low
Ferruginous hawk	1.45	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Medium	Low
Lacustrine Community (Lakes)	1.45	Not An Issue	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Mississippi Kites	1.45	Low	Not An Issue	Not An Issue	Low	Low	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Non-vascular plants (lichens mosses)	1.36	Not An Issue	Not An Issue	Low	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue
Porcupine	1.36	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Low	Not An Issue	Low
Townsend's big-eared bat	1.36	Not An Issue	Not An Issue	Medium	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue
Alberta arctic butterfly	1.27	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Arkansas darter	1.27	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Arkansas river shiner	1.27	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Bottomland eastern deciduous hardwood community	1.27	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low
Cryptobiotic soils	1.27	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Low	Not An Issue
Echinacea	1.27	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low
Mountain plovers	1.27	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Low	Not An Issue
SW Willow flycatcher	1.27	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Low	Not An Issue	Not An Issue
Volcanic cinder cone	1.27	Not An Issue	Not An Issue	High	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Africanized honeybee	1.18	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Low
Black-footed ferret	1.18	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Low
Dwarf milkweed	1.18	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Low	Not An Issue	Not An Issue

Issue Name	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Marsh rice rat	1.18	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Nutria	1.18	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Medium	Not An Issue	Not An Issue	Not An Issue
Zebra mussels	1.18	Not An Issue	Low	Not An Issue	Low	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Colorado bursage	1.00	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Giant mole cricket	1.00	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue
Palo Duro canyon mouse	1.00	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue	Not An Issue

APPENDIX K. SOUTHERN PLAINS NETWORK PRIORITIZATION WORKSHOP REPORT

JANUARY 24-25, 2006

AMARILLO, TX - HOSTED BY ALIBATES FLINT QUARRIES NM / LAKE MEREDITH NRA

K.1 OVERVIEW

This two day workshop was attended by 44 people and continued the process of developing a long-term ecological monitoring program for natural resources in the Southern Plains Inventory and Monitoring Network (SOPN). In 2004 and 2005, SOPN held scoping sessions with park managers from each SOPN park, reviewed peer-reviewed literature and gray literature, and developed conceptual models for the major ecosystems in SOPN. In 2005, SOPN held two separate workshops, one in Cheyenne, Oklahoma with short-grass and mixed-grass breakout groups, and one in Las Vegas, New Mexico with rivers and streams, reservoirs, and landscape breakout groups. The breakout groups reviewed conceptual models for the major SOPN ecosystems and a list of potential ecological indicators or “vital signs”. This process resulted in a list of 74 potential vital signs for consideration in our long-term monitoring program.

The goal of this workshop was to create a prioritized list of vital signs. Prior to the workshop, members of the technical committee led each park in ranking the potential vital signs according to management significance. The workshop was divided up into four workgroups: plants and soils, wildlife, aquatic resources, and landscape level issues (see Table K.1 for a complete list of participants and their workgroups). Each group reviewed a unique set of potential vital signs and ranked them according to ecological significance and feasibility / cost of implementation (Table K.2). To calculate a total score for each potential vital sign, the following criteria were weighted as management significance (40%), ecological significance (40%), and feasibility/cost of implementation (20%). This process resulted in a prioritized list of vital signs for SOPN.

K.2 OBJECTIVES

1. Develop a prioritized list of vital signs by evaluating potential vital signs according to three criteria.
2. Review the highest ranked vital signs (top 25%) to get feedback from meeting participants on existing protocols and monitoring programs and potential partners.

K.3 DAY 1 – PRIORITIZATION

The workshop started with a welcome from Karren Brown, Superintendent at Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument. Dusty Perkins then presented an overview of the Inventory and Monitoring Program, the SOPN, and the workshop process. In ranking ecological significance and feasibility/cost of implementation it was strongly emphasized that the workgroups stick to the pre-set criteria (See Section K.6). Each criterion and the scoring system were reviewed as a group to minimize differences in definitions and interpretations between groups. The workshop was then divided into four workgroups, with a facilitator and notetaker in each group. The facilitators were all familiar with the I+M program and the vital signs process (two were network coordinators, one was a former network coordinator, and one was an ecologist that has helped SOPN and the Greater Yellowstone Network with the vital signs development process). All vital signs and the scoring process were contained in an access database.

Each workgroup worked through their list, one vital sign at a time, reviewing fields containing information on monitoring objectives, justifications, and potential measures. The goal was to try and reach consensus on scores for ecological significance and feasibility/cost of implementation. If, after some discussion it was clear that consensus would not be reached, the facilitator asked each member of the group for a score and the mean was taken. After completing the scoring for all vital signs, the notetaker used the access database to create a report showing the prioritized list for that particular workgroup. The group was then asked to take one final look at the vital signs to ensure that ranking stayed consistent throughout the process and that the top vital signs were at or near the top of the list of vital signs. Each workgroup could also add vital signs to the list. Six new vital signs were added to the original 74 vital signs for a total of 80 potential vital signs (Table K.2).

The workgroups were also encouraged to write additional comments for each vital sign that pertained to scoring, justifications, monitoring objectives, measures or other. All of the workgroups also had suggestions for merging and combining vital signs. A summary of these comments for each list is below.

Prioritization Workshop Schedule

Tuesday January 24, 2006 – Ambassador Hotel, Amarillo, Texas		
Time	Subject	Leader
8:30-8:40	Welcome	Karren Brown
8:40-8:50	Group Introductions	
8:50-9:15	Overview of I+M and SOPN	Dusty Perkins
9:15-9:30	Prioritization Process	Dusty Perkins
9:30-9:50	Break	
9:50-12:00	Breakout Sessions – Evaluation of Potential Vital Signs Wildlife Plants and Soils Water Quality and Aquatic Resources Landscape Level Issues	Dan Licht (Facilitator) Mike DeBacker (Facilitator) Greg Shriver (Facilitator) Dan Tinker (Facilitator)
12:00-1:30	Lunch	
1:30-5:30	Breakout Sessions – Evaluation of Potential Vital Signs	Facilitators
7:00	Dinner at The Big Texan	Optional
Wednesday January 25, 2006 – Ambassador Hotel, Amarillo, TX		
8:30-9:00	Presentation of Prioritized Vital Signs List + Discussion and Day's Objectives	Dusty Perkins
8:30-11:00	Breakout Sessions – Review Top Vital Signs	Facilitators
11:00	Wrap-Ups By Breakout Group	Dusty Perkins
11:30-12:45	Lunch	
12:45-6:00	Tour at Alibates Flint Quarries National Monument	

K.3.1 Plants and Soils

General Comments

Carbon balance: NDVI may not be the best measurement for soil carbon. Microsite soil core samples is the traditional method. This would have to be a composite measurement over a fixed area. Not likely to fluctuate much from year to year. Would only want to measure once every five years. Quite variable spatially. Sampling method needs to be consistent to reduce variability (composite sample). You will want to wrap carbon testing into determining other soil variables. This is only one variable of many that would be captured in a soil sampling method.

Grassland vegetation: Certain elements of the community are more variable than others: (less variable = basal area, richness, C3 vs. C4 ratios). The vital sign itself is quite variable both spatially and temporally. Labor will be the major cost factor. Repeatability will be dependant on what/how variable is measured. Need species level identification. Need large (adequate) samples and intensive monitoring. Comparability between different data gatherers will be difficult because there is less standardization of monitoring/sampling/etc.

Riparian vegetation: Not much standardization in sampling between agencies. USFS, BLM and WRD have their methods but it remains to be seen if those methods will fit NPS needs. There is a lot of research from tamarisk.

Non-vascular plants: Vital sign derived from lack of knowledge of lichen/bryophytes as opposed to air quality. Important to biodiversity and may be indicator link to overall health of ecosystem. They may be indicator species as opposed to overall types. All responses are due to lack of knowledge and lack of an expert present and this should be taken into consideration. The group is NOT saying this does not count. This may have a park specific implication but low priority throughout the network.

Upland springs: This vital sign should look at rare fauna, water quality and water quantity, as well as vegetation. While a measure of park health, this may not be as strong as grassland extent and health. They are areas of high diversity and often contain T&E species.

Insect diseases/outbreaks on ecosystem: How would management use this data? It is difficult to apply the given criteria to this vital sign.

Woody invasive species: Mainly a land cover change issue, but there may be a structure issue.

Exotic plants: Need to focus in on key monitoring objectives, then develop measures. Needs to be cooperation between the I&M program and exotic plant management teams. Need to monitor what is there and how extensive vs. density of population. The vast majority of invasives are benign. Early detection and emphasis on species monoculture may be most cost effective. I&M needs to focus on early detection and change over time of

the problematic species. Set priorities as species-based and which resources are at risk. At risk areas should be sampled more intensively.

Cryptobiotic soils: Crust in prairie lands may not serve as critical a function as in more arid areas. Change is so slow in crust recovery. Important where it exists.

Effects of park visitors on natural resources: This is an issue of “Human Carrying Capacity.” May not affect what you monitor but where you monitor. Visitor use statistics may corroborate evidence of physical impacts.

Off-road vehicle use: Another case of where monitoring takes place, not necessarily new monitoring methods.

Fire and fuel dynamics: We assume wildland fire includes prescribed burns. From the viewpoint of the panel, this is primarily a vegetation community issue with a few additional measurements. Score based on vegetation vital signs.

Merging Suggestions

Fire and fuel dynamics and *woody invasives* should fit under the “vegetation communities (for wetlands, riparian, and grasslands). The soil vital signs should be reclassified into two new vital signs. *Soil chemistry and structure* would incorporate *carbon balance*, *soil health* as well as biological and physical elements, while *soil movement* would incorporate *erosion* and *soil budget*.

K.3.2 Landscape

General Comments

The program should consider three different classes of vital signs: Drivers/Stressors, Ecological Response, and Aesthetics. The program should think outside of park boundaries when developing protocols and analyzing vital sign data. Think of spatial distribution of vital signs in regard to the three different classes.

Visibility and particulate matter: This is a viewscape issue, not an ecological issue (human impacts for viewing?). There should be a monitoring question relating to humans. Remove phosphates from list.

Wet and dry deposition: Dry is difficult to measure. Wet Deposition is easier/cheaper than dry.

Carbon balance: There was a range of agreement/disagreement for criteria. This is more of a response than an indicator. This vital signs does provide measure for management. The Justification Statement/Measures/

Questions need to be reconsidered. Why is this under Category I (Air), Recommend moving to one of the soil vital signs. The sampling design would be critical.

Effects of wildlife diseases: Should add vectors, landscape structure, and reservoirs in surrounding landscape as a potential monitoring objective. Consider plant/animal pathogens, although plant pathogens need to be captured somewhere (another level III category). This vital signs is mixing apples and oranges.

Insect diseases/outbreaks on ecosystem: Should be renamed insect pests.

Mineral, oil, and gas extraction: This is a stressor to the environment (complex) and could be considered with human development. There was debate about whether this was for within or outside park boundaries

Human demographic data: This vital sign should analyze data in reference at different scales specifically relevant to each unit (e.g. viewshed, watershed, night skies, soundscape, etc.).

Effects of park visitors on natural resources: This vital signs needs to have a sensitivity of area to use factor (plant/soil topography). Should consider fragmentation issues. The monitoring objectives vs. measures doesn't track very well. This vital sign is not specific for the Level III classification. The vital sign could be renamed “People on the Landscape”. This is an important driver with effects. There are well-established methods available.

Fire and fuel dynamics: This vital sign should monitor fuels and historic wildfire trends outside park boundaries.

Landscape dynamics: This vital sign should be considered as a landscape structure with aspects of use. The level III classification should be renamed “landscape dynamics” and this vital sign called “Landscape Structure”.

Viewshed: The scale is critical (flat areas) vs. hills/mountains (much larger). The distance to height is critical to the impact.

New Vital Signs

This group added plant pathogens as a new vital sign. This vital sign would consider things like rust, oak wilt, sudden oak death, etc. The group noted that this new vital sign could be monitored with the existing insect outbreaks vital signs.

Merging Suggestions

The landscape group made the following recommendations for merging vital signs: *off-road vehicles* should be put under with *effects of park visitors on natural resources*; *extreme weather events* put under “*weather patterns*”;

and *human development* under *landscape dynamics*. The landscape group rated each one of vital signs that they recommended being incorporated into another vital sign a "0". This did not mean they felt it had no ecological significance or low feasibility score, but was merely a marker.

K.3.3 Wildlife

General Comments

Southwestern willow flycatcher: The group was split between 3 & 4 score for ecological significance. A more significant species would be to monitor yellow-billed cuckoo. The cost effectiveness score was based on abundance & distribution parameters only.

Mountain plovers: This species prefers fallow fields, "beat-up" habitats; often associated with prairie dog towns and is really being affected on their wintering grounds, esp. in CA. The vital signs should consider productivity in areas around parks, not just in the park lands. We don't really know what is causing decline, although the impacts to prairie-dog towns are a factor. Presence /absence data may be the best that can be accomplished because the species is found at such low densities across the landscape. With chicks, move in taller vegetation areas adjacent to nest sites. Productivity & survival may be important at park level vs. using patch-scale/regional breeding bird surveys, but more expensive.

Bald eagle: score based on wintering range.

Black-tailed prairie dogs: The scores are based on tracking distribution & size of towns over landscape, not density within a particular town.

Swift fox: They could be an indicator of changing carnivore communities (interspecies interaction with coyotes). The cost effectiveness score is based on doing distribution vs. recruitment or other demographic parameters.

Townsend's big-eared bat: The group didn't have the expertise to make an educated guess on how to score the importance of this species. At least protect the known maternity/roost sites where this occurs at Capulin Volcano NM. It is important to have a better understanding of distribution & species occurrence of bats in general. Wind farms are an issue.

