National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Pecos National Historical Park

Natural Resource Condition Assessment

Natural Resource Report NPS/PECO/NRR—2011/441

ON THE COVER
Grassland at Pecos National Historical Park.
Photograph by: NPS.

Pecos National Historical Park

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p.xix) for more information.

Executive Summary

Pecos National Monument was created in 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 by an Act of Congress in 1990 to become Pecos National Historical Park (PECO), 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). PECO comprises two units: the Pecos Unit and the Glorieta Unit. The Glorieta Unit was added to the park in 1980 by Congress 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).

Because of park management policies and mandates, the National Park Service collaborated with Natural Heritage New Mexico to conduct a Natural Resource Condition Assessment (NRCA). NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, but not replace, traditional issue- and threat-based resource assessments. NRCAs evaluate current conditions for a subset of natural resources and resource indicators in national park units.

This report includes condition analyses and reports on trends (as possible), critical data gaps, and general level of confidence for study findings. The Southern Plains Inventory and Monitoring Network and park staff helped identify indicators targeted for evaluation. Considerations in this process included the park's resource setting, status of park-level resource stewardship planning and science in identifying priority indicators for that park, and availability of useful data and qualified expertise to assess current conditions for each indicator included on a list of potential study indicators. The authors present the background, analysis, and condition summaries for the 16 key resource indicators in the project framework. In each section, the authors discuss the key resources and their measures, stressors, and reference conditions. The report presents a discussion of prevalent threats PECO natural resources face: climate change, exotic species, water pollutants, and human impacts/adjacent land use.

Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of Natural Resource Condition Assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance, and may differ in comparison to what is found in more recently published reports from this series.

Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p.xix) for more information.

1 Introduction and Resource Setting

1.1 Natural Resource Condition Assessment Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, or "parks." For these condition analyses they also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The indicators targeted for evaluation depend on a park's resource setting, status of park-level resource stewardship planning and science in identifying priority indicators for that park, and availability of useful data and qualified expertise to assess current conditions for each indicator included on a list of potential study indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, but not replace, traditional issue- and threat-based resource assessments. Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: (1) to assist selection of study indicators; (2) to recommend study data sets, methods, and reference conditions and values to use; and (3) to help provide a multi-disciplinary review of draft study findings and products.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve an informal synthesis of existing data from multiple and diverse sources, at a level of rigor and sophistication that reflects our present data and knowledge base for each resource or indicator evaluated. A successful NRCA delivers science-based information that is credible and has practical uses for a variety of park decision making, planning, and partnership activities.

1.2 Introduction to Pecos National Historical Park

1.2.1 Enabling Legislation and Management Guidance

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 by an Act of Congress on June 27, 1990, to become Pecos National Historical Park (PECO), 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).

PECO comprises two units: the Pecos Unit and the Glorieta Unit. According to Pecos National Historical Park's General Management Plan/Development Concept Plan (1995b), the purpose of the 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" (NPS 1995b). Several other management documents provide guidance for the resource stewardship of PECO, 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 (NPS, Southwest Regional office et al. 1993), which describes land protection strategies for the Glorieta Unit; and the Santa Fe National Historic Trail Comprehensive Management and Use Plan completed in 1990.

1.2.1.1. Park Purpose

The purpose statement for the park reaffirms the reasons for which PECO was set aside (NPS 2009). It also provides the guiding foundation for its management and use. For PECO, that purpose is to:

> *Preserve, protect, and interpret the 12,000-year history of the area including the cultural interaction and lifeways among diverse groups of people of the Pecos area and its "gateway" role between the plains and the Rio Grande Valley.*
>
> *Preserve and protect cultural and natural resources and enhance visitor understanding of the many archeological and historical sites, the Civil War Battlefield at Glorieta Pass, and Forked Lightning Ranch.*

1.2.1.2. Park Significance Statements

Similarly, the park's significance statements "capture the essence of the national park's importance to our country's natural and cultural heritage." The seven significance statements for PECO are:

1. *The Upper Pecos River Valley is a multi-cultural crossroads where trade, commerce, settlement and conflict occurred. The region represents the heritage of the Southwest during the last 12 millennia. The geographic corridor through Glorieta Pass contains ancient trade routes connecting the Rio Grande with the western plains. The historic Santa Fe Trail, stagecoach lines, railroads, Route 66, and interstates have travelled through the pass connecting New Mexico with destinations to the East.*

2. *The area of Pecos Pueblo, in use from ancient times to the present, is a living place still valued and used for traditional practices by descendants of those who traveled through and settled here.*

3. *Landmark excavations by Kidder (1915–1929) at Pecos provided the foundation for modern southwest archeology and resulted in a world-class, multi-cultural museum collection of artifacts and documents with scientific and cultural values.*

4. *The natural resources of the park, including the Pecos River and its tributaries and plant and animal communities, in combination with the park's geographic location, resulted in a natural environment that was suitable for the settlement and interaction of multiple groups in the area. These resources were important to people living in the region in the past and still continue to be enjoyed by people today.*

5. *The Glorieta Unit of the park encompasses the Glorieta Battlefield, where the Civil War Battle of Glorieta Pass occurred. This battle profoundly affected the future of the Southwest and the nation.*

6. *The historic and architecturally significant Forked Lightning Ranch provides visitors opportunities to experience the evolution of ranching in northern New Mexico.*

7. *The expedition of Coronado started the expansion of power and influence of Spanish culture. The park contains remains of a pueblo and a historic mission which illustrates the conflict and accommodation of cultural contact between Native Americans and Spanish Colonialists. Archeological evidence documents the construction of four churches, one of which was the largest church in 17th-century New Mexico* (NPS 2009).

It is of particular note that six of the seven significance statements directly reflect the cultural heritage of the park, affirming the importance of including a cultural landscape context as we consider the condition of natural resources at PECO.

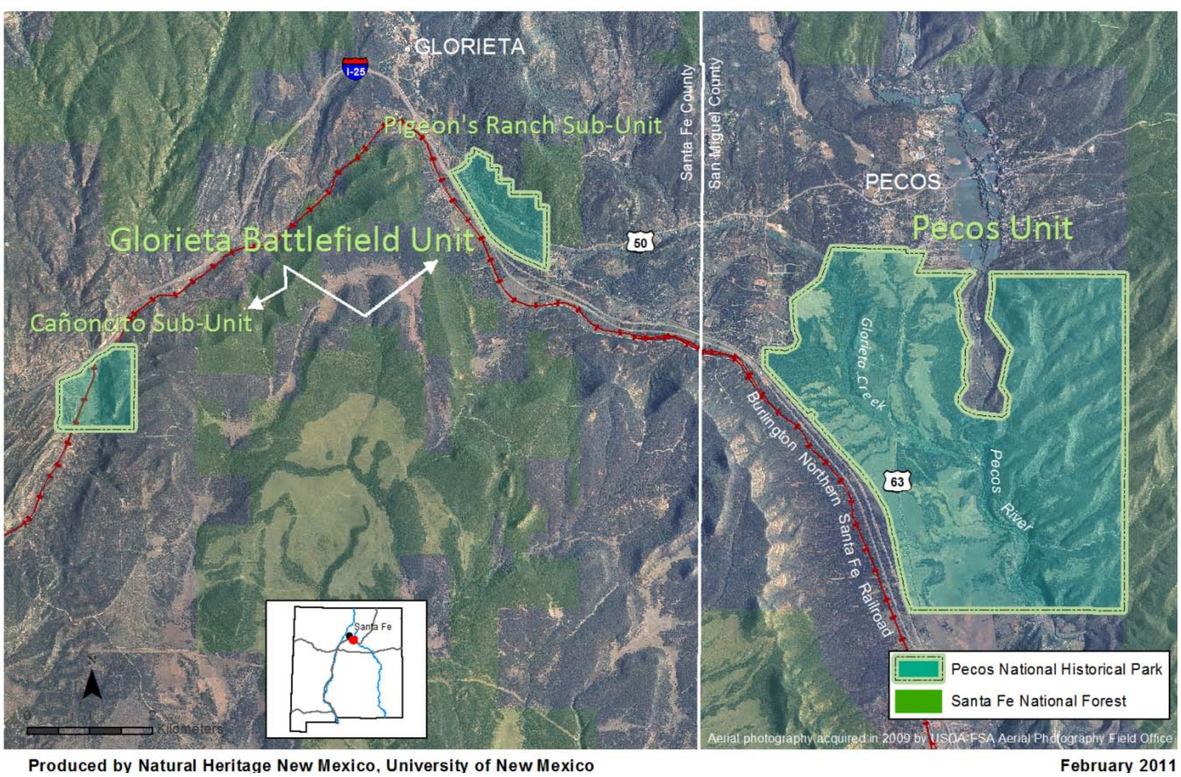

Figure 1. Boundaries of Pecos National Historical Park and Natural Resource Condition Assessment Area.

1.2.2 Geographic Setting

PECO is located in north-central New Mexico in the Pecos River Valley. The park consists of 6,670 acres.

This section is extracted from "Geologic Resource Evaluation Scoping Summary: Pecos National Historical Park, New Mexico" (n.d.):

> *Pecos National Historical Park is situated in a transition zone of three geophysical provinces: the Southern Rocky Mountains, Great Plains, and Basin and Range. In addition, the park occurs in a "cross zone" or accommodation zone of the Rio Grande Rift, which is a natural low area that native peoples and later settlers exploited. Though the park hosts the simplest geologic setting in the area, the coming together of these three provinces results in diverse geologic features in any direction from the park.*
>
> *The development of the modern landscape is driven by a combination of geologic factors: (1) inherited geologic features; (2) imposed influences of modern tectonic forces; and (3) surface response to climatic variations and forces. The inherited geologic features include a zone of weakness developed billions of years ago during Proterozoic time. This zone of weakness, which geologists refer to as the Proterozoic discontinuity, represents an ancient assembly of the continent; it has been exploited throughout geologic time as the site of mountain-building events such as the Ancestral Rocky Mountains.*

1.2.3 Cultural Setting

This section is extracted from NPS, Southern Plains Network (2008).

> *Historically, the Pecos River Valley was a diverse area, with successive populations funneling through it. Paleo-Indians, archaic people, basket makers, and Puebloan peoples all left evidence of early use and settlement in the valley. At PECO, a fortress-like pueblo was established during the 15th century and became a trading center for the region. The Spanish established a mission at PECO in the late 16th century. PECO became a trading post in the 19th century, and was later used for military expeditions during the U.S.–Mexican and Civil Wars. The Battle of Glorieta, which occurred at this site, is considered one of the most important southwestern battles of the Civil War* (NPS, Southern Plains Network 2008).

1.2.4 Visitation Statistics

> *In most years, the park has had between 30,000 and 50,000 visitors, although the numbers were somewhat higher in the 1970s. In 2008, there were approximately 32,700 visitors. Visitation in 2009 will probably be higher, with 31,822 visitors recorded through October of 2009. In all of the last five years, visitation peaked in and around the summer months; the greatest number of visitors were recorded May–October* (NPS Stats).

1.3 Natural Resources

This section is extracted and adapted from Perkins et al. (2005). The material in this section of Chapter 1 is intended to serve as general background information on park resources. See Chapter 3 for more specific, current information on individual resources and assessments of resource condition.

The following is extracted from NPS, Southern Plains Network (2008).

> *Most of PECO lies in the upper Pecos River valley, bordered by the 13,000-foot 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. Glorieta Pass connects the Apache Canyon area and the northern Rio Grande Valley to the High Plains and shortgrass prairie of New Mexico (Reed et al. 1999). Two of the largest natural resource management concerns are invasion of grasslands by piñon pine and exotic plant species.*

1.3.1 *Resource Descriptions*

1.3.1.1. **Geology and 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 down cutting of the Pecos River during the Pleistocene are largely responsible for the area's present topography. Subsequent uplifting and down cutting 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 (NPS 1995b). The federal government owns all of the mineral rights for lands within the park boundary that are under the jurisdiction of the NPS (Reed et al. 1999).

Petrified wood has been found on the eastern portion of the Pecos Unit (Reed et al. 1999). Although no fossils have been discovered from within the boundaries at PECO, two geologic units that have been reported with paleontological resources in other areas are exposed at the park. The oldest formation exposed at PECO 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. There are frequently flooded soils on the Pecos River and Glorieta Creek floodplains. 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 construction. Soils of the Glorieta Unit are identified as Cueva very stony clay, Capillo-Rock outcrop complex, Ortiz gravely 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 Cañoncito 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 (NPS 1995b).

1.3.1.2. **Hydrology**

Most of PECO lies in the Upper Pecos River Valley. Four miles of the Pecos River lie within the park boundary. Additional surface waters include Glorieta Creek, a riparian restoration area, a pond, and several marshy habitats. The section of the Pecos River that flows through PECO has been classified as impaired due to temperature and turbidity levels exceeding federal standards.The Pecos River has been experiencing a decline in water quality and quantity because of drought conditions and from upstream activities outside of the park (NPS, Southern Plains Network 2008).

Chapter 3 addresses PECO water quality, and Appendix B provides more information on PECO water quality measures.

1.3.1.3. **Air Quality**

PECO is a Class II air quality area and its air quality is rated as better than required by the national ambient air quality standards. Air quality and visibility are usually good. However, in the winter an air inversion periodically traps smoke from wood burning stoves, resulting in a haze (NPS 1995; Reed et al. 1999). The Cañoncito subunit is affected by air pollution and visual and noise intrusions from Interstate 25 (NPS 1995b). PECO has low levels of ozone exposure, making 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.

1.3.1.4. Land Use

The Pecos Unit is bounded on the east by the Santa Fe National Forest, which is generally managed in a manner consistent with NPS management standards. However, some recreational uses that are permitted in the forest are not permitted in the park. Both Glorieta Creek and the Pecos River are affected by the septic systems of private development upstream of the park. The Pigeon's Ranch and Cañoncito subunits are surrounded by private land and the Santa Fe National Forest. 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 potential for negative effects on natural and cultural resources and values. Interstate 25 also affects the Cañoncito subunit, producing visual and noise intrusions and air pollution (NPS 1995b).

1.3.1.5. **Wildlife**

There are no known federally listed threatened or endangered mammals at 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 (*Peromyscus* spp.) being the most common and widespread species. Black bear (*Ursus americanus*) tracks have been observed in the Pigeon's Ranch Unit and the Pecos Unit. Mountain lion (*Puma concolor*) tracks have also been seen in the Pecos Unit. The riparian area was also historical habitat for river otter (*Lontra canadensis*). Several exotic species are present in the park, including feral dogs (*Canis familiarus*) and cats (*Felis domesticus*) (NPS 1995b). Feral dogs are trapped and removed from the park on a regular basis (Johnson et al. 2003).

No known federally listed threatened or endangered birds occur at PECO. In 1992, a pair of southwestern willow flycatchers was observed nesting three miles north of the park (NPS 1995b). A peregrine falcon was observed flying down the Pecos River Valley near the park in June 1988. The Mexican spotted owl has been recorded in the neighboring Santa Fe National Forest. A 2002 breeding bird survey conducted by Natural Heritage New Mexico detected 79 bird species, including three willow flycatchers (Johnson et al. 2003). However, willow flycatcher subspecies cannot be distinguished by observation, and it is unclear if these birds were the northern *E. t. adastus* subspecies or the endangered southwestern *E. t. extimus* subspecies.

Ten species of breeding birds on the Partners In Flight high-priority list for the Mesa and Plains physiographic region were documented during the 2002 survey: black-chinned hummingbird (*Archilochus alexandri*), scaled quail (*Callipepla squamata*), canyon towhee (*Piplio fuscus*), Cordilleran flycatcher (*Empidonax occidentalis*), gray flycatcher (*Empidonax wrightii*), Cassin's kingbird (*Tyrannus vociferans*), gray vireo (*Vireo vicinior*), 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 was observed to be affected by brood parasitism of brown-headed cowbirds (*Molothrus ater*) (NPS 1995b). Additional bird surveys have been conducted since this 2002 effort and are summarizedin Chapter 3.

Parmenter and Lightfoot (1996) documented seven reptile species and three amphibian species. Eastern fence lizard (*Sceloporus undulatus*) and woodhouse toad (*Bufo woodhousei*) were the most commonly found species at the time. A subsequent survey during the summer of 2002 by Natural Heritage New Mexico documented 10 species (28.7%) on the project's species target list for PECO: six reptiles and four amphibians. 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).

The Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) may once have inhabited the park. Several exotic species are present in the park, including rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Parmenter and Lightfoot (1996) conducted an intensive survey for arthropods and identified 514 species, including 407 that were already known at the time of the report. The most common and widespread terrestrial invertebrates included wolf spider (Lycosidae), gnaphosid spider (Gnaphosidae), camel cricket (Rhaphidophoridae), grasshopper (Caelifera), western harvester ant (*Pogonomyrmex occidentalis*), and darkling beetles (Tenebrionidae). 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" (Parmenter and Lightfoot 1996).

For a list of special status species used for National Environmental Policy Act compliance, see Appendix G.

1.3.1.6. 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 in the park. 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 juniper grassland. A total of 3% is floodplain meadow; less than 1% is riparian deciduous forest dominated by cottonwoods and willow; 15% is pasture; and 5% is developed, altered, or 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, lanceleaf cottonwood (*Populus acuminata*). This species is believed to be a cross between narrowleaf cottonwood (*P. angustifolia*) found at higher elevations and plains cottonwood (*P. deltoides*), found at lower elevations (NPS 1995b). Approximately 40 acres of the original monument are classified as Grama-Galleta Steppe prairie. Grazing generally ceased in June 1967 when the monument's boundary fence was completed. The 64-acre core area of the old monument has been closed to grazing since the 1940s, while the newest acreage was protected from grazing in 1978 (Stubbendieck and Willson 1986).

A vegetation survey conducted by PECO between 1992 and 1994 resulted in the identification of 354 species of vascular plants, 57 of which were exotic species (Reed et al. 1999). In 1999, a study was conducted by Natural Heritage New Mexico to assess the riparian and wetland communities along Glorieta Creek in the Pecos Unit prior to the removal of two small dams and reservoirs in the lower section of Glorieta Creek in the park during that year. 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 in the best condition of each survey area, with less fragmentation and fewer impacts from the past. The middle segment sustained the most impact because of 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 no known federally listed threatened or endangered plants species within PECO. Recent surveys for sensitive plants are summarized in Johnson et al. 2010. Numerousexotic species occur 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. An old apple orchard (*Pyrus malus*) is present near the Pecos River (NPS 1995b). As of 1995 exotic trees were not abundant (Sivinski 1995), but there is the potential for invasion in wet areas (Johnson et al. 2003).

Chapter 3 addresses vegetation, exotic plants, and sensitive plants. A complete list of plant species is included as Appendix C.

1.4 Resource Issues Overview: Threats and Stressors

The diverse landscape and the park's location also contribute to many of the threats faced by its natural resources. The most prevalent threats and stressors are discussed in this section.

1.4.1 Climate Change

This section is extracted from http://science.nature.nps.gov/im/climate/index.cfm.

Climate is a factor that presents a potential stress to many ecosystem components. Climate change may have direct and/or indirect effects on streamflow and water quality and on groundwater resources. Changes in climate, combined with anthropogenic effects, are expected to alter the type (e.g., rain versus snow) and amount of precipitation and the seasonality of large precipitation events, with unknown implications for grassland systems. Increased drought has the possibility of altering the seasonality, severity, and frequency of fire as well as post-fire regeneration. The anthropogenic effect of increased atmospheric carbon has been considered an enhancement to shrub encroachment into grasslands. Climatic changes are also predicted to provide exotic plant species with new opportunities for invasion. Because they fragment native ecosystems, displace native plants and animals, and alter ecosystem function, invasive exotics are one of the most serious threats to natural ecosystem integrity. They can also alter fire regimes by causing fires to burn more swiftly or intensely. An increase in exotic invasions, in combination with decreasing soil moisture that may accompany climate change, could set the stage for fires with the potential to dramatically impact grassland ecosystems. Despite being relatively mobile, climate change may also affect birds in a variety of ways. For example, it may lead to a change in the timing of migration, changes in vegetation and insect abundance (which could affect life history constraints or reproductive strategies), and shifts in the latitudinal range for some species.

1.4.2 Exotic Species

There are several exotic species present in the park, including rainbow trout, brown trout, feral dogs and cats, and many exotic plants. The urban interface surrounding the park is a major source of feral dogs, which have been identified as potential disease vectors, are a danger to park visitors, and can impact wildlife populations.

1.4.3 Water Pollutants

The Glorieta Creek and Pecos River 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 (NPS 1995b). 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 (see Chapter 3, Water Quality). The sewage treatment plant for the city of Pecos discharges into the river two miles upstream of the park. Some private landowners also dump untreated waste by into the Pecos River and Glorieta Creek. The staging for the widening and resurfacing of New Mexico State Road 50 was in a particularly vulnerable area of Glorieta Creek, just north of the park boundary. Its use included mining for soil and gravel. In total, water quality has been impacted within the park due to the heavy erosion and ensuing sedimentation (Reed et al. 1999).

1.4.4 Human Impacts/Adjacent Land Use

PECO was established partially to preserve its scenic resources. Elements of PECO's scenery remain from the ancestral Pueblo Indian and Spanish occupation and are affected by current land use changes outside the park. Residential development continues to increase outside the park's 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 (NPS 1995b).

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

1.5 Resource Stewardship

1.5.1 Management Directives and Planning Guidance

The Southern Plains Inventory & Monitoring (I&M) Network (SOPN) and PECO's Resource Stewardship Strategy (currently in development), in addition to PECO staff input, guided the selection of natural resources for this report. We also drew upon the Foundation for Planning and Management, completed in 2009, as a source of potential resources to include in the condition assessment. The cultural resources identified in the plan were also used as a source of potential reference conditions.

1.5.2 Status of Supporting Science

The data and reports used to assess the condition or reference condition of the resources in chapter four vary significantly. The references used are listed in each section.

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2 Study Scoping and Design

This NRCA is a collaborative project between Natural Heritage New Mexico and the NPS. Stakeholders in this project include the PECO park resource management team and Intermountain Region I&M Program staff. Before embarking on the project, it was necessary to identify the specific roles of Natural Heritage New Mexico and the NPS. Preliminary scoping meetings were held, and a task agreement and a scope of work document were created cooperatively between Natural Heritage New Mexico and the NPS.

The approach we used to select natural resources to assess and the context for assessment (i.e., reference conditions) was conducted in two primary stages. The first was a preliminary scoping session (see below) when management identified fundamental and important values for the park resources (both natural and cultural). Even though the resources assessed during the NRCA process are limited to natural resources, identifying important cultural resources helps to understand the cultural context in which natural resources would be considered and, in some cases, can form the basis for reference conditions used as part of the assessment.

In addition to identifying resources, management overlays were established as part of the preliminary scoping. These overlays represent one scale of within-park reporting areas where the management priorities differ from other reporting. This helps to define the spatial context that some resources are viewed in as well as form the basis for which some reference conditions may be established.

The second primary stage of selecting resources being assessed and the reference conditions to which current conditions are compared was a second scoping session that served to refine and identify the priorities.

2.1 Preliminary Scoping

We held two scoping meetings with PECO staff. The first was focused on:

1. Identifying and roughly delineating areas of interest (management overlays) that reflect potentially different priorities or concerns with respect to the resources and management.

2. Identifying important natural and cultural resources, management priorities, and concerns in each area. For this exercise we relied heavily on the newly developed foundation plan for PECO, in addition to the park staff.

3. Identifying preliminary management and interpretive themes for areas within the management overlays.

From this meeting, a preliminary study framework was developed.

The second scoping session was a follow-up to the first and intended to:

1. Confirm the management overlays and their primary management and interpretive themes for which reference conditions would apply.

2. Prioritize the list of potential natural resources to be included in the assessment based on:

a. Importance to park.

b. Importance as information needed for ongoing planning efforts.

c. Availability and characteristics of data and/or potential for reliable assessment.

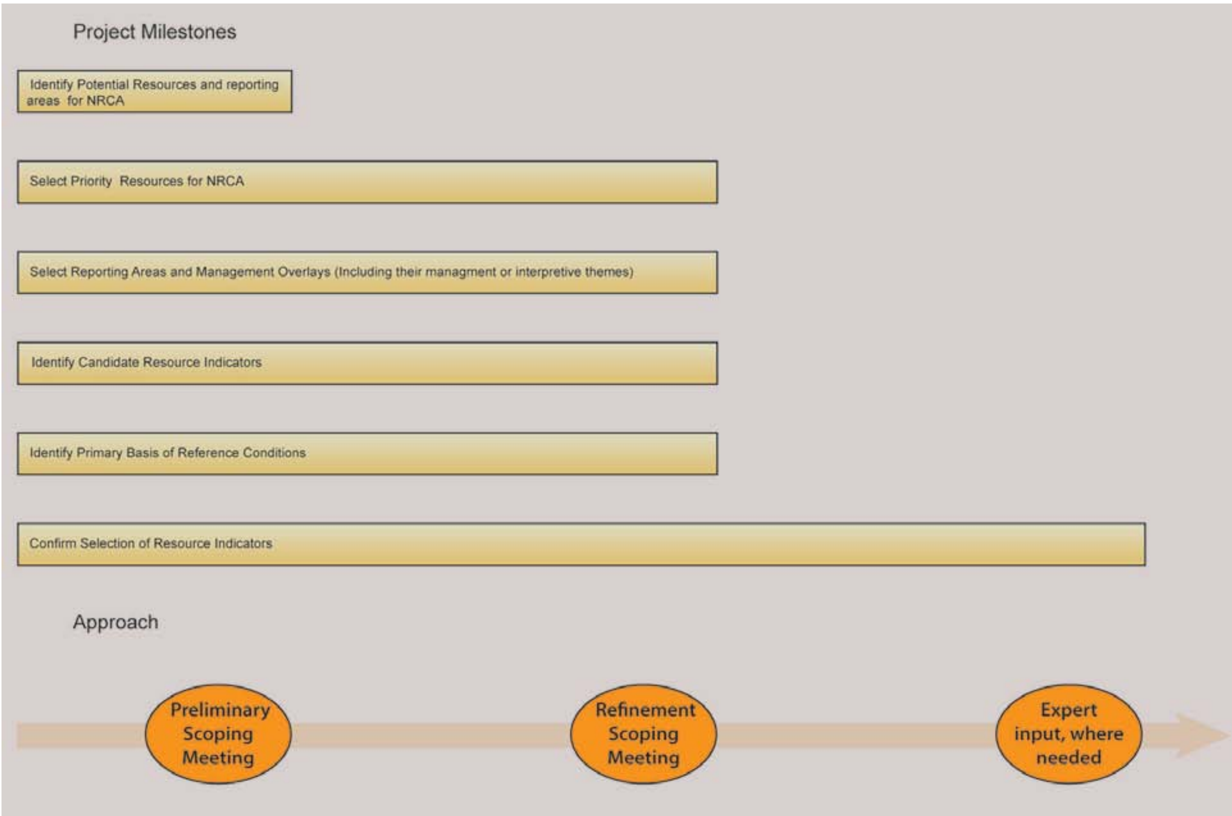

Figure 2-1. The general relationship among primary project milestones and the approach for participation during the scoping and design phase of the Pecos National Historical Park Natural Resource Condition Assessment.

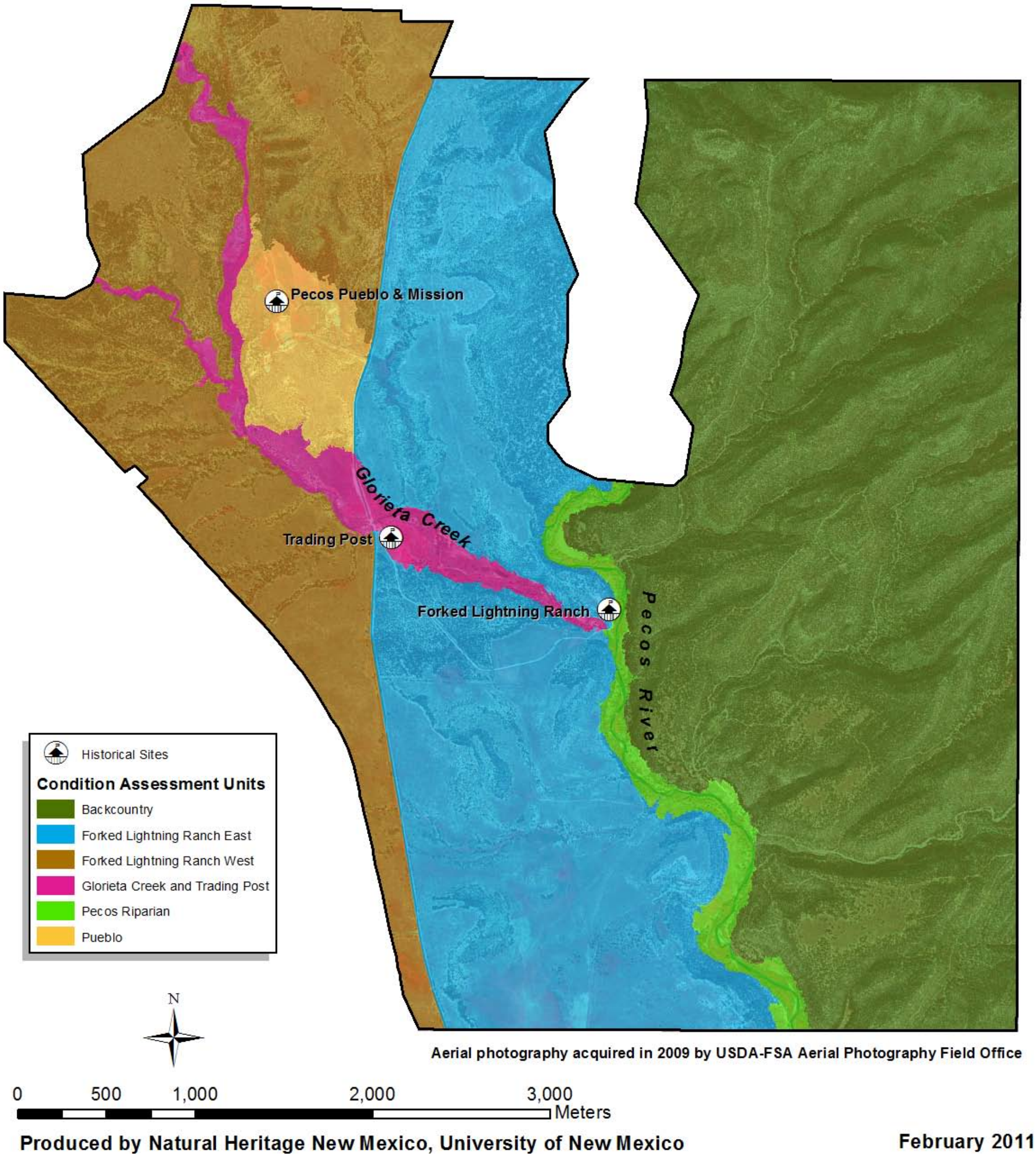

Figure 2-2. Reporting units for the Pecos National Historical Park Natural Resource Condition Assessment.

2.1.1 Reporting Units

As part of the initial scoping process, areas of management interest for the park were identified. It is important to note, however, that these do *not* represent any form of officially designated management zones. Such zones, if deemed appropriate, will be identified later during future stages of the planning process. Rather, these areas of management interest merely represent an initial attempt to identify areas that differ in the resources they contain, which may have implications for how an area is managed. Our intent for identifying them for this report is that they constitute a convenient unit of consideration as a management overlay

2.1.2 Primary Management and Interpretive Themes

Primary management and interpretive themes serve as a basis for developing resource indicators and appropriate reference conditions. These themes appear in the PECO Foundation for Planning and Management (NPS 2009).

Pueblo Unit. This unit is comprised of Pecos Pueblo and Mission ruins. The primary theme for this unit is the protection and interpretation of the ruins.

Pecos River Corridor. This unit is comprised of the Pecos River, including its associated riparian habitats. The primary management theme for this area will emphasize the ecological condition of the Pecos River with considerations for the river as part of a cultural landscape.

Glorieta Creek. This unit is comprised of Glorieta Creek, including its associated riparian habitats. This unit also includes Kozlowski's Stage Stop, a significant cultural feature. The primary theme for this area will emphasize the ecological condition of Glorieta Creek and its riparian habitat with consideration of this cultural resource.

Backcountry. This area is largely piñon-juniper habitat with scattered archeological sites. A functional piñon-juniper habitat is the primary management theme for this area. Thus, management will emphasize the ecological condition, with caveats where appropriate to protect archeological sites and three small pastures.

Forked Lightning Ranch East. This area is largely grassland with scattered encroachment of piñon-juniper and/or ponderosa pine habitats. The cultural landscape associated with the Forked-Lightning Ranch is the primary management/interpretive theme for this area. Thus, emphasis is maintaining pastures consistent with the cultural landscape, with caveats where appropriate to protect archeological and cultural sites.

Forked Lightning Ranch West. This area is largely grassland with scattered encroachment of piñon-juniper and/or ponderosa pine habitats. The cultural landscape associated with the ForkedLightning Ranch is the primary management theme for this area. The major distinction between this unit and the Forked Lightning Ranch East is that this unit has a greater number of archeological sites. Consequently, public access will likely be more restricted in this unit. As for Forked Lightning Ranch East, management will emphasize maintaining pastures consistent with the cultural landscape, with caveats where appropriate to protect archeological and cultural sites.

Pigeon's Ranch Unit. The primary theme for this unit is the Civil War, particularly the Battle of Glorieta Pass, with a secondary theme of ecological condition.

Cañoncito Unit. The primary theme for this unit is the Civil War, particularly the episode when the Union Army came off the Mesa and destroyed the confederate supply train.

2.1.2.1. Fundamental Resources and Values

Fundamental Resources and Values are defined by the PECO Foundation Plan (NPS 2009). They represent the most important ideas or concepts to be communicated to the public about PECO and warrant primary consideration for planning and management (NPS 2009). Consequently, they also warrant primary consideration for inclusion in this NRCA. Other important resources and values were identified and included in Table 2-1. They are particular to PECO, even though they do not contribute directly to the purpose and significance of the park (NPS 2009).

The fundamental or otherwise important resources and values related to the park's significance statement #4 are:

- Pecos River
- Glorieta Creek
- Glorieta Pass
- Riparian corridor
- Geology that formed the landscape
- Flora and fauna
- Visual connections in the landscape between key points
- Other important resources and values
- Soundscapes
- Air quality
- Night skies
- Historical pastures and other landscape features
- Remaining undisturbed viewsheds
- Soils

Although the fundamental resources and values for the remaining significance statements were cultural and not considered as potential resources for this NRCA, they were considered as relevant context within which to consider the condition of natural resources. Candidate study resources, as identified through initial project scoping, are shown in Appendix A.

2.1.3 Study Priorities: Resources and Indicators

It was neither practical nor feasible to conduct a condition assessment for all resources of interest to PECO. Budget limitations necessitated limiting the assessment to resources of high priority. However, it was not feasible to conduct the assessment even for all of the natural resources of high priority since not all of them had data from which to base an assessment of current condition. As such, we selected the resources to include for assessment from the list of potential resources identified during the scoping process. First we asked whether the resource was considered a high priority by the park. We also confirmed our list of priorities with resource specialists to ensure that we were not overlooking resources that may have high ecological significance, but which were not especially apparent to the park or other stakeholders. If a given resource was not considered a high priority by the park or specialists, it was not considered within the scope of this assessment. If, however, the resource was considered a high priority, we then determined whether sufficient data existed for an assessment and/or whether we had any reasonable basis to assess the current condition. In contrast to resources of lower priority, resources lacking data or an appropriate context were not excluded from the assessment; rather, they were included at a level less than that of a full assessment, but commensurate with the supporting information. This would include identification of important data gaps, as well as an appropriate descriptive narrative.

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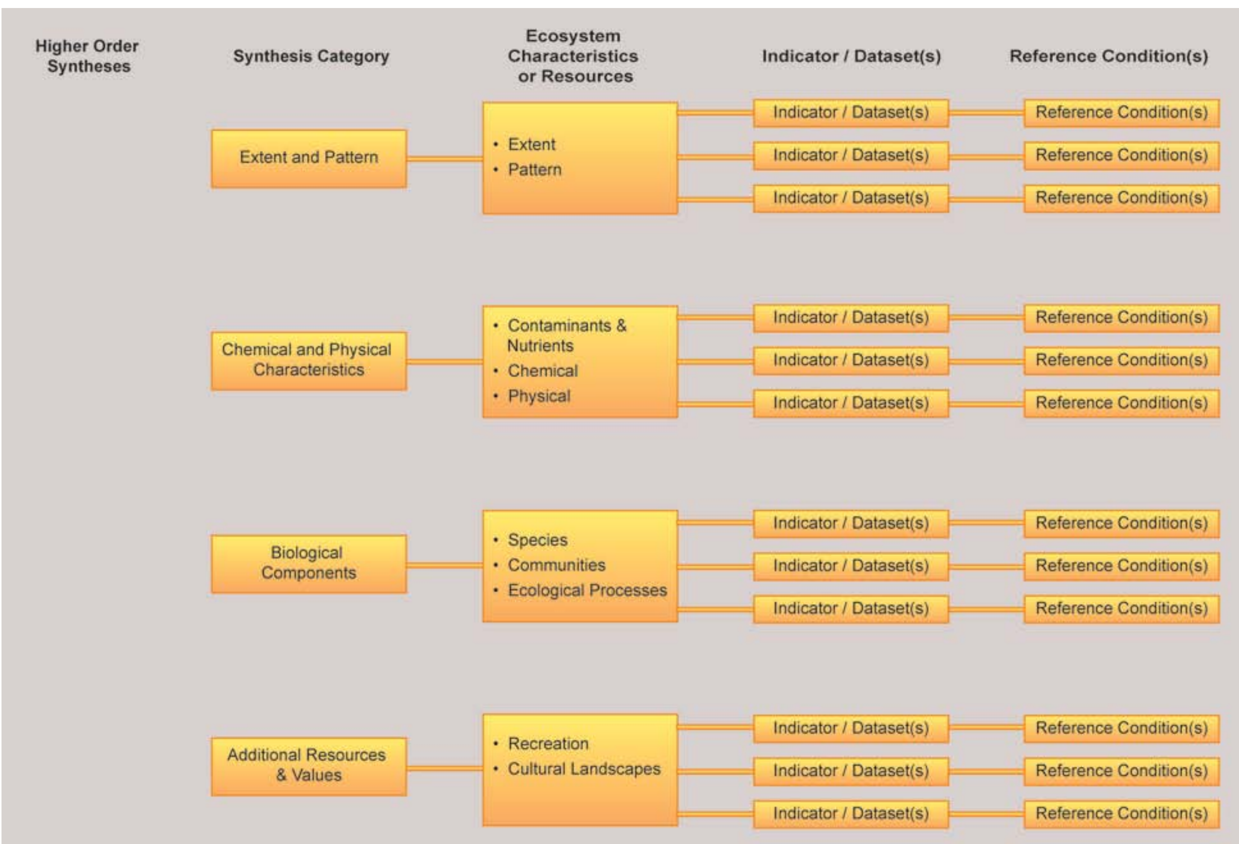

Figure 2-3. The sequence of primary criteria used to determine whether a given resource was included in the assessment, and at what level of consideration.

Table 2-1. Summary of resources presented in this assessment

Resource	Indicator	Park Level	Confidence in Data	Data Gap?	Section in Report
Air Quality					3.1
	Ozone	Exceeds (Moderate)	High	—	
	Deposition	Exceeds (Moderate)	High	—	
	Visibility	Exceeds (Moderate)	High	—	
	Mercury	Total Hg in ptt Exceeds	High	Yes	
Night Skies					3.2
				Yes	
Soundscapes					3.3
				Yes	
Geology					3.4
				Yes	
Soils					3.5
				Yes	
Water Quality					3.6
	GC Temp	Exceeds	High	—	
	GC Conductance	Exceeds	High	—	
	GC DO	Low	High	—	
	GC pH	4% Exceeded	High	—	
	GC Dissolved NO4/NO3	Exceeds	High	—	
	GC Turbidity	Exceeds	High	—	
	PR Temp	Exceeds in summer	High	—	
	PR conductance	Exceeds	High	—	
	PR DO	Exceeds	High	—	
	PR pH	9-11% samples exceeded	High	—	
	PR Turbidity	Exceeds	High	—	
Water Quantity					3.7
				Yes	

Resource	Indicator	Park Condition	Confidence in Data	Data Gap?	Section in Report
Exotic, Rare, and Sensitive Plant Species					3.8
	Senstive Plants	None	Moderate	—	
	Exotic Plants	Exceeds	High	—	
Vegetation Communities					3.9
Douglas-fir/Ponderosa pine					
				Yes	
Piñon-juniper					
				Yes	
Riparian Forest, Shrublands, and Herbaceous Wetlands					
	Lack of exotic species; stand structure	4 natives: 1 exotics; multi-aged stand structure	High	—	
Cottonwood					
	Diversity of age distribution	Diverse	High	—	
Riparian Ecosystem					3.10
	PFC Pecos Reach #1	PFC		—	
	PFC Pecos Reach #2	PFC		—	
	PFC Pecos Reach #3	PFC		—	
	PFC Glorieta Creek Reach	Functional- at risk		—	
Benthic Invertebrates					3.11
	Species Composition	Meets	Moderate	Yes	
Terrestrial Invertebrates					3.12
	Species composition	Meets	Moderate	Yes	
Fishes					3.13
	Nonnative sport fishery	Meets for breeding season	High	—	
	Native fishery	Lacking	High	—	
	Fish Tissue As	Exceeds	Low	Yes	3.6.2.4
	Fish Tissue Cd	Exceeds	Low	Yes	3.6.2.4
	Fish Tissue Hg	Exceeds	High	Yes	3.6.2.4
Herpetofauna					3.14
	Species Richness	45% of expected amphibians; 27% reptiles detected	Low	Yes	

Resource	Indicator	Park Level	Confidence in Data	Data Gap?	Section in Report
Birds					3.15
	Target list	Meets for breeding season	High	Yes	
Southwestern Willow Flycatcher					
	Presence	None detected	High	—	
Gray Vireo					
	Presence	None detected on Cañoncito	High	Yes	
Bald Eagle					
	Presence	Detected in winter	Moderate	Yes	
Mammals					3.16
	Target List	44% not present	Moderate	Yes	
Bats					
	Target List	7 of 15 expected spp.	Low	Yes	
Beaver					
	Presence	Present	High	—	
Feral dogs					
	Absence	Present	High	—	
Large Mammals					
	Target List	3 of 5 spp. Recorded	Moderate	—	

Table 2-2. Core Natural Resource Condition Assessment team

Name	Affiliation	Role	Team Function
Jeff Albright	NPS Water Resources Division	NPS Co-Lead/Key Official	Provides project direction consistent with NRCA Guidelines
Robert Bennetts	NPS Southern Plains Network	NPS Co-Lead	Provides project direction consistent with NRCA Guidelines
Kris Johnson	Natural Heritage New Mexico, University of New Mexico	Principal Investigator	Leads NRCA study effort, working within NRCA Guidelines
Teri Neville	Natural Heritage New Mexico, University of New Mexico	GIS Coordinator	Provides primary GIS support
Kathy Billings	NPS	PECO Superintendent	Ensures direction is consistent with PECO information needs
Dan Jacobs	NPS	PECO Chief Natural Resource Management	Ensures direction is consistent with PECO information needs
Auxiliary PECO Support			
Ted Benson	NPS	PECO Park Ranger/Natural Resources	
Heather Young	NPS	Museum Curator	
Environmental History Team			
Mark Feige	Colorado State University	Principal Investigator	
Maren Bzdek	Colorado State University		
Cori Knudten	Colorado State University		

2.2 Literature Cited

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3 Natural Resource Conditions

This chapter presents the background, analysis, and condition summaries for the 16 key resource indicators in the project framework. The following sections discuss the key resources and their measures and reference conditions. The order of indicators follows the project framework (Table 2-1). The summary for each indicator is arranged around the following sections:

- Background
- Data and Methods
- Reference Conditions
- Resource Description
    - Data Gaps
    - Condition of Data
- Literature Cited

3.1 Air Quality

3.1.1 Background

Even at low levels, air pollution in parks can affect ecological health, scenic views, human health, and visitor enjoyment. Therefore, NPS works to understand and preserve air quality and resources sensitive to air quality in the NPS system (NPS, Air Resources Division 2009). NPS measures progress in air quality improvement by examining trends for indicators such as visibility, atmospheric deposition, and ozone. Stable and improving air quality trends are considered signs of success (NPS, Air Resources Division 2009). The main types of data NPS uses to assess air quality are ozone, nitrogen (N) and sulfur (S) deposition, and visibility. Other parameters such as mercury are important in specific parks. The SOPN has identified wet and dry deposition as a vital sign for its parks (U.S. Department of the Interior NPS 2008).

3.1.1.1. Ozone

Ozone in the stratosphere protects against ultraviolet radiation, but ground-level ozone is an oxidizing pollutant that affects human health and vegetation. The main sources of ground-level ozone are vehicles, factories, and power plants. Although ozone sources are primarily located in urban areas, ozone precursors can travel long distances to national parks in remote areas. Human health effects include respiratory problems, such as asthma and reduced lung capacity, and impaired immune function. Laboratory studies have documented impacts to birds and other wildlife, but these findings have not been confirmed in the wild (NPS 2005).

Ample evidence does exist on the impacts of ozone to vegetation. Ozone enters plants through the stomata and oxidizes plant tissues, causing leaf injury and affecting growth (NPS 2005). NPS has identified ozone sensitive and bioindicator plant species for PECO (Table 3.1-1). Bioindicator species for ozone injury meet most/all of the following: (1) they exhibit foliar symptoms recognizable by experts; (2) their ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers; (3) they are widely distributed regionally; and 4) they are easily identified in the field. A 2004 risk assessment of SOPN parks found PECO to be at low risk for ozone damage to plants (NPS 2005).

Table 3.1-1. Ozone-sensitive plant species at Pecos National Historical Park (from NPS 2006)

PECO Ozone-Sensitive Plants
Apocynum cannabinum
Artemisia ludoviciana
Pinus ponderosa
Rhus trilobata
Salix gooddingii

The following description of the NPS standards for ozone is taken from NPS, Air Resources Division (2009).

> *The ozone standard is used as a benchmark for rating current ozone condition. This standard was revised in 2008 in order to be more protective of human health. To attain*

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this standard, the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 75 parts per billion (ppb). To derive an estimate of the current ozone condition at parks, the five-year average of the annual fourth-highest eight-hour ozone concentration is determined for each park from the interpolated values described above. If the resulting five-year average is greater than or equal to 76 ppb then the condition Significant Concern is assigned to that park. Moderate condition for ozone is assigned to parks with average five-year, -fourth-highest, eight-hour ozone concentrations from 61 to 75 ppb (concentrations greater than 80 percent of the standard). The condition Good for ozone is assigned to parks with average five-year ozone concentrations of less than 61 ppb (concentrations less than 80 percent of the standard).

Ozone concentration[1]	
Significant Concern	≥ 76 ppb
Moderate	61-75 ppb
Good	≤ 60 ppb

[1] "Ozone concentration" represents the fourth-highest daily maximum eight-hour average ozone concentration averaged over five years.

3.1.1.2. Deposition

Deposition of atmospheric N and S compounds can affect soils, water, and vegetation by forming acids when combined with water. PECO is unlikely to be greatly impacted by acidification, however, because soils and water in the area are generally high in cations such as calcium and magnesium that have acid-buffering effects. In contrast, the fertilization effects of deposited N compounds can impact N-limited southwestern systems. Native plants adapted to low-N soils can be out-competed by N-loving exotics. Thus, excessive deposited N could affect PECO by altering species composition, increasing biomass, and as a consequence, increasing fire frequency (NPS 2005).

The following description of the NPS standards for deposition is taken from NPS, Air Resources Division (2009).

Park scores for current condition of atmospheric deposition were based on wet deposition because dry deposition data is not available for most areas. Wet deposition for sites within the continental USA is calculated by multiplying N or S concentrations in precipitation by a normalized precipitation amount. (For sites outside the continental U.S., where interpolations cannot be calculated and normalized precipitation amounts are not available, five-year averages of on-site deposition are used. Deposition data are obtained from the National Atmospheric Deposition Program.)

Several factors are considered in rating deposition condition, including natural background deposition estimates and deposition effects on ecosystems. Estimates of natural background deposition for total deposition are approximately 0.25 kilograms per hectare per year (kg/ha/yr) in the West and 0.50 kg/ha/yr in the East for either N or S. For wet deposition only, this is roughly equivalent to 0.13 kg/ha/yr in the West and 0.25 *kg/ha/yr in the East. Certain sensitive ecosystems respond to levels of deposition on the order of 3 kg/ha/yr total deposition, or about 1.5 kg/ha/yr wet deposition. Evidence is not currently available that indicates that wet deposition amounts less than 1 kg/ha/yr cause ecosystem harm. Therefore, parks with wet deposition less than 1 kg/ha/yr are considered to be in Good condition for deposition; parks with from 1-3 kg/ha/yr are considered be in Moderate condition; parks with greater than 3 kg/ha/yr are considered to have a Significant Concern for deposition.*

Deposition Condition	Wet Deposition (kg/ha/yr)
Significant Concern	> 3
Moderate	1-3
Good	< 1

Scores for parks with ecosystems potentially sensitive to N or S were adjusted up one category (e.g., a park with N deposition from 1-3 kg/ha/yr that contains N-sensitive ecosystems would be assigned the deposition condition Significant Concern).

3.1.1.3. Visibility

Pollution affects visibility in parks or how far and how well visitors can see landscapes and other park features. Visibility is thus an indicator of pollutant particles and is an important value in national parks. Visibility is not monitored within any of the SOPN parks, but data on visibility-impairing particles and gases are collected at nearby monitoring sites through the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. Each IMPROVE site has a fine-particle sampler that measures the types and amounts of particles that obscure visibility (NPS 2005).

The following description of the NPS standards for visibility is taken from NPS, Air Resources Division (2009).

Individual park scores for visibility are based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions, where Group 50 is defined as the mean of the visibility observations falling within the range from the 40th through the 60th percentiles. For parks within the continental U.S., current visibility is estimated from the interpolation of the five-year averages of the Group 50 visibility. For sites outside the continental U.S., five-year averages are computed from on-site data. Visibility in this calculation is expressed in terms of a Haze Index in deciviews (dv). As the Haze Index increases, the visibility worsens. The visibility condition is expressed as

Visibility Condition = current Group 50 visibility – estimated Group 50 visibility under natural conditions.

Good condition is assigned to parks with a visibility condition estimate of less than two dv above estimated natural conditions. Parks with visibility condition estimates ranging two to eight dv above natural conditions are considered to be in Moderate condition, and parks with visibility condition estimates greater than eight dv above natural conditions are considered to have a Significant Concern. The dv ranges of these categories, while *somewhat subjective, were chosen to reflect as nearly as possible the variation in visibility conditions across the monitoring network.*

Visibility Condition	Current Group 50 – Estimated Group 50 Natural (dv)
Significant Concern	> 8
Moderate	2-8
Good	< 2

3.1.1.4. Mercury

Mercury is a persistent, bioaccumulative toxin, which means that it persists in the environment by cycling between air, water, and soil in various chemical forms, and it bioaccumulates in plant and animal tissues. Some bacteria convert mercury to methylmercury, a form that is more toxic than inorganic mercury. As methylmercury moves up the food chain, it becomes concentrated at the higher levels, as much as a million-fold in aquatic food chains. Humans bioaccumulate methylmercury by consuming fish containing mercury. Mercury is a neurotoxin; low-level exposure is associated with learning disabilities in children. It also interferes with reproduction in fish-eating animals and both methylmercury and mercuric chloride are potentially carcinogenic to humans (NADP 2008).

Certain species of fish in the Pecos River contain high concentrations of mercury in their tissues, and a fish consumption advisory for mercury is currently in effect. Sources of mercury in the environment may include runoff from certain mining activities and atmospheric deposition. The concentration of mercury in Pecos River fish did not appear to change appreciably after the Terrero Mine cleanup in 2002, in contrast to other heavy metals sampled which declined after the cleanup (see “Water Quality”). This suggests a continuing source of mercury, such as atmospheric deposition. Most mercury in deposition comes from the burning of coal for electricity production.

3.1.2 Data and Methods

Two air quality monitoring stations are located fairly close to PECO. IMPROVE Program visibility monitoring sites are located at Bandelier National Monument and Wheeler Peak in New Mexico. A National Atmospheric Deposition Program/National Trends Network (NADP/NTN) site located at Bandelier National Monument monitors precipitation chemistry (NPS 2005). Mercury wet deposition monitoring stations are located at Valles Caldera National Preserve in Sandoval County, New Mexico, and Navajo Lake in Rio Arriba County, New Mexico (Mercury Deposition Network 2010). The results for PECO are taken from these stations and evaluated against standards as described above and evaluated in NPS, Air Resources Division (2009).

3.1.3 Reference Conditions

Because ozone concentrations equal to or less than 60 ppb are considered to be good (NPS 2009), we use this cutoff as the reference condition for ozone. N and S depositions of less than 1 kg/ha/yr are considered to be good (NPS, Air Resources Division 2009); therefore, we use this cutoff as the reference condition for deposition. Because visibility less than 2 deciviews (dv) above the natural condition is considered to be good (NPS, Air Resources Division 2009), we use this cutoff as our reference condition for visibility. NPS Air Quality Division recommends a reference condition value for total mercury concentrations in rain and snow within the range of 2-3 ng/L, based on estimated pre-industrial natural background values (Meili et al. 2003; Schuster et al. 2002).

3.1.4 Resource Description

3.1.4.1. Ozone

Ozone concentration at PECO is 71.3, higher than the reference condition. This value places the park in the moderate range for ozone. (NPS, Air Resources Division 2009). These condition ranges are likely to be revised after August 2010, when EPA is planning to set an even more protective ozone standard no higher than 70 ppb.

3.1.4.2. Deposition

N and S deposition at PECO are 1.86 and 1.05, respectively. Both quantities are higher than the reference conditions. Deposition is rated as moderate for both S and N (NPS, Air Resources Division 2009).

3.1.4.3. Visibility

Visibility at PECO is 4.44 dv. This is higher than the reference condition. NPS therefore rates visibility as moderate in both parks (NPS, Air Resources Division 2009).

3.1.4.4. Mercury

Mercury concentrations in rain at PECO are estimated to be in the 14-16 ng/L range (NADP 2010), some of the highest concentrations in rain and snow in the country. The probable source is coal-fired power plants.

Deposition is a more accurate representation of mercury loading on the ecosystem than is concentration, and wet deposition in the area is relatively low at 4-6 $\mu g/m^2$/year (NADP 2010). Deposition is a function of concentration and amount of precipitation—the small volume of rain and snow in New Mexico results in a relatively low wet deposition rate. However, in the Southwest most mercury probably falls as dry deposition in the form of gases or particles; thus total deposition could be quite high (Ellen Porter, NPS Air Quality Division, pers. comm.).

No data on mercury dry deposition or background concentration are available for PECO (Caldwell 2006; Ellen Porter, pers. comm.). However, in one recent study, measurements of dry deposition at Caballo Reservoir in Sierra County, New Mexico, were estimated at 5.9 $\mu g/m^2$/year, compared to wet deposition rates of 4.2 $\mu g/m^2$/year from a nearby MDN site (Caldwell 2006). This paper suggests that dry deposition rates can be higher than wet deposition rates in arid south central New Mexico. Although measured mercury wet deposition rates in New Mexico are some of the lowest in the nation, it is likely that these wet deposition rates significantly underestimate the actual amount of mercury that is entering the ecosystem at PECO (Ellen Porter, pers. comm.).

In summary, total mercury concentrations in rain and snow at PECO are much higher than the recommended reference condition (14.2 vs. 2-3 ng/L). Although mercury wet deposition is relatively low in the area, dry deposition, which is unknown, likely adds significant mercury to the ecosystem. Fish tissue advisories indicate that mercury has entered the ecosystem at PECO and bioaccumulated in fish tissues to unacceptable levels. Given the high total mercury concentration in rain and snow, atmospheric mercury from coal-fired power plants in the region is likely a major mercury source.

3.1.5 Condition of Data

Monitoring stations used for this assessment are at Bandelier National Monument, Wheeler Peak, Valles Caldera National Preserve, and Navajo Lake. These distances may reduce somewhat the level of confidence in the current data. However, these are the only data available for these parameters. Data gaps reduce confidence regarding mercury deposition, but additional water quality sources support the impression that mercury deposition is high at the park. Thus, confidence in the air quality assessment is overall moderate.

3.1.6 Data Gaps

No data on mercury dry deposition or background concentration at PECO are available, and no data have been collected at the park. However, good monitoring data on the other parameters identified by NPS are available from other sites in New Mexico; thus data are sufficient for assessing condition of ozone, deposition, and visibility (NPS, Air Resources Division 2009).

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3.2 Night Skies

3.2.1 Background

Astronomers were the first to notice that artificial light was impacting views of night skies, causing stars and faint objects to be lost from view due to reduced contrast with a lighter sky. Light pollution is the illumination of the night sky by artificial light sources, caused by outdoor lights aimed toward the sky or sideways. Light that escapes into the sky scatters through the atmosphere and brightens the night sky, thereby diminishing the view of stars and other bright objects. Air pollution increases this scattering (NPS 2007).

Light pollution disrupts the habitat of nocturnal animals, thereby impacting their ability to hide, hunt, and navigate. Light pollution can also affect the life cycles of plants, and can annoy neighbors, which is called “light trespass.” Natural lightscapes can be integral to a park’s cultural landscape, especially in relatively remote historical parks such as PECO (NPS 2007).

National parks harbor some of the last remaining dark skies in the U.S.; however, because of the ability of light to travel long distances, even remote parks are not safe from light pollution. NPS has identified night skies as one of the scenic vistas under its stewardship. Although PECO is in a fairly rural area, night skies at PECO are still impacted by light from nearby cities and towns (Figure 3.2-1). PECO has identified natural lightscapes as an important resource for this assessment (NPS 2007).

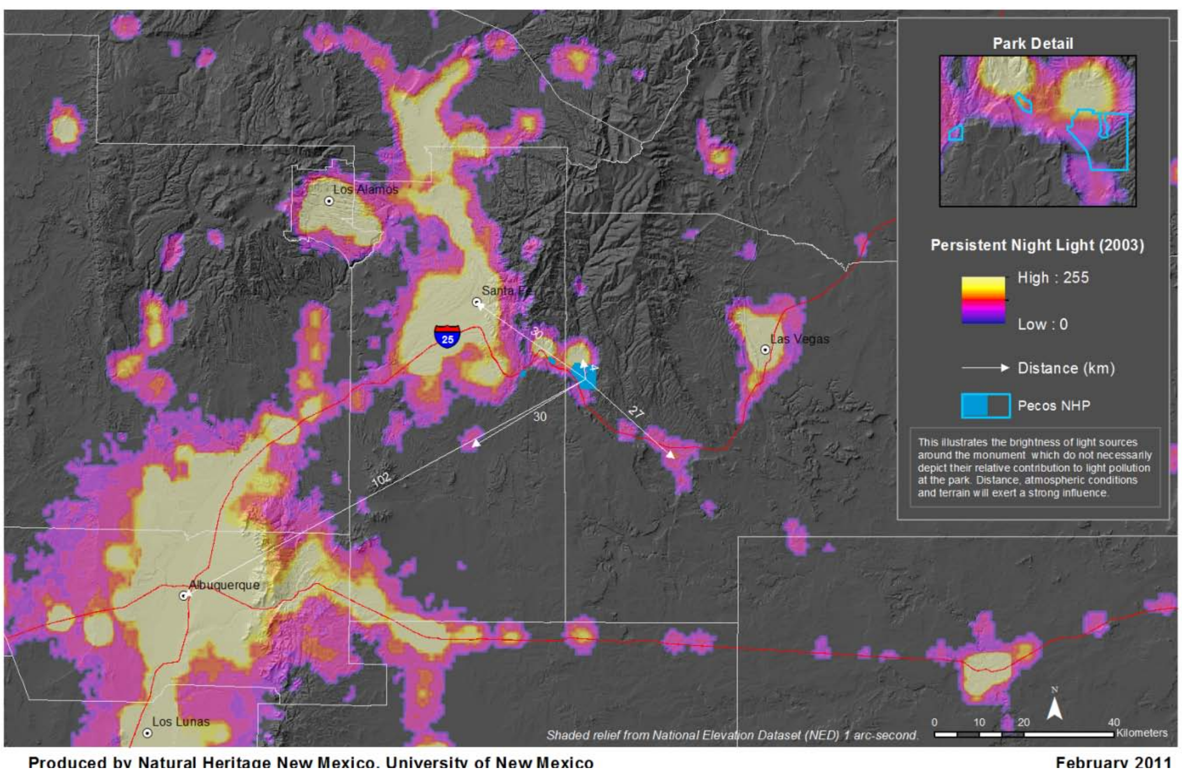

Figure 3.2-1. Night sky threats. Distance to and brightness of light sources near Pecos National Historical Park (from Elvidge et al. 1997).

3.2.2 Data and Methods

The NPS Night Sky Team collects data for assessment of night skies in several parks, but the team has not yet visited PECO.

3.2.3 Reference Conditions

A night sky assessment for PECO would collect data on light levels at PECO and indicate measures that could be used as reference conditions, for example, a natural lightscape lacking artificial light.

3.2.4 Condition of Data

Data are not currently available to assess this resource.

3.2.5 Data Gaps

A night sky assessment has not been completed for PECO. This constitutes a significant data gap. To address this data gap, the park should request a night skies assessment from the Night Sky Team Night Sky Program Manager, Chad Moore. Alternatively, in the absence of data collected at the park, some data exist for the PECO area (Figure 3.2-1). The Night Sky Team could provide a general assessment of the conditions at the park using available data (Chad Moore, pers. comm.). The park could request an interim assessment to use until data from the park become available.

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3.3 Soundscapes

3.3.1 Background

3.3.1.1. Sound Terminology

The natural soundscape is an inherent component of “the scenery and the natural and historic objects and the wildlife” protected by the Organic Act of 1916. NPS Management Policies (§ 4.9) require the NPS to preserve the park’s natural soundscape and restore the degraded soundscape to the natural condition wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscape from noise (i.e., inappropriate/undesirable human-caused sound).

Although the management policies currently refer to the term *soundscape* as the aggregate of all natural sounds that occur in a park, the Natural Sounds Program aims to update this terminology. Because the NPS works to protect and enhance park resources and visitor experiences, the Natural Sounds Program differentiates between the physical sound sources and human perceptions of those sounds. Currently, the Natural Sounds Program refers to the physical sound resources (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of audibility, at a particular location as the *acoustical environment*, while the human perception of that *acoustical environment* is defined as the *soundscape*. The Natural Sounds Program would like to move away from using *soundscape* as a blanket definition for both the physical sounds and the human perception of those sounds. Making this distinction will allow managers to create objectives for safeguarding both the *acoustical environment* and the *visitor experience*.

NPS recognizes the acoustical environment as a resource in itself, separate from its relationship to wildlife and visitors. This section of the document will focus specifically on the preserve’s acoustical environment. For a discussion on sound and its importance to wildlife and visitor experience, please see those sections below.

3.3.1.2. Characteristics of Sound

Humans perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air and is measured in terms of amplitude and frequency (Harris 1998; Templeton and Sacre 1997). Noise, essentially the negative evaluation of sound, is defined as extraneous or undesired sound (Morfey 2001). Sound pressure level is proportional to the sound power and is measured in decibels (dB). The decibel is a logarithmic scale unit that is commonly used to relate sound pressures to some common reference level, thus producing a smaller, more manageable range of numbers. The loudness of a sound as heard by the human ear is estimated by an A-weighted decibel scale, where the A-weighting provides a formula for discounting sounds at low (<1 kHz) and high (> 6 kHz) frequencies. This adjustment for human hearing is expressed as dB(A). For this discussion, the A-weighted values are used to describe potential effects on the park’s acoustical environment and soundscape. The following table (Table 3.3-1) provides examples of A-weighted sound levels.

Table 3.3-1. Examples of sound levels

Reference Sound	dB(A) Level[1]
Normal breathing	10
Leaves rustling	20
Crickets (16 feet)	40
Light traffic at 100 feet	50
Normal conversation (5 feet)	60
2 stroke snowmobile (30 mph at 50 feet)	70
Helicopter landing at 200 feet	80
Heavy truck or motorcycle (25 feet)	90
Thunder	100
Military jet (110 feet)	120
Shotgun firing	130

[1] *An increase of 10 dBA represents a perceived (to human hearing) doubling of sound pressure level; that means 20 dBA would be perceived as twice as loud as 10 dBA, 30 dBA would be perceived as 4 times louder than 10 dBA, etc.*

3.3.1.3. Wildlife

The preservation of a park's acoustical environment is vitally important to overall ecosystem health. The peer reviewed literature widely documents the critical role of sound in intra-species communication, courtship and mating, predation and predator avoidance, and effective use of habitat. Studies have shown that wildlife can be adversely affected by sounds and sound characteristics that intrude on their habitats. While the severity of the impacts varies depending on the species being studied and other conditions, research strongly supports the idea that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds (noise) and other human disturbances. Documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, and separation of mothers and young (Selye 1956; Clough 1982; NPS 1994; U.S. Department of Agriculture Forest Service 1992; Anderssen et al. 1993).

When noise elevates ambient sound levels, signals that might otherwise have been detected and recognized are missed. The noise is said to mask these signals. Masking degrades an animal's auditory awareness of its environment and fundamentally alters interactions among predators and prey. Many animal species rely almost exclusively on sounds to locate their prey (e.g., owls, gleaning bats). Masking also affects acoustic communication. Animals have been shown to alter their calling behavior and shift their vocalizations in response to noise (Brumm and Slabbekoorn 2005; Patricelli and Blickley 2006; Slabbekoorn and Ripmeester 2008; Warren et al. 2006). These shifts have been documented in a variety of signal types: begging calls of bird chicks (Leonard and Horn 2007), alarm signals in ground squirrels (Rabin et al. 2006), echolocation cries of bats (Gilman and McCracken 2007), and sexual communication signals in birds and anurans (Brumm and Slabbekoorn 2005; Patricelli and Blickley 2006; Warren et al. 2006; Slabbekoorn and Ripmeester 2007; Parris et al. 2009). Vocal adjustment likely comes at a cost to both energy balance and information transfer; however, no study has addressed receivers. Some species are unable to adjust the structure of their sounds to cope with noise even within the same group of organisms (Lengagne 2008). These differences in vocal adaptability could partially explain why some species do well in loud environments and others do poorly (Patricelli and Blickley 2006; Slabbekoorn and Ripmeester 2007).

Some large herbivores have been observed to habituate to acoustic stimuli (Krausman et al. 1998; Weisenberger et al. 1996). Habituation is a decreased responsiveness to a stimulus upon repeated exposure. For several reasons, reports of habituation to noise should be interpreted with caution. A reduction in one form of response may represent a shift to another, unobserved mode of response rather than development of complete tolerance. Observation of more tolerant population may be the result of sensitive individuals leaving the area (Bejder et al. 2006). Animals that remain may not have other viable options. Finally, a completely habituated animal has learned to ignore a class of stimuli, some of which may contain biologically significant information.

3.3.1.4. Visitor Experience

Our ability to see is a powerful tool for experiencing our world, but sound adds a richness that sight alone cannot provide. In many cases, hearing is the only option for experiencing certain aspects of our environment. Natural sounds often present the best opportunities to find wildlife because animals can be heard at much greater distances than they can be seen. The opportunity to experience an unimpaired acoustical environment is an important part of overall visitor experience and enjoyment. This perception of the acoustical environment represents what is referred to as the soundscape (see the “Natural Soundscape” section for definitions). Many natural sounds such as bird songs or the rustling of leaves can have a calming and relaxing effect. Other sounds such as the chirp of crickets or a gentle breeze can trigger memories of pleasant past experiences.

Noise can distract visitors from the resources and purposes of the park. Increasingly, even those parks that appear as they did in a historical context do not sound like they once did. Natural sounds are being masked or obscured by a wide variety of human-caused sounds. Thus, soundscape preservation and noise management are challenges to the NPS mission of preserving park resources unimpaired for the enjoyment of future generations.

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet that parks can offer. In a 1998 survey of the American public, 72% of people identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998). Additionally, 91% of NPS visitors “consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks” (McDonald, Baumgartner, and Iachan 1995). In studies of visitor preferences, respondents consistently rate many natural sounds such as birds, wind, and water as very pleasing. As a result, the presence of unwanted, uncharacteristic, or inappropriate sounds can interfere with or alter the soundscape and degrade visitor experience. Uncharacteristic sounds or sound levels affect visitors’ perceptions of solitude and tranquility and can be annoying. Visitor evaluations of annoyance are affected by many factors, including the setting in which the sounds occur, the visitors’ recreational activities, and their expectations of quiet and solitude. Characteristics of the sound also contribute to levels of annoyance. Annoyance is related to rate of occurrence, duration, loudness, and sporadic nature of sounds (Newman, Pilcher, and Manning 2005).

Impacts to visitors can also be quantified at particular decibel levels (see Table 3.3-2). These impacts could include increase in blood pressure and heart rate, sleep interruption, or speech interference. If the sound level goes over the particular decibel level listed in Table 3.3-2, the potential for that impact increases.

Table 3.3-2. Explanation of sound level values

Sound Levels (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al. 2008)
45	World Health Organization’s recommendation for maximum noise levels inside bedrooms (Berglund et al. 1999)
52	Speech interference for interpretive programs (U.S. Environmental Protection Agency 1974)
60	Speech interruption for normal conversation (U.S. Environmental Protection Agency 1974)

3.3.1.5. Cultural Soundscape

The primary mission for many national park units is to protect the resources and values related to the culture, ethnic heritage, and history of a group or a place. Many locations in national parks are significant because of the meaning, memories, and experiences people associate with them. Cultural resources include tangible materials such as structures and artifacts, as well as intangible aspects of cultural expression: oral traditions, cannon fire, and battle reenactments. Visitors to cultural and historical units of the National Park System want to better understand and embrace America's heritage in a direct and personally meaningful way. In protecting the park’s cultural soundscape (§ 5.3.1.7 of NPS Management Policies), the NPS improves a visitor’s opportunity to reach that goal.

An appropriate acoustical environment is an important element in how we experience the cultural and historical resources in the national parks. Visitors want to immerse themselves in the historical time period or cultural expressions associated with a site. Unwanted or inappropriate sounds can detract from the overall enjoyment of visitor experience. Additionally, noise can distract visitors from the resources and purposes of cultural areas—the tranquility of historical settings and the solemnity of memorials, battlefields, prehistoric ruins, and sacred sites. In order to provide a more accurate interpretation of a park’s period of significance, it is important to manage parks as they would have appeared and sounded during that time.

3.3.2 Data and Methods

Congress passed the National Parks Air Tour Management Act of 2000 to regulate commercial air tour operations over units of the National Park System. The Department of Transportation’s Volpe Transportation Center Acoustics and Air Quality Facilities are supporting the Federal Aviation Administration, Western Pacific Region, and working cooperatively with the National Park Service in the development of Air Tour Management Plans for all national parks with commercial air tours. The objective of the Air Tour Management Plans is to develop acceptable and effective measures to mitigate or prevent significant adverse impacts from air tours on the natural and cultural resources, visitor experiences, and tribal lands within the parks. An Air Tour Management Plan has not been written for PECO but one is planned for the future.

The Volpe Transportation Center conducted the first season of acoustic monitoring at PECO between July and September 2010. This study utilized specially designed low-level measurement systems deployed at multiple sites within the park and collected continuous sound-level data over a period of several weeks. Additional monitoring is planned for the winter season. Unfortunately, the September data could not be fully analyzed in time to be incorporated into this document. In the absence of these data, the following sections include a qualitative assessment of the park's natural and cultural sounds and the management of unnatural sounds.

3.3.3 Reference Conditions

A potential reference condition for natural sounds might be the natural ambient sound level, essentially the absence of human-caused sound. The park will probably wish to adopt different standards for different reporting units, based on the sound conditions and potential for modification in each. The acoustic monitoring recently conducted at the park will provide metrics for characterizing the acoustical environment at PECO and identifying a quantitative reference condition for this resource. For example, percent time of audible human-caused sounds per hour would provide a metric and a reference condition as a starting point for a quantitative evaluation.

3.3.4 Resource Description

PECO is situated in a bowl between Glorieta Mesa to the west, the Sangre de Cristo Mountains to the north, and the Back Country to the east. Sounds, both natural and human-caused, are trapped and accentuated by this topography. The park has natural and cultural sounds integral to the visitor experience, but unwanted, human-caused sounds can impact visitor experience, wildlife, and park acoustic resources.

Natural sounds at PECO include wind, the Pecos River, and wildlife vocalizations. These sounds are most detectable in the Back Country and along the Pecos River but are appropriate and desirable throughout the park. Natural sounds at PECO are important to a complete visitor experience of nature and are crucial to the survival and reproduction of many wildlife taxa that occur at PECO. For example, owls and bats need to hear to locate prey, and songbird mating and territoriality could be disrupted if male song is masked (see "Wildlife"). Cultural sounds support the visitor experience of park cultural resources. For example, the sounds of Civil War encampments, such as cooking, horseshoeing, and black powder demonstrations, support the park's cultural mission.

Highway noise is the human-caused sound with the largest impact on PECO's acoustic resources, visitors, and wildlife. The loudest source of traffic noise is Interstate 25, a four-lane, 75-miles-per-hour highway which runs along the west side of the main unit and the Cañoncito Subunit. New Mexico State Road 63 is a two-lane state road that runs through the main unit. New Mexico State Road 50 is a two-lane state road that passes through the Pigeon's Ranch Subunit. Noise from Interstate 25 is quieter at night and can be masked at times by the wind. Otherwise, Interstate 25 is a fairly consistent and intrusive source of noise. Park staff indicated that without the highway noise, the park would be extremely quiet.

In the spring and summer, restoration work on the adobe ruins requires the use of bobcats and small engine machines that could impact visitor experience and wildlife that nest or roost on or near the ruins. The restoration process is observed as part of the visitor experience that the park wishes to retain, but mitigation techniques could be implemented to reduce noise impacts. Tour buses and visitor vehicles create intermittent noise, primarily near the Visitor Center. Aircraft sound is not a major noise source at the park, but small aircraft occasionally fly over the park, and commercial jets pass over the park at 30,000 feet or higher. Engine and whistle sounds from a nearby train are detectable intermittently in the park. These are not a big concern, and in fact could be considered part of the cultural soundscape, demonstrating the historical role of PECO as a transportation corridor. The barking of feral dogs is another noise that impacts primarily visitors and the acoustic environment.

3.3.4.1. Park Management of Unnatural Sounds

Highway noise, particularly from Interstate 25, is mostly out of park control. The park has requested a speed limit reduction on New Mexico State Road 50 but has received no response. Working with the New Mexico Department of Transportation to reduce speed limits on New Mexico State Road 50 and New Mexico State Road 63 is probably the only feasible approach to addressing these noise sources.

The PECO Superintendent's Compendium (NPS 2009) identifies park policies around several noise sources. Because "the idling of vehicle engines adds unnecessary exhaust fumes to the air and diminishes the enjoyment by visitors of the peace and tranquility of the park," all motor vehicles on all park roads must shut down their engines when the vehicles are not moving. Noisy activities that require a permit include: operating a chain saw in developed areas, any type of portable motor or engine in undeveloped areas, and a public address system in connection with a permitted public event. Use of fireworks and conducting public assemblies, meetings, sports events, entertainment also require a permit. Commercial vehicles must be permitted before they can access park roads.

PECO is an air tour management plan park, which means that commercial air tour operators have been granted interim operating authority by the Federal Aviation Administration (FAA) to fly over the park. Currently, 32 flights per year are allowed over the park. The Natural Sounds Program works with the FAA to develop Air Tour Management Plans for parks. No Air Tour Management Plan has been developed for PECO yet, but there are plans to develop one in the future.

The park will probably want to adopt different soundscape standards for different areas of the park. For example, the Back Country reporting unit would be expected to have fewer human-caused sounds than areas near Interstate 25, while some machine noise and maintenance activities by park staff are necessary in areas with high visitor access. PECO staff might want to apply more stringent soundscape standards in areas such as the Pecos River, where natural sounds are especially desirable to visitors, and wildlife might be particularly vulnerable. In addition, the acoustical environment should be considered when new technologies for visitor education are proposed. For example, some NPS parks have adopted cell phone tours that can result in extraneous speaker noise. Interpretive strategies should consider what technology is appropriate for use in the park. Another strategy might involve scheduling the use of heavy equipment and engines for park maintenance activities at the same time, therefore reducing the duration of time noise is heard.

3.3.5 Condition of Data
In the absence of acoustic monitoring data, confidence cannot be assessed for this resource assessment.

3.3.6 Data Gaps
PECO is on track to fill a major data gap by completing the first round of acoustic monitoring.

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3.4 Geology

3.4.1 Background

Geology is the underlying basis for topography, soils, hydrology, and vegetation, and therefore potentially affects nearly all park resources. Geologic monitoring can provide understanding of ecosystem health, detect long-term environmental change, and help determine if management practices need revision. Finally, geologic resources are important in their own right, are some of the most impressive resources in many parks, and greatly enhance visitor experience.

3.4.2 Data and Methods

A geologic resource scoping meeting for PECO was held in Las Vegas, New Mexico, on 28 March 2006 to discuss the park's geologic resources, the status of PECO geologic maps, and management needs. Participants included PECO staff, NPS Geologic Resources Division staff, and cooperators from the New Mexico Bureau of Geology and Mineral Resources and Colorado State University (NPS 2006). The scoping meeting resulted in a scoping document (NPS 2006). Since the scoping process was completed, NPS Geologic Resources Division staff, in collaboration with the New Mexico Bureau of Geology and Mineral Resources and Colorado State University, created a digital geologic map for PECO (Croskrey et al. 2009). This map combined data from two previous maps, Ilg et al. (1997) and Read and Rawling (2002). Figure G1 was created from these digital map layers downloaded from the NPS Data Store. A final Geologic Resources Inventory report is in progress but is not expected for several years (Bruce Heise, NPS Geologic Resources Division, pers. comm.). The following summary is taken from the scoping document (NPS 2006) and an upcoming book on the geology of northern New Mexico parks (Rawling 2010).

3.4.3 Reference Conditions

No reference conditions have been identified for PECO geology.

3.4.4 Resource Description

PECO sits in the Pecos River Valley in the foothills of the Sangre de Cristo Mountains (Rawling 2010). The park is located in a transition zone of three geophysical provinces: Southern Rocky Mountains, Great Plains, and Basin and Range. The conjunction of these three provinces creates a diversity of geologic features at the park. The rock layers at PECO are mainly horizontal with minor structural undulations. The shales and sandstones forming these rock layers were formed from sediments shed from the Ancestral Rocky Mountains (NPS 2006). The pueblo and mission were built on a low ridge of red, maroon, and purple mudstones and tan-to-red sandstones and conglomerates of the Sangre de Cristo Formation, which were deposited by meandering rivers on floodplains over 280 million years ago (mya). Surrounding the ruins and covering much of the valley floor are much younger Pleistocene sand and gravel layers deposited by the Pecos River 150,000 to 300,000 years ago (Rawling 2010).