Ferruginous hawk: Winter monitoring may be more important & linked to presence of other raptor species (i.e. Eagles). Potential research questions: fledging dispersal; migratory patterns (talk to RMBO folks).

Texas horned lizard: What are trends & distribution of primary prey, harvester ant species across the parks?

Should move this species into a reptile community vital sign.

Lesser prairie chicken: Species requires large areas of quality prairie habitat. Some in the group thought the habitat conditions may have passed a threshold.

Alberta arctic butterfly: This vital sign should be considered in new lepidoptera vital sign which are an indicator group for ecological changes. There are standard protocols already developed for monitoring butterflies. There was not enough expertise in the group to effectively score this vital sign.

Reptile community: The group feels the reptile/herp community is important to track. As a community, it may indicate problems with a particular situation (i.e. loss of short-grass prairies). Long-term monitoring of communities, any community is critical (decades vs. a few years). The sampling issues still need to be worked out. Bird abundance has a program DISTANCE/fixed radius point counts, etc.), but there are no counterparts for reptiles.

Bird communities: The existing monitoring protocols are specific to season & goals/objectives. By looking at communities, it provides improved data vs. single species monitoring or keystone/indicator species monitoring. Need to be specific at what techniques available, etc. You can't answer monitoring question two without breaking the bank.

Raccoons: This was not viewed as a network-wide vital signs, rather an individual park integrated pest management issue.

Large carnivores: The group did not consider coyotes as large carnivore; they are not a good indicator of the ecologic role of large carnivores. Coyotes were included in the medium sized carnivore vital sign.

Endemic and keystone invertebrates: Network should consider selecting groups of invertebrates that have well-established monitoring/sampling protocols. Narrow the scope of interest. The intent is admirable, but can you really identify keystone invertebrates in this system?

Insect diseases/outbreaks on ecosystem: Assumed looking at extent of damage & not individual/quantitative leaf-area damage.

Effects of wildlife diseases: A number of diseases can have impact on wildlife populations & impact visitors, i.e., chronic wasting disease, West Nile virus, plague, etc. This is important for park staff to be aware of the potential diseases in their area, who to contact, symptoms, collection of sample materials, etc. Wildlife disease may be more of the stressor in the system vs. the vital sign to monitor. It

could be an annual reporting requirement (vital sign) of the parks, but there may not be a systematic monitoring program developed.

Feral dogs: Feral dogs/hogs/fire ants - vertebrate or invertebrate exotic species may be a better category of a vital sign. Dogs are also a big problem at CHIC.

Fire ants: We are considering imported fire ants, not native species.

Nutria: Don't expect nutria to be a problem in this network. Recommend close communication with state agencies, etc. to see if species is expanding its range.

Hunting/game animals: Getting handle on hunting pressures/take on game species needs to occur. Sounds like a permit system may need to be enacted. Issue hunter "cards", mail-in surveys, etc. Estimate of hunting pressure could be extrapolated to adjacent areas. Quantification of hunter pressure may be an important first step.

Effects of park visitors on natural resources: This is a stressor & not an effect.

New Vital Signs

This group added five new vital signs, *butterflies*, *native pollinators*, *yellow-billed cuckoo*, *wintering raptors*, and *grasshoppers*.

Butterflies were considered to be very sensitive to management actions and they may not be able to recolonize once extirpated. Would serve as a good indicator of prairie health. From monitoring perspective, the monitoring protocols that currently exist are reliable for detecting trends over time. Rare, endangered species (this includes the Alberta arctic butterfly) will be picked-up in these types of monitoring protocols. Lepidoptera group has existing monitoring protocols & this group are host specialists with plants that are sensitive to climate change. Small isolated parks sensitive to habitat & climate changes. These parks may serve as refugia. Taxonomy is fairly stable. They may also provide subtle info on climate change.

Native pollinators are a functionally very important group, but as a group may be difficult to monitor because of the diversity (wasps, bees, moths, flies, beetles, hummingbirds, etc.). These vital signs would really be looking at plants via seed set/recruitment before these specific host plants suffer significant declines.

Yellow-billed cuckoos are extirpated from significant portion from most of its western range, "common" in the east. A species of concern in NM's wildlife strategies implementation plan & NM's PIF plan. May be a better indicator species than southwestern willow flycatcher; it's a riparian

obligate in the western portion of its range. This species should be incorporated into sampling designs in the Bird Communities Vital Sign.

Wintering raptors could be incorporated into bird community vital signs. Potentially monitoring for contaminants may need to be considered in the prey species of raptors, as well as submit dead raptors to the USGS National Wildlife Health Lab in Madison, WI.

Grasshoppers are an alternative indicator for insect outbreaks vital sign. There is high interest to "neighbors" & other agencies (APHIS, ARS, others). Need to look at outbreak insect species in grasslands vs. forest/woodland situations. A lot of vegetation is eaten by grasshoppers. If keeping a database, you can get an indication when the next outbreak may occur. Looking for variability to be able to predict outbreaks. Weather explains approx. 25% of the variation in outbreaks. Number of data sets out there via APHIS.

Merging Suggestions

Ferruginous hawks, *bald eagles*, and *Mississippi kites* should all be under a new vital sign, *wintering raptors*.

K.3.4 Aquatic Resources

General Comments

Exotic fish: This is redundant with fish communities, it is a subset. If monitoring was done independent of the whole community, it can be cost prohibitive.

Exotic plants: Insure that exotic plants are all vegetation protocols. This vital sign can have additional costs due to focusing only on exotic plants.

Effects of park visitors on natural resources: This is the cause and not the effect. It is an indicator of the magnitude of a stressor. This could be linked to a number of vital signs. Consider renaming this to "number of visitors". Visitor numbers can correlate to effects on park resources.

Flooding processes along streams/rivers/lakes: This is redundant with water quantity. Stream geomorphology might be a better name. The lake component is unnecessary.

Fecal coliform: This is no longer considered the most appropriate for surface water. E.coli is being used instead. Fecal coliform is now used for ground water. This vital sign should be incorporated into water quality.

Amphibian communities: Focus on anurans, not so much salamanders (frogs and toads more reliable, easier to have citizen science involved).

Merging Suggestions

The aquatic group thought that *off-road vehicles* should be merged with *effects of park visitors on natural resources*. *Wetlands vegetation*, *riparian vegetation*, and *grassland vegetation*, *exotic plants (by area)*, should be merged into one new vital sign *vegetation communities*. However, the early detection of exotic plants should be a stand alone vital sign. *Arkansas darter*, *Arkansas river shiner*, *fishing* and *exotic fish* should all be incorporated into *fish communities*. *Sedimentation rates* should fit under erosion. *E. coli (Fecal coliform)* should fit under water quality.

K.4 DAY 2 – ESSENTIAL VITAL SIGNS

On the second day, the prioritized list of vital signs by each criterion and by total score was presented (Tables K.3-6). Vital signs that were rated in the top 25% were then given back to each workgroup for two final assignments. Each workgroup was asked if they felt there were any essential vital signs that were missing from the top 25%. The workgroup was also asked to brainstorm for potential existing protocols, existing monitoring programs, and potential partners for each one of the top vital signs. They were asked to brainstorm on vital signs that their group had reviewed the previous day first, and then go to any other vital signs in the top 25%. A summary of comments for each workgroup is below.

K.4.1 Plants and Soils

Essential Vital Signs

The group did not think that there were any essential vital signs missing from the top 25%.

K.4.2 Landscape

Essential Vital Signs

The group thought that *human demographics* and *effects of park visitors on natural resources* were essential vital signs. *Human demographic data* is relatively easy to get and is very useful to predict changes to the landscape. Changes in human demographics can have major impacts to resources (fertilization, run-off, air quality, water demand, exotic plants and animals, noise, light, trash, visitation, etc.). *Effects of park visitors on natural resources* is important because the data is easy to get and useful to predict changes. Visitors can have impacts on many natural resources (exotic plants, social trails, erosion, sewage, traffic, noise, sticky fingers, park infrastructure, and off-road vehicles. Both vital signs

should take a landscape perspective with spatially explicit graphical representations of data.

K.4.3 Wildlife

Essential Vital Signs

The wildlife group thought that *black-tailed prairie dogs*, the *butterfly community*, and *fire ants* were essential components to monitor. *Black-tailed prairie dogs* are keystone species that by being present can increase the chances that other rare fauna are present. In addition the group thought that burrowing owls could also be monitored at the same time as prairie dogs. *Butterflies* are important because they are sensitive indicators and respond quickly to changes in the environment. By monitoring a suite of species, you could obtain information about park management, but also how this biotic component is responding to changes at a landscape level. *Fire ants* were deemed essential due to the high impact this exotic species can have on ground-nesting birds, small mammals, invertebrates, reptiles, and amphibians.

K.4.4 Aquatic Resources

Essential Vital Signs

The aquatic group felt thought both *lotic fish communities* and *aquatic macroinvertebrate communities* were essential vital signs. These vital signs are cheap to monitor, have well established protocols, and represent an important biotic component of water quality. The group also felt that monitoring *spring communities* was essential. This monitoring should include vegetation, rare fauna, and water quality/quantity issues. An inventory of historic and existing springs is essential.

K.5 POTENTIAL PROTOCOLS, PROGRAMS AND PARTNERS

K.5.1 Weather Patterns

Protocols

Drought Monitor (Drought Mitigation Center at UNL), John Gross working on protocols, Kelly Redmond at DRI is working on climate inventories

Programs

PRISM, NPS Fire Program, Texas Forest Service, Mesonet, LCRA

Partners

National I&M John Gross, NWS, Maidment from UT Env. Eng. (developer of ArchHydro), Drought Mitigation Center (UNL), Environmental Events (UT), US Weather Service, NOAA

K.5.2 Soil Budget*Protocols*

Expect NRCS & USDA will be best source

Programs

Brian Tyler at Fed Highways in Denver

Partners

Craig Allan (USGS) at Bandelier; NRCS; Gary Lehrs (ID) at USDA-ARS, Stephen F. Austin University

K.5.3 Soil Health*Protocols*

LTER Soils Manual Phil Robertson 1999 Oxford Press; Methods in Soil Science (book). NOTE: Health/Physical Properties and Soil Chemistry should be combined into one vital sign.

Programs

NRCS (Pete Biggams can point in right direction)

Partners

Pete Biggam (soil Scientist) at NPS; Lorenz Sutherland (BEOL area), Greg Allen (WABA area) at NRCS; Gene Kelly at CSU (good advice). Stephen F. Austin University

K.5.4 Water Quantity*Protocols*

USGS gauging Programs

Programs

USGS

Partners

USGS, State water boards, Texas Water Development Board (TWDB), groundwater districts, river authorities, BOR, Army Corps

K.5.5 Water Quality*Protocols*

EPA, USGS, TCEQ. Use dataloggers instead of point measurements (where possible)

Programs

Same as above

Partners

EPA, TCEQ and other state water quality commissions, river authorities

K.5.6 Groundwater Levels*Protocols*

USGS, TCEQ, Texas Water Development Board (both deep and shallow)

Programs

Same as above

Partners

Water development boards, environmental quality commissions, groundwater districts

K.5.7 Woody Invasive Species*Protocols*

Prescribed fire protocols – NRCS, parks themselves, USFS, State forest services

K.5.8 Exotic Plants*Protocols*

Ask Brad Welch; Cynthia Huebner (USGS) invasives & understory in eastern forest (comparing protocols); adaptive sampling; remote sensing; Konza LTER for woody plants; NoCo Plateau Network (Tom O'Dell) for weed mapping; No Great Plains – Chad Prosser

Programs

EPMT; FirePro

Partners

Kendall Young at Big Bend NP; Brad Welch for National Protocols; Craig Young at HTLN; see also "Grassland

Veg”; John Briggs at AZ State (formerly Konza); Diane Larson at USGS (NoPlains work); Mike Storey for Remote Sensing Stephen F. Austin University

K.5.9 Wetland Vegetation Communities

Protocols

NETN developing a set, Army Corps has identification protocols, EPA had new rapid assessment scorecard coming out (based on vegetation) – Can get from NETN

Programs

National Wetlands Inventory

Partners

TNC, NPS, USFWS

K.5.10 Riparian Vegetation Communities

Protocols

ERMN developing riparian veg protocol. Develop permanent transects. NRCS may have some available (involved with Pecos River tamarisk control) (Mike Meechia (check spelling) involved from Fort Stockton, Farm Service Agency or NRCS – ask Glenn Longley. “Proper Functioning Condition” protocol – Joel Wagner at NPS-WRD (online); BLM & USFS riparian assessments. COE Wetland Delineation; Ohio Dept of Natural Resources – (rapid assessment for wetland condition) Cayahoga Valley; HTLN may have expanded protocol info on Ohio DNR

Programs

Tamarisk removal initiative, FirePro, check with state Natural Heritage programs and Depts. of Natural Resources; National Wetland Inventory (NWI); USFWS manages wetlands

Partners

State, NRCS, USGS, TNC, BOR, Estevan Muldavin at NHHM; David Cooper at CSU, NRCS; Playa Lakes joint venture (USFWS); Joel Wagner, Kevin Noon – WRD; Society of Wetland Scientists webpage

K.5.11 Spring Communities

Protocols

Rapid bioassessment, would be a need because no specific ones exist right now

Partners

Texas State University

K.5.12 Grassland Vegetation Communities

Protocols

USFS, BLM, USGS plant community monitoring protocols, Heartland Veg Protocol; SGS LTER protocol; Forest Service FIA