The most distinctive geologic feature is Glorieta Mesa, visible to the west of the park. The base of the mesa is formed from river and floodplain deposits of the Sangre de Cristo Formation (>286 mya, grayish red and gray Pennsylvanian sandstones). The mesa contains additional rock formations, including the Santa Rosa Formation (yellow Triassic sandstone), Moenkopi Formation (245 mya, grayish-red Triassic sandstones), Artesia Formation (orange Permian siltstones), Glorieta Formation (yellow sandstone), and Yeso Formation (<286 mya, reddishbrown Permian sandstones and siltstones) (NPS 2006). The rocks of the Yeso Formation were deposited in coastal tidal flats called *sabkhas* (Rawling 2010).

North, northeast, and northwest of the park are the Sangre de Cristo Mountains, underlain by Madera limestones and sandy limestones. The oldest rocks in the area, igneous and metamorphic rocks over one billion years old, have been uplifted along faults and are visible in the exposed summits of Glorieta Baldy, Thompson Peak, and Santa Fe Baldy (Rawling 2010).
The scoping process identified several geologic features, processes, and issues at PECO. These include streams; hillslope, eolian, and seismic features and processes; paleontological features; disturbed lands; caves and karsts; and geologic interpretation and education.

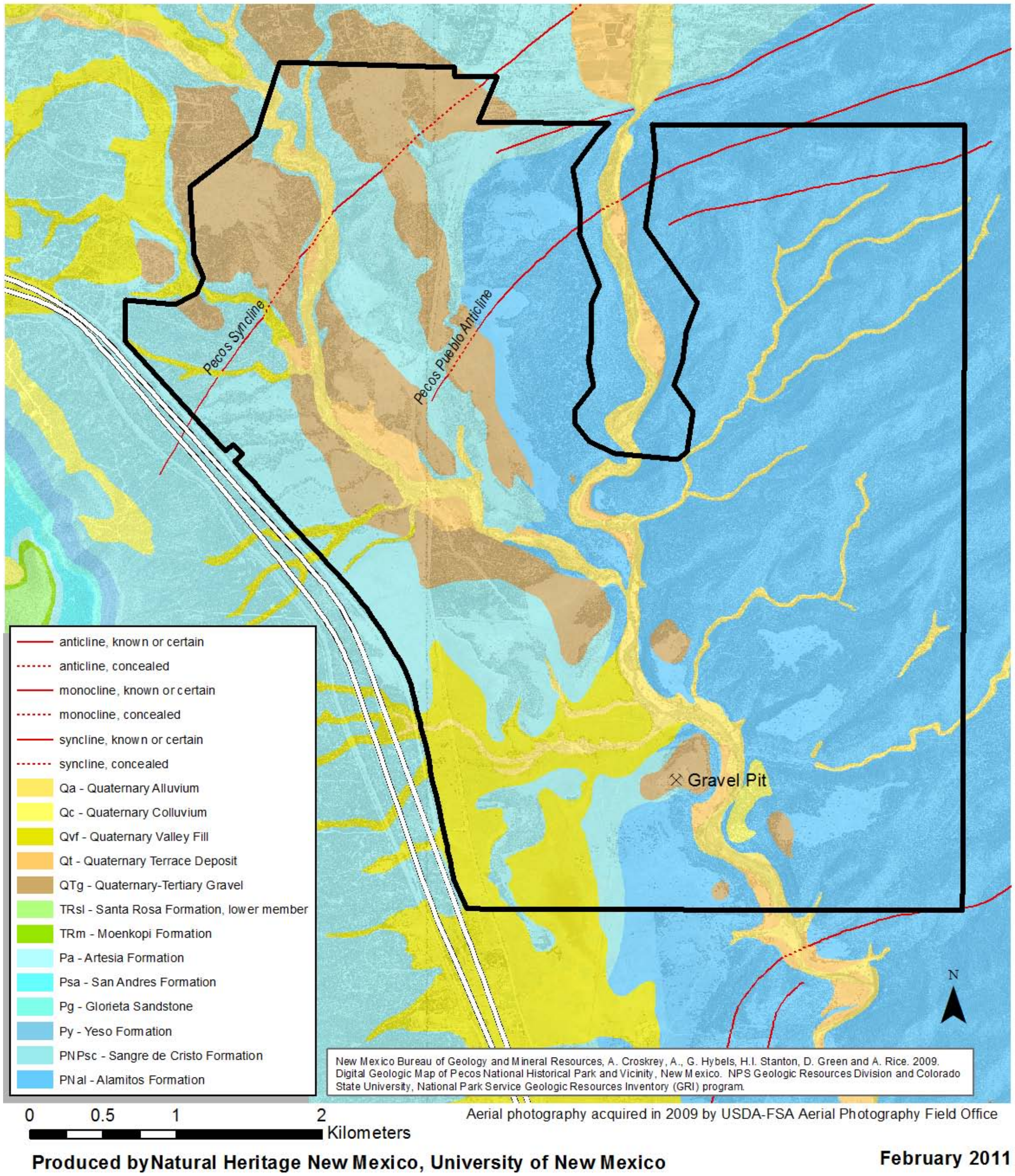

Figure 3.4-1. Geology of Pecos National Historical Park.

3.4.4.1. Streams

Galisteo Creek, Glorieta Creek, and the Pecos River flow through the park. Flooding is not a threat to park infrastructure, but fluvial erosion along the creeks may be a concern for cultural resources. The cultural site nearest the Pecos River is 23 m from the current riverbank, but other important cultural sites are over 25 m away. The mill site is 57 m from the river, and the nearest petroglyph sites are 23, 25, and 30 m from the river's edge (data extracted from a sites Access database from March 1999 used in development of Head and Orcutt 2002). Sites near the river could therefore be subject to flooding. However, at most of these sites, there is no current evidence that overbank flooding occurs (see “Riparian Assessment”). Cultural sites near the river have persisted for decades to centuries; thus, flooding is likely not an imminent threat to these resources. Down cutting and narrowing of stream channels, as well as bank erosion on the Pecos River, may impact riparian ecosystems and channel morphology (see “Riparian Assessment”).

3.4.4.2. Hillslope features and processes

No park infrastructure appears to be threatened by mass-wasting processes. Slumping occurs primarily along river corridors. Some historical roads, such as the Old Colonias Road, are sloughing away, but because these roads are not maintained mass wasting was determined not to be a concern. If the park decides to maintain these roads, sloughing would need to be addressed.

3.4.4.3. Eolian (windblown) features and processes

Periodic dust storms occur at PECO but they are not a resource management concern.

3.4.4.4. Seismic features and processes

Between 1962 and 2010, 98 earthquakes occurred in the area around PECO (Figure 3.4-2). None of these occurred on park property, but seismic activity clearly occurs in the vicinity of PECO as indicated by earthquake catalogs for New Mexico and bordering areas (Sanford et al. 2002; Sanford et al. 2006; Morton 2008).

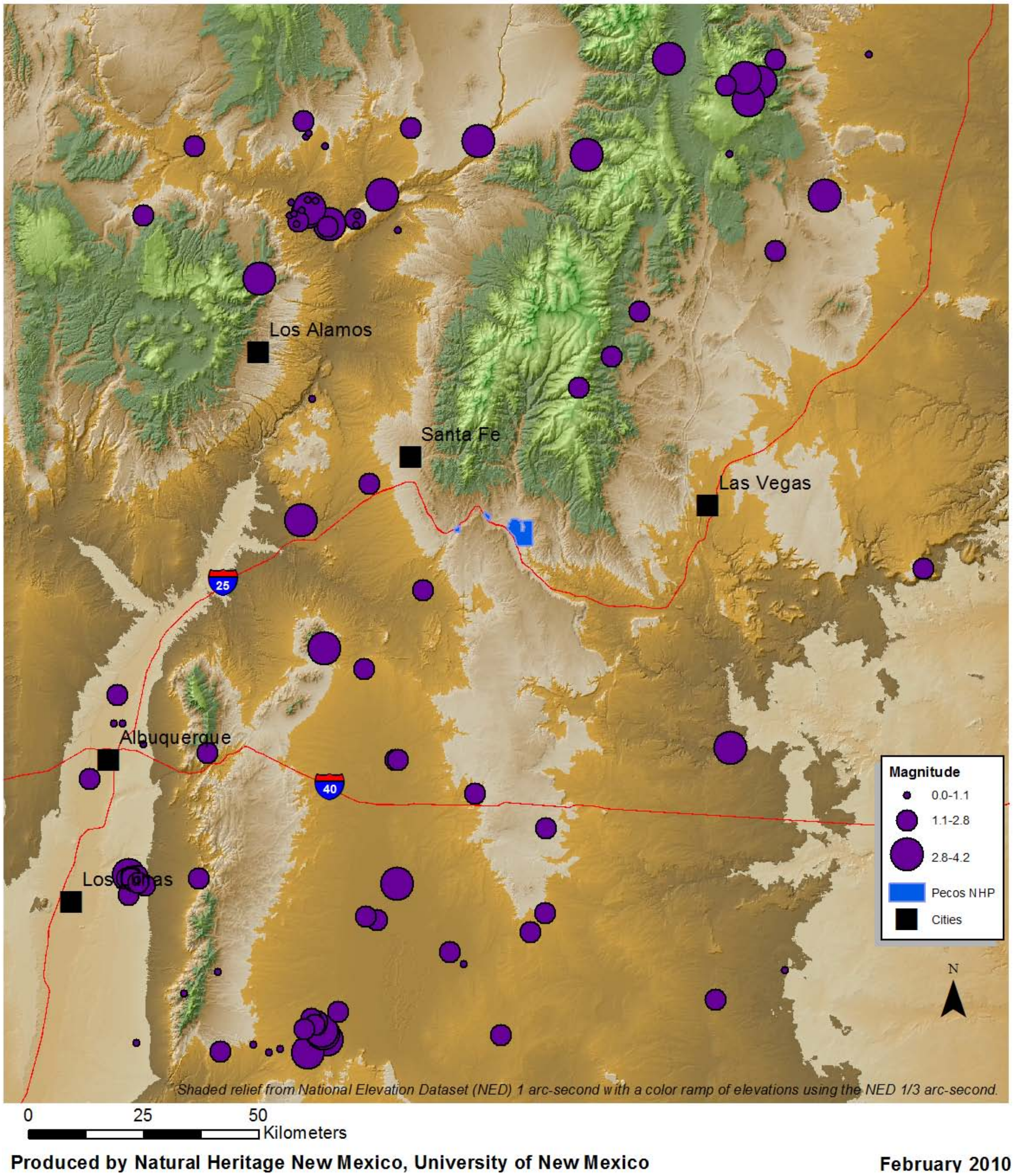

Figure 3.4-2. Earthquakes surrounding Pecos National Historical Park, 1965-2009.

3.4.4.5. Paleontological resources

No fossils have been found at PECO, but two geologic units that are exposed at the park have paleontological resources elsewhere (Koch and Santucci 2003). The first fossiliferous formation exposed at PECO is the Upper Pennsylvanian to Lower Permian Sangre de Cristo Formation. Koch and Santucci (2003) describe this formation as follows: "This approximately 500-foot-thick unit is composed of conglomerate, buff and red sandstone, red siltstone, red and greenish-gray shale, and gray limestone. Vaughn (1969, 1972, cited in Koch and Santucci 2003) reported upon multiple fossil vertebrates from the Sangre de Cristo Formation in Colorado, most notably the microsaur *Trihecaton howardinus*. Other specimens include palaeoniscoid fishes, labyrinthodont amphibians, aistopod amphibian, diadectid cotylosaur, and various pelycosaurs."

The other fossiliferous formation exposed at PECO is the Upper Pennsylvanian Upper Member of the Madera Formation. The strata are composed of gray limestone, red and greenish-gray shale, and brownish-red conglomeratic sandstone. Multiple reports of fossils from the Madera Formation suggest a strong possibility of discovering specimens at PECO (Koch and Santucci 2003). Examples of fossils found elsewhere in the Madera Formation include marine invertebrates from Sandoval County (Kues et al. 1997, cited in Koch and Santucci 2003), a large gastropod (*Pharkidonotus megalius*; Kues 1987, cited in Koch and Santucci 2003*)* from south-central New Mexico, shrimp from the Manzanita Mountains (Schram and Schram 1979, cited in Koch and Santucci 2003), a eurypterid *Adelophthalmus luceroensisi* from Valencia County (Kues and Kietzke 1981, cited in Koch and Santucci 2003), and fusulinids from Huerfano Park, Colorado (Tischler 1963, cited in Koch and Santucci 2003). In addition, the Madera Formation has yielded fossil plants, insects, conchostracans, brachiopods, and disarticulated fishes from Bernalillo County (Huber et al. 1989, cited in Koch and Santucci 2003); a new genus and species of a trimerorhachid labyrinthodont amphibian (*Lafonius lehmani*) from the Manzano Mountains (Berman 1973, cited in Koch and Santucci 2003); and various fragments of pelycosaurian reptiles, a iadectomorph reptile, an embolomerous amphibian, and a hybodont shark from central New Mexico (Cook and Lucas 1998, cited in Koch and Santucci 2003).

Petrified wood is reported in the north and east sections of the park (D. Jacobs, pers. comm.). The absence of paleontological survey data constitutes a data gap for PECO, particularly given that rock formations present at PECO have been found to contain fossils in other areas of New Mexico.

3.4.4.6. Disturbed Lands

No mining of significant economic value occurred within the park (but see "Water Quality" regarding the Terrero Mine upstream of the park).

Gravel pits were mined for the road base of Interstate 25, probably around 1965-1975 (D. Jacobs, PECO, pers. comm.). Most of these pits were reclaimed prior to the establishment of the park. One gravel pit remains in the south part of the park alongside the Old Colonias Road, just before it dips into the Pecos River Valley (NPS 2006, D. Jacobs pers. comm.).

3.4.4.7. Caves and Karst

The Baca Cave is a naturally occurring fault cave that has been enlarged in several places by human activities. It is 73.7 m long and 9.14 m deep, with a volume of approximately 283 m^3 (Burger and Allison 2008a, b). It was formed primarily along a series of north-south normal faults with east-west passages formed on joints perpendicular to the faults. The cave entrance is in a grainy sandstone bed about 9 m thick. A few feet below the floor of the entrance is a gray limestone bed about 9 m thick (Burger and Allison 2008a). The cave contains no obvious valuable minerals; this finding is supported by the geology of the surrounding area. Several passages appear to have been enlarged and juniper logs are still present inside the cave. Local legend maintains that the cave was enlarged by treasure hunters. Various graffiti and old beverage cans were present when the cave was surveyed (Burger and Allison 2008a).

The cave is not currently used by the park. Access to the cave is difficult due to a river crossing and steep terrain. The public is not allowed access to the cave, to protect both visitors and the resource. The park monitors but does not actively manage the cave and has no plans for it. Burger and Allison (2008a) noted several potential hazards, including a rock-fall hazard at the southern fissure in the cave and falling hazards on climbs into a small dome and a 30-foot shaft. The surveyors recommended not publicizing the cave, keeping it administratively closed, and monitoring it annually for signs of visitation (Burger and Allison 2008a). They also recommended that the cave be surveyed for biological and archaeological resources and graffiti removed. Building a gate at the entrance would be difficult, and they deemed a gate unnecessary at this time.

Another cave known as the Small Cave is located at the base of a cliff approximately 18.3 m southeast of Baca Cave and about 4.6 m higher in elevation. It appears to have formed on the same north-south fault as the Baca Cave (Burger and Allison 2008a). Three passages in Small Cave can be followed for about 12 m before becoming too tight to traverse.

3.4.4.8. Geologic interpretation and education

PECO interpreters often include geology information in their talks, such as during tours of the ruins. Virgil Lueth of New Mexico Bureau of Geology and Mineral Resources has led one geology tour for his staff. Jennifer Lindline, geology professor at New Mexico Highlands University, presented a poster on park geology at the 2007 Pecos Conference. She has also led several field trips in the park that included park staff. A few years ago the park offered a "Geology and Human Environment" tour. Finally, every year park interpretive staff conduct curriculum-based education programming for all Pecos Middle School students on geology. This program is about 4-5 h in duration and includes a field trip to the park with pre- and post-trip classroom visits (Christine Beekman, PECO chief of interpretation, pers. comm.).

3.4.5 Condition of Data

This assessment is descriptive in nature, due to the lack of a final inventory report; thus, confidence is low.

3.4.6 Data Gaps

At this writing, the Geologic Resources Inventory for PECO has not been completed and a full assessment is therefore not possible.

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3.5 Soils

3.5.1 Background

Soil is defined as the "unconsolidated portion of the Earth's" crust modified through physical, chemical, and biotic processes into a medium capable of supporting plant growth" (NPS 2010). Information about soil properties is essential for protecting and managing soils, vegetation, and other park resources. Because soils are important indicators of ecosystem health, the SOPN has identified soil structure and chemistry as a core vital sign and soil movement as a vital sign for the Inventory and Monitoring Program (NPS 2008).

3.5.2 Data and Methods

Soils data meeting the standards of the National Cooperative Soil Survey Standards or NPS Soil Resources Inventory are not available for PECO. Available State Soil Geographic Database (STATSGO) data are too broad and not applicable to NPS units. An interim soils report was developed for PECO by Soil and Water West, Inc., Rio Rancho, New Mexico, in 1996. This report contained neither a geospatial soils map nor a soils database and was deemed insufficient to meet the needs of the NPS (Pete Biggam, NPS Soils Program Manager, pers. comm.).

3.5.3 Reference Conditions

No reference condition has been identified for PECO soils.

3.5.4 Condition of Data

There is no confidence in a soils assessment.

3.5.5 Data Gaps

The lack of a comprehensive, recent, applicable soils survey represents a significant data gap for PECO. This gap could be filled by a survey meeting National Cooperative Soil Survey Standards.

3.5.6 Literature Cited

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3.6 Water Quality

3.6.1 Background

Surface water is crucial for riparian ecosystems, aquatic organisms, wildlife, and humans in national parks. The SOPN has identified water chemistry as a core vital sign for SOPN parks, and PECO has identified water quality as an important resource for assessment (NPS 2008). Water quality parameters such as temperature, dissolved oxygen, conductance, and pH provide an overview of water quality. *E. coli* and fecal coliforms indicate presence of biological contaminants from septic systems, livestock, and sewage effluent. In addition, the U.S. Environmental Protection Agency (EPA) and the New Mexico Environment Department monitor suites of ions, toxic metals, and antibiotics.

3.6.2 Data and Methods

The Baseline Water Quality Data Inventory and Analysis of Pecos National Historical Park (NPS 1995a) addressed water quality at PECO up to 1995. Edwards Aquifer Research and Data Center (EARDC) reviewed water quality data for the SOPN parks from the STORET (STOrage and RETrieval) database legacy period ending in 1999 (EARDC 2007).

It is important to assess more recent water quality data, in part because the 2002 remediation of the Terrero Mine site probably reduced mine impacts. At the time of this writing, the most comprehensive, recent water quality survey of the Pecos River and Glorieta Creek was conducted by New Mexico Environment Department in 2001 (New Mexico Environment Department 2004). New Mexico Environment Department collected data again in 2010 but the data were not available when this section was finalized. PECO park personnel have been collecting water quality data on a more limited set of measures from 1994-2009, and these data have recently been summarized and reviewed by Porter and Longley (2009). Data from these two studies are the most recent data available to assess current conditions for water quality parameters at PECO. We adopted state and federal water quality standards as reference conditions. These are set by the EPA and the New Mexico Environment Department and were taken from New Mexico Environment Department (2004) and Porter and Longley (2009).

As noted by EARDC (2007), heavy metal concentrations in streambed sediments or in biological tissues could provide a more reliable basis for assessing heavy metal concentrations than do water column samples. Heavy metals bioaccumulate in tissues. Three sources of data exist on toxins in fish tissue in the Pecos River. The first is a 1993 memo from Roy Irwin, NPS environmental contaminants specialist, summarizing analyses of heavy metals in six fish collected from the Pecos River, 0.25 miles north of the Forked Lightning Ranch house in August 1992. The second is a report summarizing similar analyses of 16 fish fillets collected in September 1993 from just upriver of the ranch house and 3.5 km downstream near the south park boundary (Binstock et al. 1993; Van Mouwerik 1994). The third, by the Scientific Lab Division of the New Mexico Environment Department, summarizes results for a sample of 13 fish collected in November 2003 downstream of the confluence of the Pecos River and Glorieta Creek (State of New Mexico Department of Health 2003).

3.6.2.1. Historical Data

The Baseline Water Quality Data Inventory and Analysis, Pecos National Historical Park (NPS 1995a) addressed water quality at PECO up to 1995. That study found 14 parameters that exceeded screening criteria in the Pecos River at least once. Levels for pH, cadmium, copper, lead, selenium, silver, and zinc exceeded EPA acute or chronic criteria for the protection of freshwater biota. Nitrate, sulfate, beryllium, cadmium, copper, lead, nickel, and zinc exceeded EPA drinking-water criteria. Total coliform and fecal coliform exceeded the Water Resources Division screening limits for freshwater bathing, and turbidity exceeded limits for aquatic life. However, no stations having long-term records were located within the park boundaries, and only one parameter, pH, exceeded screening criteria at a station within park boundaries.

At the time of those reports, the most severe water quality impacts to the Pecos River were associated with former mining and milling activities. The sources of most heavy metals were likely the Terrero Mine, adjacent to the river about 14 miles north of PECO, and the El Molino Mill Site, northwest of the village of Pecos on Alamitos Creek, approximately one mile above its confluence with the river (NPS 1995b). During the driest summer months, flows on Glorieta Creek may be composed primarily of effluent from the Glorieta Conference Center wastewater treatment plan (NPS 1995b). These discharges raised concerns regarding water quality on the creek. The Horizons study (NPS 1995a) reported no exceedences for Glorieta Creek, but data were limited. Additional potential nonpoint sources of pollution into Glorieta Creek included residential and commercial septic systems, stream bank erosion, and illegal dumping (NPS 1995b).

Edwards Aquifer Research and Data Center (EARDC) reviewed water quality data for the Southern Plains Network parks from the STORET database legacy period ending in 1999 (EARDC 2007). They found Pecos River water quality conditions generally suitable to meet requirements for aquatic life. A few effects of hard-rock mining were noted. Zinc and aluminum concentrations exceeded limits for aquatic life on occasion. They noted that heavy metal concentrations in streambed sediments or in biological tissues (see “Summaries for Fish Tissues”) could provide a more reliable basis for assessing heavy metal concentrations. Concentrations for nutrients were also generally low at all sites sampled (EARDC 2007).

3.6.2.2. Data Collected by PECO, 1994-2000

PECO personnel have collected data within park boundaries since 1994. Data were collected at three stations, in the Pecos River upstream from the Glorieta Creek confluence, Glorieta Creek upstream from its confluence with the Pecos River, and in the river about 1.3 miles downstream from its confluence with Glorieta Creek (Stations A, B and C, respectively on Table 3.6-1). Collections occurred monthly to bi-monthly. The main measures sampled were temperature, dissolved oxygen, specific conductance, and pH, with a few additional measures sampled for limited time periods (Porter and Longley 2009).

Analysis of the data collected at the park revealed several quality-control issues. Data collection was spotty from 2000-2002. Unexpectedly high values for specific conductance (2008-2009) and pH (2001-2004) and low values for dissolved oxygen (2003-2004) were assumed to be the result of calibration errors and were removed from the analysis (Porter and Longley 2009).

Water temperatures were higher in Glorieta Creek than in the Pecos River. Temperature showed an upward trend from 1994-2002 at both sites but may be decreasing in recent years. Median dissolvedoxygen concentrations (DO) were less than New Mexico water quality criteria for about 1.3% of Pecos River measurements and 9.4% of Glorieta Creek samples. DO has decreased in Glorieta Creek since 2000 during low flow conditions, but DO in the river has remained fairly constant. Median specific conductance values in Glorieta Creek were three times those of the Pecos River and nearly 98% exceeded New Mexico water quality standards. These values increased by more than 50% from 1994-2009. New Mexico water quality criteria for pH were not met in about 11% of samples from the Pecos River and about 4% of samples from Glorieta Creek, with decreases noted in both places since 2004 (Porter and Longley 2009). Park-collected data summaries are compared with reference condition values in Table 3.6-1.

3.6.2.3. Data Collected by New Mexico Environment Department, 2001

On several dates in 2001, New Mexico Environment Department collected water quality data in the upper Pecos River watershed. Data from three sampling sites (Figure 3.6-1) are summarized here: Glorieta Creek above its confluence with the Pecos River, Pecos River below the Village of Pecos Wastewater Treatment Plant, and Glorieta Conference Center Wastewater Treatment Plant (New Mexico Environment Department 2004). Only the Glorieta Creek site is within park boundaries, but the other two sites are upstream of the park and sampled water that subsequently flowed into the river and the creek, respectively.

New Mexico Environment Department (2004) reports only values that exceeded New Mexico water quality standards, shown in Table 3.6-1 (a-d) and Table 3.6-2 (a-c). Queries of the STORET database (James Hogan, Scott Hopkins, New Mexico Environment Department pers. comm.) provided the raw data from this survey, including detail on the other parameters sampled. At station 50PecosR777.1, Below the Village of Pecos Wastewater Treatment Plant, the following samples were collected: ions full suite; nutrients; the following ions: calcium, magnesium, hardness, and total dissolved and suspended solids (TDS/TSS); *E coli*; fecal coliforms; temperature; DO; DO saturation; pH; and turbidity. At station NM0028088, Glorieta Conference Center Wastewater Treatment Plant, New Mexico Environment Department sampled all of the above plus metals dissolved; metals total full suite; mercury/selenium; and antibiotics. At station 50Glorie001.8, Glorieta Creek above its confluence with the Pecos River, New Mexico Environment Department sampled the same parameters as at station 18 plus a full suite of ions TDS/TSS (see Appendix B).

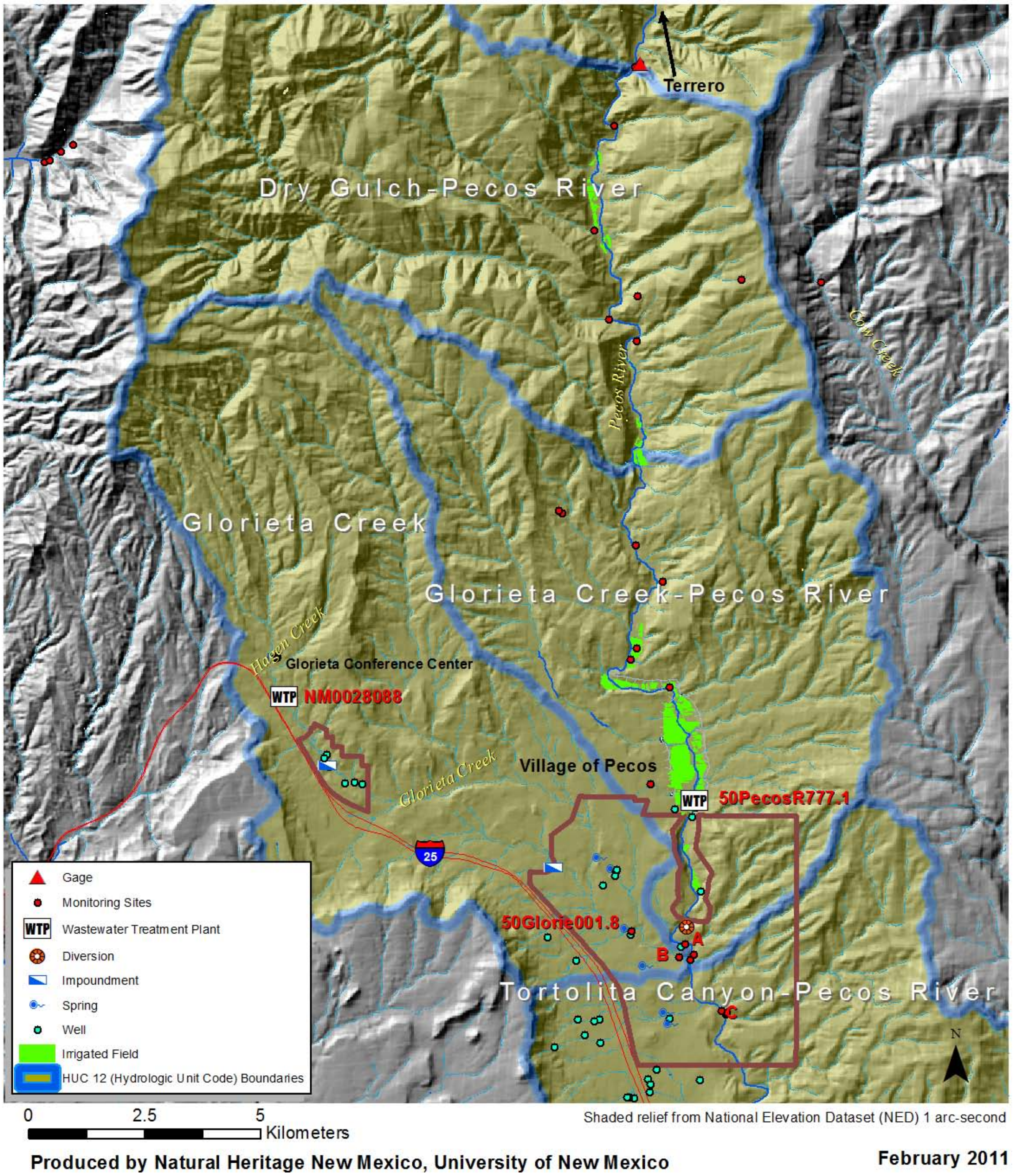


Figure 3.6-1. Watersheds of Pecos National Historical Park.

Table 3.6-1. Glorieta Creek current water quality condition, temperature and conductance (a), dissolved oxygen and dissolved oxygen saturated (b), pH and Ammonia (c), Dissolved Nitrate/Nitrite and Turbidity (d).

(a)

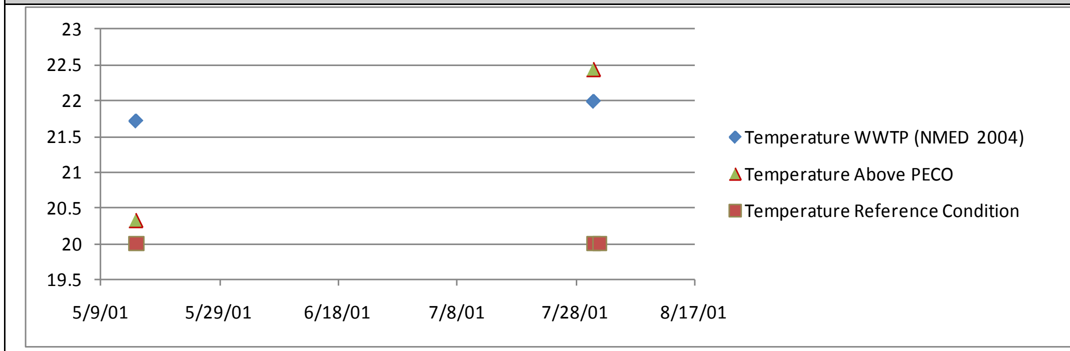
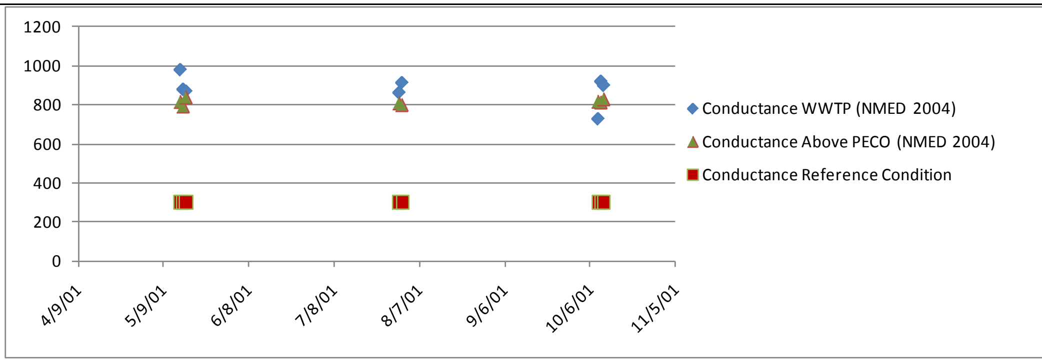
<table>
<tr><th colspan="4">Glorieta Creek</th></tr>
<tr><th></th><th>New Mexico Environment Department (2004)</th><th colspan="2">Porter and Longley (2009)</th></tr>
<tr><td rowspan="4">Temperature</td><td rowspan="4">
</td><td>Reference Condition: (°C)</td><td>20° C coldwater fishery</td></tr>
<tr><td>Trend:</td><td>Downward 2003-09, upward 1994-2003 (Porter and Longley 2009)</td></tr>
<tr><td>Confidence:</td><td>High, some values questionable and eliminated</td></tr>
<tr><td>Current Condition:</td><td>Exceedences common during summer months (Porter and Longley 2009)</td></tr>
<tr><td rowspan="4">Conductance</td><td rowspan="4">
</td><td>Reference Condition: (µS/cm)</td><td>300 µS/cm</td></tr>
<tr><td>Trend:</td><td>Increasing (Porter and Longley 2009)</td></tr>
<tr><td>Confidence:</td><td>High, some questionable values eliminated</td></tr>
<tr><td>Current Condition:</td><td>755; 98% exceeded 300 (Porter and Longley 2009)</td></tr>
</table>

Table 3.6-1 (b)

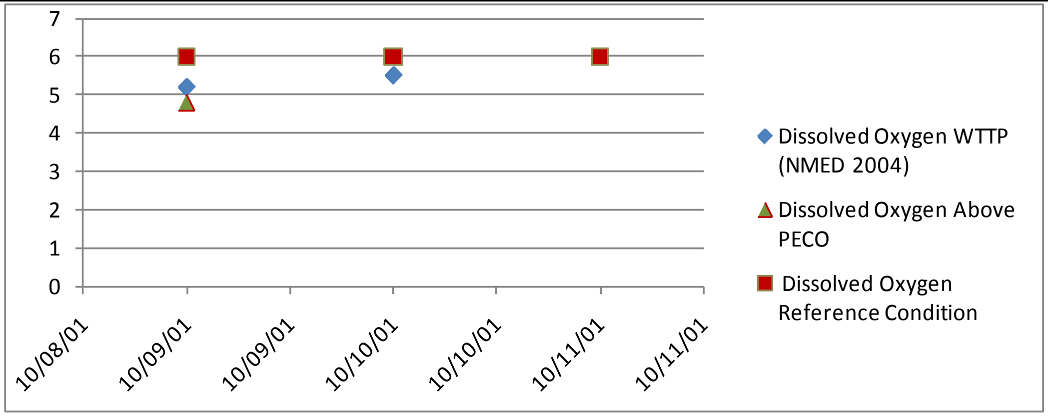
Glorieta Creek			
	New Mexico Environment Department (2004)	Porter and Longley (2009)	
Dissolved Oxygen		Reference Condition (mg/l):	6 mg/l for high quality coldwater fishery
		Trend:	Decreased since 1999 (Porter and Longley 2009)
		Confidence:	High
		Current Condition:	Generally higher than ref cond., but lower in GC than PR. < 6 in 9.4% of samples (Porter and Longley 2009)
Dissolved Oxygen Saturation	No data.	Reference Condition:	~100%
		Trend:	Decreased
		Confidence:	High
		Current Condition:	Lower than in the mid-1990s (Porter and Longley 2009)

Table 3.6-1 (c)

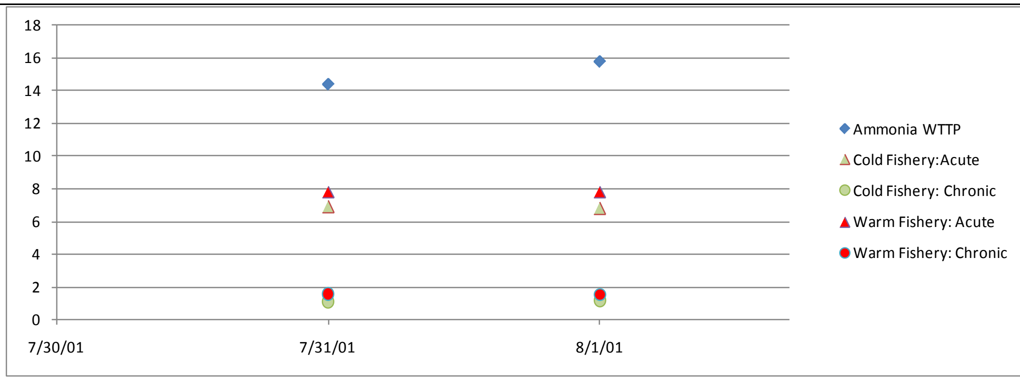
Glorieta Creek			
	New Mexico Environment Department (2004)	Porter and Longley (2009)	
pH	No data.	Reference Condition:	6.6 – 8.8 (NMED) or 6-9 (EPA)
		Trend:	Variable, possible decline
		Confidence:	High
		Current Condition:	Median =8.1; Mean = 8.1; 4% exceeded (Porter and Longley 2009)
Ammonia		Reference Condition:	No data.
		Trend:	No data.
		Confidence:	No data.
		Current Condition:	No data.

Table 3.6-1 (d)

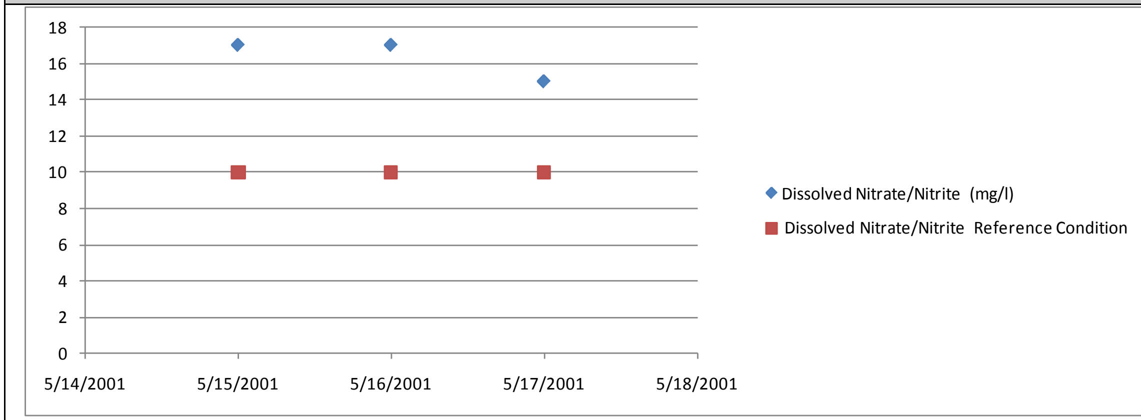
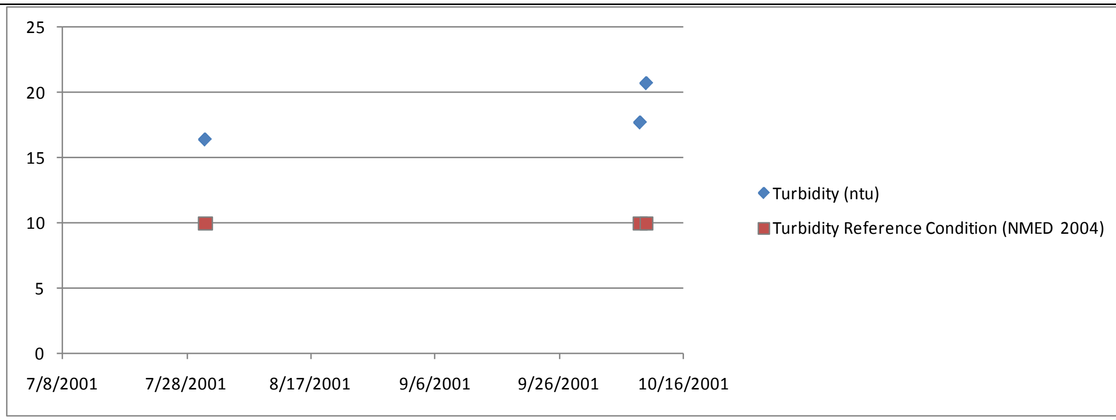
Glorieta Creek			
	New Mexico Environment Department (2004)	Porter and Longley (2009)	
Dissolved Nitrate/Nitrite		Reference Condition:	No data.
		Trend:	No data.
		Confidence:	No data.
		Current Condition:	No data.
Turbidity		Reference Condition:	No data.
		Trend:	No data.
		Confidence:	No data.
		Current Condition:	No data.

Table 3.6-2. Pecos River water quality condition, temperature and conductance (a), dissolved oxygen and dissolved oxygen saturated (b), pH and turbidity (c).

(a)

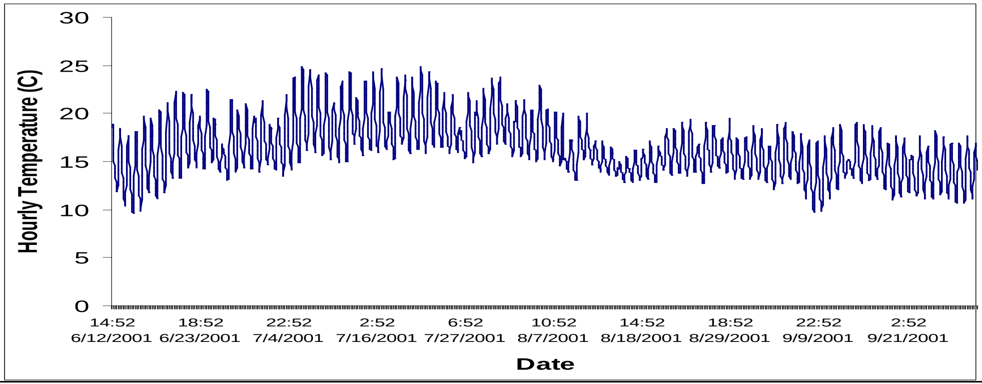
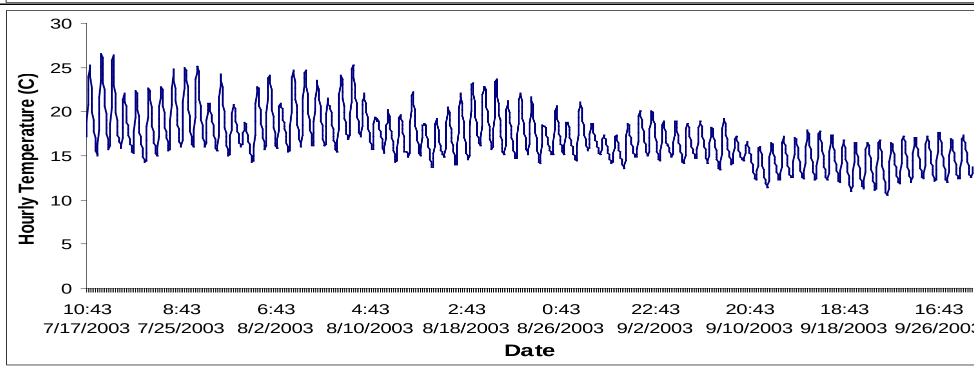
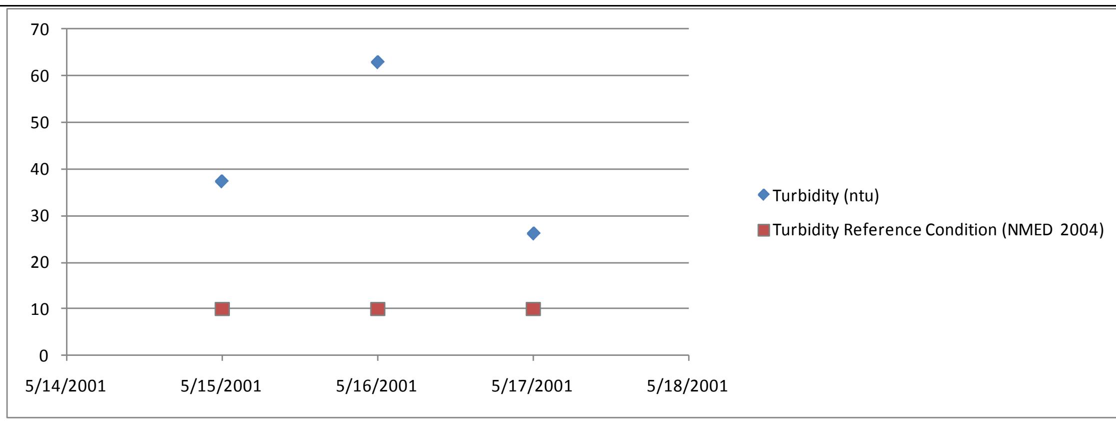
Pecos River			
	Patten and Frey (2004)	Porter and Longley (2009)	
Temperature		Reference Condition: (°C)	20° C coldwater fishery
		Trend:	Downward 2003-09, upward 1994-2003 (Porter and Longley 2009)
		Confidence:	High
		Current Condition:	Exceedences common during summer months (Porter and Longley 2009)
		No data.	
Conductance	No data.	Reference Condition: (µS/cm)	300 µS/cm
		Trend:	Uniform (Porter and Longley 2009)
		Confidence:	High, some questionable values eliminated
		Current Condition:	Median = 218; < 5% exceeded 300 (Porter and Longley 2009)

Table 3.6-2
(b)

Pecos River			
	New Mexico Environment Department (2004)	Porter and Longley (2009)	
Dissolved Oxygen	No data.	Reference Condition (mg/l):	6 mg/l for high quality coldwater fishery
		Trend:	Relatively uniform (Porter and Longley 2009)
		Confidence:	High, some questionable values eliminated
		Current Condition:	Generally higher than ref cond., but lower in GC than PR. < 6 in 1.3% of samples (Porter and Longley 2009)
Dissolved Oxygen Saturated	No data.	Reference Condition:	~100%
		Trend:	Decreased
		Confidence:	High
		Current Condition:	Generally around 100 (Porter and Longley 2009)

Table 3.6-2 (c)

Pecos River			
	New Mexico Environment Department (2004)	Porter and Longley (2009)	
pH	No data.	Reference Condition:	6.6 – 8.8 (NMED) or 6-9 (EPA)
		Trend:	Variable, possible decline at site A
		Confidence:	High
		Current Condition:	Median =8.3; Mean =8.1; 11% exceeded site A, 9% exceeded site C (Porter and Longley 2009)
Turbidity		Reference Condition:	--
		Trend:	--
		Confidence:	--
		Current Condition:	--

New Mexico Environment Department (2004) found exceedences in Glorieta Creek in temperature (both stations); DO (both stations); conductance (both stations); and ammonia, dissolved nitrate/nitrite, and turbidity (at Conference Center Wastewater Treatment Plant). New Mexico Environment Department (2004) found exceedences in the Pecos River below the Village of Pecos Wastewater Treatment Plant in turbidity. Park-collected data were in agreement regarding exceedences in temperature, DO, and conductance in Glorieta Creek. Park-collected data for the river indicated additional exceedences in temperature during the summer months (Porter and Longley 2009).

In summary, the most recent water quality data suggest that water quality in the Pecos River is not currently significantly impacted by mining contaminants. Heavy metals and other ions in the water column did not exceed New Mexico water quality standards in the New Mexico Environment Department 2001 survey (New Mexico Environment Department 2004). Other indicators were within limits, with the exception of high values for turbidity below the village of Pecos Wastewater Treatment Plant (New Mexico Environment Department 2004), and high values for temperature, especially during the summer months. Temperature, however, shows a downward trend from 2003-2009 (Porter and Longley 2009). Water in Glorieta Creek was found in both studies to exceed limits in temperature, DO, and conductance. New Mexico Environment Department (2004) also found several values outside limits for ammonia, dissolved nitrate/nitrite, and turbidity at the Conference Center Wastewater Treatment Plant.

3.6.2.4. Fish Tissue Data

As noted by EARDC (2007), heavy metal concentrations in streambed sediments or in biological tissues could provide a more reliable basis for assessing heavy metal concentrations than do water column samples. Heavy metals bioaccumulate in tissues. Three sources of data exist on toxins in fish tissue in the Pecos River. The first is a 1993 memo from Roy Irwin, NPS environmental contaminants specialist, summarizing analyses of heavy metals in six fish collected from the Pecos River, 0.25 miles north of the Forked Lightning Ranch house in August 1992. The second is a report summarizing similar analyses of 16 fish fillets collected in September 1993 from just upriver from the ranch house and 3.5 km downstream near the south park boundary (Binstock et al. 1993; Van Mouwerik 1994). The third, by the Scientific Lab Division of the New Mexico Environment Department, summarizes results for a sample of 13 fish collected in November 2003 downstream of the confluence of the Pecos River and Glorieta Creek (Scientific Lab Division 2003). Table 3.5-2 compares the results of these three analyses. Criteria have not been developed for concentrations of most heavy metals in fish tissues. However, fish consumption limits are available for some pollutants. For that reason, and to facilitate comparisons among the various heavy metals, we include the risk-based fish consumption limits for use as reference conditions, where limits have been specified (EPA 2000).

It is instructive to compare the Irwin memos, written before the Terrero Mine remediation, with the New Mexico Environment Department report, written in the year after the mine was cleaned up (Table 3.6-2). Irwin (1993) indicated that levels of arsenic, chromium, and lead were highly elevated in some samples, enough to cause concern for fish and wildlife predators and possibly humans. Arochlor-1260 (a PCB), and cadmium concentrations were above concern levels in one sample of dace muscle.

Mercury levels were moderately elevated. In addition, selenium was high enough to cause concern for predators, and copper concentrations suggested a pollution source for that metal. The data summarized by Irwin (1993) came from a small sample of fish (N=6) and were considered preliminary. They therefore should be viewed with caution (R. Irwin, pers. comm.).

A follow-up study on a larger sample of 16 fish fillets found that for most samples concentrations of all five metals were low or unelevated, "however, two fillets were above National Survey mean fillet values for chromium, as were two for lead, one for mercury, and one for cadmium. Also, two lead fillet concentrations were close to the recommended limit for human consumption. Though not a cause for alarm…" (Van Mouwerik 1994). Van Mouwerik (1994) recommended continued sampling for these four metals in fillets . From a perspective of predator-protection levels, whole-body concentrations of three metals (chromium, lead, and mercury) were very high and, for chromium and lead, were high in all or most of the samples; thus, Pecos River fish were not safe for consumption by predators (Van Mouwerik 1994).

Heavy metal concentrations in most samples decreased between the 1992 and 1993 samples, which may indicate sampling error in the six 1992 samples. We therefore focus here on the 2003 vs. 1993 (where available) data. Arsenic, chromium, and lead were lower in most 2003 samples than in 1993, while selenium, copper, and zinc decreased between 1992 and 2003 (no 1993 samples were available for these metals). These decreases may be attributable to the cleanup of the Terrero Mine, with the caveat that values in the smaller 1992 sample were highly variable and should be viewed with caution. In addition, mercury and cadmium concentrations did not decrease appreciably between 1993 and 2003.

Based on fish consumption limits (EPA 2000; New Mexico Department of Game and Fish et al. 2009), as of 2003, fish tissues in the Pecos River were too high in arsenic, cadmium, and mercury concentrations to allow for unlimited human consumption. Consumption-based non-carcinogenic limits for arsenic ranged from 2-16 fish (depending on levels in individual fish) and 0.5-no fish for carcinogenic limits. Cadmium limits for the fish sampled were 16-unlimited. Mercury-based fish consumption limits ranged from 4-16. Of the four metals for which fish consumption criteria exist, only selenium concentrations in fish allowed for unrestricted consumption. Currently, New Mexico Department of Game and Fish recommends that no more than 12 brown trout 10"-14" long and no more than 4 brown trout 14"-18" long from the Pecos River (Pecos NHP to headwaters) be consumed per month, due to concerns over mercury contamination (New Mexico Department of Game and Fish et al. 2009). No fish tissue limits exist for chromium, copper, lead, or zinc.

Summarizing, fish tissue heavy metal data provide a somewhat different picture than water column samples. Although heavy metal concentrations have apparently decreased in water and fish since the Terrero Mine cleanup, concentrations of some heavy metals are still high enough to warrant fish consumption limits. Of greatest concern is mercury, which has not decreased appreciably since the mine was remediated. Other metals that warrant fish consumption advisories are arsenic and cadmium. Fish tissue concentration and consumption limits do not exist for the other heavy metals.

3.6.3 Condition of Data

New Mexico Environment Department data should be of high quality and therefore merit high confidence. However, the data in this report are ten years old. As an indication of current water quality, they merit moderate confidence. Due to calibration errors that resulted in data loss, we have moderate confidence in the park-collected data. The historical data are useful for historical comparison but not as reference conditions or indicators of current water parameters.

3.6.4 Data Gaps

Because the New Mexico Environment Department data summarized here were collected in 2001, it is important to acquire the data and report from 2010 New Mexico Environment Department surveys. Apparently due to problems with instrument calibration, some park-collected data were eliminated from Porter and Longley's (2009) analysis. Care should be taken to properly calibrate all instruments used by park personnel. Fish tissue data for As, Cd, and other heavy metals are from 2003, and sample sizes of PECO fish were small. Confidence is therefore moderate for these metals. Confidence is high for mercury in fish tissues, because more recent data exist for mercury.

3.6.5 Literature Cited

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3.7 Water Quantity

3.7.1 Background

Available water is one of the key drivers of ecosystem function in the Great Plains. Quantity of water affects ecosystem productivity, species distribution and abundance, nutrient cycles, and ecosystem resilience (NPS 2006). Natural disturbances such as fire and drought, and human activities such as livestock grazing, agriculture, and groundwater pumping, change groundwater quantity, surface water quantity, and watershed conditions, indirectly influencing aquatic and terrestrial communities. Significant changes have occurred in the amounts of surface water since pre-Colombian times due to ranching, irrigation, flood control, and other human activities. In most river systems of the Great Plains, dewatering has impacted flows, temperatures, nutrient levels, sediment transport, and plant and animal community structure (NPS 2006). Groundwater overdrafts in the SOPN are a leading stressor than can contribute to the spread of exotic species such as salt cedar (*Tamarix* spp.).

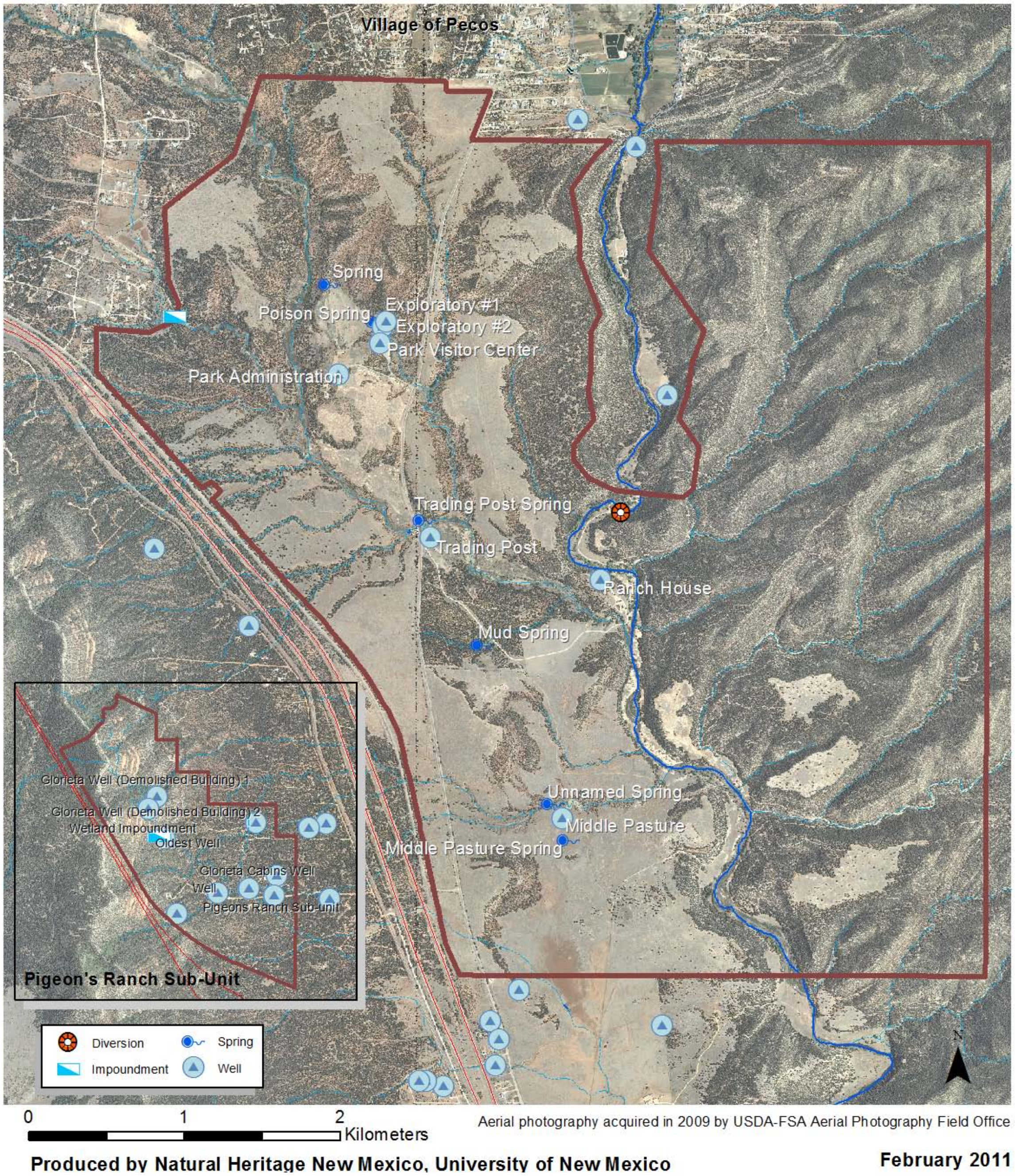
All of the SOPN cultural parks, including PECO, are located near rivers because of the importance of water to Native Americans and early settlers. Hence, water quantity is crucial to PECO and other SOPN parks not only as a natural resource, but also because of its cultural and historical importance. The SOPN has identified ground water levels and water quantity as core vital signs (NPS 2008), and PECO has targeted water quantity as an important resource for this assessment.

3.7.2 Data and Methods

We were unable to acquire accurate locations of the park wells and springs. To create Figure 3.7-1, we pieced together information on approximate well and spring names and locations from a map in Head and Orcutt (2002), NPS (1995), and personal communication from Dan Jacobs.

Very little information exists regarding water quantity in the park wells. Two records of well depths were found housed in the Water Resources Division Resource Room in Fort Collins, CO (Paul Christensen, NPS Water Resources Division, pers. comm.).

Limited flow data for Glorieta Creek were provided by Paul Christensen, NPS Water Resources Division. For the Pecos River, a U.S. Geological Survey gaging station (08378500) nine miles upriver from the town of Pecos collects Pecos River discharge data; no other station exists in or nearer the park (Figure 3.6-1). Based on these data, Paul Christensen created a hydrograph of minimum, median, and average daily discharge data from the Pecos gaging station from 1920-



2008 (Figure 3.7-2).

Figure 3.7-1. Water structures and springs at the main unit and Pigeon's Ranch subunit.

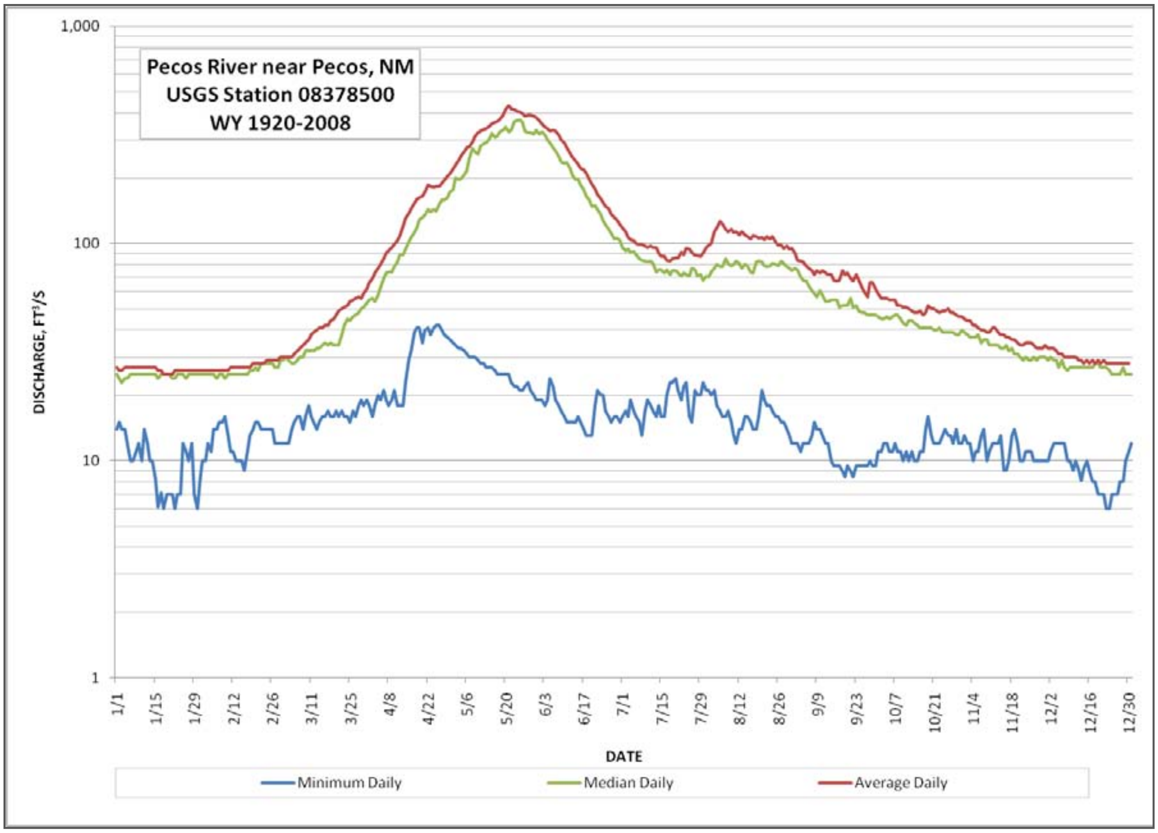


Figure 3.7-2. U.S. Geological Survey gaging station data from 1920-2008 north of the park at Pecos National Historical Park.

3.7.3 Reference Conditions

No reference conditions have been identified for water quantity at PECO, and park data to allow assessment of this resource are limited.

3.7.4 Resource Description

PECO water sources include the Pecos River, Glorieta Creek, Galisteo Creek, 12 wells, and six springs (Figure 3.7-1). The seven main unit wells agreed upon by park maintenance staff and Dan Jacobs, chief ranger, are located at the administration area, visitor center, trading post, ranch house, middle pasture, and two exploratory wells north of the Visitor Center well. The five wells at the Pigeon's Ranch Subunit are two wells at demolished buildings, the "oldest well" near the wetland impoundment, one at the Glorieta Cabins, and another due west of the Glorieta Cabins.

The springs are: an unnamed spring north of the Pecos Pueblo, Poison Spring east of the Pueblo, Trading Post Spring adjacent to Kozlowski's Trading Post, Mud Spring south of Kozlowski's Trading Post, Middle Pasture Spring, and an unnamed spring north of Shin'po (D. Jacobs, pers. comm.; Head and Orcutt 2002). In addition, a historical reservoir is located at the south park boundary.

Well No. 1 at Pecos National Monument was measured at 47.7 m (156.5 ft) below the top of the casing on 14 September 1977. Well No. 2, at the Visitor Center, was measured at 36.86 m (120.96 ft) below the top of the casing on 14 June 1979. Similarly, no data exist on water quality or quantity of any PECO springs.

The NPS has one established right for the PECO headquarters well but does not have water rights for the wells at the Visitor Center, Trading Post, or Ranch House. Water Resource Division personnel are working with the Office of the State Engineer to obtain water rights for the three wells (Paul Christensen, pers. comm.).

No long-term discharge record exists for Glorieta Creek. During the driest summer months flows may be composed primarily of effluent from the Glorieta Conference Center Waste Water Treatment Plant (NPS 1995). At the time of the 1995 PECO Water Resources Management Plan, the conference center was capable of housing 2,500 people and treating 170,000-200,000 gal/d (NPS 1995). Some of the hotel accommodations have since been closed, and capacity is now around 1,500 people (Anita Lucero, Glorieta Sales, pers. comm.). Flow data were collected from Glorieta Creek in May and June of 1993 and 1994 at two stations, one about 300 m upstream from the confluence with the Pecos River and the other about 3,200 m upstream from the New Mexico State Road 63 bridge. Flow rates varied from 2.23 to 4.18 ft/s^3 over five sampling dates (data sheets provided by Paul Christensen, NPS Water Resources Division). Two data summaries containing higher values (7.39 ft/s^3 and 13.76 ft/s^3 on 27 May 1994 and 18 May 1993, respectively) were not included in the summary of these data, which suggests that the values might have been thrown out. There is no report available to verify this speculation.

A U.S. Geological Survey gaging station (08378500) nine miles upriver from the town of Pecos collects Pecos River discharge data; no other station exists in or closer the park (see Figure 3.7-1).

Inputs from streams in the Dry-Gulch-Pecos River and Glorieta Creek-Pecos River HUC 12 Watersheds augment flow between the gage and the park, and flows from the Glorieta Creek Watershed (primarily Glorieta Creek) are added within the park boundaries (Figure 3.7-1). Unknown volumes of water are removed for irrigation between the gage and the park boundary, and unused volumes are presumably returned to the river.

A hydrograph of minimum, median, and average daily discharge data from the Pecos gaging station from 1920-2008 is shown in Figure 3.7-2. Estimates of Pecos River water consumed by upstream irrigation were computed by Paul Christensen and were adjusted by Natural Heritage New Mexico based on current GIS-derived areas of irrigated fields between the Pecos gaging station and the PECO north boundary (Table 3.7-1). Together, the hydrograph and the estimated irrigation volumes provide a general picture of the impacts of irrigation withdrawals on Pecos River volumes within the park through the growing season. For example, during peak irrigation in July, estimated withdrawals of 2.3 ft^3/s (Table 3.7-1) would leave water in the river in even the driest years (Figure 3.7-2) and would not have significant impacts in years of average flow. These estimates, however, provide only limited insight into actual flows, because no estimates exist of the inputs from streams in the three watersheds.

3.7.5 Condition of Data

Due to the scarcity of reliable data on water quantity at PECO, a quantitative assessment could not be conducted.

3.7.6 Data Gaps

Geographic coordinates for the wells in the park were unavailable, and locations are approximate, based on park staff knowledge. The lack of precise information on well locations is an important data gap that could be easily remedied with a GPS (Global Positioning System) unit and a few hours of staff time. Similarly, no data exist on water quality or quantity of any PECO springs.

No long-term discharge record exists for Glorieta Creek. The discharge data from the U.S. Geological Survey Pecos station do not reflect actual flow rates within the park, due to the unknown inputs and outputs, which are difficult or impossible to accurately assess. The lack of water quantity data from the park's primary water source constitutes an important data gap that could be addressed by placing a gaging station at the northern boundary of the park. Similar data gaps exist for discharges from Glorieta Creek, Galisteo Creek, and the five springs. Galisteo Creek flows intermittently and Glorieta Creek discharges are highly influenced by conference center effluent; thus, acquiring discharge data from the Pecos River is likely a priority over data from the creeks. The Water Resource Management Plan (NPS 1995) recommended that the park conduct a full inventory of wells and springs, including water rights, quality, and supply. These data gaps have apparently not yet been addressed.

Table 3.7-1. Estimated average monthly discharge from the U.S. Geological Survey Pecos National Historical Park gaging station.

	Month							
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Growing degree days, 50 M, Precipitation Station, Santa Fe 2, No. 298085, 1972-2008, Western Regional Climate Center	72	246	512	646	584	372	118	2550
Percent of total growing degree days	2.8%	9.6%	20.1%	25.3%	22.9%	14.6%	4.6%	
Estimated Pecos River water consumed by upstream irrigation, A-ft	21.5	73.5	152.9	192.9	174.4	111.1	35.2	
Estimated Pecos River water consumed by upstream irrigation, ft^3/s	0.4	1.2	2.6	3.2	2.9	1.9	0.6	
Corrected estimate based on current GIS-derived acreage of irrigated fields, ft^3/s	0.3	0.9	1.8	2.3	2.1	1.3	0.4	

3.7.7 Literature Cited

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3.8 Exotic, Rare, and Sensitive Plant Species

3.8.1 Background

In addition to the condition of vegetation communities, PECO is particularly interested in exotic and rare plants, both of which are indicative of ecological health. Exotic plants are a significant threat to natural resources in national parks because they tend to replace native species, thereby disrupting ecosystem processes. In addition, once established, exotic plants are often difficult to eliminate. NPS is working to manage invasive species on park lands. The SOPN has identified early detection of exotic plants as a core vital sign (NPS 2008; NPS 2010).

National parks have responsibility for conserving threatened and endangered plant and animal species. The mission of the NPS Endangered Species Program is to reduce the risk of extinction of plants and animals in parks and to restore native species that have been lost. PECO has therefore identified rare plants as a resource of interest.

3.8.2 Data and Methods

Four different studies provided information on plant species at PECO. The majority of species were provided by Sivinksi (1995), who performed a thorough plant survey of the park, and Muldavin et al. (2010), who provided species lists from plot data collected for the PECO vegetation map. A few additional species were provided by Laura Trader (2010), from an NPS fire database, and Tomye Foltz-Zettner (2010), from a pilot weed study. Survey points for these studies are depicted in Figure 3.8-1. An associated Geographic Information System (GIS) project provides species lists associated with each survey point. Vegetation communities are discussed in a separate chapter.

3.8.3 Reference Conditions

One potential reference condition for rare plants would be park populations that are stable or increasing. However, since no rare plants are currently known to occur at the park, and no data exist on the existence of rare plants in the past, it is not currently possible to designate a reference condition for this resource.

A reference condition of no exotic plants could be adopted for the park. Another approach would be to adopt a reference condition of zero noxious weeds or zero noxious weed species of a certain class. A reference condition with a noxious weed focus is perhaps more practical than a condition of no exotics, if the reference condition is to be consulted in planning for weed management. For management, the highest priority weeds for control and eradication are the four class A species, followed by the two class B species. The eradication all exotic species is extremely unlikely and of questionable merit, due to the effort and expense that would be required. In addition, some exotic species were present during historical periods of emphasis at the park and may thus be desirable components of the PECO flora for reasons of cultural interest (e.g., apple trees).

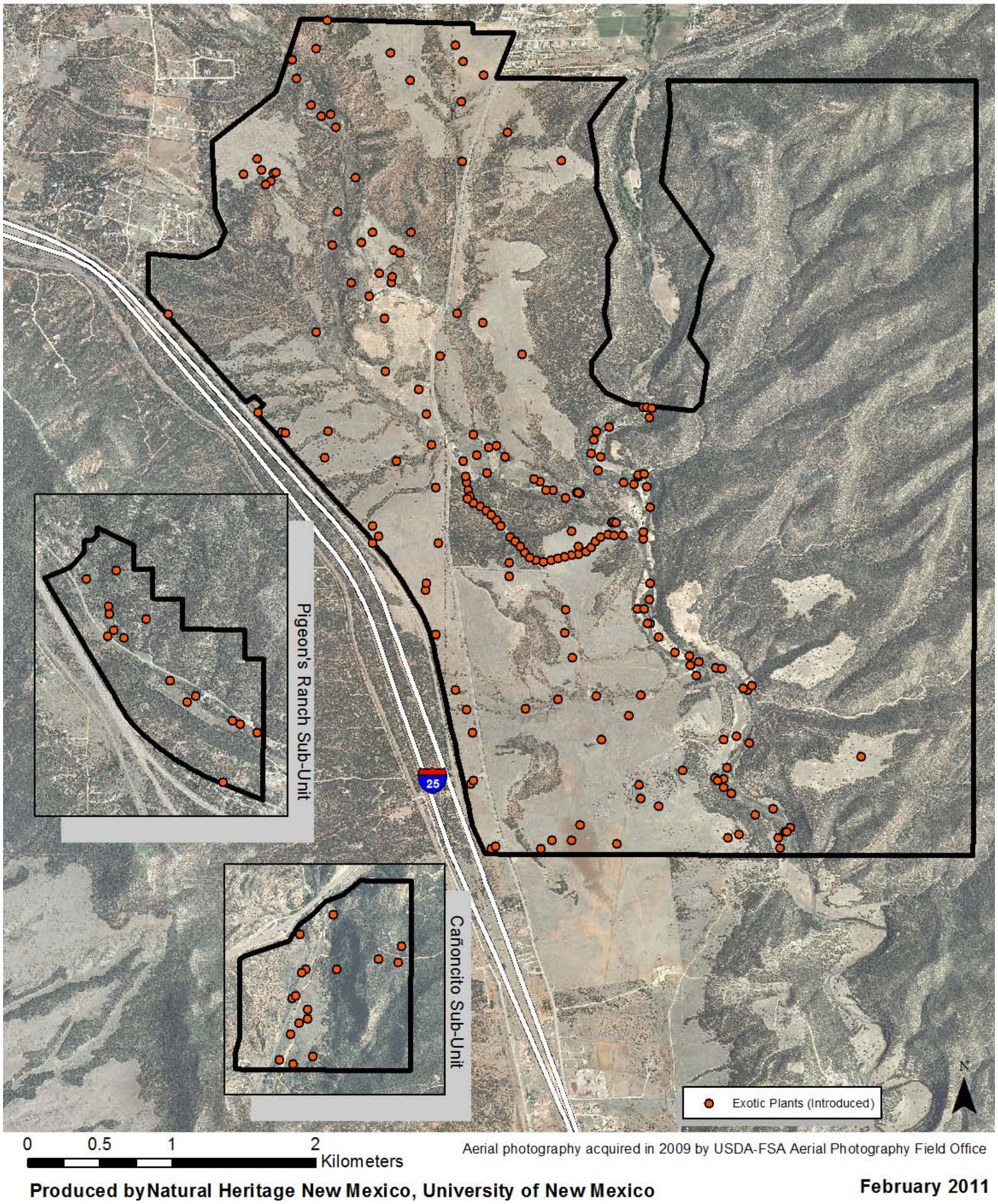

Figure 3.8-2. Locations of exotic plants at Pecos National Historical Park (from Muldavin et al. 2010, T. Foltz-Zettner, L. Trader).

3.8.4 Resource Description

3.8.4.1. Exotic Plants

At PECO, 500 species and subspecies of plants have been identified (Table 3.8-1; Sivinski 1995; Muldavin et al. 2010; Foltz-Zettner 2010; Trader 2010). Of these, 71 are exotic plant species (Figure 3.8-2), and the remaining 439 are native. Of the exotic species, 12 are classified as noxious weeds in New Mexico. None is on the federal list of noxious weeds (U.S. Department of Agriculture 2006). Fifteen exotic species have been found at the ruins and two of those are considered noxious weeds in New Mexico. Of the 12 noxious weeds in the park, four are Class A Species (New Mexico Department of Agriculture 2009), meaning they are a top priority for eradication before they spread. Two species are Class B Species, meaning that the infestations of these species should be contained. Five species are Class C Species, meaning that they are already widespread and management decisions should be made locally. The remaining noxious weed is a Watch List Species, meaning that its locations should be documented and the proper authorities contacted (Table 3.8-1).

3.8.4.2. Sensitive Plants

As part of his botanical inventory of PECO, Sivinski (1995) produced a list of sensitive plant species that could potentially occur at the park: dwarf milkweed (*Asclepias uncialis*), Holy Ghost ipomopsis (*Ipomopsis sancti-spiritus*), grama grass cactus (*Toumeya papyracantha*), Wright's pincushion cactus (*Mammillaria wrightii*), Great Plains lady tresses (*Spiranthes magnicamporum*), giant Helleborine orchid (*Epipactis gigantea*), and Pecos groundcherry (*Physalis virginiana*). Sivinski (1995) searched the habitats of these species and found only the dwarf milkweed. This species, a federal C2 candidate at the time, currently has no state or federal listing status. From 2008-2010, Natural Heritage New Mexico surveyed for sensitive plants in the Pigeon's Ranch and Cañoncito subunits (Johnson et al. 2010). For that survey, only three sensitive plant species were considered potential inhabitants of the two subunits: Santa Fe cholla (*Opuntia viridiflora*), cyanic milkvetch (*Astragalus cyaneus*), and grama grass cactus (*Sclerocactus papyracanthus*).

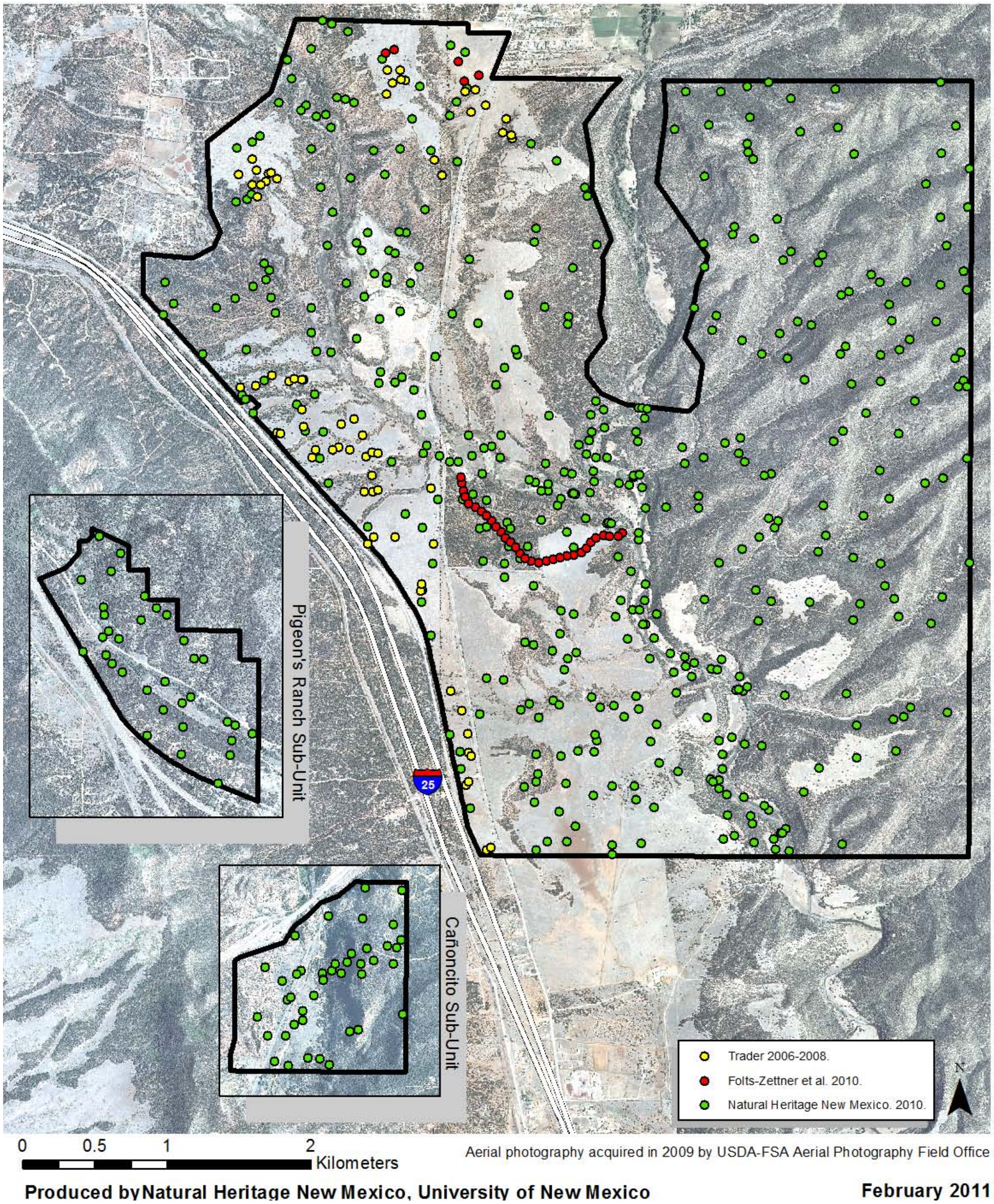

Figure 3.8-1. Pecos National Historical Park vegetation survey sites from three sources.