Programs

Fire Pro, EPMT

Partners

TNC, Kelly Kindscher at Kansas Biological Survey; Jennifer DeLisle at KS Natural Heritage; John Blair at Konza Prairie LTER; Bill Lauenroth at SGS LTER; Scott Collins at Sevilleta LTER; Angie Evenden at NoCO Plateau Network; Amy Symstad at NoPlains Network. Stephen F. Austin University

K.5.13 Lotic Fish And Macroinvertebrate Communities

Protocols

USEPA rapid bio assessment, Index Biotic Integrity (IBI), Barbor et al. 1999, Texas has receiving water assessments manual (TCEQ), USGS NAWQA program, EPA biological condition gradient

Partners

State game and fish agencies

K.5.14 Amphibian Communities

Protocols

Amphibian and reptile monitoring initiative (ARMI), USGS, Frogwatch. ARMI protocol may not work very well in this region.; frog loggers; PARC

Programs

PARC, NMFWA (National Military Fish & Wildlife Association) Herp Working Group, state non-game departments, state heritage programs, areas universities, USGS ARMI

Partners

ARMI, TNC, Frogwatch, PARC, NMFWA Herp Working Group, state non-game departments, state heritage programs, area universities, USGS BRD, USFWS (refuges)

K.5.15 Bird Communities*Protocols*

HTLN Peitz & Fancy protocol; point transects stratified by habitat; BBS, MAPS, CBC, individual species (yellow-billed cuckoo, southwestern willow flycatcher, long-billed curlew, lesser prairie chicken, burrowing owl, ferruginous hawks); specific training to be able to identify key species; seasonal component (breeding & winter for wintering raptors)

Programs

BBS; Partners in Flight; BBS, CBC, MAPS, state PIF plans national PIF monitoring plan & protocols, MOSI (monitoring overwinter survival), Bald Eagle Watch, Avian Knowledge Network (Cornell OL), RMBO point transect program, state mourning dove counts, NM Burrowing Owl Working Group/surveys. Should review state PIF plans & state wildlife conservation strategy plans for habitats & species already identified for monitoring, state heritage Programs

Partners

Brett Sandercock at Konza; David Peitz at HTLN; David Hanni at Rocky Mountain Bird Observatory; Fritz Knopf at USGS(?) in CO; Larkin Powell at U of Nebraska, state game & fish depts., RMBO, Cornell, USGS, Audubon, Joint Ventures (Intermountain, Playa), Forest Service, USFWS, state PIF working groups, NM Burrowing Owl Work Group, Hawk Watch International, Institute for Bird Populations, Ducks Unlimited, Quail Unlimited, state wildlife federation chapters, area universities

K.5.16 Small Mammal Communities*Protocols*

CDC (rodent protocols), Allen O'Connell (USGS Patuxant) and Baccus do small mammal monitoring. Wildlife Techniques published by The Wildlife Society, mark/recapture, permanent trapline transects stratified by habitat; could tie into spot lighting surveys

Programs

LTER, LCTA (Land Condition Trend Analysis on DOD lands), area universities, state heritage Programs

Partners

Cheryl Schmidt at independent SD – surveys No Plains; Jennifer DeLisle at KS Biological Survey; Mike Bogan at USGS; UNM has good small mammal biologists; Lynn Robbins at MO State, state game & fish departments, ARS, DOD

K.5.17 Ungulates*Protocols*

spot light surveys, aerial surveys, 'drive' counts, distance sampling, check stations (age & sex ratios), could make note of other mammal species

Programs

state game & fish departments

Partners

The Big Texan, Kroll at SFA (white-tail); Sam Fuhlendorf (grazing) at OK State; Ben Bobowski at NPS; Bob Hamilton (TNC) at Tallgrass Prairie Preserve, state game & fish departments, Rocky Mountain Elk Foundation, Mule Deer Foundation, IUCN (bison genetics issues), state Wildlife Federation Chapters, area universities, local sporting groups, scouting organizations

K.5.18 Fire and Fuel Dynamics*Protocols*

Texas Agricultural Extension Unit, John Baccus from Texas State San Marcos, Fire PRO. Look at plot replication for determining fire effects/fuel load/other stuff. Address fuel load outside park units. Drought, Extreme Weather Events, Human Influence, Exotics, Abandoned Agriculture Lands, Removal of grazing all need to be considered. Fire Monitoring Handbook; Nested frequencies; HTLN veg protocol

Programs

Fire PRO, Land Fire, USFS Fire and Fire Surrogates Program, State Forestry Programs, GPCESU/DSCESU Fire History of Capulin, USGS – Fire History of the Great Plains, FirePro; USFS Fire Science in Boise

Partners

USFS, BLM, NPS, TNC, Federal Interagency Fire Program, Drought Mitigation Center (UNL), David Heartnet at Konza; Jim DeCoster, Linda Kerr at NPS fire ecologists; Kara Paintner at NPS fire/bio liaison; Cody Wienk at No

Great Plains fire ecologist; Dave Engel at Iowa State; Sam Fuhlendorf at OK State; Mark Paschke at CSU; Carlton Britton at TX Tech

K.5.19 Landscape Dynamics

Protocols

National Capitol region, John Gross WASO is developing LU/LC protocols. They should include SOPN lands and surrounding regions and should use human census/demographic data. The monitoring frequency may vary. Available for use: MODIS, ASTER, IKONOS, Quick Bird, LANDSAT, SPOT. Recommend development of time series of historical and projected future trends

Partners

USGS (MRLC), NASA, GAP, EPA, TNC, State Heritage Programs, National Wetland Inventories, State Resource Surveys, USDA (NAIP), Ducks Unlimited, NOAA, Jim Merchant at CALMIT; Kevin Price at U of KS; Andy Hansen at Montana State; Robert Weih at U of Arkansas-Monticello; David Kulhavy at SFA

K.5.20 Human Demographics

Protocols

GCCESU already working on this, spatially explicit graphical representations, Landscape perspective (not just numbers)

Programs/Partners

US Census econ/soc/demo data, Jim Gramann, NPS, Visitor Survey Program

K.5.21 Viewshed

Protocols

DSC (planning), USFS (scenic beauty estimation method), Planning team at Sand Creek, NPS Air resources division (class I parks), Cell Towers/Wind Farms/Utilities (EIS Statements)

Partners

State Historical Preservation Offices

K.6 VITAL SIGNS PRIORITIZATION WORKSHOP – SCORING CRITERIA

K.6.1 Management Significance (40%) – Ranked by parks prior to workshop

Criteria and Scoring

The final score is the average of all of the park's scores. Each park will state that they agree or disagree for the following 8 statements for each vital sign. The database will use these responses to calculate the score from 1 to 5. The final management significance score will be the average of the score for all 11 parks. The statement are as follows:

1. There is an obvious, direct application of the data to a key management decision, or for evaluating the effectiveness of past management decisions.
 2. Monitoring results are likely to provide early warning of resource impairment, and will save park resources and money if a problem is discovered early.
 3. The vital sign is of high importance to park natural resource management goals.
 4. Data are of high interest to the public.
 5. There is an obvious, direct application of the data to performance (GPRA) goals.
 6. Data are needed to give managers a better understanding of park resources so that they can make informed decisions. Contributes to increased understanding that ultimately leads to better management.
 7. Parks are required to monitor this resource by legal mandate or identification in major park planning document. Examples might include species that are federally listed as endangered or threatened, are in the park's enabling legislation, or are an issue/species that is a major management concern.
 8. 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.
-

The final score is tabulated based on total number of statements the reviewer agreed with and is broken down as follows:

- 5 = Agrees with 7-8 statements
- 4 = Agrees with 5-6 statements
- 3 = Agrees with 3-4 statements
- 2 = Agrees with 2 statements
- 1 = Agrees with 1 statement
- 0 = Does not agree with any statements

K.6.2 Ecological Significance (40%) – Ranked at workshop, mostly by experts

Criteria and Scoring

The facilitator will shoot for a consensus score. If consensus cannot be reached, the facilitator will ask each member of the group for their score and the average will be taken. On the database the notetaker will enter a number (with up to 1 decimal place) for the ecological significance score.

1. 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).
2. 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.]
3. The vital sign responds to change in a predictable and explainable manner.
4. The vital sign has low natural variability (high signal to noise ratio).
5. There are reference conditions that exist within the region and/or threshold values that could be determined to assess deviance from a natural condition.
6. 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.]
7. 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 is tabulated based on total number of statements the reviewer agreed with and is broken down as follows:

- 5 = Agree with 6-7 statements
- 4 = Agree with 4-5 statements
- 3 = Agree with 3 statements
- 2 = Agree with 2 statements
- 1 = Agree with 1 statement
- 0 = Do not agree with any statement

K.6.3 Cost of Implementation and Feasibility (20%) – Ranked at workshop, mostly by experts

Criteria and Scoring

The facilitator will shoot for a consensus score. If consensus cannot be reached, the facilitator will ask each member of the group for their score and the average will be taken. On the database the notetaker will enter a number (with up to 1 decimal place) for the cost of implementation and feasibility score.

1. The cost of monitoring the vital sign is not prohibitive. Consider all costs such as capital equipment, data collection, and analysis.
2. The methods for the vital sign well established, repeatable, and are widely used and accepted.
3. The vital sign is being monitored by other entities so that efficiencies can be realized in data acquisition, analysis, or other means.
4. The methods of monitoring the vital sign are subject to limited human error, including errors due to different observers.
5. The sampling will have limited negative impact on park resources.

The final score is tabulated based on total number of statements the reviewer agreed with and is broken down as follows:

- 5 = Agree with 5 statements
- 4 = Agree with 4 statements
- 3 = Agree with 3 statements
- 2 = Agree with 2 statements
- 1 = Agree with 1 statement
- 0 = Do not agree with any statement

Table K.1 List of workshop participants. (F) denotes the facilitator and (N) denotes the notetaker for each workgroup

Participants by Workgroup		
Person	Organization	Expertise
Plants and Soils Group		
Mike DeBacker (F)	National Park Service – Heartlands I+M Network	Prairie vegetation, long-term monitoring
Tomye Folts Zettner (N)	Texas A+M Graduate Student	Vegetation
Tim Seastedt	University of Colorado	Soils, invasive plants, long-term monitoring
Brad Welch	National Park Service	Invasive plants
Pam Benjamin	National Park Service	Vegetation
James Stubbendieck	University of Nebraska	Grasslands
Alan Knapp	Colorado State University	Grassland vegetation, global climate change, monitoring
Karie Cherwin	Southern Plains Associate	Soils, restoration
Fran Pannebaker	Bent's Old Fort NHS	Chief of Natural Resources
Brian Quigley	Capulin Volcano NM	Chief Ranger
Ted Benson	Pecos NHP	Ranger, Natural Resources
Felix Revello	Fort Larned NHS	Chief Ranger
Wildlife Group		
Dan Licht (F)	National Park Service – Northern Great Plains Network	Grassland vertebrates, long-term monitoring
Hildy Reiser (N)	National Park Service – Chihuahuan Network	Desert ecology, long-term monitoring
Roel Lopez	Texas A+M University	Wildlife Ecology, GPS, GIS
Anthony Joern	Kansas State University	Grazing, bison, invertebrates
David Hanni	Rocky Mountain Bird Observatory	Grassland birds
Jeff Kelly	University of Oklahoma	Vertebrate Ecology
Ray Matlack	West Texas A+M	Mammalian ecology
John Hughes	US Fish and Wildlife Service	Grazing, burning, vertebrates
Steve Burrough	Chickasaw NRA	Chief of Resource Management
Arlene Wimer	Lake Meredith NRA / Alibates Flint Quarries NM	Environmental Specialist
Aquatic Resources Group		
Greg Shriver (F)	University of Delaware	Long-term monitoring, avian ecology
Heidi Sosinski (N)	Southern Plains Network	Data Manager
Tim Bonner	Texas State University	Fish, stream ecology
Kevin Noon	National Park Service	Wetland Ecology
Don Huggins	University of Kansas	Aquatic ecology, entomology
Glen Longley	Texas State University	Edwards Aquifer Water Quality
Matt Whiles	Southern Illinois University	Vertebrates, stream ecology
Melissa Trammell	National Park Service – Intermountain Region	Fisheries
Paul Eubank	Lake Meredith NRA / Alibates Flint Quarries NM	Chief of Resource Management
Landscape Issues Group		
Dan Tinker (F)	University of Wyoming	Conceptual modeling, forest ecology
Jason Lott (N)	Lyndon B. Johnson NHP	Integrated Resource Specialist
Michael Huston	Texas State University	Landscape ecology
Mike Story	National Park Service	Remote sensing
Kathy Tonnessen	NPS – Rocky Mountain Cooperative Ecosystems Studies Unit	Air Quality
Gillian Bowser	NPS – Gulf Coast Cooperative Ecosystems Studies Unit	Genetics, vertebrate landscape ecology
Gary Willson	NPS – Great Plains Cooperative Ecosystems Studies Unit	Grasslands, fire
Doug Goodin	Kansas State University	Climate, remote sensing
Carol Wessman	University of Colorado	Landscape ecology, woody invasion
Alexa Roberts	Sand Creek Massacre NHS	Superintendent
Tulia DeFex	Texas A+M Graduate Student	Landscape dynamics
Floaters		
Karren Brown	Lake Meredith NRA / Alibates Flint Quarries NM	Superintendent
Dusty Perkins	Southern Plains Network	Network Coordinator

Table K.2 List of vital signs reviewed at the prioritization workshop. The list includes 74 vital signs on the original list and 6 new vital signs that were added at the workshop for a total of 80 vital signs. Vital signs in *italics* were added at the workshop