The Santa Fe cholla is listed as endangered by the State of New Mexico. This piñon-juniper (*Pinus edulis*, *Juniperus* spp.) habitat species is known from only two areas in northern Santa Fe County, Fort Marcy Park in Santa Fe and the Pojoaque Reservation to the north (NMBiotics Database 2009; New Mexico Rare Plant Technical Council 1999).

The cyanic milkvetch is not formally listed but is considered sensitive by the State of New Mexico. It is listed by both U.S. Fish and Wildlife Service and U.S. Forest Service as a Species of Concern. It is endemic to north-central New Mexico, occurring in Rio Arriba, Santa Fe, and

Taos Counties. It inhabits dry hillsides and gullied banks in sandy or gravelly soils in piñon-juniper habitat (New Mexico Rare Plant Technical Council 1999) and flowers in April and May.

A third species, the grama grass cactus, has no state or federal listing status, has been dropped as a species of concern by the U.S. Forest Service, but is retained as a species of concern by the Bureau of Land Management. Bureau of Land Management botanist Mike Howard and Natural Heritage New Mexico botanist Phil Tonne have noted that this species has disappeared from areas of the state where it was formerly present. This species has a widespread distribution oriented from north-central New Mexico near Abiquiu to Dell City, Texas and south to the Mexican border (NMBiotics Database 2009; New Mexico Rare Plant Technical Council 1999). It also occurs near Holbrook, Arizona, and southward towards the Mogollon Rim. Although it is possible that a seed bank exists in these areas and favorable weather will bring the cactus back, there is concern that the species may be in trouble. It is difficult to find because of its small size and tendency to grow within grass tufts. Thorough surveys targeting this species require surveying in multiple above-average-precipitation years. Re-locating known populations of this plant has recently proven difficult (Johnson et al. 2010). Opportunities to find new locations may be limited due to a possible bottleneck throughout its range. Declining populations appear to coincide with range-wide shifts in the abundance and timing of precipitation.

In 2008, 2009, and 2010, Natural Heritage New Mexico conducted concentrated surveys for the above three target species in suitable habitat on the subunits. The surveys detected none of the target plants on either of the two subunits. Pockets of interesting habitat, especially on the Cañoncito Subunit, could support endemic species that might be detected in future surveys. An area of promising habitat in the low hills of this subunit could potentially support the cyanic milkvetch and grama grass cactus. Natural Heritage New Mexico did not detect the Santa Fe cholla; because it is relatively easily detected, it is not expected to occur there. The other species are much more cryptic and are more likely to have escaped detection (Johnson et al. 2010).

3.8.5 Condition of Data

The list of exotic species is derived from several thorough studies and therefore confidence in these data is high. Any assessment based on these data should also merit high confidence. Several surveys, particularly those by Sivinski (1995) and Johnson et al. (2010) could have detected rare plants if they are present at the park. However, as noted by Johnson et al. (2010), to rule out the existence of any rare plant species at PECO would require additional surveys at different times and under various weather conditions. Thus, our confidence in the rare plant assessment is currently moderate.

3.8.6 Data Gaps

All units of PECO have been surveyed for sensitive plan species and none has been found to date. However, flowering times may vary according to weather, and repeated surveys are therefore desirable. Repeated surveys for the potential sensitive plant species should be conducted before concluding that no sensitive plant species occur at PECO.

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3.9 Vegetation Communities

3.9.1 Background

The vegetation communities of PECO are diverse and are represented by some 50 or more plant associations distributed among eight groups per the National Vegetation Classification hierarchy (Federal Geographic Data Committee 2008). The SOPN identified grassland and wetland vegetation communities as vital signs for SOPN parks, and PECO identified vegetation community health as a target natural resource for this condition assessment.

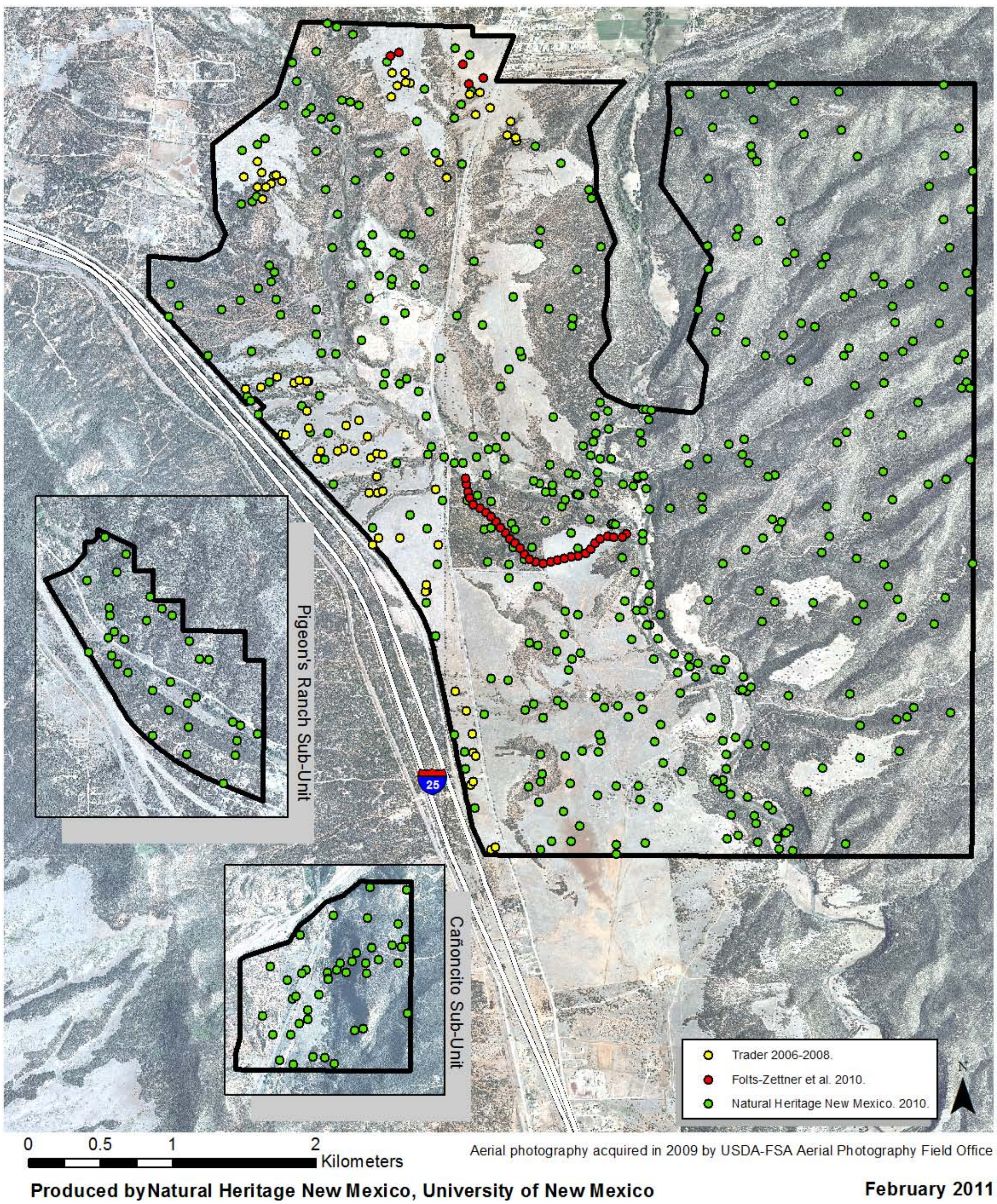

Figure 4.4-1. Vegetation surveys of Pecos National Historical Park.

3.9.2 Data and Methods

We conducted a provisional assessment of the ecological health of PECO vegetation communities using the draft vegetation classification and map for the park (Muldavin et al., in press) as a base. We compared composition and structure as currently known to reference conditions as presented in Biophysical Setting (BpS) models of the Landfire project (Schmidt et al. 2002; http://www.landfire.gov/NationalProductDescriptions20.php), and the Vegetation Dynamics Development Tool (VVDT) models of The Nature Conservancy's Southwest Forest Assessment project (Schussman and Smith 2006). Quantitative data on ecosystem conditions at PECO are limited and hence our assessment is essentially qualitative. Our primary intent is to identify key factors related to ecosystem health in the park, provide what information is available on park conditions, and suggest data needs to support future, more quantitative assessments. Accordingly, we provide a description of the composition and ecology of the major vegetation communities of the park, a brief review of available information on reference conditions, our provisional PECO assessment, and a short section on data needs.

3.9.3 Resource Description

3.9.3.1. Douglas-fir and Ponderosa Pine Forests

3.9.3.1.1. Composition and Ecology

The forests on PECO extend from about 7,400 ft (2,250 m) down to 6,750 ft (2,060 m) and are distributed among a variety of local environments. At the coolest and most mesic end of the gradient is the <u>Southern Rocky Mountain White Fir-Douglas-fir Dry Forest</u>, represented by the Douglas-fir-Gambel Oak (*Pseudotsuga menziesii-Quercus gambelii*) association. While elsewhere in the southwest these forests can be co-dominated by an array of conifers, on PECO, Douglas-fir is the dominant with ponderosa pine (*Pinus ponderosa*) as a co-dominant, usually forming closed canopies (>60% cover). Rocky Mountain juniper (*Juniperus scopulorum*), oneseed juniper (*Juniperus monosperma*), and piñon pine (*Pinus edulis*) often occur in the understory as small-statured trees. On PECO, these forests are limited in extent and are found on the east side of the park as small stands on the relatively moist northerly, middle to lower slopes of canyons and sometimes extending down the canyon as "stringers" to the Pecos River.

On warmer and drier slopes, the Douglas-fir-dominated forests give way to the <u>Southern Rocky Mountain Ponderosa Pine Forest and Woodland</u>. Here, ponderosa pine is the clear dominant and Douglas-fir is uncommon or absent, but low-statured conifers such as piñon pine, oneseed juniper, and Rocky Mountain juniper may still be common in the understory. The canopies range from open to closed (25%-75% cover). The understories can be dominated by shrubby oaks (Gambel oak, wavyleaf oak [*Q. pauciloba*]). The herbaceous layer tends to be sparse (< 5% cover) and made up of up scattered bunch grasses such as Scribner's needlegrass (*Achnatherum scribneri*), mutton bluegrass (*Poa fendleriana*), and sideoats grama (*Bouteloua curtipendula*) along with deer sedges (e.g., *Carex inops* ssp. *heliophila*).

<u>Southern Rocky Mountain Ponderosa Pine Savanna</u> occurs on gentler slopes (<5%) primarily on the rolling hills and plains of the western side of the park. Overall, these are very open to open canopied woodlands (10%-60% canopy cover) that are typically dominated in the understory by bunch grasses with covers commonly between 5% and 30% and as high as 60%; shrubs are scattered or absent. The most common associations are the Ponderosa Pine/Little Bluestem

(*Pinus ponderosa/Schizachyrium scoparium*), Ponderosa Pine/Blue Grama (*Pinus ponderosa/Bouteloua gracilis*), and Ponderosa Pine/Western Wheatgrass (*Pinus ponderosa/Pascopyrum smithii*). The graminoid component of these associations has strong affinities with the Great Plains grasslands as reflected not only in the dominance of little bluestem, blue grama and western wheatgrass, but also the presence of forbs such as white prairie clover (*Dalea candida*), hairy goldenaster (*Heterotheca villosa*), and slimflower scurfpea (*Psoralidium tenuiflorum*). These associations typically occur below about 7,000 ft (2,130 m) where stands are often inter-fingered with Rocky Mountain Piñon-Juniper Woodland, particularly on rockier sites and in small canyons.

In addition to soils, terrain, and climatic factors, fire has played an important role in shaping the structure and composition of the Douglas-fir and ponderosa pine forests of the park. Because ponderosa pine is highly fire tolerant (Bradley et al. 1992) and relatively drought tolerant, it often occupies sites that are drier and that have higher natural fire frequencies than those of the mixed conifer zone (DeVelice et al. 1986; Allen and Peet 1990; Touchan et al. 1996). Based on fire history studies from elsewhere in the southern Rocky Mountains of New Mexico, in the past, low-intensity fires would burn through ponderosa pine stands every 8 to 15 years, removing competing understory vegetation and woody debris (Weaver 1951; Cooper 1960; Mehl 1992; Swetnam and Baisan 1996; Touchan et al. 1996). Savanna woodlands with their high grass cover were likely to have the most frequent ground fires, while forests tended to occur on steeper, rocky slopes with less "fine fuels," hence fire return intervals were likely longer. After fires, the shade-intolerant seedlings such as those of ponderosa pine become established in open areas, usually in pulses correlated to favorable precipitation years (Mast et al. 1997; Mast el al. 1998; Savage et al. 1996). The other conifers such as Douglas-fir are less drought- and fire-tolerant and at a disadvantage on these sites. Either they fail to become established or are removed by subsequent surface fire, leading to forest stands dominated by ponderosa (with even-aged tree groups embedded in the stands, depending on recruitment pulses). On the more mesic sites of the rugged canyons, Douglas-fir does survive naturally and can come to dominate or co-dominate stands with ponderosa. At the other end of the spectrum, ponderosa pine has been shown to have invaded adjacent grasslands where fires have been suppressed (Allen 1984, 1989). Hence, some stands of the various savanna associations may be considered invasive depending on edaphic conditions and disturbance history.

3.9.3.1.2. Reference Conditions

For southwestern mixed conifer in general, Smith (2006a) stated the following regarding reference conditions and the historical range of variability:

> *"Very little is known about the historical condition of mixed conifer forests, except that in general forests had a more open structure, with a larger proportion of older, larger trees, and a smaller proportion of younger, smaller trees. Historically, these forests were less dense, although there were small patches of trees in several age classes and, in areas that experienced frequent fire, there were fewer fire-sensitive species, such as white fir, and a mixture of age classes. Areas that experienced less frequent and more severe fires probably had even-aged stands of trees, although these patches were smaller than those areas that experienced more frequent fire. At the landscape scale, these forests were probably very patchy or heterogeneous, with dispersion of high and low frequency fire*

> *patches controlled by some combination of topography, soils, and vegetation (Touchan et al. 1996, Muldavin and Tonne 2003)."*

Smith (2006a) provides an example of tree stocking rates for two mixed-conifer stands in northern Arizona with historical tree densities ranging from 65 to 100 trees/ac and basal areas around 75 ft^2/ac, but no data are provided for northern New Mexico nor are data differentiated with respect to mesic or dry mixed-conifer communities. He also provides a state and transition model for historical conditions that has four successional stages predicated on a combination of a mixed fire regime of patchy surface and stand replacement fires at 5- to 33-year intervals, plus interactions with aspen and oak, and insect pest outbreaks.

Landfire provides a similar, five-stage BpS successional model designed specifically for Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest (2810510) within the Landfire Zone 28 that contains PECO (and the southern Rocky Mountains). Fire return intervals in their model range from 26 to 275 years with an average for a mixed-fire regime of 107 years.

For ponderosa pine forest and woodlands, Smith (2006b) states:

> *"Many of the studies of stand dynamics of ponderosa pine forests have focused on ponderosa pine-bunchgrass communities, with general trends in size and age of stands inferred from existing stands, and remnants of past stands. Ponderosa pine forests in the Southwest generally experienced a high-frequency, low-intensity surface fire regime, although on a small scale, individual trees occasionally may have torched via fuel ladders carrying surface fire into the crowns over small areas (Swetnam and Baisan 1996, Vankat 2006). Beyond fire studies, little is known about historic disturbance factors that shaped ponderosa pine forests in historic times, because settlement and disturbance disruption occurred simultaneously."*

With respect to stocking, Smith (2006b) reports historical densities in New Mexico ponderosa pine forest from 24 to 90 trees/ac with basal areas from 21 to 62 ft^2/ac. These are not differentiated as to whether they represent forests or woodland savannas. As with mixed conifer forests, he provides a state and transition model under historical conditions for a ponderosa pine/bunch grass ecosystem (more or less equivalent to the ponderosa pine savannas described for PECO). The model has five successional stages driven by surface fires at 5- to 36-year intervals.

Landfire provides five-stage BpS models for both Southern Rocky Mountain Ponderosa Pine Woodland (2710541) and Southern Rocky Mountain Ponderosa Pine Savanna (2811170). Models for Southern Rocky Mountain Ponderosa Pine Woodland can have montane shrubs (Gambel's oak or mountain mahogany) as a significant component in the understory under closed canopies at late stages of development. The fire regime is still considered predominantly that of frequent surface fires (12-year intervals), but localized mixed-severity fires can occur under natural conditions. In the Southern Rocky Mountain Ponderosa Pine Savanna model, grasses are the predominant surface fuel under moderately open canopies. Fire intervals range between 5 and 15 years based on Swetnam and Baisan (1996), with infrequent stand replacement possibly between 300 and 500 years.

3.9.3.1.3. Park Condition

With the cessation of natural fire regimes during the 20th century, younger age classes of both ponderosa pine and Douglas-fir have become more prevalent across the southwest, and possibly on PECO. This can create ladder fuels in the understory that favor crown fires and a commensurate decrease in fine fuels that support surface fires. Hence, for dry, mixed conifer and ponderosa pine forests, a shift may occur from a mixed-surface/crown-fire fire regime to a greater prevalence of larger stand-replacement fires. Similarly, ponderosa pine savannas may undergo a reduction in grass cover and may shift to a mixed- or stand-replacement fire regime.

The evidence for increases in young age class tree densities on PECO is limited. Most ponderosa savanna stands have some ponderosa saplings and poles (Douglas-fir is usually absent), but whether densities are high enough to pose an increased risk of crown fire needs to be evaluated. The more mesic sites of the eastern canyons tend to have both young ponderosa pine and Douglas-fir, but similarly, whether they are over-stocked or within the natural range of variability remains to be measured and understood. While mixed fire regimes of surface and patch crown fire tend to be the norm in these types of forests, the relative amount and frequency of surface fire in the canyon forest may be dependent on the degree of landscape connectivity between the woodland savanna and grassland ecosystems, with their natural surface-fire regimes. That is, where terrain is heterogeneous or streams potentially break the run of fire out of the grass-dominated ecosystems, the expectation would be for less surface fire and more patch-crown fire or stand-replacement fires as the norm. In addition, shrubby oak-dominated associations that create a natural ladder-fuel matrix in the understory may be more prone to crown fires, but this would still be considered within the natural range of variation.

3.9.3.2. Southern Rocky Mountain Two-needle Piñon-Juniper Woodland

3.9.3.2.1. Composition and Ecology

Piñon-juniper woodlands dominate the rolling plains and foothills of PECO between 6,700 ft (2,040 m) and 7,500 ft (2,290 m). In general, tree canopies vary from very open to nearly closed (10%-60% cover) and are dominated by piñon pine, with oneseed juniper and/or Rocky Mountain juniper as either co-dominant or subordinate associates. Ten plant associations that vary with respect to understory shrub and grass composition have been described for the park. Five of them are savanna-like, with moderately open canopies and grassy inter-canopy spaces dominated by mountain muhly (*Muhlenbergia montana*), blue grama (*Bouteloua gracilis*), sideoats grama, little bluestem, or western wheatgrass. Shrubs in these associations are scattered and seldom exceed 5% total cover. These grassy, savanna-like associations tend to be most prevalent in the rolling hills of the western portion of the park. In contrast, three woodland associations occur in the rockier foothills and canyons of the east side where grasses play a minor role. These tend to be shrub-dominated in the understory, where Gambel’s oak, wavyleaf oak, or mountain mahogany (*Cercocarpus montanus*), along with a variety of other montane shrubs, can approach 50%-60% total cover, or they may lack shrubs entirely. The herbaceous layer is usually relatively sparse (seldom over 5% cover) and represented by scattered bunch grasses and forbs such as mutton bluegrass, Scribner’s needlegrass (*Achnatherum scribneri*), and littleseed ricegrass (*Piptatherum micranthum*) that are most common in the shady understory of individual trees.

Fire is also an important disturbance factor in piñon-juniper woodlands. Romme et al. (2009) recently provided an overview of the role of fire in the dynamics and structuring of western U.S. piñon-juniper woodlands. They recognized the "savanna woodlands" as a separate element with a specific fire regime of high-frequency, low-intensity surface fires. The five savanna-like associations of the park would fall within this type. The shrub-dominated associations described here would be considered part of their "wooded shrubland" with a mixed-fire regime of crown and surface fires of moderate to high intensity and frequency. They also described a "persistent woodland" with limited surface fuels that would have either low-frequency, high-intensity crown fires or none, depending on canopy density. The closest analogue to this type of woodland on PECO would be the Two-needle Piñon/Scribner's Needlegrass Woodland association. Romme et al. (2009) state that spreading, low-intensity, surface fires had a very limited role in molding stand structure and dynamics of many or most shrubland and persistent piñon woodlands. On PECO, many stands have likely naturally gone long periods without fire other than isolated lightning ignitions that burned only single trees or small patches and produced no significant changes in stand structure.

3.9.3.2.2. Reference Conditions

Gory and Bate (2007) provide a detailed evaluation of reference conditions and succession using Romme et al. (2009) types as described above. They looked closely at the fire regime evidence across the southwest as well as climate variation, insect outbreaks, and seed dispersal by birds and small mammals as they affect stand structure and vegetation composition. They provide historical cover data from northern Arizona, southern Utah, southwest Colorado where savannas had canopies between 6% and 15% cover; shrub woodlands between 15% and 25%, and persistent woodlands ranged from 10% to 65% canopy. Similarly, historical tree densities ranged from 22 to 122 stems/ac in savannas; 215 to 1,422 trees/ac in shrub woodlands, to 948 to 3,989 trees/ac in persistent woodlands. Clearly, stand structures varied widely across the region and type and there is a need for more data on the ecosystem as whole. Gory and Bate (2007) state:

> *"Historically, juniper size distributions were discontinuous with greater numbers of trees in certain size classes and fewer trees in others (i.e., peaks and troughs), while piñons showed a more even size distribution; stands were generally dominated numerically by smaller piñon trees although among the larger size classes, junipers normally dominated. Recruitment by piñons and junipers was relatively continuous over hundreds of years punctuated by establishment peaks presumably due to favorable climate conditions for recruitment (or survivorship). This recruitment pattern gave rise to mixed age stands across all piñon-juniper types….More studies over a broader geographic area (and elevational range) are needed to fully describe the historical range of variation in composition and structure for shrub and persistent woodlands (and grass savannas)."*

Landfire provided a BpS model for Southern Rocky Mountain Piñon-Juniper Woodland (2810590), which includes a significant shrub element and canopies that approach 40% cover in late successional stages.

3.9.3.2.3. Park Condition

While tree density and canopy coverage have increased substantially during the past 150 years in many piñon and juniper woodlands, the pattern of infill and expansion has not been uniform and may have remained unchanged or declined in others (Romme et al. 2009). What appears to be infill can be a function of many factors beyond alterations of fire regimes; e.g., recovery from past, severe disturbance; natural, ongoing, Holocene range expansion; livestock grazing; and effects of climatic variability and rising atmospheric CO_2. Given the intensive, human-influenced ecological history at PECO, woodland stand structures have likely been altered extensively by people over the past half millennium—from pre-Columbian wood harvest through to the clearing of woodlands by chaining in the 1950s and 1960s to create open pasture. While the evidence of direct impacts of intensive grazing on infill and expansion has been equivocal, the lowering of surface fire frequency because of reduced fine fuels in the savanna-like types, and concurrent detected tree infill and expansion, seems a logical conclusion. Yet by and large and specifically on PECO, we lack evidence of what the actual fire frequency was in the grass-dominated woodland ecosystems by which to gauge if infill is a function of reduced fire frequency or other causes. Accordingly, why piñon-juniper woodlands are currently structured as they are on PECO remains an open and complex question requiring thorough evaluation of many factors to guide management.

3.9.3.3. Rocky Mountain Subalpine-Montane Riparian Forest, Shrublands, and Herbaceous Wetlands

3.9.3.3.1. Composition and Ecology

These montane riparian forests, shrublands, and herbaceous wetlands occur along perennial stream channels of moderate gradient (1% to 5%) of the park (the Pecos River and Glorieta Creek) between 6,700 ft (2,040 m) and 7,250 ft (2,210 m). Among forests, seven plant associations have been identified. These are dominated by various broadleaf trees such as narrowleaf cottonwood (*Populus angustifolia*), Rio Grande cottonwood (*P. deltoides* ssp. *wislizeni*), and box elder *(Acer negundo*), with various combinations of shrub or graminoid-dominated understories. On PECO, the shrub understories are largely native; e.g., skunkbush sumac (*Rhus trilobata*), Wood’s rose (*Rosa woodsii*), coyote willow (*Salix exigua*), bluestem willow (*Salix irrorata*). Herbaceous layers tend to be dominated by exotic grasses and forbs; e.g., smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), tall fescue (*Festuca arundinacea*), etc. Similarly, among shrub associations, with the exception of an occasional Russian olive (*Eleagnus angustifolia*) and saltcedar (*Tamarix chinensis*), native shrub species prevail, but exotics dominate among the grasses and forbs. Emergent wetlands on PECO are dominated by native graminoids such as Nebraska sedge (*Carex nebrascensis*), Baltic rush (*Juncus arcticus* var. *balticus*), and softstem bulrush (*Schoenoplectus pungens*), but exotic species often co-dominante.

3.9.3.3.2. Reference Conditions

Flooding and hydrological regime are the major processes that structure these communities. Little information is available on regional reference conditions for montane riparian ecosystems. Muldavin et al. (2010) provide a description of montane riverine wetlands in terms of flow regimes, expected stream channel characteristics, floodplain fluvial geomorphology, and vegetation. They state:

> *“Streams may be perennial or intermittent, have annual overbank flow (defined bed and bank), and support a riparian zone. Gravel and cobble dominate beds and banks, but sand and silt may be present in the banks and often form a floodplain surface. These wadeable channels have a moderate to low degree of confinement and are found on*

developed floodplains with room for lateral movement. Valley widths exceed 80 m. Channels have moderate slopes on the order of 1% to 4% and have a channel width ranging from 2 to 5 m. Channel features that may be present include point bars runs, riffles, pools, and backwaters. The drainage area feeding the streams ranges from 18 to 800 km². Characteristic stream types are typical of Rosgen "C" channels or Rosgen "E" channels. These channel types are typically found in broad, alluvial valleys, have moderate sinuosity, have an entrenchment ratio exceeding 2.2, and a width/depth ratio greater than 12".

The hydrology is characterized by peak flows in April through June, as a result of snowmelt runoff, followed by extended periods of low to moderate base flows. Rain events associated with summer monsoonal precipitation events may result in flow spikes of short duration.

With respect to vegetation, communities are expected to be dominated by obligate or facultative native wetland species, and floodplains should maintain a diversity of community types in various stages of succession from young, recently deposited gravel bars dominated by annual and perennial emergent wetland vegetation, to willow shrublands of intermediate age, to riparian woodlands up to 150-200 years in age. Sites that are overly represented by one successional stage or dominated by exotic invasive species are considered departed from reference conditions.

3.9.3.3.3. Park Condition

The lack of significant incursion of exotic shrubs into these montane riparian ecosystems is the norm throughout most of northern New Mexico. While individuals of exotic species are 1.5 times as common as natives, four times as many native as exotic species occur in this PECO ecosystem. This suggests a relatively functional riparian system that is further supported by the presence of reproducing native trees, particularly native cottonwoods, and stands of apparently different ages along the riparian corridor. This likely reflects the more-or-less intact hydrological regime both within and above the park, with limited draw-downs for agriculture or domestic use. Results of a recent rapid assessment of riparian condition at the park are discussed in the Riparian Assessment section of this report.

3.9.4 Condition of Data

Because this assessment is based on plot data recently collected for a vegetation map of the park, confidence in the data is relatively high. However, some ecosystem processes are still not understood (see "Data Gaps") due to lack of information on historical fire frequency, stand structure, and fuel loads. Until this information becomes available, we can only describe conditions in each of the main park vegetation communities, and an adequate comparison to reference conditions cannot be completed.

3.9.5 Data Gaps

Data are lacking on the historical fire frequency in the grass-dominated woodland ecosystems. This information would allow evaluation of the causes of infill in these communities. Understanding stand structure among the different pinyon woodland associations at PECO, in conjunction with past fire evidence and in the context of environmental history and landscape controls, would also significantly aid resource planning. Ultimately, to understand whether the PECO forests are out of natural range of variability will require investigations of the fire history, current stand structure, and fuel loads in a landscape context.

The following data are needed:

1) Detailed forest and woodland stands should include a spatial component to evaluate landscape connectivity with respect to structure data (e.g, species densities, ages, basal area) to compare to regional data on reference conditions.

2) Forest and woodland fire histories to determine current and historical fire frequencies (based on tree ring fire scars and fire atlases). The analysis of fire within the park.

3) Data on pest outbreaks as they have affected stand structure.

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3.10 Riparian Ecosystem

3.10.1 Background

Healthy wetlands are vitally important in storing water, preventing flooding, improving water quality, and recharging groundwater. Riparian areas are also highly productive and support high biodiversity. Management of wetlands is considered among the highest priorities for parks with those areas (NPS 2010). Wetland vegetation communities are a core vital sign and flooding processes a vital sign for the SOPN (NPS 2008). PECO has identified condition of its riparian habitats as important natural resources for this condition assessment.

3.10.2 Data and Methods

This chapter on the condition of riparian areas at PECO is based on a Proper Functioning Condition assessment of the Pecos River and lower Glorieta Creek, conducted on 6-9 June 2010 by Joel Wagner, NPS Water Resources Division Wetland Program lead; Michael Martin, Water Resources Division hydrologist; and Yvonne Chauvin, Natural Heritage New Mexico botanist (Wagner and Martin 2010). The Proper Functioning Condition assessment followed a Bureau of Land Management (BLM) rapid assessment protocol for riparian areas (USDI BLM 1998).

For this method, an interdisciplinary team of technical experts evaluated 17 hydrologic, vegetation, soil, and geomorphology elements for each riparian assessment area, following instructions in the user guide (USDI BLM 1998). The above team evaluated and scored all 17 elements on the data sheets and supported their decisions with technical notes. Based on assessment of the individual elements, the team assigned one of three summary ratings to a site. The descriptions below are taken from (USDI BLM 1998, cited in Wagner and Martin 2010):

> "<u>Proper Functioning Condition</u>: *Streams and associated riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:*
>
> > *1. Dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;*
> >
> > *2. filter sediment, capture bedload, and aid floodplain development;*
> >
> > *3. improve floodwater retention and groundwater recharge;*
> >
> > *4. develop root masses that stabilize stream banks against cutting action;*
> >
> > *5. develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and*
> >
> > *6. support greater biodiversity.*"

<u>Functional-At Risk</u>: These riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly functioning riparian system, but it may be poised to suffer severe erosion during a large storm in the future due to likely migration of a headcut or increased runoff associated with recent urbanization in the watershed. When this rating is

assigned to a stream reach, then its "trend" toward or away from Proper Functioning Condition is assessed.

Nonfunctional: These are riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, sustaining desirable channel and riparian habitat characteristics, and so on as described in the Proper Functioning Condition definition. The absence of certain physical attributes such as a floodplain where one should exist is an indicator of nonfunctioning conditions."

The 17 elements were assessed for each of three riparian reaches, three along the Pecos River and corresponding to the three fishing program beats, and one on Glorieta Creek from the New Mexico State Road 63 bridge to the lower end of the artificial levee (0.5 stream miles).

3.10.3 Reference Conditions

Reference conditions are those categories listed above: Proper Functioning Condition, Functional-At Risk, and Nonfunctional, as defined in USDI BLM (1998). Park condition in each of the four reaches was compared to the above standards.

3.10.4 Resource Description

Pecos River Reach #1, from the northern park boundary to its confluence with Glorieta Creek, was rated Proper Functioning Condition. Fifteen of seventeen criteria were rated positively. Two items were marked "NA": those relating to beaver dams and plant communities providing adequate coarse/large woody material for maintenance/recovery. No evidence of trailing, localized vegetation trampling, bank destabilization, or trash associated with fishing access was observed.

Pecos River Reach #2, from its confluence with Glorieta Creek to the abandoned iron bridge, was rated Proper Functioning Condition. All items in the checklist were rated as for Reach #1, above, with the same two elements rated "NA." No evidence of trailing, localized vegetation trampling, bank destabilization, or trash associated with fishing access was observed.

Pecos River Reach #3, from the abandoned iron bridge to the south park boundary, was rated Proper Functioning Condition. All items were rated the same as for Reaches 1 and 2. No evidence of trailing, localized vegetation trampling, bank destabilization, or trash associated with fishing access was observed.

Glorieta Creek Reach, from the New Mexico State Road 63 bridge to the lower end of the remaining levee, was rated as Functional-At Risk. A total of 13 of the 17 items were given a "Yes," and the question on plant communities providing adequate coarse/large woody material for maintenance/recovery received a "NA." Three items were rated "No": those relating to sinuosity, widening, and lateral stream movement. All three negative items related to the remaining levee in the lower third of the reach. The levee constrains the channel and restricts stream migration. This in turn limits the size and structural complexity of the riparian area. The team saw no evidence of excessive erosion, sediment loading, channel incision, or loss of existing aquatic and wetland habitat. However, they noted a risk that a large flood could cause the creek to erode a new channel through the upper end of the levee and deposit eroded levee material into the restored wetlands and the Glorieta Creek channel downstream. They recommended the removal of the remaining levee.

3.10.5 Condition of Data

Confidence in this assessment is high. The assessment team had the necessary expertise, an established protocol was followed, and the assessment is current.

3.10.6 Data Gaps

This assessment was conducted over a three-day period, and as such it represents a fairly cursory look at PECO riparian condition. However, there is no apparent reason to doubt the conclusions of the assessment. Assuming that NPS is satisfied with a rapid assessment, the data are complete and current. A similar assessment or some other monitoring protocol should be conducted regularly to assess potential impacts to banks, riparian vegetation, and water quality as a result of the fishing program. If the levee in the Glorieta Creek Reach is removed, the results there should also be re-assessed post-removal and regularly monitored.

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3.11 Benthic Macroinvertebrates

3.11.1 Background

Benthic macroinvertebrates are an important food source for fishes and indicators of water quality. The Water Resource Management Plan for PECO (NPS 1995) recommends that the park assess stream habitat, biological diversity, community composition, relative species abundance, and overall productivity, to provide baseline data for tracking future changes. The SOPN has identified aquatic invertebrates as a vital sign indicative of water quality (NPS 2008).

3.11.2 Data and Methods

Jacobi and Jacobi (1998) extensively sampled the PECO benthic macroinvertebrate community in 1995 and 1996. In March and September of 1995 and March and October of 1996, they sampled sites on Glorieta Creek and the Pecos River (Figure 3.11-1).

Sanders (2008) sampled benthic macroinvertebrates at three sites in the park (Figure 3.11-2) on 4 and 5 March 2008. Each site was sampled three times at 0.059 m^2. The purpose of this study was to assess the primary forage base for the fishery.

3.11.3 Reference Conditions

The most comprehensive study evaluating benthic invertebrates at PECO (Jacobi and Jacobi 1998) provides both data and reference conditions for several sites inside the park (Figure 3.11-1). Sites upstream and outside of the park (G1 on Glorieta Creek, and P1 on the Pecos River) were used as controls for the downstream sites within the park to assess the effects of agriculture and other human impacts on sites in the park. Another site on nearby Dalton Creek (DC1), a creek similar to Glorieta Creek, was used as a substitute for G1 when it had no flowing water.

3.11.4 Resource Description

Jacobi and Jacobi (1998) found a wide variety of benthic macroinvertebrate taxa at five sampling sites on the Pecos River and six sites on Glorieta Creek. They identified 105 taxa on the Pecos River and 90 on Glorieta Creek. On the Pecos River they found 55 *Diptera* (true flies), of which 31 were *Chironomidae* (non-biting midges), 66 *Trichoptera* (caddisflies), 15 *Plecoptera* (stoneflies), 10 *Ephemeroptera* (mayflies), six *Coleoptera* (beetles), and 13 other taxa from nine other groups (Table D-1). On Glorieta Creek, there were 46 *Diptera,* of which 31 were *Chironomidae*, eight *Trichoptera*, eight *Plecoptera*, four *Ephemeroptera*, six *Coleoptera*, and 18 other taxa from 10 other groups (Table 3.11-1). Species of *Ephemeroptera*, *Plecoptera*, and *Trichoptera* are known to be prey for fish and are widely used as indicators of good stream habitat. More specifically, Jacobi and Jacobi (1998) have noted the species within these taxa that are especially sensitive or moderately tolerant (see Table D-1 and below). Also, *Trichoptera*, *Ephemeroptera,* and midge larvae (*Diptera*) are important components of the diet of native Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*; Pritchard and Cowley 2006 and references therein).

Jacobi and Jacobi (1998) concluded that the Pecos River locations inside the park downstream from the control have similar water quality to the control sites. Sensitive species in the order *Plecoptera* (stone flies), such as *Pteronarcys californica*, *Pteronarcella badia*, *Claasenia sabulosa*, *Hesperoperla pacifica*, and *Isogenoides elongates*, were present at all locations on the Pecos River. These species indicate good water quality and provide food for high-quality cold-water fisheries (Table D-1; Jacobi and Jacobi 1998). While the macroinvertebrates indicate good water quality compared to the upstream control, this part of the Pecos River has been determined to be “not supporting” the designated use of cold water fishery because mercury contamination renders the fish dangerous for human consumption (New Mexico Water Quality Control Commission 2010, p. 374; “Water Quality”).

On Glorieta Creek, however, the quality of the benthic macroinvertebrate community is inferior to that of the control site. Glorieta Creek downstream of the Glorieta Conference Center is effluent-driven, having low flow, high turbidity, and high sediment (see “Water Quality”). The sediment-tolerant worm in the family Tubificidae was present in relatively large numbers downstream of the Glorieta Conference Center compared to both control sites (DC1 and G1). The opportunistic black fly *Simulium* comprised a large proportion of the organisms sampled at G2, indicating both low biodiversity and poor water quality. In addition, sensitive species of the *Plecoptera* listed above were completely absent from Glorieta Creek, including the control site G1. Some of these sensitive species were present at the control at DC1. The absence of *Plecoptera* at the G1 control site could have been due to low flow, but this explanation does not suffice for the reach downstream of the Glorieta Conference Center, where water was always present (Table D-1; Jacobi and Jacobi 1998).

Glorieta Creek has been designated for high-quality cold-water aquatic life but is not supporting that use due to contaminants, low oxygen, high temperature, and high turbidity (New Mexico Water Quality Control Commission 2010, p. 364; “Water Quality”). Jacobi and Jacobi (1998) recommended improving the wastewater treatment on both bodies of water upstream of the park.

The results of this extensive survey support the designated use of these two bodies of water within PECO as “high-quality cold-water fisheries,” even though neither currently qualifies. The Pecos River benthic macroinvertebrate community is diverse and productive, including species that are important for trout food, *Pteronarcella badia* and *Pteronarcys californica*. Nonetheless, serious issues remain, particularly on Glorieta Creek, due to waste water contamination from Glorieta Conference Center and high sediment loads and increased turbidity during runoff from road crossings. These issues need to be addressed to maintain and improve the quality of the aquatic communities at PECO.

Sanders (2008) found a lower diversity of benthic macroinvertebrates than Jacobi and Jacobi (1998). Sanders reported a total of 26 taxa: five each of Plecoptera, Ephemeroptera, and Trichoptera, seven Diptera, one Annelida, two Coleoptera, and one Lepidoptera. Because Sanders’ study involved less sampling effort and a different method, the results of the two studies cannot reliably be compared.

Sanders (2008) noted that the site furthest downstream from the north border and the town of Pecos (Site 1 in the study) was the least impacted by anthropogenic effects because it had less aquatic vegetation, periphyton, substrate cementing, and bank erosion. Sanders also noted that the number of perturbation-tolerant organisms increased with proximity to the town. Sanders concluded that the community of benthic invertebrates is almost homogeneous along Pecos River in PECO, but that the effects of the town are indicated by the condition of the river.

3.11.5 Condition of Data

The 1998 Jacobi and Jacobi study was a comprehensive survey of benthic macroinvertebrates within the park. Sanders's (2008) study used different methods and was much less comprehensive, since the intention was to assess food for the fishery only. A monitoring program should include a regular sampling schedule, consistent methods, and sampling repeated spatially and temporally within each survey.

The Jacobi and Jacobi (1998) survey was comprehensive, with large sample sizes and good coverage of the park. Confidence in the data quality is high, but because the study is old, the benthic invertebrate fauna could have changed. The Sanders's (2008) study was recent but used different methods from the previous study and was not comprehensive. Therefore, we have moderate confidence in this assessment**.**

3.11.6 Data Gaps

The 1998 Jacobi and Jacobi study was a comprehensive survey of benthic macroinvertebrates within the park. Sanders's (2008) study used different methods and was much less comprehensive, since the intention was to assess food for the fishery only. A monitoring program should include a regular sampling schedule, consistent methods, and sampling repeated spatially and temporally within each survey.

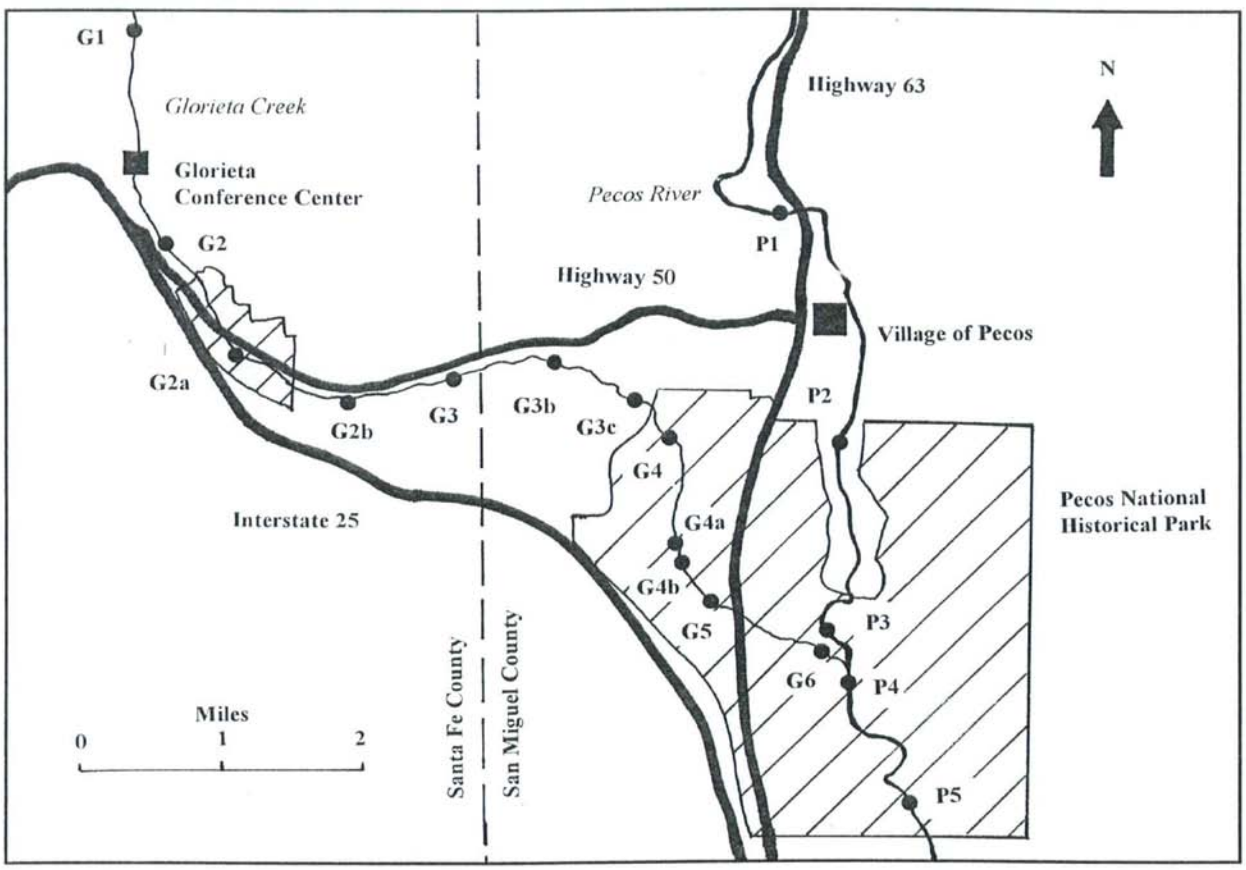

Figure 3.11-1. Collection sites for Jacobi and Jacobi (1998) study. Reference sites are G1 and P1. DC1 is not shown.

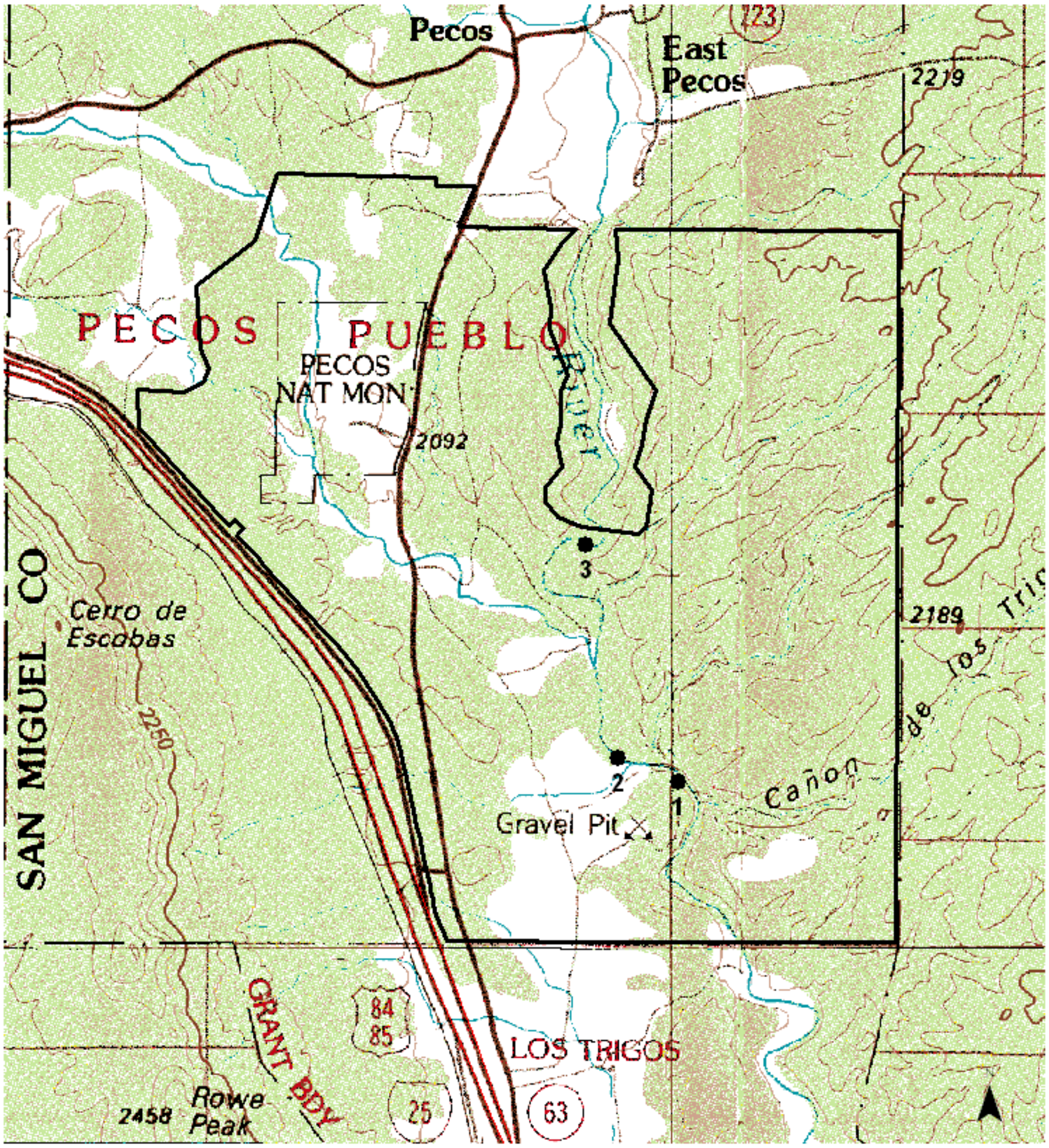

Figure 3.11-2. Three benthic invertebrate sampling sites along the Pecos River used in Sanders (2008).

3.11.7 Literature Cited

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3.12 Terrestrial Invertebrates

3.12.1 Background

Terrestrial invertebrates make up a significant proportion of biodiversity and perform many necessary ecological roles, but they are typically under-studied and under-protected. Insects, making up part of the polyphyletic group invertebrates, are the most diverse taxon. Insects make up more than half of all known species, an under-estimate because they are not as well catalogued and studied as mammals and birds (May 1992). Many insects also are good indicators of ecosystem health (Coleoptera: Cicindelidae, Lepidoptera: Morphinae and Satyrinae, Hymenoptera: Apoidae, Vespidae, and Sphecidae; Hilty and Merenlender 2000). The SOPN has identified native pollinators, insect pests and outbreaks, and moths and butterflies as vital signs (NPS 2008).

3.12.2 Data and Methods

In 1995, Parmenter and Lightfoot (1996) conducted an intensive, qualitative study of terrestrial invertebrates at the main PECO unit. They sampled all habitat types on the main unit to maximize the number of species found. They captured insects using pitfall traps, dip net, aquatic drift net, hand collection at lights, sweep nets for collection from shrubs, aerial insect nets for collection of active diurnal insects, hand collection under rocks and logs and at flowers, and tracking the sound of calling insects such as crickets.

3.12.3 Reference Conditions

There is no target list against which to compare Parmenter and Lightfoot's results. However, diversity of the invertebrate fauna at similar areas in New Mexico (Sevilleta National Wildlife Refuge, El Malpais National Monument, Petroglyphs National Monument, and Bandelier National Monument) can serve as a general reference condition.

3.12.4 Resource Description

The list includes two phyla: Arthropoda and Mollusca. The list of Arthropoda includes the classes Arachnida, Malacostraca, Diplopoda, Chilopoda, and Hexapoda. Hexapoda was by far the most heavily represented class (386 of 451 taxa) including the orders Ephemeroptera, Odonata, Plecoptera, Mantodea, Orthoptera, Phasmida, Dermaptera, Isoptera, Thysanoptera, Hemiptera, Homoptera, Neuroptera, Coleoptera (including eight species from NMBCC (2007), Diptera, Trichoptera, Lepidoptera, and Hymenoptera (Table E-1, -2). They concluded that the arthropods found were characteristic of similar areas in New Mexico and that the list is relatively large because of the contributions of riparian habitats.

Parmenter and Lightfoot (1996) also conducted a quantitative study of arthropods to compare piñon-juniper woodlands to grasslands that had been created by clearing piñon-juniper woodland. From this study, they concluded that the presence of the grassland habitat at PECO increases arthropod diversity.

These surveys found no threatened or endangered species; however, the large terrestrial snail *Ashmunella thomsoniana* they found to be abundant in the riparian habitats along the Pecos River is endemic to the Sangre de Cristo Mountains and is ranked as vulnerable by NatureServe (NatureServe 2009).

They concluded that the insect communities they found in the woodland, grassland, and riparian habitats are similar to those in similar habitats they have sampled at other locations in New Mexico such as Sevilleta National Wildlife Refuge, El Malpais National Monument, Petroglyphs National Monument, and Bandelier National Monument. The diversity of invertebrate fauna at PECO compared favorably with the reference sites.

3.12.5 Condition of Data

Confidence in the species list is high, because all habitat types were sampled using a variety of trapping methods. However, because the study was conducted in 1995 and the subunits have not been sampled, confidence in this study as representing the 2010 terrestrial invertebrate fauna is moderate.

The single invertebrate survey at PECO, although comprehensive in terms of habitats, methods, and taxa, should be updated. To address this data gap, the park should establish a protocol for ongoing monitoring. In addition, the Pigeon’s Ranch and Cañoncito Subunits have not been sampled; these areas should be included in any future survey and monitoring efforts.

3.12.6 Data Gaps

The single invertebrate survey at PECO, although comprehensive in terms of habitats, methods, and taxa, should be updated. To address this data gap, the park should establish a protocol for ongoing monitoring. In addition, the Pigeon’s Ranch and Cañoncito Subunits have not been sampled; these areas should be included in any future survey and monitoring efforts.

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3.13 Fishes

3.13.1 Background

The SOPN has identified fish communities as a vital sign (NPS 2008). The Pecos River and the biodiversity it supports are arguably the most important natural resources at PECO (see "Riparian Assessment"). The river supports a quality trout fishery (Frey 2007), and a limited public fishing program has recently been initiated. Recent surveys suggest that six fish species currently occur in the PECO reach of the Pecos River. An additional species, the fathead minnow, was present in 1993 (Stumpf 1993) and 1997 (Pittenger 1997) and may still be present but may have been missed by Frey (2007).

3.13.2 Data and Methods

Four recent studies of the PECO fish community exist. Patten and Fry (2004) surveyed fishes in the Pecos River. Frey (2007, 2010) surveyed Pecos River fishes again in 2006 and 2010. Pittenger (1997) assessed fish and habitats in Glorieta Creek prior to the 1999-2000 floodplain restoration.

Jacobi and Jacobi (1998) conducted extensive surveys of benthic macroinvertebrates at five sites on the Pecos River and six sites on Glorieta Creek. They conducted surveys in March and September 1995 and March and October 1996. Sanders (2008) took three samples each at three sites on the Pecos River. Samples were collected in March 2008, with a focus on taxa important as trout foods.

3.13.3 Reference Conditions

We can suggest several approaches to reference conditions for fishes. One possible reference condition would be the species composition prior to the introduction of exotic species, in the late 1800s. Although not documented in recent literature, the Rio Grande cutthroat trout could have been present at that time. It was present in the upper tributaries of the Pecos River between 1971 and 1980 (Sublette et al. 1990), and cutthroat or hybrids currently occur there. The Rio Grande cutthroat hybridizes with rainbow trout and suffers from competition with brown trout (Sublette et al. 1990); both likely impacted any native cutthroats originally present in the area.

Another reference condition for park fishes would emphasize the sport fishery. Given that the community of fishes at PECO comprises mainly nonnative trout, likely there to stay, the reference condition could focus on relative composition of rainbow and brown trout, if greater diversity were desired. Focus on the sport fishery could also consider population health, sustainability, and harvest potential.

For trout foods, Jacobi and Jacobi (1998) can be used as a reference condition, because it was a thorough study performed over 10 years ago.

Table 3.13-1. Fish species observed in Pecos National Historical Park

Common Name	Scientific Name	Native	Source						
			Sublette et al. 1990[1] (1901-1950)	**Sublette et al. 1990 (1951-1960)**	**Sublette et al. 1990 (1961-1970)**	**Sublette et al. 1990 (1971-1980)**	**Stumpff 1995[2]**	**Pittenger 1997[3]**	**Frey 2007[4]**
Rainbow trout	*Oncorhynchus mykiss*		X			X			X
Brown trout	*Salmo trutta*		X			X	X	X	X
Rio Grande chub	*Gila pandora*	X						X	X
White sucker	*Catostomus commersoni*	X	X		X		X	X	X
Longnose dace	*Rhinichthys cataractae*	X					X	X	X
Fathead minnow	*Pimephales promelas*	X					X	X	

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3.13.4 Resource Description

The current community of fishes at PECO is dominated by the brown trout, which in Frey's (2007) surveys comprised 60% of individuals captured and 53% of biomass. Rainbow trout comprised 1% of fish captured and 5% of biomass in that survey. Both are nonnative species, introduced to the United States in the early 1900s and 1896, respectively (Sublette et al. 1990). Thus, as of 2007, approximately 61% of the fish (58% of biomass) at PECO were nonnative. The three other species present during that survey, white sucker (14%, 37% biomass), Rio Grande chub (11%, 4% biomass), and longnose dace (14%, 1% biomass), are all native species, as is the fathead minnow, which was not detected.

Frey's (2010) survey found slightly different species composition, with brown trout comprising 57% of individuals and 50% of biomass. Rainbow trout were 3% and 4%, white sucker 18% and 42%, Rio Grande chub 6% and 2%, and longnose dace 16% and 2%, respectively (Frey 2010). Non-native species comprised 60% of individuals and 54% of biomass in 2010.

Proportional stock distribution is a measure of the percentage of individuals in various size classes and is an indicator of the quality of the sport fishery. The Frey studies demonstrate how stock distribution can vary among years. Between 2004 and 2007 the abundance of brown trout doubled at two PECO sites (Frey 2007), but the fish captured were smaller than in 2004. The size change probably occurred due to recruitment of younger fish associated with increased river flows in 2005 and 2006. Fish were shorter in 2007, indicating a higher proportion of one- and two-year-old fish. A relative decrease in weight suggests that the increased population size resulted in competition for food.

By 2010, the abundance of adult (≥ 130 mm or 5 in) brown trout had roughly doubled since the 2007 survey, a statistically significant increase. However, the 2010 abundance was not significantly different from the 2004 survey (Frey 2010). The 2007 increase was probably due to an abnormally large age class moving through the population, and the 2004 and 2010 estimates likely provide closer approximations of the base population in the Pecos River.

In keeping with the population changes, the brown trout size distribution returned to 2004 levels in 2010, a result of the large younger age class present in 2007 recruiting into the larger size class in 2010. Mean length and relative weight also returned to near 2004 levels in 2010, after a decrease in 2007.

Pittinger's (1997) survey of Glorieta Creek fishes and habitats was conducted to assess potential impacts from the 1999-2000 restoration of the creek which eliminated two reservoir ponds and introduced wetland plants. This survey sampled four sites in the creek and one each in the reservoirs, using seines. Rio Grande chub comprised 55% of the fish sampled, followed by fathead minnow (28%), longnose dace (8%), white sucker (8%), and brown trout (1%). Rio Grande chub was most abundant in the creek, while fathead minnow was most abundant in the reservoirs.

As a nonnative sport fishery, the fishery in the Pecos River appears relatively healthy. Frey (2010) concluded that the pilot fishing program is not negatively impacting the brown trout population in the Pecos River. Other fish species such as the native white sucker, Rio Grande chub, and longnose dace, also remained stable between surveys. However, the absence of the only trout species native to the Pecos River diminishes the quality as a sport fishery. As a native fishery, the Pecos River is clearly lacking, due to the dominance of nonnative trout and the absence of native trout.

Jacobi and Jacobi (1998) concluded that the benthic macroinvertebrate community at PECO was diverse, including taxa containing trout foods such as the *Ephemeroptera* (10 species), *Plecoptera* (15), and *Trichoptera* (66). The results indicated good water quality and sufficient food for a high-quality, cold-water fishery. Sanders (2008) found all three taxa represented, but much lower species richness (*Ephemeroptera*-5, *Plecoptera*-5, and *Trichoptera*-5). Because effort and methods were different in the two studies, it is not possible to determine whether the macroinvertebrate fauna actually declined between 1998 and 2008.

3.13.5 Condition of Data

Confidence in Frey's (2007, 2010) surveys is high. Confidence is low in Pittenger's (1997) data because of their age and subsequent hydrological and habitat changes in the creek. We are confident in the assessment, if a sport fishery is the reference condition. We have not provided an assessment for other potential reference conditions; e.g., a native fishery.

Confidence in Jacobi and Jacobi's (1998) study is high for its time, but it does not reflect the current condition of the benthic macroinvertebrate community at PECO. Sanders's (2008) study is more recent, but sampling was not thorough enough to provide more than moderate confidence.

Data such as Frey's are necessary to understand the health of fish populations and the state of the sport fishery. Surveys should be continued at least every three years, and more frequently if the park changes the fishing program. Pittenger's (1997) study of Glorieta Creek occurred before habitats along the creek were restored. The data are not current or applicable to the current state of the creek, and new surveys should be conducted there.

Frey (2007) recommends that aquatic macroinvertebrates also be monitored, to serve as indicators of stream health (see "Aquatic Macroinvertebrates"). The most comprehensive survey of macroinvertebrates was that of Jacobi and Jacobi (1998). Sanders's (2008) survey was much less thorough than that of Jacobi and Jacobi (1998). Apparently only three samples were taken at each of three sites on the river. Hence, Sanders's data cannot be compared to the Jacobi and Jacobi (1998) data and should not be considered a monitoring study. A monitoring program should employ similar methods and sampling effort each time a site is sampled. A monitoring program need not sample as extensively as did Jacobi and Jacobi (1998), if trout are to be the focus. Sanders's study could be followed with regular monitoring at the same sites and using similar methods. However, a reliable monitoring study would incorporate more temporally and spatially repeated sampling. Until a careful and thorough monitoring program is established, the absence of consistent data on benthic macroinvertebrates can be considered a data gap.

3.13.6 Data Gaps

Data such as Frey's are necessary to understand the health of fish populations and the state of the sport fishery. Surveys should be continued at least every three years, and more frequently if the park changes the fishing program. Pittenger's (1997) study of Glorieta Creek occurred before habitats along the creek were restored. The data are not current or applicable to the current state of the creek, and new surveys should be conducted there.

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3.14 Herpetofauna

3.14.1 Background

The SOPN has identified amphibian communities as a vital sign for its parks (NPS 2008). New Mexico harbors "an interesting and diverse herpetofauna" (Degenhardt et al. 1996) and, owing to its variety of habitats, PECO is likewise expected to have a diversity of amphibians and reptiles. For amphibians, the Pecos River and Glorieta Creek provide aquatic habitats on the main unit, and Glorieta Creek runs through the Pigeon's Ranch Subunit. The various terrestrial habitats, including grassland, piñon-juniper, ponderosa, and developed areas, are expected to yield high reptilian biodiversity.

Although the contribution of herpetofauna to vertebrate biodiversity is important in its own right, the recent dramatic worldwide decline of amphibians (Stuart et al. 2004) is an even more compelling reason to assess and monitor herpetofaunal resources at national parks. Rapid, poorly understood amphibian declines are taking place for reasons other than typical causes of biodiversity loss, such as habitat loss and overexploitation. These declines have occurred even in protected areas such as Yosemite National Park (Stuart et al. 2004). Of particular relevance to PECO is the finding that the virulence of the fungal disease chytridiomycosis, a major cause of amphibian decline, is higher among streamside species and at higher elevations. In addition, four families contribute disproportionately to the number of declining species (Stuart et al. 2004). Representatives of three of these families—Bufonidae, Hylidae, and Ranidae—are expected to occur at PECO, although the Ranidae family has not yet been detected there (Table 3.14-1).

3.14.2 Data and Methods

Two lists of potential herpetofauna species exist for PECO. The same two sources also conducted limited field surveys. Parmenter and Lightfoot (1996) identified 26 species of reptiles (19) and amphibians (7) that they expected to occur at PECO (Table 3.14-1). Johnson et al. (2003) included 35 species on their target list (Table 3.14-1). To assess the herpetofauna at PECO, we compared the list of species detected in both studies to the combined target list.

3.14.3 Reference Conditions

We used the combined lists from both studies as a reference condition for PECO herpetofaunal diversity. The combined target list includes 41 species of amphibians and reptiles (Table 3.14-1). Included in the Parmenter and Lightfoot (1996) target list but not in the Johnson et al. (2003) list are: tree lizard, side-blotched lizard, common kingsnake, plains black-headed snake, New Mexico garter snake, and western diamondback rattlesnake. Johnson et al. (2003) included 15 species not targeted by Parmenter and Lightfoot (1996) (see Table 3.14-1 for species).

3.14.4 Resource Description

Parmenter and Lightfoot (1996) detected eight reptile and three amphibian species on their surveys. Johnson et al. (2003) listed ten observed species, four amphibians and six reptiles. Combining both lists of observed species yields five amphibian and eight reptile species, 13 species total. None of the detected or target species is federally or state listed. However, the northern leopard frog is ranked by the State of New Mexico as S1, meaning it is considered critically imperiled in the state.

Considerably fewer species have been detected than are expected. Five of the 11 (45%) potential amphibian species and eight of 30 potential (27%) reptile species were detected in these two studies. The discrepancies between the detected and potential species lists are likely a result of the limited sampling conducted by both studies, and not necessarily an indication of a depauperate herpetofaunal species assemblage. Parmenter and Lightfoot (1996) surveyed by visual observations made during the course of other field work on their project, and they conducted no trapping. Johnson et al. (2003) surveyed using walking transects, live traps, and call identification (amphibians only). They used cover boards, drift fences, aquatic turtle traps, and noose-and-pole capture methods on walking transects. However, trapping and walking surveys were targeted at riparian areas.

3.14.5 Condition of Data

Due to the limited surveys previously conducted, confidence in this assessment is low.

3.14.6 Data Gaps

Because previous surveys for herpetofauna have been limited in scope, actual species richness at PECO is likely larger than surveys indicate. To address this data gap, a more comprehensive herpetofaunal survey should be conducted, including all habitat types over several surveys and covering the Pigeon’s Ranch and Cañoncito Subunits. A variety of survey methods is most effective in detecting reptile (Garden et al. 2007; Ryan et al. 2002) and amphibian species (Farmer et al. 2009; Ryan et al. 2002). To detect declines of amphibians and other sensitive taxa, an ongoing monitoring program would be necessary.

Table 3.14-1. Herpetofauna species in Pecos National Historical Park

Order	Family	Common Name	Scientific Name	Johnson et al. 2003[1]		Parmenter and Lightfoot 1996[2]	
				Target List	Observed	Target List	Observed
Caudata	Ambystomatidae	Tiger Salamander	*Ambystoma tigrinum*	X	X (NPS)	X	
Anura	Bufonidae	Great Plains Toad	*Bufo cognatus*	X		X	
Anura	Bufonidae	Red-spotted Toad	*Bufo punctatus*	X		X	
Anura	Bufonidae	Woodhouse's Toad	*Bufo woodhousii*	X	X		X
Anura	Hylidae	Canyon Treefrog	*Hyla arenicolor*	X			X
Anura	Hylidae	Western Chorus Frog	*Pseudacris triseriata*	X		X	
Anura	Pelobatidae	Plains Spadefoot	*Spea bombifrons*	X		X	
Anura	Pelobatidae	New Mexico Spadefoot	*Spea multiplicata*	X	X		X
Anura	Ranidae	Plains Leopard Frog	*Rana blairi*	X	X		
Anura	Ranidae	Bullfrog	*Rana catesbeiana*	X		X	
Anura	Ranidae	Northern Leopard Frog	*Rana pipiens*	X		X	
Squamata	Iguanidae	Collared Lizard	*Crotaphytus collaris*	X	X (NPS)		X
Squamata	Iguanidae	Lesser Earless Lizard	*Holbrookia maculata*	X		X	
Squamata	Iguanidae	Short-horned Lizard	*Phrynosoma douglasii*	X			X
Squamata	Iguanidae	Eastern Fence Lizard	*Sceloporus undulatus*	X	X		X
Squamata	Iguanidae	Tree Lizard	*Urosaurus ornatus*			X	
Squamata	Iguanidae	Side-blotched Lizard	*Uta stansburiana*			X	
Squamata	Scincidae	Many-lined Skink	*Plestiodon multivirgatus*	X		X	
Squamata	Scincidae	Great Plains Skink	*Plestiodon obsoletus*	X		X	
Squamata	Teiidae	Chihuahuan Spotted Whiptail	*Aspidoscelis exsanguis*	X		X	
Squamata	Teiidae	Little Striped Whiptail	*Aspidoscelis inornata*	X		X	
Squamata	Teiidae	Colorado Checkered Whiptail	*Aspidoscelis tesselata*	X		X	
Squamata	Teiidae	Plateau Striped Whiptail	*Aspidoscelis velox*	X	X		X
Serpentes	Colubridae	Ringneck Snake	*Diadophis punctatus*	X		X	
Squamata	Colubridae	Red Cornsnake	*Pantherophis guttatus*	X			
Serpentes	Colubridae	Night Snake	*Hypsiglena torquata*	X		X	
Serpentes	Colubridae	Common Kingsnake	*Lampropeltis getula splendida*			X	
Serpentes	Colubridae	New Mexico Milksnake	*Lampropeltis triangulum celaenops*	X			X
Serpentes	Colubridae	Coachwhip	*Masticophis flagellum*	X		X	
Serpentes	Colubridae	Striped Whipsnake	*Masticophis taeniatus*	X		X	
Serpentes	Colubridae	Gopher Snake	*Pituophis catenifer*	X	X (NPS)		X

Order	Family	Common Name	Scientific Name	Johnson et al. 2003[1]		Parmenter and Lightfoot 1996[2]	
				Target List	Observed	Target List	Observed
Serpentes	Colubridae	Mountain Patchnose Snake	*Salvadora grahamiae*	X		X	
Serpentes	Colubridae	Plains Black-headed Snake	*Tantilla nigriceps*			X	
Serpentes	Colubridae	Blackneck Garter snake	*Thamnophis cyrtopsis*	X		X	
Serpentes	Colubridae	Wandering Gartersnake	*Thamnophis elegans vagrans*	X	X		X
Serpentes	Colubridae	New Mexico Gartersnake	*Thamnophis sirtalis dorsalis*			X	
Squamata	Colubridae	Lined Snake	*Tropidoclonion lineatum*	X			
Serpentes	Colubridae	Smooth Green Snake	*Liochlorophis vernalis*	X		X	
Squamata	Leptotyphlopidae	Texas Threadsnake	*Leptotyphlops dulcis*	X			
Serpentes	Viperidae	Western Diamondback Rattlesnake	*Crotalus atrox*			X	
Serpentes	Viperidae	Prairie Rattlesnake	*Crotalus viridis*	X	X		X

[1] Johnson, K., G. Sadoti, G. Racz, J. Butler, and Y. Chauvin. 2003. National Park Service Southern Plains Network Final Inventory report for New Mexico parks. Natural Heritage New Mexico, UNM, Albuquerque, NM.

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3.15 Birds

3.15.1 Background

Conservation of wildlife is at the heart of the NPS mission. Bird communities are important as wildlife and as indicators of ecosystem health. More species of birds occur at SOPN parks than any other vertebrate. In addition, long-term trends in bird diversity and abundance provide measures of ecological integrity and sustainability of prairie, riparian, and piñon-juniper ecosystems (NPS 2010). For these reasons, SOPN has chosen bird communities as a core vital sign (NPS 2008).

3.15.2 Data and Methods

Birds are the most thoroughly studied animal group at PECO, with four surveys completed (Figure 3.15-1). Mukai (1989) conducted a thorough survey of the Forked Lightning Ranch before it became part of the park. More recently, surveys of the main unit were done in 2002 (Johnson et al. 2003), 2008 and 2009 (Johnson et al. 2010), and 2009 (NPS 2009). In addition, a Breeding Bird Survey (U.S. Geological Survey Patuxent Wildlife Research Center 2010) route starts in the town of Pecos and proceeds south along New Mexico State Road 63 through some of the high grassland habitat of the main unit. The Breeding Bird Survey started in 1973 and continues every year. In addition, a few species were noted by park personnel.

For this study, species lists from all these surveys were compiled into one list (Table F-1) and compared to the target list for PECO compiled for the SOPN (Johnson et al. 2003). We also attempted to break down the comparison by habitat and to assess any changes in the avian community over time.

3.15.3 Reference Conditions

No reference conditions for bird community composition or abundance have been established for PECO. Therefore, we use the target list created for the SOPN (Johnson et al. 2003) as a general guide to expected birds species richness in the park. This list is compared to the complete list comprising all species detected in the surveys conducted to date.

3.15.4 Resource Description

A total of 148 bird species are recorded at PECO (Table 3.15-1). All data except Mukai's and a few park staff observations were recorded in the breeding season. The target list contained 91 potential bird species for PECO (Johnson et al. 2003). This list was for breeding birds only and is not comparable with the list of birds observed year-round, but it can provide a reference condition for species richness in the breeding season. All bird species on the breeding season target list have been observed by at least one of the five data sources (Table F-1). Most species that were observed in the park but were not on the target list were not on the list because they were expected in the non-breeding season. Species expected to be rare or at the edge of their range were not included on the target list; this accounts for several discrepancies. Nonetheless, eight not particularly rare species found at the park during the breeding season were not included on the target list: Eurasian Collared-Dove, White-winged Dove, Ladder-backed Woodpecker, Downy Woodpecker, Cactus Wren, White-crowned Sparrow, Indigo Bunting, and Red Crossbill. Based on data from several studies over a 20-year period, actual species richness in the breeding season therefore exceeded expectations, as indicated by the target list (Johnson et al. 2003).

Of the 148 species observed in the park, 98 have been assigned to one or more habitats based on the location of the points at which they were recorded. Of these, 88 are typically associated with riparian areas, 51 with grassland, 59 with piñon-juniper, and 22 with ponderosa pine. These numbers reflect in part the areas of available habitat types on the main unit; for example, the area of ponderosa pine is the smallest of the four habitats and only 22 ponderosa pine species are recorded. Relative richness is also affected by survey effort. Piñon-juniper habitats are the most abundant in area, but survey effort has been disproportionately lower there. To understand relative bird species richness across habitats, survey effort will need to be more equitably distributed among habitat types (see "Data Gaps"). Nonetheless, riparian habitats are quite high in species richness.

The Mukai (1989) survey is probably the best overall reference for birds on the main unit because her survey covered the entire area and occurred in three seasons: spring, summer, and winter. Her survey, along with Breeding Bird Survey data, can be used to assess changes in the birds at PECO over time. Differences between Mukai's list, Breeding Bird Survey, and more recent surveys might be due to chance, indicate a real change in the birds at the park, or suggest that insufficient data exist to allow conclusions.

Mukai recorded five species only in winter that were seen more recently in the breeding season: Ladder-backed Woodpecker, White-crowned Sparrow, Dark-eyed Junco, Pine Siskin, and Red Crossbill. The first four species were seen in small numbers, so the discrepancies between surveys can be discounted. Red Crossbills, however, were seen on four different occasions in recent surveys and during the Breeding Bird Survey survey, indicating that this species is breeding on the main unit of the park, but perhaps was not present during Mukai breeding surveys.

Mukai recorded 29 species that were not seen in the three recent surveys. Mukai observed two species (Ferruginous Hawk and Townsend's Solitaire) in the winter, and three species (Tree Swallow, Ruby-crowned Kinglet, and Townsend's Warbler) were recorded as migrants. Additional surveys in winter and migration could find that these five species are still present at PECO outside the breeding season. Two of the remaining species not seen in recent surveys but recorded by Mukai during the breeding season, the European Starling and the House Sparrow (recorded in 10%-24% of her visits), are introduced from Europe and live in greater numbers around human habitation. Changes in human land use have probably caused these changes (e.g., decrease in grazing and/or animals being kept more often in barns). The Breeding Bird Survey recorded these two species, but this is expected because the route starts in the town of Pecos and passes by houses on the highway. Finally, Gray Vireos were documented by Mukai (1989), the Breeding Bird Survey (two birds in 1973), and Parmenter and Lightfoot (1996), but this species was not documented by any surveyor in the three most recent surveys within the main unit of the park. This may indicate a decrease of Gray Vireos at the main unit. Gray Vireos are easy to detect, and the Breeding Bird Survey route passes through a large portion of suitable habitat on New Mexico State Road 63.

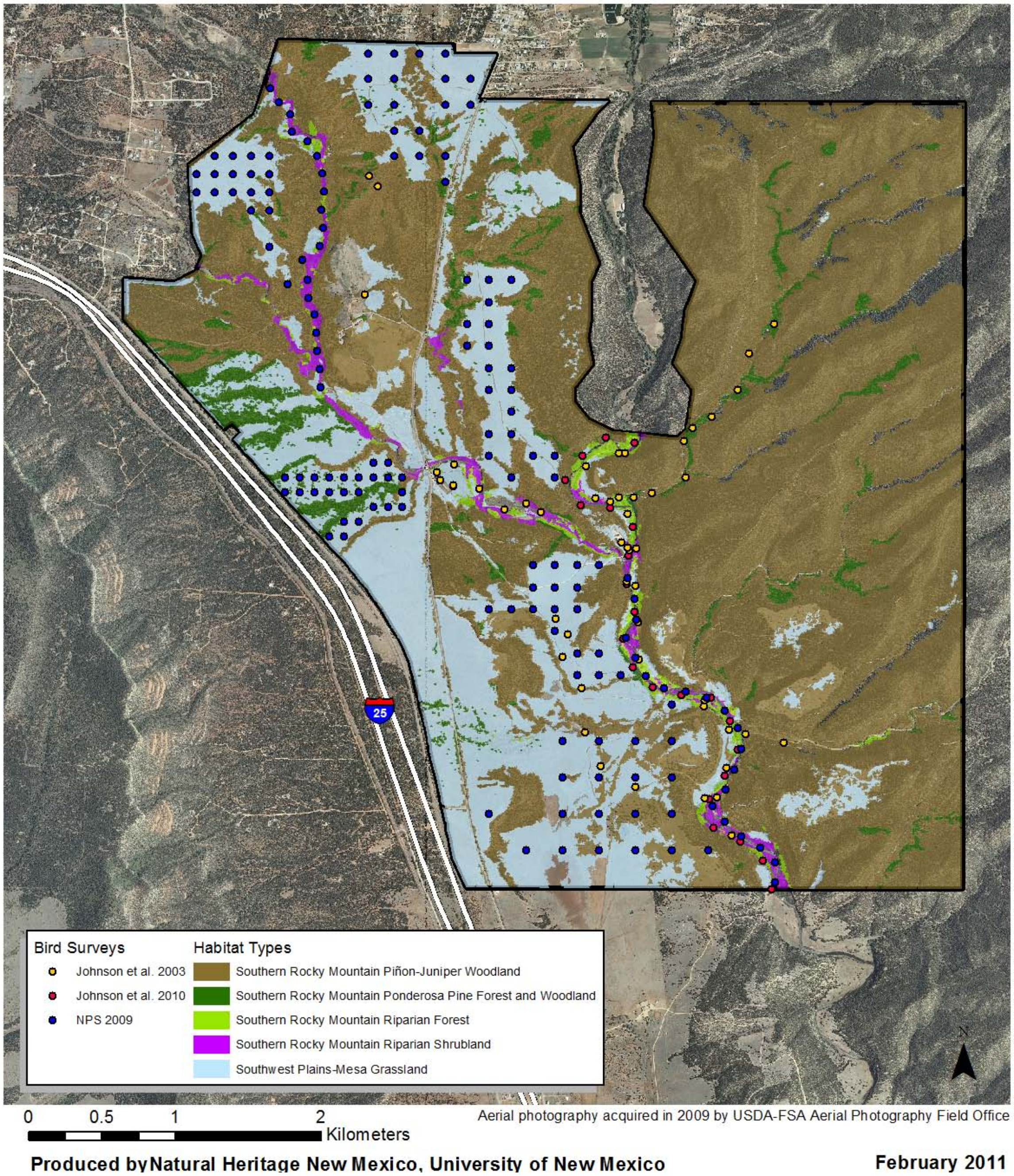

Figure 3.15-1. Survey points for recent bird surveys at Pecos National Historical Park. Habitats named by proposed group level names of the National Vegetation Classification and assigned based on the draft park vegetation map, using Geographic Information System (GIS) (Muldavin et al. 2009).