Southern Plains Network Potential Vital Signs							
The following list represents SOPN's potential vital signs organized into the NPS Ecological Monitoring Framework. This framework is a systems-based, hierarchical, organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in ecological monitoring. Vital signs selected by parks and networks for monitoring are assigned to the Level 3 category that most closely pertains to that vital sign.							
Level 1	Level 2	Level 3	Vital Sign	Plants/ Soils	Wildlife	Aquatic Resources	Landscape / Other
Air and Climate	Air Quality	Wet and Dry deposition	Wet and dry deposition				•
		Visibility and Particulate matter	Visibility and particulate matter				•
	Weather and Climate	Weather and Climate	Weather patterns				•
			Carbon balance in soil	•			•
Geology and Soils	Geomorphology	Stream/River Channel Characteristics	Erosion – slopes, lakeshores, banks			•	
		Hillslope Features and Processes	Volcanic cinder cone	•			
	Soil Quality	Soil Function and Dynamics	Soil health	•			
			Cryptobiotic soils	•			
			Erosion index	•			
Water	Hydrology	Groundwater Dynamics	Groundwater levels			•	
		Surface Water Dynamics	Water quantity			•	
			Flooding processes along river/ stream/ lake			•	
			Sedimentation rates			•	
	Water Quality	Water Chemistry	Water quality			•	
		Toxics	Fecal coliform			•	
			Contaminants in fishery/food chain			•	
		Aquatic Macro-invertebrates and Algae	Aquatic invertebrates (riverine systems)			•	

Table K.2 List of vital signs reviewed at the prioritization workshop (continued)

Level 1	Level 2	Level 3	Vital Sign	Plants/ Soils	Wildlife	Aquatic Resources	Landscape / Other
Biological Integrity	At-risk Biota	T&E Species and communities	Bald Eagle		•	•	
			Arkansas river shiner			•	
			Arkansas darter			•	
			Alberta Arctic butterfly		•		
			Black-tailed prairie dogs		•		
			Burrowing Owl		•		
			Ferruginous hawk		•		
			Lesser prairie chicken		•		
			Mountain plover		•		
			Southwestern willow flycatcher		•		
			Swift fox		•		
			Texas horned lizard		•		
			Townsend's big-eared bat		•		
			<i>Yellow-billed cuckoo</i>		•		
	Focal Species or Communities	Wetland Communities	Upland springs – vegetation communities	•		•	
			Wetlands – vegetation communities	•		•	
		Riparian Communities	Riparian community – vegetation communities	•		•	
		Freshwater Communities	Lacustrine community – Plankton richness, abundance, and diversity			•	
		Grassland/Herbaceous Communities	Grassland Vegetation	•			
		Vegetation Communities	Non-vascular plants	•			•
			Montane/grassland ecotone	•			•
		Birds	Bird Communities		•		
			Migratory stopover area		•		

Table K.2 List of vital signs reviewed at the prioritization workshop (continued)

Level 1	Level 2	Level 3	Vital Sign	Plants/ Soils	Wildlife	Aquatic Resources	Landscape / Other
Biological Integrity	Focal Species or Communities	Birds	Mississippi kites		•		
			Wintering Raptors		•		
		Mammals	Large carnivores		•		
			Medium-sized (meso) carnivores		•		
			Small mammal communities		•		
			Raccoons		•		
			Ungulates		•		
		Fish	Fish communities (riverine systems)			•	
	Terrestrial Invertebrates	Endemic + keystone invertebrates		•	•		
			<i>Butterflies and Moths</i>		•		
			<i>Grasshoppers</i>		•		
			<i>Native Pollinators</i>		•		
	Amphibians and reptiles	Reptile community			•		
			Amphibian Community		•	•	
	Invasive/Exotic plants	Woody invasive species		•			
			Exotic plants	•		•	
	Invasive Species	Invasive/Exotic animals	Zebra mussels			•	
			Nutria		•	•	
			Exotic Fish			•	
			Exotic ungulates		•		
			Feral Dogs		•		
			Feral Hogs		•		
			Fire Ants		•		
	Infestations and disease	Insect pests	Insect diseases/ outbreaks on ecosystem	•	•		•

Table K.2 List of vital signs reviewed at the prioritization workshop (continued)

Level 1	Level 2	Level 3	Vital Sign	Plants/ Soils	Wildlife	Aquatic Resources	Landscape / Other
Biological Integrity	Infestations and disease	Animal diseases	Effects of wildlife diseases		•		•
		Plant Diseases	<i>Plant Pathogens</i>				•
Human Use	Consumptive Use	Consumptive Use	Mineral, oil, and gas extraction				•
			Hunting / Game animals		•		
			Fishing			•	
	Visitor and Recreation Use	Visitor usage	Effects of park visitors on natural resources	•	•	•	•
			Off-road vehicle use	•	•	•	•
	Non-point source human effects	Non-point source human effects	Demographic data				•
Landscapes (Ecosystem Patterns and Processes)	Viewscape	Viewscape/Night Sky	Viewshed				•
			Night sky				•
	Fire	Fire and Fuel Dynamics	Fire and fuel dynamics	•			•
	Landscape Dynamics	Landscape Dynamics	Landscape dynamics				•
Landscapes (Ecosystem Patterns and Processes)	Landscape Dynamics	Landscape Dynamics	Human Development (Road density, impervious cover, house density)				•
	Extreme disturbance events	Extreme disturbance events	Tornadoes, record floods, ice storms				•
	Soundscape	Soundscape	Soundscape				•

Table K.3 Management significance ranking results (sorted by average score).

Potential Vital Sign	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Exotic plants	4.55	4	4	5	5	5	5	4	4	5	4	5
Grassland Vegetation	4.45	4	4	5	5	5	4	3	5	4	5	5
Woody invasive species	4.09	4	4	5	5	3	4	4	4	4	3	5
Fire and fuel dynamics	3.91	0	3	5	5	4	3	4	5	4	5	5
Bird Communities	3.82	3	3	5	4	3	4	3	4	4	5	4
Ungulates	3.45	4	1	4	5	2	2	3	5	4	5	3
Riparian community – vegetation communities	3.45	4	4	0	5	4	0	3	4	4	5	5
Water quantity	3.36	0	4	0	5	3	4	4	4	4	4	5
Viewshed	3.18	3	4	3	3	4	3	0	4	4	4	3
Effects of park visitors on natural resources	3.09	3	0	2	5	0	4	3	4	4	4	5
Small mammal communities	3.00	2	3	4	5	0	4	2	3	4	3	3
Erosion – slopes, lakeshores, banks	2.91	0	1	5	4	4	4	0	3	4	4	3
Water quality	2.91	0	2	0	5	2	3	4	5	5	3	3
Groundwater levels	2.73	0	4	1	5	2	3	0	3	3	4	5
Reptile community	2.64	2	2	3	4	0	3	3	3	3	2	4
Wetlands – vegetation communities	2.64	0	4	0	5	0	3	0	3	4	5	5
Weather patterns	2.55	4	3	3	2	1	3	2	4	3	3	0
Amphibian Communities	2.55	2	2	0	4	2	3	3	3	3	2	4
Soil budget (inflow/outflow)	2.55	0	2	3	3	4	2	0	3	2	4	5
Erosion index	2.55	0	2	4	3	3	2	0	3	2	4	5
Migratory stopover area	2.45	2	3	3	4	0	2	2	3	3	5	0
Soil health	2.45	0	2	4	3	0	3	0	3	3	4	5
Night sky	2.45	2	2	3	0	0	3	3	4	3	2	5
Flooding process along river / stream / lake	2.36	0	4	0	3	3	0	0	4	3	4	5
Landscape dynamics	2.27	0	2	0	5	3	1	0	3	3	3	5
Soundscape	2.27	2	1	1	4	0	2	3	3	2	2	5
Human Development	2.09	0	1	0	5	2	3	0	3	4	2	3
Wet and dry deposition	2.00	2	3	5	1	0	0	0	2	0	4	5
Medium-sized (meso) carnivores	2.00	2	1	4	3	0	2	0	2	3	2	3
Effects of Wildlife diseases	2.00	0	2	3	4	0	3	0	4	3	3	0
Fecal Coliform	2.00	0	1	0	5	1	0	4	4	1	3	3
Upland springs – vegetation communities	1.91	0	1	0	5	0	2	0	3	2	3	5
Human Demographic data	1.91	0	1	2	5	3	1	0	3	4	2	0
Insect diseases / outbreaks on ecosystem	1.82	0	2	3	4	0	1	0	4	4	2	0
Visibility and particulate matter	1.73	2	2	5	1	0	1	2	2	1	2	1
Carbon balance in soil	1.73	0	3	0	3	0	2	0	0	2	4	5
Texas horned lizard	1.73	3	1	0	4	0	1	3	3	1	0	3
Fish communities (riverine systems)	1.73	2	2	0	4	0	0	0	3	3	2	3

Table K.3 Management significance ranking results (continued)

Potential Vital Sign	Average Score	ALFL	BEOL	CAVO	CHIC	FOLS	FOUN	LAMR	LYJO	PECO	SAND	WABA
Large carnivores	1.73	0	1	4	3	0	2	0	2	4	0	3
Aquatic invertebrates (riverine and palustrine systems)	1.73	0	2	0	4	0	0	0	4	2	2	5
Contaminants in fishery/food chain	1.73	0	1	0	5	0	0	3	3	4	0	3
Endemic and keystone invertebrates (terrestrial systems)	1.55	0	2	3	3	0	1	0	2	1	2	3
Black-tailed prairie dogs	1.45	0	4	0	0	5	2	0	0	0	5	0
Cryptobiotic soils	1.36	0	0	0	4	0	1	0	0	2	3	5
Tornadoes, record floods, ice storms	1.36	0	3	0	3	0	1	0	4	1	3	0
Bald Eagle	1.27	2	0	2	3	0	0	0	3	3	1	0
Mississippi kites	1.27	3	1	0	4	0	0	3	0	0	0	3
Montane / grassland ecotone	1.27	0	0	5	0	0	3	0	0	1	0	5
Mineral, oil, and gas extraction	1.27	4	0	0	0	0	0	4	0	0	2	4
Sedimentation rates	1.27	0	3	0	3	0	0	0	4	1	0	3
Ferruginous hawk	1.09	2	1	0	0	0	2	0	0	2	5	0
Non-vascular plants	1.09	0	0	4	1	0	1	0	2	1	0	3
Feral Hogs	1.09	0	0	0	5	0	0	0	2	0	5	0
Fishing	1.09	0	1	0	5	0	0	0	2	4	0	0
Exotic Fish	1.00	0	1	0	5	0	0	0	3	2	0	0
Mountain plover	0.91	2	0	0	0	0	0	0	0	3	5	0
Burrowing Owl	0.91	2	1	0	1	0	1	0	0	0	5	0
Feral Dogs	0.91	0	0	0	4	0	0	0	2	4	0	0
Fire Ants	0.91	0	0	0	5	0	0	0	5	0	0	0
Exotic ungulates	0.82	0	0	0	4	0	0	0	5	0	0	0
Hunting / Game animals	0.82	0	0	0	5	0	0	4	0	0	0	0
Arkansas darter	0.73	0	2	0	1	0	0	0	0	0	5	0
Lesser prairie chicken	0.73	0	0	0	0	0	0	0	0	0	5	3
Lacustrine community	0.73	0	0	0	5	0	0	2	0	1	0	0
Raccoons	0.73	0	1	0	5	0	0	0	2	0	0	0
Arkansas river shiner	0.64	3	0	0	0	0	0	4	0	0	0	0
Swift fox	0.55	0	1	0	0	0	0	0	0	0	5	0
Zebra mussels	0.55	0	0	0	4	0	0	0	2	0	0	0
Nutria	0.55	0	0	0	3	0	0	0	3	0	0	0
Off-road vehicle use	0.55	0	0	0	2	0	0	4	0	0	0	0
Southwestern willow flycatcher	0.45	2	0	0	0	0	0	0	0	3	0	0
Townsend's big-eared bat	0.45	0	1	4	0	0	0	0	0	0	0	0
Alberta Arctic butterfly	0.45	0	0	5	0	0	0	0	0	0	0	0
Volcanic cinder cone	0.45	0	0	5	0	0	0	0	0	0	0	0

Table K.4 Ecological significance scoring results. “NR” denotes the item was not actually ranked due to lack of expertise with that particular vital sign.

Score	Potential Vital Sign
5.00	Soil health
5.00	Water quality
5.00	Groundwater levels
5.00	Weather patterns
5.00	Riparian community – vegetation communities
5.00	Woody invasive species
5.00	Landscape dynamics (land cover, condition, connectivity, pattern, land change)
5.00	Fire and fuel dynamics
5.00	Wet and dry deposition
5.00	Wetlands – vegetation communities
5.00	Water quantity
5.00	Volcanic cinder cone
5.00	Grassland Vegetation
5.00	Fish communities (riverine systems)
5.00	Human Demographic data (human density, traffic volume, land ownership patterns, land value)
5.00	Lesser prairie chicken
5.00	Amphibian Communities
5.00	Aquatic invertebrates (riverine and palustrine systems)
5.00	Soil budget (inflow/outflow)
5.00	Yellow-billed cuckoo
4.75	Bird Communities
4.70	Plant Pathogens
4.50	Insect diseases / outbreaks on ecosystem
4.50	Small mammal communities
4.50	Upland springs – vegetation communities
4.50	Ungulates

Score	Potential Vital Sign
4.50	Fire Ants
4.00	Arkansas river shiner
4.00	Lacustrine community – Plankton richness, abundance, and diversity
4.00	Arkansas darter
4.00	Ferruginous hawk
4.00	Large carnivores
4.00	Feral Hogs
4.00	Black-tailed prairie dogs
4.00	Exotic plants
4.00	Visibility and particulate matter
4.00	Other native pollinators
4.00	Lepidoptera
4.00	Mineral, oil, and gas extraction
4.00	Cryptobiotic soils
4.00	Sedimentation rates
4.00	Carbon balance in soil
4.00	Erosion – slopes, lakeshores, banks
4.00	Flooding process along river / stream / lake
4.00	Viewshed
4.00	Texas horned lizard
3.90	Soundscape
3.75	Burrowing Owl
3.70	Night sky
3.60	Effects of Wildlife diseases
3.50	Southwestern willow flycatcher
3.50	Grasshoppers

Table K.4 Ecological significance scoring results. (continued)

Score	Potential Vital Sign	Score	Potential Vital Sign
3.50	Montane / grassland ecotone	1.00	Feral Dogs
3.38	Effects of park visitors on natural resources	1.00	Fecal Coliform
3.00	Exotic ungulates	1.00	Nutria
3.00	Mountain plover	1.00	Hunting / Game animals
3.00	Wintering raptors	0.75	Raccoons
2.00	Zebra mussels	0.50	Off-road vehicle use
1.50	Mississippi kites	0.50	Migratory stopover area
1.50	Endemic and keystone invertebrates (terrestrial systems)	0.50	Bald Eagle
1.50	Medium-sized (meso) carnivores	0.00	Fishing
1.50	Swift fox	0.00	Erosion index
1.50	Reptile community	0.00	Contaminants in fishery/food chain
1.00	Exotic Fish	0.00	Tornadoes, record floods, ice storms
1.00	Non-vascular plants	0.00	Human Development (Road density, impervious cover, house density)

Table K.5 Feasibility and cost of implementation scoring results. “NR” denotes the item was not actually ranked due to lack of expertise with that particular vital sign.

Score	Potential Vital Sign	Score	Potential Vital Sign
5.00	Burrowing Owl	5.00	Fishing
5.00	Fecal Coliform	5.00	Lesser prairie chicken
5.00	Water quantity	5.00	Zebra mussels
5.00	Water quality	5.00	Bird Communities
5.00	Groundwater levels	5.00	Arkansas darter
5.00	Fire Ants	5.00	Ferruginous hawk
5.00	Weather patterns	5.00	Swift fox
5.00	Woody invasive species	5.00	Black-tailed prairie dogs
5.00	Wetlands – vegetation communities	5.00	Arkansas river shiner
5.00	Montane / grassland ecotone	5.00	Mississippi kites

Table K.5 Feasibility and cost of implementation scoring results (continued)

Score	Potential Vital Sign	Score	Potential Vital Sign
5.00	Bald Eagle	4.00	Exotic Fish
5.00	Southwestern willow flycatcher	4.00	Non-vascular plants
5.00	Mineral, oil, and gas extraction	4.00	Sedimentation rates
5.00	Lacustrine community	4.00	Contaminants in fishery/food chain
5.00	Grassland Vegetation	4.00	Visibility and particulate matter
5.00	Yellow-billed cuckoo	4.00	Wet and dry deposition
5.00	Lepidoptera	4.00	Fire and fuel dynamics
5.00	Amphibian Communities	4.00	Feral Dogs
5.00	Human Demographic data	3.50	Large carnivores
5.00	Ungulates	3.50	Nutria
5.00	Fish communities (riverine systems)	3.50	Medium-sized (meso) carnivores
5.00	Aquatic invertebrates (riverine and palustrine systems)	3.33	Effects of park visitors on natural resources
5.00	Soil health	3.00	Wintering raptors
5.00	Soil budget (inflow/outflow)	3.00	Mountain plover
5.00	Landscape dynamics	3.00	Other native pollinators
4.80	Viewshed	3.00	Cryptobiotic soils
4.50	Upland springs – vegetation communities	3.00	Raccoons
4.50	Grasshoppers	3.00	Exotic ungulates
4.50	Riparian community – vegetation communities	3.00	Texas horned lizard
4.50	Exotic plants	2.50	Night sky
4.50	Small mammal communities	2.25	Effects of Wildlife diseases
4.50	Migratory stopover area	2.00	Reptile community
4.33	Insect diseases / outbreaks on ecosystem	1.00	Soundscape
4.30	Plant Pathogens	1.00	Endemic and keystone invertebrates (terrestrial systems)
4.05	Carbon balance in soil	0.75	Off-road vehicle use
4.00	Feral Hogs	0.00	Human Demographic data (human density, traffic volume, land ownership patterns, land value)
4.00	Erosion – slopes, lakeshores, banks	0.00	Erosion index
4.00	Volcanic cinder cone	0.00	Tornadoes, record floods, ice storms
4.00	Hunting / Game animals	NR	Alberta Arctic butterfly
4.00	Flooding process along river / stream / lake	NR	Townsend's big-eared bat

Table K.6 Final vital signs prioritization list. Vital signs in bold text represent the top 25%.

Potential Vital Sign	Total Score	Management Significance	Ecological Significance	Cost Effectiveness and Feasibility
Grassland Vegetation	4.78	4.45	5.00	5.00
Woody invasive species	4.64	4.09	5.00	5.00
Bird Communities	4.42	3.81	4.75	5.00
Fire and fuel dynamics	4.36	3.90	5.00	4.00
Water quantity	4.34	3.36	5.00	5.00
Exotic plants	4.32	4.54	4.00	4.50
Riparian community – vegetation communities	4.28	3.45	5.00	4.50
Ungulates	4.18	3.45	4.50	5.00
Water quality	4.16	2.90	5.00	5.00
Groundwater levels	4.09	2.72	5.00	5.00
Wetlands – vegetation communities	4.05	2.63	5.00	5.00
Soil budget (inflow/outflow)	4.02	2.54	5.00	5.00
Weather patterns	4.02	2.54	5.00	5.00
Amphibian Communities	4.02	2.54	5.00	5.00
Soil health	3.98	2.45	5.00	5.00
Landscape dynamics (land cover, condition, connectivity, pattern, land change)	3.91	2.27	5.00	5.00
Small mammal communities	3.90	3.00	4.50	4.50
Viewshed	3.83	3.18	4.00	4.80
Human Demographic data (human density, traffic volume, land ownership patterns, land value)	3.76	1.90	5.00	5.00
Aquatic invertebrates (riverine and palustrine systems)	3.69	1.72	5.00	5.00
Fish communities (riverine systems)	3.69	1.72	5.00	5.00
Wet and dry deposition	3.60	2.00	5.00	4.00
Erosion – slopes, lakeshores, banks	3.56	2.90	4.00	4.00
Yellow-billed cuckoo	3.56	1.40	5.00	5.00
Lepidoptera	3.56	2.40	4.00	5.00
Upland springs – vegetation communities	3.46	1.90	4.50	4.50
Insect diseases / outbreaks on ecosystem	3.39	1.81	4.50	4.33
Plant Pathogens	3.38	1.60	4.70	4.30
Flooding process along river / stream / lake	3.34	2.36	4.00	4.00

* vital sign was scored a 0 by the landscape group because they felt it was incorporated by another vital signs.

^ vital sign was scored a 0 by the plants and soils group because they felt it was incorporated by another vital signs.

NR denotes the item was not ranked due to lack of expertise with the particular vital sign.

Table K.6 Final vital signs prioritization list. (continued)

Potential Vital Sign	Total Score	Management Significance	Ecological Significance	Cost Effectiveness and Feasibility
Other native pollinators	3.28	2.70	4.00	3.00
Lesser prairie chicken	3.29	0.72	5.00	5.00
Effects of park visitors on natural resources	3.25	3.09	3.38	3.33
Grasshoppers	3.18	2.20	3.50	4.50
Black-tailed prairie dogs	3.18	1.45	4.00	5.00
Fire Ants	3.16	0.90	4.50	5.00
Mineral, oil, and gas extraction	3.11	1.27	4.00	5.00
Carbon balance in soil	3.10	1.72	4.00	4.05
Visibility and particulate matter	3.09	1.72	4.00	4.00
Ferruginous hawk	3.04	1.09	4.00	5.00
Large carnivores	2.99	1.72	4.00	3.50
Volcanic cinder cone	2.98	0.45	5.00	4.00
Night sky	2.96	2.45	3.70	2.50
Wintering raptors	2.92	2.80	3.00	3.00
Sedimentation rates	2.91	1.27	4.00	4.00
Montane / grassland ecotone	2.91	1.27	3.50	5.00
Arkansas darter	2.89	0.72	4.00	5.00
Texas horned lizard	2.89	1.72	4.00	3.00
Lacustrine community – Plankton richness, abundance, and diversity	2.89	0.72	4.00	5.00
Burrowing Owl	2.86	0.90	3.75	5.00
Arkansas river shiner	2.85	0.63	4.00	5.00
Feral Hogs	2.84	1.09	4.00	4.00
Cryptobiotic soils	2.74	1.36	4.00	3.00
Effects of Wildlife diseases	2.69	2.00	3.60	2.25
Soundscape	2.67	2.27	3.90	1.00
Southwestern willow flycatcher	2.58	0.45	3.50	5.00
Fecal Coliform	2.20	2.00	1.00	5.00
Mountain plover	2.16	0.90	3.00	3.00
Exotic ungulates	2.12	0.81	3.00	3.00
Mississippi kites	2.11	1.27	1.50	5.00

* vital sign was scored a 0 by the landscape group because they felt it was incorporated by another vital signs.
 ^ vital sign was scored a 0 by the plants and soils group because they felt it was incorporated by another vital signs.
 NR denotes the item was not ranked due to lack of expertise with the particular vital sign.

Table K.6 Final vital signs prioritization list. (continued)

Potential Vital Sign	Total Score	Management Significance	Ecological Significance	Cost Effectiveness and Feasibility
Medium-sized (meso) carnivores	2.10	2.00	1.50	3.50
Migratory stopover area	2.08	2.45	0.50	4.50
Reptile community	2.05	2.63	1.50	2.00
Zebra mussels	2.02	0.54	2.00	5.00
Swift fox	1.82	0.54	1.50	5.00
Bald Eagle	1.71	1.27	0.50	5.00
Non-vascular plants	1.64	1.09	1.00	4.00
Exotic Fish	1.60	1.00	1.00	4.00
Feral Dogs	1.56	0.90	1.00	4.00
Hunting / Game animals	1.52	0.81	1.00	4.00
Contaminants in fishery/food chain	1.49	1.72	0.00	4.00
Fishing	1.44	1.09	0.00	5.00
Endemic and keystone invertebrates (terrestrial systems)	1.42	1.54	1.50	1.00
Nutria	1.32	0.54	1.00	3.50
Raccoons	1.19	0.72	0.75	3.00
Erosion index	1.02	2.54	0.00^	0.00
Human Development (Road density, impervious cover, house density)	0.84	2.09	0.00*	0.00
Off-road vehicle use	0.57	0.54	0.50*	0.75
Tornadoes, record floods, ice storms	0.54	1.36	0.00*	0.00
Alberta Arctic butterfly	0.18	0.45	NR	NR

* vital sign was scored a 0 by the landscape group because they felt it was incorporated by another vital signs.

^ vital sign was scored a 0 by the plants and soils group because they felt it was incorporated by another vital signs.

NR denotes the item was not ranked due to lack of expertise with the particular vital sign.

APPENDIX L. VITAL SIGNS SELECTION REPORT

SOUTHERN PLAINS NETWORK TECHNICAL COMMITTEE

MEETING MINUTES - JANUARY 26, 2006

AMARILLO, TX - HOSTED BY ALIBATES FLINT QUARRIES NM / LAKE MEREDITH NRA

L.1 ATTENDING

Ted Benson – PECO (Committee Member)
 Steve Burrough – CHIC (Committee Member)
 Paul Eubank – LAMR/ALFL (Committee Member)
 Jason Lott – LYJO (Committee Member)
 Fran Pannebaker - BEOL (Committee Member)
 Dusty Perkins – SOPN (Committee Member)
 Brian Quigley – CAVO (Committee Member)
 Felix Revello - FOLS (Committee Member)
 Alexa Roberts – SAND (Committee Member)
 Gillian Bowser – Gulf Coast CESU
 Tomye Folts Zettner - Texas A+M
 Heidi Sosinski – SOPN
 Arlene Wimer – LAMR/ALFL

Meeting Commenced at 8:30.

D. Perkins began the meeting with an overview of the results from the prioritization workshop, the goals of the day, and the next steps.

L.2 RANK NEW VITAL SIGNS

New vital signs that were added during the prioritization workshop were ranked for management significance.

L.2.1 Ranked Vital Signs

Each park was asked for their management significance score for *plant pathogens, yellow-billed cuckoo, wintering raptors, lepidoptera, native pollinators, and grasshoppers*. T. Benson (PECO) provided the scores for FOUN as this position is currently vacant.

Action Item: WABA did not have their member present, so the Technical Committee decided to divide the management significance score by 10 parks as opposed to 11.

L.2.2 Unranked Vital Signs

Two vital signs, *Townsend's big-eared bat* and *Alberta arctic butterfly* were not given scores for ecological significance and feasibility / cost of implementation during the prioritization workshop.

Action Item: The technical committee decided against soliciting additional experts to rank these two vital signs because the committee did not think they would make our selected vital signs list.

L.3 VITAL SIGNS MERGING SUGGESTIONS

The technical committee considered the suggestions for merging vital signs that were made by the workgroups at the prioritization workshop.