Twenty-three species were recorded in recent surveys but not recorded by Mukai. Of these, nine species were seen only once in any of three complete surveys. Four species (Eurasian Collared-Dove, White-winged Dove, Cordilleran Flycatcher, and Common Yellowthroat) were seen in two or all of the recent surveys, but not seen by Mukai, suggesting that they have increased in numbers since her surveys. Eurasian Collared-Doves have undergone a dramatic range expansion since their introduction in the Bahamas in the mid-1970s (Romagosa 2002); perhaps they had not reached Pecos at that time. White-winged Doves have also expanded their range with the increase in human population and have probably only recently arrived in the park. In cases such as the Cordilleran Flycatcher and the Common Yellowthroat, the discrepancies may be simply due to chance or error.

Two species (Scaled Quail and Pygmy Nuthatch) were on the original target list, have been seen in the area (Breeding Bird Survey), but have not been documented yet at the park. The Pecos Breeding Bird Survey route goes through the main unit of the park, but is not entirely in the park. Therefore we cannot know if birds seen on that route were inside or outside park boundaries. Park survey sites may not have been in appropriate habitat, or these species may not be present at the park.

3.15.4.1. Species of Conservation Concern

3.15.4.1.1. Southwestern Willow Flycatcher

The park has responsibility for species of conservation concern. The Southwestern Willow Flycatcher (*Empidonax traillii extimus*), a federally endangered subspecies, breeds in dense riparian habitats of the southwestern United States. Southwestern Willow Flycatchers are threatened by loss of riparian habitat due to water diversion, impoundment, and channelization; livestock grazing; and brown-headed cowbird (*Molothrus ater*) brood parasitism. Willow flycatchers were identified at PECO on three days in June 2002 (Johnson et al. 2003), but because they were detected during the migration season, they could not be identified as the southwestern subspecies.

Occupied Southwestern Willow Flycatcher breeding sites always have dense vegetation in the interior, and the densest vegetation typically occurs within 3-4 m above ground. Native riparian habitat is often characterized by an overstory of broadleaf trees such as cottonwood (*Populus* spp.) and an understory of willow (*Salix* spp.) or other shrubs. Slow-moving water and/or saturated soil are typically present at breeding sites. For Southwestern Willow Flycatcher at PECO, a habitat reference condition would be suitable breeding habitat with these features (Sogge et al. 1997).

The habitat along Galisteo Creek in the Cañoncito Subunit resembles arroyo riparian more than stream riparian habitat. Its incised banks are lined primarily by rabbitbrush, with a few scattered relict cottonwoods and small willows. This stream is clearly unsuitable for Southwestern Willow Flycatcher breeding. The riparian habitat on Glorieta Creek in the Pigeon's Ranch Subunit lacks the proper structure for Southwestern Willow Flycatcher breeding, and the riparian habitat along Glorieta Creek between the Forked Lightning Ranch and the Visitor Center is not suitable for Southwestern Willow Flycatcher breeding. Although a few patches of coyote willow are there, these patches do not have adequate overstory for Southwestern Willow Flycatcher breeding. However, these patches may provide suitable stopover habitat for migrant Southwestern Willow Flycatcher (Johnson et al. 2010).

Riparian vegetation along the Pecos River in the main PECO unit shows potential to develop into suitable Southwestern Willow Flycatcher breeding habitat. Near the south end of the park, willow patches are large enough to support Southwestern Willow Flycatchers and after several years could attain sufficient height. Cottonwood or other suitable tree overstory is a potential problem there; however, coyote willows and large cottonwoods or Gooding's willow (*Salix gooddingii*) occur together in only a few areas along the riparian corridor. Two breeding seasons of riparian surveys along the Pecos River failed to detect Southwestern Willow Flycatcher or Yellow-billed Cuckoo. However, the fact that migrant willow flycatchers (not necessarily of the southwestern subspecies) have been detected along the Pecos River suggests that this area holds the most potential for future use (Johnson et al. 2003, 2010).

3.15.4.1.2. Gray Vireo

The Gray Vireo (*Vireo vicinior*) is listed as threatened by the State of New Mexico. Throughout its range, the Gray Vireo breeds in piñon-juniper, scrubland, or chaparral habitats in arid, mountainous terrain or high plains (Barlow et al. 1999). In New Mexico, it is primarily associated with juniper woodlands and savannahs of the foothills and mesas, usually with a well developed grassy understory, and in some areas, a piñon or oak component (New Mexico Department of Game and Fish 2005). The Gray Vireo is threatened by clearing of piñon-juniper woodlands, construction and development, habitat alteration for livestock grazing, and brown-headed cowbird brood parasitism. Gray Vireos have been recorded at PECO, but rarely. The Breeding Bird Survey recorded the Gray Vireo in 1973 (U.S. Geological Survey Patuxent Wildlife Research Center 2010). Mukai (1989) recorded Gray Vireo twice in “piñon-juniper woodland east of Casa Grande” (not currently a known place name at the park), and Parmenter and Lightfoot (1996) report observing a single Gray Vireo “during a separate survey of [threatened and endangered] species on potential NPS Development Sites within Pecos Unit” (report unavailable). Most avian surveys have been concentrated in riparian areas and not in their preferred juniper habitats (Mukai 1989; Johnson et al. 2003; NPS 2009; this study). Large areas of piñon-juniper vegetation on the main unit of PECO may provide habitat for Gray Vireos.

At the Cañoncito Subunit, the badland habitat west of the railroad tracks is unsuitable for Gray Vireo, mainly due to absence of ground cover and rough, varied topography. The piñon-juniper habitat at the base of the mesa is marginal for Gray Vireos, lacking sufficient area for a breeding territory and sloping too sharply up the mesa side. Piñon-juniper habitat on the mesa top is not suitable for Gray Vireo, and surveys in 2009 and 2010 did not detect Gray Vireos at the base of the mesa (Johnson et al. 2010). Little or no suitable habitat for Gray Vireo occurs at the Pigeon’s Ranch Subunit. The terrain is too steep in most wooded areas, elevation is too high, and areas of favored piñon-juniper woodland and juniper savannah are insufficient (Johnson et al. 2010).

Piñon-juniper habitat is abundant on the main PECO unit. Juniper savannah habitat there may have been the most suitable Gray Vireo habitat at the park, but most of this vegetation type has been destroyed by recent juniper removal projects in the main PECO unit. To address a data gap, potential Gray Vireo habitat on the main unit should be assessed and Gray Vireo breeding season surveys conducted in suitable habitat.

3.15.4.1.3. Bald Eagle

The Bald Eagle (*Haliaeetus leucocephalus*) is listed as threatened by the state of New Mexico. It was removed from the federal list of threatened species in 2007. Bald Eagles typically breed in forested areas near water. In New Mexico they nest in tall trees near lakes or reservoirs. Fish is an important food, but in New Mexico Bald Eagles also eat jackrabbits, prairie dogs, and pocket gophers. In New Mexico, Bald Eagles nest in several locations, mainly in Sierra and Colfax Counties. In winter and migration they are fairly common along rivers and reservoirs (New Mexico Partners in Flight 2007).

Bald Eagles have been observed by park personnel along the Pecos River in winter (Dan Jacobs, pers. comm.). They have been observed for several days in a row but it is unclear whether they are wintering in the park or passing through. They have not been recorded in the park during the breeding season. A winter survey for bald eagles would begin to address the question of the park’s importance as a wintering site for this species.

3.15.5 Condition of Data

Relative to other vertebrate taxa, breeding bird survey data for PECO are abundant. Because several careful studies have been conducted, confidence in the species list and condition evaluation are high for breeding birds at PECO. However, due to data gaps in certain habitats and seasons, a complete understanding of the PECO avifauna is lacking.

3.15.6 Data Gaps

In spite of multiple bird surveys conducted in the park over the past 20 years, several conspicuous data gaps exist. The back country area encompasses primarily piñon-juniper, with small amounts of ponderosa pine and Douglas-fir vegetation types. This reporting unit has received almost no survey effort, but it covers approximately 44% of the main unit. To address this data gap, relative bird survey effort could be reduced in riparian areas and increased in these woodland and forest habitats. A second data gap exists in non-breeding seasons. All except Mukai's surveys have covered the breeding season only, and that study is 20 years old.

The Gray Vireo, one of only two listed bird species known from the park, has not been seen in any of the recent surveys. This may be largely due to the data gap discussed above—the dearth of data from piñon-juniper habitats. This species is of particular importance to the park, not only because of the un-surveyed potential habitat in the park, but also because removal of trees and shrubs in pastures may have destroyed habitat for this species. Winter surveys for Bald Eagles would address a data gap concerning the importance of the park for this species. Foraging surveys would be useful to determine whether Bald Eagles are taking significant numbers of fish. Due to the likelihood of mercury in fish tissues (see "Water Quality"), information on sizes and numbers of fish taken by wintering eagles would allow assessment of mercury risk to the eagles.

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3.16 Mammals

3.16.1 Background

The SOPN has identified ungulates and small mammal communities as vital signs (NPS 2008), and PECO staff identified mammal biodiversity as an important park resource and an indicator of the health of the various habitat types at the park. Several mammalian taxa are of particular interest at PECO.

Bats have potential as bioindicators of climate change, water quality, agriculture intensification, forest loss and fragmentation, disease, wind turbine impact, pesticide use (Jones et al. 2009), and habitat disruption (Fenton et al. 1992). They are currently of increased conservation concern, because of impacts such as wind turbines (Cryan and Barclay 2009), and white-nose syndrome, a fungus (Blehert et al. 2009; Turner and Reeder 2009), on bat populations. At PECO, bat habitat occurs as potential roosting sites in crevices in rocky cliffs, trees, and caves. Potential foraging areas are available along Glorieta Creek and the Pecos River.

Beavers are important to natural hydrological regimes in western riparian ecosystems. They are particularly influential in willow establishment and hence in maintaining riparian ecosystems (Peinetti 2002; Wolf et al. 2007). Beavers occur throughout riparian areas in the main unit. Large mammals indicate ecosystem productivity and habitat abundance and can enhance the visitor experience. Feral dogs are a common, ongoing, and significant problem in the park. They harass, chase, and kill wildlife and have threatened humans.

3.16.2 Data and Methods

Only one fairly comprehensive survey of mammals has been conducted at PECO (Parmenter and Lightfoot 1996). That study created a list of 33 mammal species likely to occur in the park, compiled using available literature, but not recorded in their surveys. The study was primarily a trapping study of small and medium-sized mammals. Bats were sampled with mist nets along Glorieta Creek only, and gophers were trapped in subterranean tube traps at three sites. Presence of large mammals was determined by observations of individuals (including with spotlights), tracks (including in snow), or scat. We added several additional species by searching the Museum of Southwestern Biology mammal collection. One bat species was added based on a report on the Baca Cave (Burger and Allison 2008).

3.16.3 Reference Conditions

For the reference condition, we started with Parmenter and Lightfoot's (1996) list of likely mammal species, which includes 33 species from 12 families. A reference list of mammal species can be obtained by combining the list of all detected species with the additional species on the likely species list, which together include 61 species (Table 4.8-1). A reference condition for feral dogs would be the absence of all feral dogs in the park.

3.16.4 Resource Description

The list of mammal species detected from all sources includes 33 species from 13 families (Table 3.16-1). Thus, 27 species (44%) of mammals expected by Parmenter and Lightfoot (1996) have not been recorded in the park. Particularly noticeable gaps occur in the bats, Family Vespertilionidae, with only 7 of 15 species detected. None of the three likely shrew species, Family Soricidae, has been detected in the park. Only one of the five expected species in the Family Mustelidae, long-tailed weasel (*Mustela frenata*), was observed in the park.

Only one listed mammal species (New Mexico meadow jumping mouse, *Zapus hudsonius luteus*) has been recorded near the park, and it was collected in 1988, just east of the eastern boundary of the main unit (Museum of Southwestern Biology 2010).

3.16.4.1. Taxa of particular interest

Bats were underrepresented in the park in the only survey that looked for them (7 of 15 expected species detected).

3.16.4.1.1. Beavers

Two beaver dams and associated ponds are situated on Glorieta Creek at approximately 0.27 and 0.35 stream miles below the New Mexico State Road 63 bridge (Wagner and Martin 2010). Both dams are well-stabilized by riparian shrubs and are being actively maintained by beavers. A third beaver dam exists on a small side channel of the river near the south park boundary. It is PECO policy that beavers are a natural and welcome part of the park environment. However, the park does manage beaver activity by protecting trees in focal areas.

The park protects mature cottonwoods and a representative number of cottonwoods of younger age classes by wrapping selected trees in critical areas to protect them from beavers. Some young and middle-aged cottonwoods are left for beaver use (Dan Jacobs, pers. comm.). Critical areas where trees have been wrapped are those with higher beaver activity and cultural significance such as below the Forked Lightning Ranch house.

3.16.4.1.1. Large Mammals

Three species of large mammals from three families have been recorded in the park: black bear (Ursidae), mountain lion (Felidae), and mule deer (Cervidae). Elk and white-tailed deer (Cervidae) are considered potential park residents (Parmenter and Lightfoot 1996), but no official documentation of either species exists. According to local stories, 20-40 years ago elk came into the park to escape harsh weather at higher elevations. This would not be surprising, given the park's location in a corridor between the Tecolote Hills to the east and Glorieta Mesa to the west; however, no elk sightings have been documented in the park (Dan Jacobs, pers. comm.). There is no reason to believe that the large mammal assemblage at PECO is depauperate relative to surrounding areas having similar elevation and habitats.

3.16.4.1.2. Feral Dogs

For at least seven years the park has been capturing and removing an average of 10-15 feral dogs per year. The park maintains records of individual captures but no summary data or reports have been prepared.

Table 3.16-1. Mammal species in Pecos National Historical Park

			Parmenter and Lightfoot 1996[1]		Burger and Allison 2008[2]	Museum of Southwestern Biology[3]
Order	**Family**	**Scientific Name**	**Target List**	**Observed**	**Observed**	**Collection**
Insectivora	Soricidae	*Sorex monticolus*	X			
Insectivora	Soricidae	*Sorex nanus*	X			
Insectivora	Soricidae	*Sorex palustris*	X			
Chiroptera	Vespertilionidae	*Myotis lucifugus*	X			
Chiroptera	Vespertilionidae	*Myotis yumanensis*	X			X
Chiroptera	Vespertilionidae	*Myotis evotis*	X			
Chiroptera	Vespertilionidae	*Myotis auriculus*	X			
Chiroptera	Vespertilionidae	*Myotis thysanodes*		X		
Chiroptera	Vespertilionidae	*Myotis volans*	X			X
Chiroptera	Vespertilionidae	*Myotis leibii*	X			
Chiroptera	Vespertilionidae	*Myotis ciliolabrum*				X
Chiroptera	Vespertilionidae	*Lasionycteris noctivagans*		X		X
Chiroptera	Vespertilionidae	*Eptesicus fuscus*	X			
Chiroptera	Vespertilionidae	*Lasiurus cinereus*	X			
Chiroptera	Vespertilionidae	*Lasiurus ega*		X		
Chiroptera	Vespertilionidae	*Corynorhinus townsendii*	X		X	
Chiroptera	Vespertilionidae	*Antrozous pallidus*	X			
Chiroptera	Vespertilionidae	*Tadarida brasiliensis*	X			
Lagomorpha	Leporidae	*Sylvilagus nuttallii*	X			
Lagomorpha	Leporidae	*Sylvilagus audubonii*		X		
Lagomorpha	Leporidae	*Lepus californicus*		X		
Rodentia	Sciuridae	*Neotamias minimus*	X			
Rodentia	Sciuridae	*Neotamias quadrivittatus*		X		X
Rodentia	Sciuridae	*Spermophilus variegatus*		X		X
Rodentia	Sciuridae	*Sciurus aberti*	X			
Rodentia	Sciuridae	*Tamiasciurus hudsonicus*				X
Rodentia	Geomidae	*Thomomys bottae*		X		X
Rodentia	Heteromyidae	*Perognathus flavescens*	X			
Rodentia	Heteromyidae	*Perognathus flavus*		X		X
Rodentia	Heteromyidae	*Dipodomys ordii*	X			
Rodentia	Castoridae	*Castor canadensis*		X		

			Parmenter and Lightfoot 1996[1]		Burger and Allison 2008[2]	Museum of Southwestern Biology[3]
Order	**Family**	**Scientific Name**	**Target List**	**Observed**	**Observed**	**Collection**
Rodentia	Muridae	*Reithrodontomys megalotis*		X		X
Rodentia	Muridae	*Peromyscus maniculatus*		X		X
Rodentia	Muridae	*Peromyscus boylii*		X		X
Rodentia	Muridae	*Peromyscus truei*		X		X
Rodentia	Muridae	*Peromyscus nasutus*		X		X
Rodentia	Muridae	*Neotoma albigula*	X			
Rodentia	Muridae	*Neotoma mexicana*		X		X
Rodentia	Muridae	*Neotoma cinerea*				X
Rodentia	Muridae	*Microtus pennsylvanicus*		X		X
Rodentia	Muridae	*Microtus longicaudus*	X			X
Rodentia	Muridae	*Ondatra zibethicus*		X		X
Rodentia	Muridae	*Mus musculus**	X			X
Rodentia	Zapodidae	*Zapus hudsonius***	X			
Rodentia	Erethizontidae	*Erethizon dorsatum*		X		
Carnivora	Canidae	*Canis latrans*		X		
Carnivora	Canidae	*Vulpes vulpes*	X			
Carnivora	Canidae	*Urocyon cinereoargenteus*		X		
Carnivora	Ursidae	*Ursus americanus*		X		
Carnivora	Procyonidae	*Bassariscus astutus*	X			
Carnivora	Procyonidae	*Procyon lotor*	X			
Carnivora	Mustellidae	*Mustela frenata*		X		
Carnivora	Mustelidae	*Neovison vison*	X			
Carnivora	Mustelidae	*Taxidea taxus*	X			
Carnivora	Mustelidae	*Spilogale gracilis*	X			
Carnivora	Mustelidae	*Mephitis mephitis*	X			
Carnivora	Felidae	*Lynx rufus*	X			
Carnivora	Felidae	*Puma concolor*		X		
Artiodactyla	Cervidae	*Cervus canadensis*	X			
Artiodactyla	Cervidae	*Odocoileus hemionus*		X		X
Artiodactyla	Cervidae	*Odocoileus virginianus*	X			

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Order	Family	Scientific Name	Parmenter and Lightfoot 1996[1]		Burger and Allison 2008[2]	Museum of Southwestern Biology[3]
			Target List	Observed	Observed	Collection

* *Mus musculus* is an exotic species.

** *Zapus hudsonius luteus* (New Mexico meadow jumping mouse) is a Federal Candidate and State Endangered subspecies.

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3.16.5 Condition of Data

Missing representatives of expected mammal taxa suggest that sampling effort may have been uneven in the single previous study. The missing taxa and the age of the study (15 years) reduce confidence in the mammal assessment to moderate.

3.16.6 Data Gaps

Differences between the expected and actual mammal species at PECO are more likely due to data gaps resulting from incomplete sampling than to an actual absence of mammal species richness. Bats have only been netted at Glorieta Creek. Tomahawk traps baited for medium-sized predators failed to capture any animals (Parmenter and Lightfoot 1996). Missing Mustelids, most of which are expected to be common, would likely require more intensive sampling to detect. Shrews are typically under-sampled by the usual small mammal trapping techniques (Bury and Corn 1987). In addition, an updated single mammal survey is needed.

The mammal data gaps could be addressed by a new, comprehensive survey of mammals targeting all likely families with appropriate trapping techniques and with effort focused toward underrepresented families. A thorough mist net survey of bats at potential foraging sites throughout the park is needed. Anabat detectors could supplement mist net data in areas where setting nets is difficult, for example over the Pecos River when flow is high.

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Appendix A: Summary of Resources or Ecological Attributes Identified During Scoping

Table A-1. Natural resources or ecological attributes identified during initial project scoping that could be included in this assessment and the possible context contributing to their importance to the park

Resource		Possbile Context(s) for Significance to Park and/or for Decisions and Management	Reference Condition
Water		1. The Pecos River and its tributaries were important for the settlement as both a source of water and a location to raise crops, fish and hunt.	Fundamental Resource / Value (Significance Statement [SS] 1, SS2)
	Water Quality	1. Pecos River is to be managed to Wild and Scenic River standards.	Desired Condition (SS4)
	Water Quantity	1. The Pecos River is one of five perennial waterways in New Mexico.	Fundamental Resource / Value; Importance (SS4)
		2. Consideration is being given to the opportunity for designation of the Pecos River as a Wild and Scenic River.	Opportunities (SS4)
		3. The reliable water source influenced the long sequence and pattern of settlement.	Fundamental Resource / Value; Importance (SS4)
	Ground Water	1. Groundwater withdrawals from private wells could influence surface flows and affect the landscape	Park Concerns (SS1)
		2. Erosion and groundwater withdrawals could affect the landscape such as roads and orchards.	Park Concerns (SS6)
Geology		1. The geology and landscape features (e.g., confluence of water and topography) made travel through the area a physical necessity.	Fundamental Resource / Value (SS1)
		2. Geologic features created the pass and valley.	Fundamental Resource / Value (SS2, SS4)
Vegetation		1. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
	Riparian	1. Erosion is diminished or is under control and the health of the river and the surrounding watershed is sustainable and supports a healthy riparian and upland habitat.	Desired Condition (SS4)
		2. The Pecos River and its tributaries form a riparian/wetland habitat that is one of the rare ecosystems in the arid southwest which makes this one of the most precious natural features of the park.	Fundamental Resource / Value, Importance (SS4)
	Cottonwoods	1. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
	Grasslands	1. Historic grasslands of the area are maintained and the biological diversity	Desired Condition (SS4)

Resource		Possbile Context(s) for Significance to Park and/or for Decisions and Management	Reference Condition
		enhanced.	
		2. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
		3. Healthy, sustainable, grass dominated communities within the piñon juniper woodland are restored and will stabilize soils and protect cultural resources.	Desired Condition (SS4)
		4. Pastures of the Forked-lightning Ranch (FR); Historic structures and sites are managed in a manner that sustains their character defining features and significance.(DC)	Fundamental Resource / Value and Desired Condition (SS6)
	Piñon-Juniper	1. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
		2. Healthy, sustainable, grass dominated communities within the piñon juniper woodland are restored and will stabilize soils and protect cultural resources.	Desired Condition (SS4)
	Exotic Plants	1. Nonnative invasive species are absent in the park's ecosystems, or if present are effectively controlled.	Desired Condition (SS4)
	Ponderosa Pine	1. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
	Sensitive Plant Species	1. Native plant communities relative to species composition in former range are restored and woody stemmed densities and fuel loading are managed.	Desired Condition (SS4)
Wildlife		1. Flora and fauna	Fundamental Resource / Value (SS4)
	Birds	Birds are a conspicuous and highly valued component of many ecosystems and can be an important reflection of the habitats on which they depend.	NRCA Scoping Process
	Southwest Willow Flycatcher	Willow habitats at PECO presently lack suitable structure and area for the federally endangered Southwest Willow Flycatcher, but some habitat patches in the main unit have potential for suitable habitat with further development.	NRCA Scoping Process, Johnson et al. (2010)
	Gray Vireo	Although not recorded at PECO, some Piñon-Juniper areas of the main unit are potentially suitable habitat for the New Mexico state listed (as threatened) Gray Vireo.	NRCA Scoping Process, Johnson et al. (2010)
	Bald Eagles		NRCA Scoping Process
	Beaver		NRCA Scoping Process
	Amphibians		NRCA Scoping Process

Resource		Possbile Context(s) for Significance to Park and/or for Decisions and Management	Reference Condition
	Exotic Animals (Feral Dogs)	1. Nonnative invasive species are absent in the park's ecosystems, or if present are effectively controlled.	Desired Condition (SS4)
		2. Feral dogs and wildlife poaching have the potential to threaten / adversely impact wildlife populations in the park.	Park Concerns (SS4)
	Large Mammals (deer, bear, Elk, Bobcats)	1. Decrease in the number of mule deer and associated species within the region	Trends (SS4)
	Bats		
	Cutthroat Trout		
	Nonnative Trout		
	Aquatic Invertebrates		
Soundscapes		1. Current levels of night skies and natural soundscapes are maintained	Fundamental Resource / Value and Desired Condition (SS4)
		2. Soundscape issues associated with Interstate-25 interferes with visitor experience and park values	Park Concerns (SS1); Fundamental Resource / Value and Desired Condition (SS4)
Air Quality		1. Air quality is a fundamental resource that affects visitor experience as well as a host of other resources.	Fundamental Resource / Value (SS4)
Night Skies		1. Current levels of night skies and natural soundscapes are maintained	Fundamental Resource / Value and Desired Condition (SS4)
Viewshed		1. Enhances visitor understanding of the role of the "gateway".	Fundamental Resource / Value (SS1)
		2. Important scenic vistas are not significantly diminished by development	Desired Condition (SS1, SS2)
		3. Visual connections` in the landscape between key points	Fundamental Resource / Value (SS4)
		4. Significant battlefield (Glorieta) viewsheds are restored.	Desired Condition (SS5)
Soils		1. Erosion is increasing due to inappropriate drainage from I-25 and other highways.	Trends and Concerns (SS1)
		2. The soils used to build adobe brick	Fundamental Resource / Value (SS2)
		3. Erosion and groundwater withdrawals could affect the landscape such as roads and orchards.	Park Concerns (SS6)
		4. Erosion is diminished or is under control and the health of the river and the surrounding watershed is sustainable and supports a healthy riparian and upland habitat.	Desired Condition (SS4)

[1] Resources for which information and/or data exist to assess its current condition as well as potential reference conditions are given full treatment (full assessment) in this assessment within the limitations of the data. Resources that either lack data to determine its current condition and/or information to derive meaningful reference conditions are more limited in their treatment (partial assessment) and the information gaps identified.

Appendix B: Water Quality

Table B-1. Water quality stations with measures

Measure	NMED Station Name[1]		
	Glorieta Conference Center WWTP (NM0028088)	**Glorieta Creek above confluence with Pecos River (50Glorie001.8)**	**Pecos River below Village of Pecos WWTP**
Ions full suite			
Alkalinity	X	X	X
Bicarbonate	X	X	X
Calcium	X	X	X
Carbonate	X	X	X
Chloride	X	X	X
Hardness	X	X	X
Magnesium	X	X	X
Potassium	X	X	X
Sodium	X	X	X
Sulfate	X	X	X
Total Dissolved Solids	X	X	X
Total Suspended Solids	X	X	X
Metals dissolved			
Aluminum	X		
Antimony	X		
Arsenic	X		
Barium	X		
Beryllium	X		
Boron	X		
Cadmium	X		
Calcium	X		
Chromium	X		
Cobalt	X		
Copper	X		
Iron	X		
Lead	X		
Magnesium	X		
Manganese	X		
Molybdenum	X		
Nickel	X		
Selenium	X		
Silicon	X		
Silver	X		
Strontium	X		
Thallium	X		
Tin	X		
Uranium-234/235/238	X		
Vanadium	X		
Zinc	X		
Metals total full suite			
Aluminum	X		

Measure	NMED Station Name[1]		
	Glorieta Conference Center WWTP (NM0028088)	Glorieta Creek above confluence with Pecos River (50Glorie001.8)	Pecos River below Village of Pecos WWTP
Antimony	X		
Arsenic	X		
Barium	X		
Beryllium	X		
Boron	X		
Cadmium	X		
Calcium	X		
Chromium	X		
Cobalt	X		
Copper	X		
Iron	X		
Lead	X		
Magnesium	X		
Manganese	X		
Mercury	X		
Molybdenum	X		
Nickel	X		
Selenium	X		
Silicon	X		
Silver	X		
Strontium	X		
Thallium	X		
Tin	X		
Uranium-234/235/238	X		
Vanadium	X		
Zinc	X		
Nutrients total			
Ammonia	X	X	X
Nitrate + Nitrite (N)	X	X	X
Phosphorus, Total	X	X	X
Total Kjehldal Nitrogen	X	X	X
Total Organic Carbon	X	X	X
Ions TDS/TSS			
Calcium	X	X	
Hardness	X	X	
Magnesium	X	X	X
Total Dissolved Solids	X	X	
Total Suspended Solids	X	X	
Metals (dissolved)			
Aluminum	X	X	
Antimony	X	X	
Arsenic	X	X	
Barium	X	X	X
Beryllium	X	X	X
Boron	X		
Cadmium	X		

Measure	NMED Station Name[1]		
	Glorieta Conference Center WWTP (NM0028088)	Glorieta Creek above confluence with Pecos River (50Glorie001.8)	Pecos River below Village of Pecos WWTP
Calcium	X		
Chromium	X		
Cobalt	X		
Copper	X		
Iron	X		
Lead	X		
Magnesium	X		
Manganese	X		
Molybdenum	X		
Nickel	X		
Selenium	X		
Silicon	X		
Silver	X		
Strontium	X		
Thallium	X		
Tin	X		
Uranium-234/235/238	X		
Vanadium	X		
Zinc	X		
Metals (Hg/Se)			
Mercury	X		
Selenium	X		
Antibiotics			
Chlortetracycline	X		
Erythromycin A	X		
Lincomycin	X		
Minocycline	X		
Oleandomycin	X		
Oxytetracycline	X		
Tetracycline	X		
Tiamulin	X		
Tilmicosin	X		
Tylosin	X		
Bacteria (E. coli)			
E. coli	X	X	X
Bacteria (fecal coliforms)			
Fecals	X	X	X
Temperature	X	X	X
EC	X	X	X
DO	X	X	X
DOsat	X	X	X
pH	X	X	X
Turbidity	X	X	X

[1] New Mexico Environment Department. 2004. Water quality survey summary for the upper Pecos River Watershed, part I (between headwaters and Villanueva State Park) 2001. Prepared by Surface Water Quality Bureau, NMED, Santa Fe, NM.

Table B-2. Fish toxins observed in Pecos National Historical Park

	1992[a]				1993[b]				2003[c]			
Sample Size	**6**				**16**				**13**			
	Min. ppm Wet	**Min. AMC* Noncancer /Cancer**	**Max. ppm Wet**	**Max. AMC Noncancer /Cancer**	**Min. ppm Wet**	**Min.AMC Noncancer /Cancer**	**Min. ppm Wet**	**Max. AMC Noncancer/ Cancer**	**Min. ppm Wet**	**Min. AMC Noncancer /Cancer**	**Max. ppm Wet**	**Max. AMC Noncancer /Cancer**
Al									<1 (n=8)			
As	0.62	4/0	6.25	0/0	<0.125	16/0.5	0.154	16/0	<0.1 (n=11)	2/0.5	<1.0 (n=1)	16/0
Cd	<0.04	U**	0.668	4	<0.025	U	0.067	U	<0.1	16-U	<0.1	16-U
Hg	0.055	16	0.227	4	<0.025	U	0.188	4	≤0.05	16	.06 (n=2), 0.12, 0.14	12, 4, 4
Se	1.9	16	13.6	3	--	--	--	--	<0.5	U	0.8	U
Cr	0.8	--	16.4	--	<0.075	--	1.21	--	0.3	--	0.6	--
Cu	1.21	--	7.76	--	--	--	--	--	<1	--	2	--
Pb	0.18	--	2.27	--	<0.125	--	0.29	--	<0.1	--	0.2	--
Zn	3.89	--	40.7	--	--	--	--	--	6	--	24	--

[a] Irwin, R. 1993. Review of Pecos River contaminants data. NPS memo from Roy Irwin, senior contaminants specialist, Water Operations Branch, to Sam Kunkle, chief scientist, Southwest Regional Office.

[b] Binstock, D.A., P.M. Grohse, and W.F. Gutknecht. 1993. Analysis of fish tissue, sediment, and water samples. Report to Bobbi Simpson, Pecos National Historical Park. Research Triangle Institute, Research Triangle Park, NC.

[c] State of New Mexico Department of Health. 2003. Heavy metals analysis of brown trout collected from Pecos National Historical Park in 2003. Report of lab results prepared by the Scientific Lab Division at the State of New Mexico Department of Health for the Surface Water Quality Bureau, NMED Surveillance Program.

* AMC= Allowable Monthly Consumption (ppm wet) based on an assumed meal size of 8 oz (0.227 kg)/month. Source: Environmental Protection Agency. 2000. Guidance for assessing chemical contaminant data for use in fish advisories volume 2, risk assessment and fish consumption limits. Third edition. USEPA Office of Water, Washington, DC.)

** U=Unrestricted AMC

Appendix C: Summary of Vegetation

Table C-1. Summary of vegetation species occurring in Pecos National Historical Park

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Aceraceae	*Acer negundo*	box elder			X	X		
Agavaceae	*Yucca angustissima*	narrowleaf yucca			X			X
Agavaceae	*Yucca baccata*	banana yucca			X	X		
Agavaceae	*Yucca intermedia*	intermediate yucca				X		
Amaranthaceae	*Amaranthus albus*	prostrate pigweed			X			
Amaranthaceae	*Amaranthus hybridus*	slim amaranth			X			
Anacardiaceae	*Rhus trilobata*	skunkbush sumac			X	X		
Anacardiaceae	*Toxicodendron radicans*	eastern poison ivy			X			
Apiaceae	*Aletes filifolius*	TransPecos Indian parsley				X		
Apiaceae	*Cicuta maculata*	spotted water hemlock			X	X		
Apiaceae	*Conium maculatum*	poison hemlock	B		X	X		
Apiaceae	*Cymopterus acaulis* var. *fendleri*	mountain springparsley			X			
Apiaceae	*Harbouria trachypleura*	whiskbroom parsley			X			
Apocynaceae	*Apocynum cannabinum*	Indianhemp			X	X		
Asclepiadaceae	*Asclepias involucrata*	dwarf milkweed			X	X		
Asclepiadaceae	*Asclepias macrotis*	longhood milkweed			X			
Asclepiadaceae	*Asclepias speciosa*	showy milkweed				X		
Asclepiadaceae	*Asclepias subverticillata*	whorled milkweed			X	X	X	X
Asclepiadaceae	*Asclepias tuberosa*	butterfly milkweed			X			
Asclepiadaceae	*Asclepias uncialis* ssp. *uncialis*	wheel milkweed			X			
Asclepiadaceae	*Asclepias viridiflora*	green comet milkweed			X			
Asteraceae	*Achillea millefolium*	common yarrow			X	X		
Asteraceae	*Ageratina herbacea*	fragrant snakeroot			X	X		
Asteraceae	*Ambrosia acanthicarpa*	flatspine burr ragweed			X			
Asteraceae	*Ambrosia artemisiifolia*	annual ragweed				X		
Asteraceae	*Ambrosia confertiflora*	weakleaf bur ragweed			X	X		
Asteraceae	*Ambrosia psilostachya*	Cuman ragweed				X		
Asteraceae	*Antennaria parvifolia*	smallleaf pussytoes			X	X		
Asteraceae	*Antennaria rosulata*	Kaibab pussytoes			X			

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Asteraceae	*Arctium minus*	lesser burdock			X			
Asteraceae	*Artemisia campestris*	field sagewort				X		
Asteraceae	*Artemisia carruthii*	Carruth's sagewort			X	X		X
Asteraceae	*Artemisia dracunculus*	tarragon			X	X	X	X
Asteraceae	*Artemisia frigida*	fringed sagewort			X	X		X
Asteraceae	*Artemisia ludoviciana*	white sagebrush			X	X		X
Asteraceae	*Bahia dissecta*	ragleaf bahia			X	X		X
Asteraceae	*Brickellia brachyphylla*	plumed brickellbush				X		
Asteraceae	*Brickellia eupatorioides* var. *chlorolepis*	false boneset			X	X		
Asteraceae	*Brickellia grandiflora*	tasselflower brickellbush			X			
Asteraceae	*Brickelliastrum fendleri*	Fendler's brickellbush			X	X		
Asteraceae	*Chaetopappa ericoides*	rose heath			X	X		X
Asteraceae	*Cirsium arvense*	Canada thistle	A			X		
Asteraceae	*Cirsium neomexicana*	New Mexico thistle						X
Asteraceae	*Cirsium ochrocentrum*	yellowspine thistle			X	X		X
Asteraceae	*Cirsium undulatum*	wavyleaf thistle				X		
Asteraceae	*Cirsium vulgare*	bull thistle	C			X	X	
Asteraceae	*Conyza canadensis*	Canadian horseweed			X	X		X
Asteraceae	*Dieteria canescens*	hoary aster			X	X		
Asteraceae	*Dieteria canescens* var. *glabra*	hoary tansyaster				X		
Asteraceae	*Dyssodia papposa*	fetid marigold			X			
Asteraceae	*Ericameria nauseosa*	rubber rabbitbrush				X	X	X
Asteraceae	*Ericameria nauseosa* var. *bigelovii*	rubber rabbitbrush			X	X		
Asteraceae	*Ericameria nauseosa* var. *graveolens*	rubber rabbitbrush			X			
Asteraceae	*Ericameria nauseosa* var. *latisquamea*	rubber rabbitbrush				X		
Asteraceae	*Erigeron canus*	hoary fleabane			X	X		
Asteraceae	*Erigeron divergens*	spreading fleabane			X	X	X	X
Asteraceae	*Erigeron eximius*	sprucefir fleabane				X		
Asteraceae	*Erigeron flagellaris*	trailing fleabane			X	X		X
Asteraceae	*Erigeron formosissimus*	beautiful fleabane			X	X		
Asteraceae	*Erigeron formosissimus* var. *viscidus*	beautiful fleabane				X		
Asteraceae	*Erigeron philadelphicus*	Philadelphia fleabane				X		

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Asteraceae	*Erigeron speciosus*	aspen fleabane			X	X		
Asteraceae	*Gaillardia aristata*	common blanketflower			X	X		
Asteraceae	*Gaillardia pinnatifida*	red dome blanketflower			X	X		X
Asteraceae	*Gaillardia pulchella*	firewheel				X		
Asteraceae	*Grindelia squarrosa*	curlycup gumweed			X	X		
Asteraceae	*Gutierrezia sarothrae*	broom snakeweed			X	X	X	X
Asteraceae	*Helianthus annuus*	common sunflower			X	X		
Asteraceae	*Helianthus ciliaris*	Texas blueweed				X		
Asteraceae	*Helianthus petiolaris*	prairie sunflower			X	X		X
Asteraceae	*Helianthus spp*	common sunflower				X		
Asteraceae	*Heliopsis helianthoides*	sunflower heliopsis			X			
Asteraceae	*Heterotheca fulcrata*	rockyscree falsegoldenaster				X		
Asteraceae	*Heterotheca villosa*	hairy goldenaster				X	X	X
Asteraceae	*Heterotheca villosa* var*. minor*	hairy false goldenaster			X	X		
Asteraceae	*Hymenopappus filifolius*	fineleaf hymenopappus			X	X	X	X
Asteraceae	*Hymenopappus filifolius* var. *cinereus*	fineleaf hymenopappus				X		
Asteraceae	*Hymenoxys ambigens*	Pinaleno Mountain bubberweed					X	
Asteraceae	*Hymenoxys richardsonii*	pingue hymenoxys			X	X	X	X
Asteraceae	*Hymenoxys richardsonii* var. *floribunda*	Colorado rubberweed				X		
Asteraceae	*Iva xanthifolia*	Giant sumpweed			X			
Asteraceae	*Lactuca serriola*	prickly lettuce			X	X	X	X
Asteraceae	*Lactuca tatarica* var. *pulchella*	blue lettuce			X			
Asteraceae	*Laennecia schiedeana*	pineland marshtail			X			
Asteraceae	*Leucanthemum vulgare*	oxeye daisy	A			X		
Asteraceae	*Liatris punctata*	dotted gayfeather			X			X
Asteraceae	*Lygodesmia juncea*	rush skeletonplant			X			
Asteraceae	*Machaeranthera pinnatifida*	lacy tansyaster					X	X
Asteraceae	*Machaeranthera tanacetifolia*	tanseyleaf aster			X	X		
Asteraceae	*Melampodium leucanthum*	plains blackfoot			X	X		
Asteraceae	*Onopordum acanthium*	Scotch thistle	A		X	X		
Asteraceae	*Packera fendleri*	Fendler's ragwort			X	X		
Asteraceae	*Packera neomexicanus* var. *mutabilis*	New Mexico groundsel			X			