- **Suggestion:** *Off-road vehicle use* incorporated into *effects of visitors on natural resources*.
Action Item: Adopted.
- **Suggestion:** *Extreme weather patterns* incorporated into *weather patterns*.
Action Item: Adopted.
- **Suggestion:** *Human development* incorporated into *Landscape dynamics*.
Action Item: Adopted.
- **Suggestion:** *Arkansas river shiner, Arkansas darter, and exotic fish* incorporated into *fish community*.
Action Item: Adopted.
- **Suggestion:** *Fecal coliform* should be incorporated into *water quality* and *E. coli* may be a better measure.
Action Item: Adopted.
- **Suggestion:** *Bald eagles* and *ferruginous hawks* should be renamed as a new vital sign *wintering raptors*.
Action Item: Adopted.
- **Suggestion:** There were three different suggestions for combining the following vital signs: *grassland vegetation, wetlands vegetation, riparian vegetation, fire and fuel dynamics, woody invasive species* and *exotic plants*.
Action Item: *Riparian vegetation* was incorporated into *wetlands vegetation*, but *grassland vegetation* was kept separate. Both *grassland vegetation* and *wetland vegetation* would incorporate *woody invasive species* and the area component of *exotic plants*. The *exotic plants* vital signs was renamed to *exotic plants – early detection* and kept as separate

vital signs. *Fire and fuel dynamics* was also kept as a separate vital sign.

- **Suggestion:** There were two different suggestions for combining the following vital signs: *soil health*, *carbon balance*, *sedimentation rates*, *erosion index*, *cryptobiotic soils*, and *soil budget*.
Action Item: Two new vital signs were created. *Soil chemistry and structure* incorporates *carbon balance*, *soil health*, *cryptobiotic soils* and will be a measure of physical and biological elements of soil. *Soil movement* incorporates *sedimentation rates*, *erosion index*, and *soil budget*.
- **Suggestion:** The new vital sign, *yellow-billed cuckoo* incorporated into *bird communities*.
Action Item: Adopted.
- **Suggestion:** *Groundwater levels* incorporated into *water quantity*.
Action Item: Adopted.

These suggestions resulted in a new prioritized list of vital signs (Table L.1). Combined vital signs retained the highest score of those that were grouped together to create the new vital sign. For a complete list of ranking results by criteria and by park, please see Appendix K: Southern Plains Network Prioritization Workshop Report

L.4 VITAL SIGNS SELECTION PROCESS

At the prioritization workshop, the top 25% ranked vital signs were given to the workgroups who were asked if there were any vital signs missing that they felt were essential for our monitoring program. During the technical committee meeting, D. Perkins presented all vital signs that were listed at, or higher than, the lowest rated “essential vital signs”. This resulted in a list of 30 vital signs (see Table L.1).

L.4.1 Additions and Removals To Vital Signs List

The first discussion item was to determine if there were any items that the technical committee felt should be removed or added to this list.

- *Viewshed* was the first item proposed for removal. This resulted in much discussion about whether this was a “natural” or “cultural” value, and whether it should be incorporated into the monitoring program.
Action Item: The item was removed from the list by majority vote.
- *Weather patterns* was the next item proposed for removal. Many in the group felt that this was an important component to a monitoring program, but that it should not be considered a vital sign.

Action Item: The item remained on the list by majority vote.

- There was discussion about combining *native pollinators* with *butterflies* and discussion about expanding *butterflies* to *butterflies and moths*.
Action Item: *Butterflies* was expanded to *butterflies and moths*, but was kept as a separate vital sign from *native pollinators* by majority vote.

Further motions for the addition, deletion, or combination of vital signs were tabled to discuss core vital signs.

L.4.2 Core, Secondary, and Tertiary Vital Signs

D. Perkins asked for nominations for the core vital signs. These vital signs would be where the network will focus its efforts in the near future and would comprise most of our monitoring program. Selected vital signs that are not on the core list will probably not be monitored unless there are existing programs or additional funding (non vital signs sources) that could make monitoring possible. The goal was to establish a list of 5-10 core vital signs.

During the core nomination process, vital signs that were nominated to be a core vital sign but did not receive a unanimous consensus were tabled until the end of the nomination discussion.

Action Item: The following vital signs were nominated and received unanimous votes in favor of being a core vital sign: *grassland vegetation communities*, *bird communities*, *fire and fuel dynamics*, *water quantity*, *early detection of exotic plants*, *wetland vegetation communities*, *water quality*, *soil structure and chemistry*, *landscape dynamics*, and *human demographic data* (Table L.2).

There were 10 vital signs that had unanimous votes for inclusion as a core vital sign. All vital signs that had been previously nominated as a core vital sign, but did not receive unanimous support as a core vital sign became secondary vital signs. Additional nominations were made for the secondary list. Not all of the vital signs included on the secondary list were unanimous; many decisions were made by majority vote. Secondary vital signs would be the next area that the network focuses on if additional funding were available.

Action Item: This process resulted in 8 secondary vital signs (Table L.2).

Action Item: The remaining 10 vital signs that were not determined to be core or secondary vital signs were deemed tertiary vital signs (Table L.2).

All vital signs are deemed equal in value within the core, secondary, and tertiary vital sign categories. Future

decisions within each category will be made based on cost, logistics, and other factors.

Action Item: *Grasshoppers* was removed from the tertiary vital sign list because *butterflies and moths* was considered to be a better invertebrate vital sign for grasslands.

L.5 REQUEST TO ATTEND BOARD OF DIRECTORS MEETING

D. Perkins requested that 3-5 members of the technical committee attend the presentation of the selected vital signs to the Board. This meeting will take place March 29, 2006 in Las Animas, CO (BEOL as host). F. Revello, J. Lott, S. Burrough, P. Eubank, A. Roberts, and F. Pannebaker all expressed interest in attending pending scheduling conflicts.

Table L.1 Vital signs prioritization list developed at the conclusion of the prioritization workshop. Vital signs in bold text represent the starting point for default “selected vital signs”.

Potential Vital Sign	Total Score	Management Significance	Ecological Significance	Cost Effectiveness and Feasibility
Grassland vegetation communities	4.78	4.45	5.00	5.00
Bird communities	4.42	3.81	4.75	5.00
Fire and fuel dynamics	4.36	3.90	5.00	4.00
Water quantity	4.34	3.36	5.00	5.00
Early detection of exotic plants	4.32	4.54	4.00	4.50
Wetland vegetation communities	4.28	3.45	5.00	4.50
Ungulates	4.18	3.45	4.50	5.00
Water quality	4.16	2.90	5.00	5.00
Soil Movement	4.02	2.54	5.00	5.00
Weather patterns	4.02	2.54	5.00	5.00
Amphibian Communities	4.02	2.54	5.00	5.00
Soil structure and chemistry	3.98	2.45	5.00	5.00
Landscape dynamics (land cover, condition, connectivity, pattern, land change)	3.91	2.27	5.00	5.00
Small mammal communities	3.90	3.00	4.50	4.50
Viewshed	3.83	3.18	4.00	4.80
Human Demographic data (human density, traffic volume, land ownership patterns, land value)	3.76	1.90	5.00	5.00
Aquatic invertebrates (riverine and palustrine systems)	3.69	1.72	5.00	5.00
Fish communities (riverine systems)	3.69	1.72	5.00	5.00
Wet and dry deposition	3.60	2.00	5.00	4.00
Lepidoptera	3.56	2.40	4.00	5.00
Upland spring communities	3.46	1.90	4.50	4.50
Insect pests	3.39	1.81	4.50	4.33
Plant Pathogens	3.38	1.60	4.70	4.30
Flooding process along river / stream / lake	3.34	2.36	4.00	4.00
Other native pollinators	3.28	2.70	4.00	3.00
Lesser prairie chicken	3.29	0.72	5.00	5.00
Effects of park visitors on natural resources	3.25	3.09	3.38	3.33

Table L.1 Vital signs prioritization list developed at the prioritization workshop (continued).

Potential Vital Sign	Total Score	Management Significance	Ecological Significance	Cost Effectiveness and Feasibility
Grasshoppers	3.18	2.20	3.50	4.50
Black-tailed prairie dogs	3.18	1.45	4.00	5.00
Fire Ants	3.16	0.90	4.50	5.00
Mineral, oil, and gas extraction	3.11	1.27	4.00	5.00
Visibility and particulate matter	3.09	1.72	4.00	4.00
Large carnivores	2.99	1.72	4.00	3.50
Volcanic cinder cone	2.98	0.45	5.00	4.00
Night sky	2.96	2.45	3.70	2.50
Wintering raptors	2.92	2.80	3.00	3.00
Montane / grassland ecotone	2.91	1.27	3.50	5.00
Texas horned lizard	2.89	1.72	4.00	3.00
Lacustrine community – Plankton richness, abundance, and diversity	2.89	0.72	4.00	5.00
Burrowing Owl	2.86	0.90	3.75	5.00
Feral Hogs	2.84	1.09	4.00	4.00
Effects of Wildlife diseases	2.69	2.00	3.60	2.25
Soundscape	2.67	2.27	3.90	1.00
Southwestern willow flycatcher	2.58	0.45	3.50	5.00
Mountain plover	2.16	0.90	3.00	3.00
Exotic ungulates	2.12	0.81	3.00	3.00
Mississippi kites	2.11	1.27	1.50	5.00
Medium-sized (meso) carnivores	2.10	2.00	1.50	3.50
Migratory stopover area	2.08	2.45	0.50	4.50
Reptile community	2.05	2.63	1.50	2.00
Zebra mussels	2.02	0.54	2.00	5.00
Swift fox	1.82	0.54	1.50	5.00
Non-vascular plants	1.64	1.09	1.00	4.00
Feral Dogs	1.56	0.90	1.00	4.00
Hunting / Game animals	1.52	0.81	1.00	4.00
Contaminants in fishery/food chain	1.49	1.72	0.00	4.00
Fishing	1.44	1.09	0.00	5.00
Endemic and keystone invertebrates (terrestrial systems)	1.42	1.54	1.50	1.00
Nutria	1.32	0.54	1.00	3.50
Raccoons	1.19	0.72	0.75	3.00
Alberta Arctic butterfly	NA	0.45	NR	NR
Townsend's big-eared bat	NA	0.45	NR	NR

NR - denotes the item was not actually ranked due to lack of expertise with that particular vital sign

Table L.2 Selected vital signs pending approval from SOPN Board of Directors. A comprehensive monitoring program would include all of the vital signs listed below. The network will first allocate resources to core vital signs, and these will likely make up the majority of the monitoring program for the near future. Secondary and tertiary vital signs will be considered for monitoring when additional funding is made available, or if there are existing programs that make inclusion of these vital signs cost effective. Vital signs are listed in no particular order.

Core	Secondary	Tertiary
Grassland vegetation communities	Amphibian communities	Ungulates
Bird communities	Fish communities	Soil movement
Fire and fuel dynamics	Aquatic invertebrates	Weather patterns
Water quantity	Wet and dry deposition	Small mammal communities
Early detection – exotic plants	Upland spring communities	Moths and butterflies
Wetland vegetation communities	Native pollinators	Insect pests
Water quality	Effects of park visitors on natural resources	Plant pathogens
Soil structure and chemistry	Black-tailed prairie dogs	Flooding processes
Landscape dynamics		Lesser prairie chicken
Human demographic data		Fire ants

APPENDIX M. SOUTHERN PLAINS NETWORK SELECTED VITAL SIGNS

The Southern Plains Network (SOPN) has selected 29 vital signs that represent a comprehensive monitoring program for the ecosystems present in the 11 network parks. The current level of funding will not be sufficient to monitor all of these vital signs. Therefore, SOPN has further divided them into core, secondary, and tertiary classifications. SOPN will devote most of its resources to the core vital signs that will represent the monitoring program for the near future. SOPN will consider monitoring secondary and tertiary vital signs when other entities are doing the majority of data collection, data analysis, and/or writing of reports.

The 29 vital signs are listed according to their core, secondary or tertiary classification. Within each classification they are listed according to the three tiered Ecological Monitoring Framework developed by the Inventory and Monitoring Program.

M.1 CORE VITAL SIGNS

M.1.1 Soil Structure and Chemistry

NPS Ecological Framework

Geology and Soils – Soil Quality – Soil Function and Dynamics

Justification

Interactions between soil and plants are central to ecosystem functions in the Southern Plains. Changes in soil structure and chemistry can have cascading effects on vegetation communities and the faunal communities that depend on them. Soil structure and chemistry can affect or control nutrient cycling, hydrologic function, and site stability. Soil stability has a strong influence on water infiltration, soil strength, erosion, water runoff, aeration, and the soil's ability to transmit liquids, solutes, gases, and heat. Increasing patches of bare soil can reduce soil nitrogen retention and result in a loss of food supply for soil bioturbators. These bioturbators, such as ants and termites, are essential for water infiltration and redistributing and decomposing organic matter. Changes in soil carbon balance may be a predictor of future vegetation change and

subsequent faunal community changes. Grazing and fire management practices at SOPN parks can greatly affect the structure and function of soil structure and chemistry.

Preliminary Monitoring Objectives

1. Determine trends in annual soil respiration measurements.
2. Detect changes in ecosystem carbon and nitrogen balance.
3. Determine status and annual trends in soil cover, aggregate stability, compaction and erosion.

Potential Measures

productivity (NDVI - normalized distribution vegetation index), soil core samples, stability class, soil moisture and temperature, soil surface condition, soil nutrient levels

M.1.2 Ground Water Levels

NPS Ecological Framework

Water – Hydrology – Ground Water Dynamics

Justification

Groundwater levels are a major natural resource concern for several SOPN parks. Natural disturbance processes such as fire, and human land-use activities (e.g. livestock grazing, agricultural clearing and groundwater pumping) alter watershed conditions and thus indirectly influence aquatic communities. Groundwater overdrafts in the SOPN are a leading anthropogenic stressor that can contribute to the establishment and spread of non-native species like Tamarisk that can alter ecosystem dynamics such as the frequency and severity of fires.

Preliminary Monitoring Objectives

1. Determine the long-term trends in groundwater quantity levels.
2. Document changes in hydrologic regime associated with hydrological modifications (e.g., dams, diversions) in the SOPN.

Potential Measures

Depth to groundwater (spatial and temporal variations), recharge, consumption, changes in water use, infiltration rate

M.1.3 Water Quantity - Surface

NPS Ecological Framework

Water – Hydrology – Surface Water Dynamics

Justification

Available water is one of the key drivers of ecosystem function in the Great Plains and provides insights into overall system productivity, shifts in species abundance and distributions, nutrient cycles, and the occurrence and ecosystem response to disturbance events. Natural disturbance processes such as fire, and human land-use activities including livestock grazing, agricultural clearing and groundwater pumping alter watershed conditions and water quantity levels and thus indirectly influence aquatic communities.

Preliminary Monitoring Objectives

1. Determine the long-term hydrologic trends for stream flow and lake water levels.
2. Document changes in hydrologic regime associated with hydrological modifications (e.g., dams, diversions) in the SOPN.

Potential Measures

recharge, changes in water use, infiltration rate, lake elevation, timing and rates of streamflow, hydroperiod of wetlands

M.1.4 Water Quality

NPS Ecological Framework

Water – Water Quality – Water Chemistry

Justification

Surface water quality is important to maintain a healthy habitat for many aquatic organisms, wildlife, and humans. Water quality can provide insights into overall system productivity, can shift species abundances and distributions, and alter nutrient cycles. Water quality parameters such as pH, conductivity, dissolved oxygen, and temperature are good measurements that provide an overview of water quality. Biological contamination from *Escherichia coli* is a threat to water quality in SOPN parks. Sources include treated effluent, septic systems, and livestock operations.

E. coli can be further exacerbated by a decrease in water quantity, which can concentrate pollutants. Water quality monitoring is required to ensure visitor health and safety in SOPN parks, to comply with relevant environmental legislation and NPS mandates, and to evaluate potential biochemical stressors in SOPN water bodies.

Preliminary Monitoring Objectives

1. Determine the long-term trends in water quality vital signs at SOPN water bodies.
2. Determine trends in water chemistry in association with other network monitoring programs.
3. Determine fecal coliform levels and trends.

Potential Measures

fecal coliform, dissolved oxygen, temperature, pH, conductivity

M.1.5 Exotic Plants – Early Detection

NPS Ecological Framework

Biological Integrity – Invasive Species – Invasive / Exotic Plants

Justification

Exotic plants represent one of the most significant threats to natural resources in national parks. Exotic plants are a concern due to their abilities to reproduce prolifically, rapidly colonize new areas, displace native species, alter ecosystem processes across multiple scales, and detract from the interpretive value of park resources. In the Great Plains, grasslands have been increasingly degraded and fragmented, which results in increasing chances of exotic plant species invasion. There is often a time lag between the initial establishment of an invasive exotic and its rapid expansion toward local carrying capacity, therefore early detection and subsequent eradication is essential. This vital sign will focus on the early detection of exotic plants and areas most likely to see new colonizations. The area and percentage of exotic plants will be covered by the comprehensive vegetation protocols (Grassland Vegetation Communities and Wetland Vegetation Communities).

Preliminary Monitoring Objective

1. Detect incipient populations and new introductions of invasive exotic plant species.

Potential Measures

Presence, abundance, and distribution of new populations

M.1.6 Grassland Vegetation Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Grassland / Herbaceous Communities

Justification

Grasslands are the dominant ecosystem type in SOPN parks. In the Great Plains, grasslands have been converted to agricultural land and urban areas, their hydrology has been altered, and they have been degraded due to overgrazing, increased land fragmentation, fire suppression, and exotic species invasion. Changes in the vegetation communities can lead to subsequent changes in the faunal communities and natural processes. Land fragmentation, exotic species, and altered fire regimes with subsequent invasion by native woody species are major threats to SOPN grasslands. Land fragmentation can increase the chances of exotic plant species invasion and isolates SOPN grasslands from ecosystem processes and immigration and emigration of species. Exotic plants can greatly alter ecosystem processes and displace native communities. Woody species such as Eastern red cedar, mesquite, Ashe juniper, and pinion juniper are invading SOPN parks and converting native grasslands to shrublands. In addition, grassland vegetation can be used to evaluate the effectiveness of management practices (prairie restoration, grazing, and fire).

Preliminary Monitoring Objectives

1. Define the trends in status of the vegetation species composition, structure, and diversity of remnant, disturbed, and restored prairies.
2. Determine trends in cool season (C3) vegetation versus warm season (C4) vegetation.
3. Determine long-term trends in invasive woody species abundance and distribution.
4. Determine long-term trends in exotic plant abundance and distribution.
5. Compare long-term trends in areas where exotic plants and woody invasives are purposefully managed.

Potential Measures

Prairie community structure, phenology (flowering time, green-up), response to precipitation, above ground production and biomass, % of seral plants, basal area of perennial grasses, C4 vs. C3 plant cover/abundance, species richness, species composition, and species diversity, distribution and abundance of woody species, distribution and abundance of exotic species

M.1.7 Wetland Vegetation Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Wetland Community

Justification

Wetlands are limited in extent in SOPN but are important sites for biodiversity. Wetlands serve many important ecological functions, including groundwater recharge, habitat for flora and fauna, soil erosion control, chemical uptake and transformation, and flood water control. Threats to SOPN wetlands include decreased water quantity, pollution, and invasion by exotic species. Exotic plants can greatly alter ecosystem processes and communities in wetland systems. Several plant species (woody seedlings, exotic plants, wetland obligate plants) can give information on future changes in the system.

Preliminary Monitoring Objectives

1. Determine temporal and spatial trends in species composition and richness, abundance, structure, and diversity of wetland plant communities.
2. Quantify changes in the cover, richness, and species diversity of key woody native and non-native wetland trees within network parks.
3. Determine long-term trends in exotic plant abundance and distribution.
4. Compare long-term trends in areas where exotic plants are purposefully managed.

Potential Measures

Cover by species, tree seedling/sapling density, vegetation structure, cover and extent of riparian vegetation, distribution and abundance of exotic species

M.1.8 Bird Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities – Bird Communities

Justification

Songbird communities are good indicators of the health of ecosystems because they respond quickly to changes in resource conditions and there are comparable regional and national datasets. Grassland birds, in particular, respond to management practices such as grazing and fire. Long-term trends in the community composition and abundance of breeding bird populations provide a measure

for assessing the ecological integrity and sustainability of prairie, riparian and piñon-juniper systems.

Preliminary Monitoring Objectives

1. Identify significant temporal changes in composition, abundance, and spatial distribution of bird communities at SOPN parks.
2. Follow trends in bird populations for correlations with fragmentation and loss of connectivity.

Potential Measures

species richness, abundance, nesting success, distribution, temporal pattern of use, change in functional groups, indices

M.1.9 Human Demographic Data

NPS Ecological Framework

Human Use – Non-Point Source Human Effects – Non-Point Source Human Effects

Justification

Information on human demographic data is essential for understanding impacts to parks from the surrounding area. Many of the parks in the SOPN are subject to encroaching and changing agricultural, residential and urban development, and these landscape modifications are closely linked to park ecosystem function. Due to the small size of many SOPN parks, the natural resources can be more influenced by land uses surrounding the park than actual management practices within the park. By following changes in human development park managers can take pre-emptive actions to minimize the effects from habitat fragmentation, increased pollution sources, increased avenues for exotic pests, and audio/visual change.

Preliminary Monitoring Objective

1. Detect trends in human demographic data in the vicinity of SOPN parks.

Potential Measures

Land ownership patterns, land value, traffic volume, human density

M.1.10 Fire and Fuel Dynamics

NPS Ecological Framework

Landscapes – Fire and Fuel Dynamics – Fire and Fuel Dynamics

Justification

Fire is one of the most influential disturbance processes in Great Plains ecosystems. Fire is an important aspect to monitor because it influences vegetative succession and distribution, wildlife habitat, soil parameters, hydrology, water quality and air quality. In addition, the natural fire regime (fire frequency, fire extent and severity) is likely to respond to local and global climate changes. Baseline monitoring of fire parameters will provide explanatory variables for other ecological changes detected.

Preliminary Monitoring Objectives

1. Track the location, extent, timing, and severity of wildland and prescribed fires in SOPN parks.
2. Track successional effects of fire and burn severity on: the species composition and structure of vegetation; soil temperature and moisture; and animal community composition.

Potential Measures

Number of fires, fire extent and configuration, fire severity, frequency of fire, vegetation responses to fire, fuel loads

M.1.11 Landscape Dynamics

NPS Ecological Framework

Landscapes – Landscape Dynamics – Land Cover and Land Use

Justification

Landscape pattern and land use have major implications for fire frequency, exotic species distributions, water quality, air quality, habitat fragmentation, soil erosion, general ecosystem functions. Information on land condition is essential to understand how ecosystem resistance and resilience are impacted by anthropogenic and natural factors. Monitoring on park lands will give information on differences between natural and anthropogenic causes of land-condition change and can allow managers to act proactively to minimize the effects of changes in land cover. An assessment of land-cover changes over time will provide estimates of habitat changes within and around parks that can identify ecosystems of concern within the park.

Preliminary Monitoring Objectives

1. Determine annual variation and trends in the seasonally integrated normalized difference vegetation index (NDVI) for SOPN park lands.
 2. Determine long-term trends in land-use change within and adjacent to SOPN parks.
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3. Determine habitat conversion to urban and agricultural landscapes, creation of edge effects, reduction of functional ecosystem size, and elimination of important habitats.

Potential Measures

Land use/land cover (LULC), road density/impervious cover, percentage of exotic vs. native plant cover, spatial statistics and landscape metrics such as patch size & connectivity, house density, disturbed/undisturbed lands, land use and vegetation change, cumulative normalized differential vegetation index (NDVI)

M.2 SECONDARY VITAL SIGNS

M.2.1 Wet and Dry Deposition

NPS Ecological Framework

Air and Climate – Air Quality – Wet and Dry Deposition

Justification

Atmospheric deposition of nitrogen and sulfur compounds affects ecosystems in a variety of ways, including acidification, fertilization, and eutrophication. Nitrogen deposition can cause changes in soil that affect soil microorganisms and vegetation. Excess nitrogen deposition can cause unwanted fertilization effects, leading to changes in plant community structure and diversity, including increases in exotic plants. Elevated ozone levels signal potential ecosystem impacts that are regional and global in scale. Ozone is harmful to humans and phytotoxic to plants, causing foliar injury and growth effects. Certain plant species are known to be sensitive to ozone, and several of these sensitive species have been identified for all SOPN units. Mercury is a persistent, toxic, and volatile heavy metal that is globally distributed via the atmosphere and can bioaccumulate in aquatic food webs, directly harming humans, animals, and the ecosystem.

Preliminary Monitoring Objectives

1. Determine broad-scale trends in nitrogen and sulfur (and others) deposition in SOPN park units.

Potential Measures

nitrogen concentrations (continuous or passive), sulfur, mercury, sulfur dioxide, plant composition

M.2.2 Aquatic Invertebrates

NPS Ecological Framework

Water – Water Quality – Aquatic Macroinvertebrates and Algae

Justification

Aquatic invertebrate communities have been used as indicators of biotic integrity in river systems. They can be a good indicator of the biological significance of management actions and land-use changes. They are useful as indicators because they represent a diverse group of relatively long-lived, sedentary species that react strongly and often predictably to human influences on aquatic systems. Invertebrate community surveys directly relate to actual ambient conditions, take into account a large range of species representing a variety of environmental exposure pathways, and some species are sensitive to changes in water quality. Monitoring the integrity of prairie stream ecosystems using benthic invertebrates as indicators of disturbance is necessary to support restoration efforts and management decisions affecting these resources.

Preliminary Monitoring Objectives

1. Determine trends in invertebrate species communities and diversity.
2. Determine if the species composition is changing over time (i.e. higher exotic to native species ratio, functional groups).

Potential Measures

invertebrate community composition, richness, abundance, indices

M.2.3 Upland Spring Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities – Wetland Community

Justification

Upland springs are a major natural resource for Chickasaw NRA and are present at 5 other SOPN parks. They are limited in extent but represent areas of high diversity, including endemic species. Recreational use and grazing can degrade these communities making the monitoring of water quantity levels essential to ensure these unique communities are maintained.

Preliminary Monitoring Objectives

1. Determine trends and changes in aquatic and riparian vegetation associated with seeps and springs on an annual basis.
2. Measure aquatic fauna community present in spring waters.
3. Determine the long-term trends in water quantity levels at springs.

Potential Measures

flow rate or discharge, extent and composition of vegetation, presence and trends of unique/endemic species, presence and trends of groundwater fauna

M.2.4 Native Pollinators

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Terrestrial Invertebrates

Justification

Native pollinators (wasps, bees, moths, flies, beetles, hummingbirds, etc.) are a very important functional group, yet many populations have suffered declines which could have adverse effects on ecosystems. For example, the loss of pollinators could lead to subsequent effects on vegetation and the fauna that depend on them.

Preliminary Monitoring Objectives

1. Determine trends in species richness and communities (indices) over time.
2. Determine trends in specific pollinators of concern.

Potential Measures

invertebrate community composition, richness, abundance, indices

M.2.5 Fish Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities – Fish Communities

Justification

Fish communities may be good indicators of biotic integrity and the biological significance of management actions and land-use changes in river systems. Fish community surveys directly relate to actual ambient conditions, take

into account a large range of species representing a variety of environmental exposure pathways, and some species are sensitive to changes in water quality. Trends in the composition and abundance of fish populations have been used successfully to assess the biological integrity of prairie streams. This vital sign would also provide information on two rare species, Arkansas river shiner and Arkansas darter, that are found within SOPN.

Preliminary Monitoring Objectives

1. Determine trends in fish species diversity.
2. Determine population trends of specific species of concern.
3. Determine long-term trends in abundance and spatial distribution trends of the fish community in SOPN parks.
4. Determine trends in species composition over time (i.e. higher exotic to native species ratio, functional groups).

Potential Measures

Species distribution and abundance, species diversity, change in functional groups, indices, exotic fish occurrence

M.2.6 Amphibian Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Amphibians and Reptiles

Justification

The natural history and biology of amphibians make them more susceptible to environmental degradation than many other communities of animals. Amphibians are affected by numerous environmental changes and impacts to the ecosystem. They breathe through their skin so are sensitive to environmental gradients, they are less mobile than other taxa so they may be more representative of local biotic integrity, and they change trophic levels during their complete life cycle making them dependent on a wide variety of environmental conditions. Introduced fire ants may have caused some species to decline in the SOPN.

Preliminary Monitoring Objectives

1. Determine trends in amphibian species diversity at each park.
 2. Determine population trends in specific species of concern.
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3. Determine long-term trends in abundance and spatial distribution trends of the amphibian community in SOPN parks.
4. Determine trends in species composition over time (i.e. higher exotic to native species ratio, functional groups).

Potential Measures

Species distribution and abundance, species diversity, community indices

M.2.7 Black-tailed Prairie Dogs

NPS Ecological Framework

Biological Integrity – At-Risk Biota – T&E Species and Communities

Justification

This species is a candidate for federal threatened status and is state-listed by two states where SOPN parks are located. This species occurs at 3 (possibly 4) SOPN parks. Prairie dog towns can increase the probability that several other rare species (mountain plovers, burrowing owls, swift fox) may be present. There has been considerable debate in the scientific literature about whether prairie dogs are keystone species. Policy directs NPS to protect state listed species as much as possible. Monitoring information for this species can trigger the need for protection of key activity areas or active restoration of critical habitat. This vital sign also has the potential to provide information about two additional rare species, mountain plovers and burrowing owls, that are tied to prairie dog towns.

Preliminary Monitoring Objectives

1. Determine the distribution and abundance of black-tailed prairie dogs at SOPN parks.
2. Determine population trends of black-tailed prairie dogs.
3. Monitor changes in vegetation composition in relation to black-tailed prairie dog habitat.
4. Determine the status of black-tailed prairie dog populations [size (N) estimate, distribution, and structure (age/size class ratios, sex ratios)] at Sand Creek Massacre NHS, Bent's Old Fort NHS, and Fort Larned NHS.
5. Monitor population for bubonic plague infection and risk to visitors.

Potential Measures

abundance, survival, spatial distribution, sex and age-class ratio, productivity

M.2.8 Effects of Park Visitors on Natural Resources

NPS Ecological Framework

Human Use – Visitor and Recreation Use – Visitor Use

Justification

The majority of SOPN visitors confine their activities to formal trails and park facilities with developed infrastructure (bathrooms, parking lots, etc). Depending on the type and intensity of human activity and the fragility of the habitats affected, dispersed recreational activities can have adverse impacts to ecosystem elements and processes. Information about changes in numbers and distribution of visitors among areas of a park will support management decisions. This vital sign would also include the effects of off-road vehicles that are permitted at Lake Meredith NRA. These ORVs can severely degrade park natural resources by destroying vegetation, introducing exotic species, increasing habitat fragmentation, increasing erosion and pollution, and put visitors at a risk to serious injury. ORV use opens the potential for deteriorated aesthetics and increased noise and air pollution.

Preliminary Monitoring Objectives

1. Determine the amount, type, and temporal and spatial distribution of visitor uses over time.
2. Determine trends in recreation-related resource degradation and the extent of the impacts.

Potential Measures

trail proliferation, park use density and distribution, number of visitors by useage class (hikers, boats, vehicles, etc.), area trampled, vegetation change on and near trails

M.3 TERTIARY VITAL SIGNS

M.3.1 Weather Patterns

NPS Ecological Framework

Air and Climate – Weather and Climate – Weather and Climate

Justification

Weather is a key driver of ecosystem and landscape processes. Meteorologic data are essential to

understanding and interpreting ecosystem trends that will be detected from all aspects of the SOPN long-term monitoring program. This includes normal variations and extreme events such as ice storm, tornados, blizzards, and drought. Information from the monitoring of weather conditions will contribute to the understanding of weather controls on landscape and ecosystem change. Extreme disturbance events are generally rare occurrences. Some data suggests they are increasing in frequency and intensity as our climate changes. Each event is a unique opportunities to document the effects and recovery of flora, fauna, and ecosystems.

Preliminary Monitoring Objectives

1. Determine trends in weather parameters (air temperature and precipitation).
2. Identify extreme weather events.
3. Examine how climate trends (i.e., temp, precipitation) correlate with other network monitoring programs.
4. Document effects and severity of extreme disturbance event on selected ecological communities.
5. Document frequency of extreme disturbance events.

Potential Measures

ambient temperature, precipitation, wind speed, wind direction, soil moisture, soil temperature, relative humidity, extreme events

M.3.2 Soil Movement

NPS Ecological Framework

Geology and Soils – Soil Quality – Soil Function and Dynamics

Justification

Feedbacks between soil and vegetation are central to the conceptual models developed for SOPN. It is widely held that the ability of a site to retain soil, water and nutrients is critical to ecosystem resilience. The loss of these functions leads to reduced vigor and productivity of vegetation, increased soil erosion, and increased susceptibility to invasion by exotic plants. Shoreline wave action disturbance and upland land use activities can both contribute to sedimentation. Sediments are a source of contaminants and affect water temperatures, quality and quantity. Grazing and fire dynamics can affect the structure and function of soils in SOPN parks. Changes

in soil budgets can have cascading effects on vegetation communities and the faunal communities that depend on them. Soil aggregate stability has a strong influence on infiltration, soil strength, erosion, aeration, and the soil's ability to transmit liquids, solutes, gases, and heat. Aquatic resources within SOPN have been dramatically altered by water diversion (dams) and human development. Dams, roads and other structures can alter sedimentation rates along rivers and streams.

Preliminary Monitoring Objectives

1. Determine trends in soil aggregate stability and soil cover.
2. Determine the status and trend of unprotected bare soil, i.e., between vascular plants.
3. Detect changes in soil budgets over time.
4. Detect trends in sedimentation and bank erosion rates in SOPN rivers, streams, and reservoirs.

Potential Measures

rate of soil loss, accumulation/decomposition rates, percent aggregate stability, stability class, rate of sedimentation

M.3.3 Flooding Processes

NPS Ecological Framework

Water – Hydrology – Surface Water Dynamics

Justification

Stressors to steams of this region include activities that disrupt natural flows of water and sediment, including damming or diversion of stream flow or construction of channel stabilization structures and diversion for agricultural purposes. These stressors alter channel and flood plain forming processes and typically result in the loss or ecological simplification of native riparian communities. Physical processes define and maintain the aquatic habitats in which aquatic communities occur. Changes in physical habitat can cause large-scale and potentially irreversible impacts to aquatic communities. Further, physical habitat monitoring can provide the information necessary to link distant watershed disturbances to the degradation of SOPN river systems. Alterations to flooding processes can also contribute to the establishment and spread of non-native species like Tamarisk, which alter ecosystem properties such as the frequency and intensity of fires.

Preliminary Monitoring Objectives

1. Determine changes in flooding processes associated with hydrological modifications (e.g., dams, diversions) in the SOPN.
2. Detect trends in the cross sectional area, bankfull width, bankfull mean/max depth, flood-prone width, slope, and sediment composition (measured variables) of SOPN rivers and streams .
3. Detect trends in the entrenchment ratio, width/depth ratio, sinuosity, bank erodibility hazard rating, sediment supply, and Pfankuch channel stability rating (derived variables) of SOPN rivers and streams.

Potential Measures

discharge, recurrence rates and duration of flood events, channel cross sectional profile, riparian and riverine community parameters, areal extent of flooding

M.3.4 Fire Ants*NPS Ecological Framework*

Biological Integrity – Invasive Species – Invasive / Exotic Animals

Justification

Fire ants have invaded the southern portion of SOPN. This invasion may have led to a decrease in some species of reptiles, amphibians, small mammals, and ground-nesting birds. A recent vertebrate inventory at Lyndon B. Johnson NHP did not detect several herpetological and mammalian species that were historically present before fire ants had invaded the area. If fire ants truly decimate faunal communities, then there will be a cascading effect on the rest of the ecosystem.

Preliminary Monitoring Objectives

1. Determine long-term trends in fire ant abundance and distribution on network parks.
2. Compare long-term trends in different communities, cover types, and/or geographic areas with respect to native fauna populations.

Potential Measures

Presence and abundance, distribution, rate of spread, correlations with native fauna

M.3.5 Insect Pests*NPS Ecological Framework*

Biological Integrity – Infestations and Disease – Insect Pests

Justification

Insect/disease outbreaks are natural processes that contribute to overall ecosystem and landscape diversity. Although various factors control insect/disease outbreaks, this disturbance can be strongly related to climatic patterns. Consecutive years of extreme climatic conditions can predispose vegetation to insect/disease outbreaks. The monitoring of extreme climatic events provides important information for assessing trends in natural disturbance regimes as well as in a range of other vital signs.

Preliminary Monitoring Objectives

1. Determine the trends in the extent and configuration of insect pest outbreaks in SOPN park units and surrounding area.
2. Develop early detection monitoring program for insect outbreaks.

Potential Measures

extent of insect related mortality, distribution and extent of standing dead/stressed/diseased trees, early detection, insect damage on vegetation

M.3.6 Plant Pathogens*NPS Ecological Framework*

Biological Integrity – Infestations and Disease – Plant Pathogens

Justification

Plant pathogens, such as sudden oak death, have the potential to completely change an ecological community by affecting the ecological function and appearance of a park.

Preliminary Monitoring Objectives

1. Determine the rate of spread and frequency in the plant population.
2. Determine the distribution of pathogens among target populations.
3. Determine trends in mortality rates in the target populations.

Potential Measures

Fungi and rusts, infection rate, symptoms observed on vegetation, percent mortality, distribution, vectors

M.3.7 Moths and Butterflies

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Terrestrial Invertebrates

Justification

These species are extremely sensitive to management actions (e.g. grazing, weed control, prescribed burns/fires) and may not be able to re-colonize areas once extirpated. These reasons make Lepidoptera a good response indicator of prairie health. This group, when combined with plant hosts, is also sensitive to climate change.

Preliminary Monitoring Objectives

1. Determine trends in species richness and communities (indices) over time.

Potential Measures

invertebrate community composition, richness, abundance, indices

M.3.8 Ungulates

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Mammals

Justification

Ungulates are an important component of park ecosystems as the dominant native grazer/browser species. However, lack of natural predators can make species like deer vulnerable to over population and related disease problems. High deer populations contribute to over-browsing, which can lead to plant mortality, decreased plant reproduction, reduced tree regeneration, an increased potential for invasion by exotic species, and impacts to breeding birds. Shifts in species assemblages can reduce plant diversity on a local level and cause changes in the functioning of a plant community. Conversely, the lack of large grazers (bison) and/or their replacement with cattle at SOPN parks has had major impacts to grasslands. In addition, hunting of big game species is allowed at two SOPN parks. This vital sign would include both native and exotic ungulates.

Preliminary Monitoring Objectives

1. Determine annual and long-term changes in ungulate numbers and population composition within each park.
2. Determine trends and correlations in deer abundance with vegetation and/or bird populations.
3. Follow trends in harvest levels of big game populations.

Potential Measures

abundance, survival, distribution, sex and age-class ratio, productivity, harvest levels, success rates of hunters, browsing/grazing rates

M.3.9 Small Mammal Communities

NPS Ecological Framework

Biological Integrity – Focal Species or Communities
– Mammals

Justification

Small mammals can represent a larger proportion of biomass on the landscape than other animal classes. Small mammals consume seeds, fungi and invertebrates and provide a key prey source for raptor species and carnivorous mammals. As a result of their position in the food chain, small mammals play an important ecological role by having the ability to influence species above and below them in the food chain.

Preliminary Monitoring Objectives

1. Determine long-term trends in abundance and spatial distribution trends of the small mammal community in SOPN parks.
2. Monitor changes in vegetation composition in relation to small mammal habitat.
3. Determine population trends of species and communities.

Potential Measures

community structure, diversity, distribution, abundance, species richness

M.3.10 Lesser Prairie Chicken

NPS Ecological Framework

Biological Integrity – At-Risk Biota – T&E Species and Communities

Justification

This species a candidate for listing under the federal endangered species act and is listed by three states as rare/endangered/species of concern where SOPN parks are located. This species may occur at SOPN parks and there is a historic lek in the vicinity of Sand Creek Massacre NHS. National Parks are required under law to protect federally listed threatened and endangered species. Policy directs NPS to protect state listed species as much as possible. Monitoring information for this species can trigger the need for protection of key activity areas or active restoration of critical habitat.

Preliminary Monitoring Objectives

1. Determine trends in occupancy of nesting territories and productivity.
2. Determine the distribution and abundance of lesser prairie chickens.
3. Determine population trends of lesser prairie chickens.

Potential Measures

abundance, survival, distribution, sex and age-class ratio, nesting success and productivity