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Asteraceae	*Packera pseudaurea* var. *flavula*	falsegold groundsel				X		
Asteraceae	*Picradeniopsis oppositifolia*	oppositeleaf bahia				X		
Asteraceae	*Pseudognaphalium viscosum*	winged cudweed			X			
Asteraceae	*Psilostrophe tagetina*	woolly paperflower				X		
Asteraceae	*Psilostrophe tagetina* var. *cerifera*	woolly paperflower			X			
Asteraceae	*Ratibida columnifera*	upright prairie coneflower			X	X		X
Asteraceae	*Ratibida tagetes*	green prairie coneflower			X	X		X
Asteraceae	*Rudbeckia laciniata*	cutleaf coneflower				X		
Asteraceae	*Rudbeckia laciniata* var. *ampla*	cutleaf coneflower				X		
Asteraceae	*Sanvitalia abertii*	Albert's creeping zinnia			X			
Asteraceae	*Schkuhria multiflora*	manyflower false threadleaf				X		
Asteraceae	*Scorzonera laciniata*	cutleaf vipergrass			X	X		
Asteraceae	*Senecio flaccidus* var. *flaccidus*	threadleaf ragwort				X		
Asteraceae	*Senecio spartioides*	broom groundsel				X		X
Asteraceae	*Senecio spartioides* var. *multicapitatus*	broomlike ragwort			X			
Asteraceae	*Solidago canadensis*	Canada goldenrod				X		
Asteraceae	*Solidago canadensis* var. *glivocanescens*	shorthair goldenrod			X	X		
Asteraceae	*Solidago simplex* ssp. *simplex* var. *simplex*	Mt. Albert goldenrod				X		
Asteraceae	*Solidago wrightii*	Wright's goldenrod				X		
Asteraceae	*Solidago wrightii var. wrightii*	Wright's goldenrod				X		
Asteraceae	*Sonchus asper*	spiny sowthistle			X	X		
Asteraceae	*Stephanomeria pauciflora*	brownplume wirelettuce				X		X
Asteraceae	*Symphyotrichum falcatum* var. *crassulum*	white prairie aster			X			
Asteraceae	*Symphyotrichum lanceolatum* ssp. *hesperium*	white panicle aster			X			
Asteraceae	*Taraxacum officinale*	common dandelion			X	X		
Asteraceae	*Tetraneuris acaulis*	stemless hymenoxys				X		
Asteraceae	*Tetraneuris argentea*	perkysue			X	X		
Asteraceae	*Tetraneuris scaposa*	stemmy four-nerve daisy				X		
Asteraceae	*Thelesperma filifolium*	stiff greenthread			X	X		X
Asteraceae	*Thelesperma longipes*	longstalk greenthread				X		
Asteraceae	*Thelesperma megapotamicum*	Hopi tea greenthread			X	X	X	X
Asteraceae	*Townsendia annua*	annual townsend daisy				X		

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Asteraceae	*Townsendia eximia*	tall townsendia			X	X		
Asteraceae	*Townsendia exscapa*	stemless townsendia			X	X		
Asteraceae	*Tragopogon dubius*	yellow salsify			X	X	X	X
Asteraceae	*Tragopogon pratensis*	meadow salsify				X		
Asteraceae	*Verbesina encelioides*	golden crownbeard			X	X		
Asteraceae	*Xanthisma spinulosum*	lacy tansyaster			X	X		
Asteraceae	*Xanthium strumarium*	rough cocklebur			X	X		
Asteraceae	*Zinnia grandiflora*	Rocky Mountain zinnia			X	X		
Berberidaceae	*Berberis fendleri*	Colorado barberry			X	X		
Betulaceae	*Alnus incana* ssp. *tenuifolia*	thinleaf alder			X	X		
Boraginaceae	*Cryptantha cinerea*	James' catseye				X		X
Boraginaceae	*Cryptantha cinerea* var. *cinerea*	James' catseye			X	X		
Boraginaceae	*Cryptantha fendleri*	sanddune cryptantha			X			
Boraginaceae	*Cryptantha thyrsiflora*	calcareous cryptantha			X			
Boraginaceae	*Hackelia besseyi*	Bessey's stickseed			X	X		
Boraginaceae	*Lappula occidentalis*	flatspine stickseed			X	X		X
Boraginaceae	*Lithospermum incisum*	narrowleaf gromwell						X
Boraginaceae	*Lithospermum multiflorum*	manyflowered gromwell			X	X		
Brassicaceae	*Alyssum simplex*	alyssum			X	X		
Brassicaceae	*Arabis fendleri*	Fendler's rockcress			X			
Brassicaceae	*Barbarea orthoceras*	American yellowrocket			X			
Brassicaceae	*Barbarea vulgaris*	garden yellowrocket				X		
Brassicaceae	*Boechera fendleri*	Fendler's rockcress				X		
Brassicaceae	*Camelina microcarpa*	littlepod false flax				X		
Brassicaceae	*Capsella bursa-pastoris*	shepherd's purse			X			
Brassicaceae	*Cardaria draba*	hoary cress	A		X	X		
Brassicaceae	*Chorispora tenella*	crossflower			X	X		
Brassicaceae	*Descurainia obtusa ssp. obtusa*	blunt tansymustard				X		
Brassicaceae	*Descurainia sophia*	herb sophia				X		
Brassicaceae	*Draba cuneifolia*	wedgeleaf draba			X	X		
Brassicaceae	*Draba helleriana*	Heller's draba				X		
Brassicaceae	*Erysimum inconspicuum*	shy wallflower			X	X		

Family	Scientific Name	Common Name	Weed Class/Status NM	Weed Class/Status Federal	Source Sivinski[1]	Source Muldavin[2]	Source Folts-Zettner[3]	Source Trader[4]
Brassicaceae	*Lepidium densiflorum*	common pepperweed				X		
Brassicaceae	*Lesquerella rectipes*	straight bladderpod				X		
Brassicaceae	*Nasturtium officinale*	watercress			X	X		
Brassicaceae	*Noccaea montanum*	alpine pennycress				X		
Brassicaceae	*Pennellia micrantha*	mountain mock thelypody			X	X		
Brassicaceae	*Physaria rectipes*	straight bladderpod			X	X		
Brassicaceae	*Rorippa sylvestris*	creeping yellowcress				X		
Brassicaceae	*Schoenocrambe linearifolia*	slimleaf plainsmustard			X	X		X
Brassicaceae	*Sisymbrium altissimum*	tall tumblemustard			X	X		X
Brassicaceae	*Thelypodium wrightii*	Wright's thelypody				X		
Brassicaceae	*Thlaspi arvense*	field pennycress				X		
Cactaceae	*Cylindropuntia imbricata*	tree cholla			X	X		
Cactaceae	*Echinocereus coccineus*	scarlet hedgehog cactus				X		
Cactaceae	*Echinocereus dasyacanthus*	rainbow cactus				X		
Cactaceae	*Echinocereus fendleri*	pinkflower hedgehog cactus			X	X		
Cactaceae	*Echinocereus fendleri* var. *fendleri*	Fendler's hedgehog cactus				X		
Cactaceae	*Echinocereus viridiflorus*	nylon hedgehog cactus			X	X		
Cactaceae	*Escobaria vivipara*	spinystar			X	X		
Cactaceae	*Opuntia phaeacantha*	tulip pricklypear			X	X		
Cactaceae	*Opuntia polyacantha*	plains pricklypear			X	X		
Cactaceae	*Opuntia polyacantha* var. *polyacantha*	hairspine pricklypear			X			
Cactaceae	*Opuntia polyacantha* var. *tricophora*	hairspine pricklypear			X			
Capparaceae	*Cleome serrulata*	Rocky Mountain beeplant			X			
Caryophyllaceae	*Arenaria fendleri*	Fendler's sandwort						X
Caryophyllaceae	*Arenaria lanuginosa*	spreading sandwort			X			
Caryophyllaceae	*Drymaria glandulosa*	fendler's drymary			X			
Caryophyllaceae	*Silene scouleri ssp. pringlei*	Pringle's campion			X			
Celastraceae	*Paxistima myrsinites*	myrtle boxleaf				X		
Chenopodiaceae	*Atriplex canescens*	fourwing saltbush			X	X		
Chenopodiaceae	*Atriplex rosea*	tumbling saltweed			X			
Chenopodiaceae	*Chenopodium album*	lambsquarters			X	X	X	X
Chenopodiaceae	*Chenopodium graveolens*	fetid goosefoot				X		

			Weed Class/Status		Source			
Family	**Scientific Name**	**Common Name**	**NM**	**Federal**	**Sivinski[1]**	**Muldavin[2]**	**Folts-Zettner[3]**	**Trader[4]**
Chenopodiaceae	*Chenopodium incanum*	mealy goosefoot				X		
Chenopodiaceae	*Chenopodium leptophyllum*	narrowleaf goosefoot			X	X		
Chenopodiaceae	*Chenopodium pallescens*	slimleaf goosefoot					X	
Chenopodiaceae	*Chenopodium pratericola*	desert goosefoot			X	X		
Chenopodiaceae	*Chenopodium watsonii*	Watson's goosefoot				X		
Chenopodiaceae	*Kochia scoparia*	common kochia			X	X	X	
Chenopodiaceae	*Krascheninnikovia lanata*	winterfat			X	X		
Chenopodiaceae	*Salsola tragus*	prickly Russian thistle			X	X	X	
Commelinaceae	*Commelina dianthifolia*	birdbill dayflower			X	X		
Convolvulaceae	*Convolvulus arvensis*	field bindweed			X	X	X	X
Crassulaceae	*Sedum cockerellii*	Cockerell's stonecrop			X	X		
Cucurbitaceae	*Cucurbita foetidissima*	buffalo gourd			X	X		
Cupressaceae	*Juniperus monosperma*	oneseed juniper			X	X		X
Cupressaceae	*Juniperus scopulorum*	Rocky Mountain juniper			X	X		X
Cyperaceae	*Carex hystericina*	porcupine sedge				X		
Cyperaceae	*Carex inops* ssp. *heliophila*	sun sedge				X		
Cyperaceae	*Carex microdonta*	littletooth sedge				X		
Cyperaceae	*Carex nebrascensis*	Nebraska sedge			X	X		X
Cyperaceae	*Carex occidentalis*	western sedge			X	X		
Cyperaceae	*Carex pellita*	woolly sedge				X		
Cyperaceae	*Carex praegracilis*	clustered field sedge				X		
Cyperaceae	*Carex stipata*	owlfruit sedge				X		
Cyperaceae	*Carex vulpinoidea*	fox sedge				X		
Cyperaceae	*Cyperus fendlerianus*	Fendler's flatsedge				X		X
Cyperaceae	*Cyperus schweinitzii*	Schweinitz's flatsedge			X			
Cyperaceae	*Eleocharis palustris*	common spikerush			X	X		
Cyperaceae	*Eleocharis parishii*	Parish's spikerush			X	X		
Cyperaceae	*Schoenoplectus acutus*	hardstem bulrush			X	X		X
Cyperaceae	*Schoenoplectus pungens*	common threesquare				X		
Cyperaceae	*Schoenoplectus pungens* var. *longispicatus*	common threesquare			X			
Cyperaceae	*Schoenoplectus tabernaemontani*	softstem bulrush				X		
Dipsacaceae	*Dipsacus fullonum*	Fuller's teasel	B			X		

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Dryopteridaceae	*Woodsia neomexicana*	New Mexico cliff fern				X		
Elaeagnaceae	*Elaeagnus angustifolia*	Russian olive	C		X	X		
Equisetaceae	*Equisetum arvense*	field horsetail			X	X		
Equisetaceae	*Equisetum laevigatum*	smooth horsetail				X		
Euphorbiaceae	*Chamaesyce fendleri*	Fendler's sandmat			X	X	X	X
Euphorbiaceae	*Croton texensis*	Texas croton			X	X		
Euphorbiaceae	*Euphorbia brachycera*	horned spurge			X	X		
Euphorbiaceae	*Euphorbia davidii*	David's spurge			X	X	X	
Euphorbiaceae	*Tragia ramosa*	branched noseburn			X	X		
Fabaceae	*Amorpha canescens*	leadplant			X			
Fabaceae	*Astragalus brandegeei*	Brandegee's milkvetch			X			
Fabaceae	*Astragalus flexuosus*	stinking milkvetch			X			
Fabaceae	*Astragalus humillimus*	Mancos milkvetch			X			
Fabaceae	*Astragalus humistratus* var. *humistratus*	groundcover milkvetch			X	X		
Fabaceae	*Astragalus lonchocarpus*	rushy milkvetch			X	X		
Fabaceae	*Astragalus lotiflorus*	lotus milkvetch			X	X		
Fabaceae	*Astragalus missouriensis*	Missouri milkvetch			X	X		X
Fabaceae	*Astragalus mollissimus*	woolly milkvetch			X	X		X
Fabaceae	*Astragalus praelongus*	stinking milkvetch			X	X		
Fabaceae	*Dalea candida*	slender white prairieclover			X	X	X	X
Fabaceae	*Dalea jamesii*	James' prairieclover			X	X	X	X
Fabaceae	*Dalea purpurea*	purple prairieclover			X			
Fabaceae	*Desmanthus cooleyi*	Cooley's bundleflower			X	X		
Fabaceae	*Desmanthus obtusus*	bluntpod bundleflower				X		
Fabaceae	*Glycyrrhiza lepidota*	American licorice			X	X		
Fabaceae	*Lathyrus eucosmus*	bush peavine			X	X		
Fabaceae	*Lathyrus latifolius*	perennial pea			X	X		
Fabaceae	*Lupinus argenteus*	silvery lupine			X			
Fabaceae	*Lupinus kingii*	King's lupine			X	X		
Fabaceae	*Medicago lupulina*	black medick			X	X		
Fabaceae	*Medicago sativa*	alfalfa			X	X		
Fabaceae	*Melilotus indicus*	annual yellow sweetclover				X		

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Fabaceae	*Melilotus officinalis*	yellow sweetclover			X	X	X	X
Fabaceae	*Oxytropis lambertii*	Lambert's crazyweed			X	X		
Fabaceae	*Oxytropis sericea*	silvery lupine			X	X		
Fabaceae	*Psoralidium tenuiflorum*	slimflower scurfpea			X	X		X
Fabaceae	*Psorothamnus scoparius*	broom dalea						X
Fabaceae	*Trifolium pratense*	red clover			X	X		
Fabaceae	*Trifolium repens*	white clover			X	X		
Fabaceae	*Vicia americana*	American vetch			X	X		
Fagaceae	*Quercus ×pauciloba*	wavyleaf oak			X	X		
Fagaceae	*Quercus gambelii*	Gambel's oak			X	X		
Geraniaceae	*Erodium cicutarium*	redstem stork's bill			X	X	X	
Geraniaceae	*Erodium texanum*	Texas filaree				X		
Geraniaceae	*Geranium caespitosum*	pineywoods geranium			X	X		
Grossulariaceae	*Ribes aureum*	golden currant			X	X		
Grossulariaceae	*Ribes cereum*	wax currant			X	X		
Hydrangeaceae	*Philadelphus microphyllus*	littleleaf mockorange				X		
Iridaceae	*Iris missouriensis*	Rocky Mountain iris			X	X		
Iridaceae	*Sisyrinchium demissum*	dwarf blue-eyed grass				X		
Iridaceae	*Sisyrinchium idahoense* var. *occidentale*	Idaho blue-eyed grass			X			
Juncaceae	*Juncus arcticus*	arctic rush				X		
Juncaceae	*Juncus arcticus* var. *balticus*	Baltic rush				X		
Juncaceae	*Juncus arcticus* var. *mexicanus*	Mexican rush			X			
Juncaceae	*Juncus articulatus*	jointleaf rush				X		
Juncaceae	*Juncus bufonius*	toad rush			X			
Juncaceae	*Juncus dudleyi*	slender rush				X		
Juncaceae	*Juncus ensifolius*	swordleaf rush			X			
Juncaceae	*Juncus longistylis*	longstyle rush			X	X		
Juncaceae	*Juncus tenuis*	poverty rush			X			
Juncaceae	*Juncus torreyi*	Torrey's rush			X	X		
Krameriaceae	*Krameria lanceolata*	trailing krameria				X		
Lamiaceae	*Hedeoma drummondii*	Drummond's false pennyroyal			X	X		
Lamiaceae	*Marrubium vulgare*	horehound			X	X		

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Lamiaceae	*Mentha arvensis*	wild mint			X	X		
Lamiaceae	*Monarda pectinata*	pony beebalm			X	X		X
Lamiaceae	*Nepeta cataria*	catnip			X	X		
Lamiaceae	*Prunella vulgaris*	common selfheal			X	X		
Lamiaceae	*Salvia reflexa*	lanceleaf sage			X			
Liliaceae	*Allium cernuum*	nodding onion			X	X		
Liliaceae	*Allium geyeri*	Geyer's onion			X			
Liliaceae	*Asparagus officinalis*	garden asparagus			X	X		
Liliaceae	*Maianthemum stellatum*	starry false Solomon's seal			X			
Linaceae	*Linum lewisii*	prairie flax			X	X		
Linaceae	*Linum puberulum*	plains flax			X	X		
Loasaceae	*Mentzelia albicaulis*	whitestem blazingstar				X		
Loasaceae	*Mentzelia multiflora*	manyflowered mentzelia				X		
Loasaceae	*Mentzelia multiflora* var. *multiflora*	Adonis blazingstar			X	X		
Malvaceae	*Malva neglecta*	common mallow			X			
Malvaceae	*Sidalcea candida*	white checkermallow				X		
Malvaceae	*Sphaeralcea coccinea*	scarlet globemallow			X	X		X
Malvaceae	*Sphaeralcea fendleri*	Fendler's globemallow			X	X	X	X
Malvaceae	*Sphaeralcea hastulata*	spear globemallow				X		
Monotropaceae	*Pterospora andromedea*	woodland pinedrops			X			
Najadaceae	*Najas guadalupensis*	southern waternymph			X			
Nyctaginaceae	*Mirabilis diffusa*	ribbed spreading four o'clock			X			
Nyctaginaceae	*Mirabilis linearis*	narrowleaf four o'clock				X		X
Nyctaginaceae	*Mirabilis multiflora*	Colorado four o'clock				X		
Nyctaginaceae	*Mirabilis oxybaphoides*	smooth spreading four o'clock			X	X		
Oleaceae	*Forestiera pubescens* var. *pubescens*	New Mexico olive				X		
Oleaceae	*Fraxinus pennsylvanica*	green ash			X	X		
Oleaceae	*Menodora scabra*	rough menodora			X	X	X	X
Onagraceae	*Calylophus hartwegii*	Hartweg's sundrops			X	X		
Onagraceae	*Epilobium ciliatum*	hairy willowherb			X			
Onagraceae	*Gaura coccinea*	scarlet beeblossom			X	X		X
Onagraceae	*Gaura mollis*	velvetweed				X		

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Onagraceae	*Gaura parviflora*	velvetweed			X			
Onagraceae	*Oenothera albicaulis*	whitest eveningprimrose			X			X
Onagraceae	*Oenothera coronopifolia*	crownleaf evening-primrose				X		X
Onagraceae	*Oenothera elata* ssp. *hirsutissima*	Hooker's eveningprimrose			X			
Onagraceae	*Oenothera pallida*	pale eveningprimrose			X	X		
Orchidaceae	*Platanthera huronensis*	Huron green orchid				X		
Orobanchaceae	*Conopholis alpina* var. *mexicana*	Mexican cancer-root			X	X		
Orobanchaceae	*Orobanche ludoviciana* ssp. *multiflora*	manyflowered broomrape				X		
Oxalidaceae	*Oxalis alpina*	alpine woodsorrel			X	X		
Pinaceae	*Pinus edulis*	pinyon pine			X	X		X
Pinaceae	*Pinus ponderosa*	ponderosa pine			X	X		X
Pinaceae	*Pseudotsuga menziesii*	Douglas-fir			X	X		
Plantaginaceae	*Plantago argyrea*	saltmeadow plantain			X	X		
Plantaginaceae	*Plantago lanceolata*	english plantain			X	X		
Plantaginaceae	*Plantago major*	common plantain			X	X		
Plantaginaceae	*Plantago patagonica*	woolly plantain			X	X		
Poaceae	*Achnatherum hymenoides*	Indian ricegrass			X	X		
Poaceae	*Achnatherum lettermanii*	Letterman's needlegrass						X
Poaceae	*Achnatherum robustum*	sleepygrass			X	X		
Poaceae	*Achnatherum scribneri*	Scribner's needlegrass			X	X		
Poaceae	*Agropyron desertorum*	desert wheatgrass			X	X	X	
Poaceae	*Agrostis exarata*	spike bentgrass			X			
Poaceae	*Agrostis gigantea*	redtop			X	X		
Poaceae	*Agrostis stolonifera*	creeping bentgrass				X		
Poaceae	*Andropogon gerardii*	big bluestem			X	X		
Poaceae	*Aristida arizonica*	Arizona threeawn				X	X	X
Poaceae	*Aristida divaricata*	poverty threeawn				X		
Poaceae	*Aristida havardii*	Havard's threeawn			X			
Poaceae	*Aristida purpurea*	purple threeawn				X		X
Poaceae	*Aristida purpurea* var. *longiseta*	red threeawn			X	X		
Poaceae	*Aristida purpurea* var. *nealleyi*	Nealley's threeawn				X		
Poaceae	*Blepharoneuron tricholepis*	pine dropseed			X	X		

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Poaceae	*Bouteloua curtipendula*	sideoats grama			X	X	X	X
Poaceae	*Bouteloua gracilis*	blue grama			X	X	X	X
Poaceae	*Bouteloua hirsuta*	hairy grama			X	X	X	X
Poaceae	*Bromus anomalus*	nodding brome				X		
Poaceae	*Bromus catharticus*	rescuegrass			X	X		
Poaceae	*Bromus inermis*	smooth brome			X	X	X	
Poaceae	*Bromus japonicus*	Japanese brome			X	X		
Poaceae	*Bromus lanatipes*	woolly brome			X	X		
Poaceae	*Bromus tectorum*	cheatgrass	C		X	X		X
Poaceae	*Buchloe dactyloides*	buffalograss			X			
Poaceae	*Calamagrostis canadensis*	Canada reedgrass				X		
Poaceae	*Chloris verticillata*	tumble windmill grass			X			
Poaceae	*Dactylis glomerata*	orchardgrass			X	X		
Poaceae	*Distichlis spicata*	inland saltgrass				X		
Poaceae	*Echinochloa muricata* var. *microstachya*	rough barnyardgrass			X			
Poaceae	*Elymus canadensis*	Canada wildrye			X	X		X
Poaceae	*Elymus elymoides*	bottlebrush squirreltail			X	X	X	X
Poaceae	*Elymus lanceolatus*	streambank wheatgrass			X			
Poaceae	*Elymus repens*	quackgrass	W			X		
Poaceae	*Elymus trachycaulus* ssp. *trachycaulus*	slender wheatgrass				X		
Poaceae	*Elymus x pseudorepens*	false quackgrass				X		
Poaceae	*Elytrigia elongata*	tall wheatgrass			X			X
Poaceae	*Eragrostis barrelieri*	Mediterranean lovegrass			X		X	
Poaceae	*Festuca arundinacea*	tall fescue			X	X		
Poaceae	*Festuca rubra*	red fescue			X	X		
Poaceae	*Glyceria grandis*	American mannagrass				X		
Poaceae	*Hesperostipa comata*	needle-and-thread grass			X	X		
Poaceae	*Hesperostipa comata* ssp. *comata*	needle-and-thread grass				X		
Poaceae	*Hesperostipa neomexicana*	New Mexico needlegrass				X		
Poaceae	*Hilaria jamesii*	galleta						X
Poaceae	*Hordeum jubatum*	foxtail barley			X	X		
Poaceae	*Hordeum jubatum* var. *jubatum*	foxtail barley				X		

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Poaceae	*Hordeum pusillum*	little barley			X			
Poaceae	*Koeleria macrantha*	prairie junegrass			X	X		X
Poaceae	*Lolium perenne*	perennial ryegrass			X			
Poaceae	*Lycurus setosus*	bristly wolfstail			X	X	X	X
Poaceae	*Muhlenbergia asperifolia*	alkali muhly			X	X		
Poaceae	*Muhlenbergia montana*	mountain muhly			X	X		
Poaceae	*Muhlenbergia pauciflora*	New Mexico muhly			X	X		
Poaceae	*Muhlenbergia racemosa*	marsh muhly			X			
Poaceae	*Muhlenbergia repens*	creeping muhly			X	X		
Poaceae	*Muhlenbergia richardsonis*	Mat muhly				X		
Poaceae	*Muhlenbergia torreyi*	ring muhly			X	X	X	X
Poaceae	*Muhlenbergia wrightii*	spike muhly			X	X	X	X
Poaceae	*Panicum bulbosum*	bulb panicgrass				X		
Poaceae	*Panicum capillare*	witchgrass			X			
Poaceae	*Panicum obtusum*	vine mesquite			X	X		
Poaceae	*Pascopyrum smithii*	western wheatgrass			X	X		
Poaceae	*Phalaris arundinacea*	reed canarygrass				X		
Poaceae	*Phleum pratense*	timothy			X	X		
Poaceae	*Piptatherum micranthum*	littleseed ricegrass			X	X		X
Poaceae	*Pleuraphis jamesii*	galleta			X	X		
Poaceae	*Poa bigelovii*	Bigelow's bluegrass			X	X		
Poaceae	*Poa compressa*	Canada bluegrass			X	X		
Poaceae	*Poa fendleriana*	muttongrass			X	X		X
Poaceae	*Poa pratensis*	Kentucky bluegrass			X	X		
Poaceae	*Psathyrostachys juncea*	Russian wildrye			X	X		
Poaceae	*Puccinellia nuttalliana*	Nuttall's alkaligrass			X			
Poaceae	*Schedonnardus paniculatus*	tumblegrass			X	X		X
Poaceae	*Schizachyrium scoparium*	little bluestem			X	X		X
Poaceae	*Setaria viridis*	green bristlegrass			X			
Poaceae	*Sorghastrum nutans*	Indiangrass			X			
Poaceae	*Sporobolus airoides*	alkali sacaton			X	X		
Poaceae	*Sporobolus cryptandrus*	sand dropseed			X	X		X

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Poaceae	*Vulpia octoflora*	sixweeks fescue			X	X		
Polemoniaceae	*Ipomopsis aggregata*	skyrocket gilia				X		X
Polemoniaceae	*Ipomopsis aggregata* ssp. *formosissima*	scarlet skyrocket			X			
Polemoniaceae	*Ipomopsis longiflora*	flaxflowered gilia			X	X		X
Polemoniaceae	*Phlox nana*	Santa Fe phlox			X	X		X
Polygonaceae	*Eriogonum alatum*	winged buckwheat			X	X		X
Polygonaceae	*Eriogonum jamesii*	James' buckwheat				X	X	X
Polygonaceae	*Eriogonum jamesii* var. *jamesii*	James' buckwheat			X	X		
Polygonaceae	*Eriogonum racemosum*	redroot buckwheat			X			
Polygonaceae	*Persicaria lapathifolia*	curlytop knotweed				X		
Polygonaceae	*Polygonum aviculare*	prostrate knotweed			X			
Polygonaceae	*Polygonum convolvulus*	black bindweed			X			
Polygonaceae	*Polygonum douglasii*	Douglas' knotweed				X		
Polygonaceae	*Polygonum persicaria*	Lady's thumb			X			
Polygonaceae	*Rumex crispus*	curly dock			X	X		
Portulacaceae	*Phemeranthus brevicaulis*	dwarf fameflower			X	X		
Portulacaceae	*Phemeranthus parviflorus*	sunbright			X	X		
Portulacaceae	*Portulaca oleracea*	common purslane			X	X		X
Primulaceae	*Androsace septentrionalis*	pygmyflower rockjasmine			X	X		
Pteridaceae	*Cheilanthes feei*	slender lipfern			X			
Pteridaceae	*Cheilanthes fendleri*	Fendler's lipfern				X		
Pteridaceae	*Pellaea atropurpurea*	purple cliffbrake			X			
Ranunculaceae	*Clematis columbiana*	rock clematis			X	X		
Ranunculaceae	*Clematis columbiana var.columbiana*	rock clematis				X		
Ranunculaceae	*Clematis ligusticifolia*	western white clematis			X	X		
Ranunculaceae	*Ranunculus acris*	tall buttercup			X			X
Ranunculaceae	*Ranunculus cymbalaria*	alkali buttercup			X	X		
Ranunculaceae	*Ranunculus macounii*	Macoun's buttercup				X		
Ranunculaceae	*Thalictrum fendleri*	Fendler's meadowrue			X	X		
Rosaceae	*Argentina anserina*	silverweed cinquefoil			X	X		
Rosaceae	*Cercocarpus montanus*	mountain mahogany			X	X		
Rosaceae	*Fallugia paradoxa*	Apacheplume			X	X		X

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Rosaceae	*Holodiscus dumosus*	rockspirea				X		
Rosaceae	*Malus pumila*	apple			X	X		
Rosaceae	*Petrophyton caespitosum*	mat rockspirea				X		
Rosaceae	*Physocarpus monogynus*	mountain ninebark			X	X		
Rosaceae	*Potentilla hippiana*	woolly cinquefoil				X		
Rosaceae	*Potentilla pensylvanica*	Pennsylvania cinquefoil			X	X	X	X
Rosaceae	*Prunus virginiana*	common chokecherry				X		
Rosaceae	*Rosa woodsii*	Woods' rose			X	X		
Rosaceae	*Rubus neomexicana*	New Mexico raspberry			X			
Salicaceae	*Populus angustifolia*	narrowleaf cottonwood			X	X		
Salicaceae	*Populus angustifolia*	narrowleaf cottonwood			X	X		
Salicaceae	*Populus deltoides* ssp. *wislizeni*	Rio Grande cottonwood			X	X		
Salicaceae	*Populus x acuminata*	lanceleaf cottonwood			X	X		
Salicaceae	*Salix amygdaloides*	peachleaf willow			X	X		X
Salicaceae	*Salix exigua*	coyote willow			X	X		
Salicaceae	*Salix gooddingii*	Goodding's willow			X	X		
Salicaceae	*Salix irrorata*	bluestem willow			X	X		
Santalaceae	*Comandra umbellata* ssp. *pallida*	pale bastard toadflax			X			
Saururaceae	*Anemopsis californica*	yerba mansa			X	X		
Saxifragaceae	*Heuchera parvifolia*	littleleaf alumroot			X	X		
Scrophulariaceae	*Besseya plantaginea*	White River coraldrops				X		
Scrophulariaceae	*Castilleja integra*	wholeleaf Indian paintbrush			X	X		X
Scrophulariaceae	*Cordylanthus wrightii*	Wright's birdbeak			X	X		X
Scrophulariaceae	*Penstemon barbatus*	beardlip penstemon			X	X		
Scrophulariaceae	*Penstemon jamesii*	James' beardtongue			X	X	X	X
Scrophulariaceae	*Penstemon secundiflorus*	sidebells penstemon			X			X
Scrophulariaceae	*Penstemon virgatus*	upright blue beardtongue				X		X
Scrophulariaceae	*Penstemon whippleanus*	Whipple's penstemon				X		
Scrophulariaceae	*Verbascum thapsus*	common mullein			X	X	X	
Scrophulariaceae	*Veronica americana*	American speedwell			X	X		
Scrophulariaceae	*Veronica peregrina* ssp. *xalapensis*	hairy purslane speedwell				X		
Selaginellaceae	*Selaginella mutica*	bluntleaf spikemoss			X	X		

Family	Scientific Name	Common Name	Weed Class/Status		Source			
			NM	Federal	Sivinski[1]	Muldavin[2]	Folts-Zettner[3]	Trader[4]
Solanaceae	*Chamaesaracha coronopus*	greenleaf five eyes			X			
Solanaceae	*Lycium pallidum*	pale wolfberry				X		
Solanaceae	*Physalis hederifolia*	ivyleaf groundcherry						X
Solanaceae	*Physalis hederifolia* var. *fendleri*	Fendler's groundcherry			X	X		
Solanaceae	*Physalis longifolia* var. *longifolia*	longleaf groundcherry				X		
Solanaceae	*Physalis subulata* var. *neomexicana*	New Mexican groundcherry			X			
Solanaceae	*Physalis virginiana*	Virginia groundcherry			X		X	X
Solanaceae	*Solanum elaeagnifolium*	silverleaf nightshade			X		X	
Solanaceae	*Solanum fendleri*	Fendler's horsenettle			X			
Solanaceae	*Solanum jamesii*	wild potato						X
Tamaricaceae	*Tamarix ramosissima*	saltcedar	C		X	X		
Typhaceae	*Typha domingensis*	southern cattail				X		
Typhaceae	*Typha latifolia*	broadleaf cattail			X	X		
Ulmaceae	*Ulmus pumila*	Siberian elm	C		X	X		
Valerianaceae	*Valeriana acutiloba* var. *acutiloba*	sharpleaf valerian			X			
Verbenaceae	*Glandularia bipinnatifida*	Dakota mock vervain			X	X		
Verbenaceae	*Glandularia wrightii*	Davis Mountain mock vervain						X
Verbenaceae	*Verbena bracteata*	bigbract verbena			X			
Verbenaceae	*Verbena macdougalii*	MacDougal verbena			X	X		X
Viscaceae	*Arceuthobium vaginatum* ssp.*cryptopodum*	pineland dwarf mistletoe			X			
Viscaceae	*Phoradendron juniperinum*	juniper mistletoe			X	X		
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper			X	X		
Zygophyllaceae	*Tribulus terrestris*	puncturevine			X		X	

[1]Sivinski, R. 1995. A botanical inventory of Pecos National Historical Park, New Mexico, National Park Service Southwest Regional Office Santa Fe Garden Club.

[2]Muldavin, E., Y. Chauvin, T. Neville, P. Arbetan, and P. Neville. 2010. A Vegetation Classification and Map, Pecos National Historic Park. Natural Resource Technical Report NPS/SOPN/NRTR-200X/00X, National Park Service, Fort Collins, Colorado (Draft version 1.0).

[3]Folts-Zettner, T. 2010. Pecos and Fort Union pilot vegetation data, excel spreadsheet.

[4]Trader, L. 2010. Species list from PECO.

Appendix D: Benthic Invertebrate Species

Table D-1. Benthic invertebrate species observed at Pecos National Historical Park

			Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
Order/Phylum	**Species**	**Water Quality Sensitivity**	**P1**	**P2**	**P3**	**P4**	**P5**	**DC1[1]**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Amphipoda	*Hyalella azteca*		6	6	0	0	0	0	0	17	62	11	0	0
Amphipoda	*Orcocnetes virilus*		0	0	0	0	0	0	0	0	0	6	0	0
Annelida	*Lumbricidae*		0	0	0	6	0	88	39	821	34	193	23	0
Annelida	*Naididae*		0	0	0	0	0	0	0	227	368	6	0	0
Annelida	*Tubificidae*	sediment tolerant	0	0	23	23	6	0	0	2274	305	3526	46	0
Arthropoda	*Hydracarina A*		0	6	975	46	0	0	12	6	6	6	0	57
Arthropoda	*Hydracarina B*		0	0	51	6	0	0	0	0	0	0	0	0
Aschelminthes	*Nematoda*		0	0	0	6	6	0	0	0	0	0	0	12
Coleoptera	*Curculionidae*		0	0	0	0	0	0	0	6	0	0	0	0
Coleoptera	*Cybister sp.*		0	0	0	0	0	0	23	176	40	17	0	0
Coleoptera	*Dytiscidae*		0	0	0	0	0	0	0	0	6	6	0	6
Coleoptera	*Helichus sp.*		11	11	34	0	6	24	23	0	45	6	0	34
Coleoptera	*Microcylloepus sp.*		0	0	0	0	0	48	0	6	119	11	11	17
Coleoptera	*Noteridae*		0	0	0	0	0	0	0	0	0	0	6	0
Coleoptera	*Optioservus sp.*		1542	1072	3510	1950	1260	296	6	0	148	23	0	22
Coleoptera	*Prionocyphon sp.*		0	0	0	0	0	0	6	0	0	0	0	0
Decopoda	*Orcocnetes virilus*		0	0	0	0	0	0	0	0	11	12	0	0
Diptera	*Antocha monticola*		29	11	6	0	0	0	0	0	6	0	0	28
Diptera	*Atherix pachypus*		80	141	1253	266	91	0	6	0	6	0	0	0
Diptera	*Bezzia sp.*		6	0	6	34	6	0	0	12	23	56	39	46
Diptera	*Bibiocephala grandis*		0	6	6	0	6	0	0	0	0	0	0	0
Diptera	*Brillia sp.*		0	0	0	0	0	0	0	86	0	0	0	0
Diptera	*Cardiocladius sp.*		28	770	57	23	34	0	0	0	0	147	0	0
Diptera	*Chelifera sp.*		0	0	12	6	0	0	0	40	11	6	0	74
Diptera	*Cladotanytarsus sp.*		0	0	0	28	0	0	0	0	0	0	0	0
Diptera	*Clinocera sp.*		0	17	153	6	6	0	0	0	0	0	0	6
Diptera	*Corynoneura sp.*		6	6	0	11	0	0	0	6	136	74	0	6
Diptera	*Cricotopus sp.*		74	45	40	272	17	32	0	62	1792	5250	119	720

Order/Phylum	Species	Water Quality Sensitivity	Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
			P1	P2	P3	P4	P5	DC1[1]	G1	G2	G3	G4	G5	G6
Diptera	*Cryptochironomus sp.*		0	0	0	0	0	0	0	0	11	6	0	17
Diptera	*Diamesa sp.*		244	1032	505	494	45	0	0	686	3685	176	0	232
Diptera	*Dicranota sp.*		0	22	0	0	0	80	141	34	119	6	0	6
Diptera	*Dicrotendipes sp.*		0	0	0	0	0	0	0	0	0	17	0	0
Diptera	*Diplocladius sp.*		0	0	0	0	0	0	0	23	0	0	0	0
Diptera	*Dixa sp.*		0	0	0	0	0	0	0	17	0	0	0	0
Diptera	*Empididae*		0	0	0	0	0	0	0	0	0	6	0	0
Diptera	*Erioptera sp.*		0	0	0	0	0	0	0	0	11	0	0	0
Diptera	*Eukiefferiella sp.*		136	362	606	641	443	40	6	148	471	221	11	1713
Diptera	*Hemerodromia sp.*		0	17	28	45	28	0	0	0	40	68	96	102
Diptera	*Hexatoma A*		137	108	289	283	176	0	6	0	154	0	0	0
Diptera	*Holorusia grandis*		0	0	0	0	0	0	0	85	23	108	34	28
Diptera	*Hydrobaenus sp.*		0	17	0	68	0	0	0	0	28	0	0	12
Diptera	*Limnophora*		0	0	0	0	0	0	0	0	28	0	0	0
Diptera	*Limnophora sp.*		0	0	0	0	0	0	0	0	28	6	0	0
Diptera	*Limonia sp.*		11	6	0	0	0	0	11	159	142	0	0	0
Diptera	*Macropelopia sp.*		0	0	0	0	0	0	164	62	0	0	0	0
Diptera	*Micropsectra sp.*		11	6	11	6	6	24	11	640	113	23	17	0
Diptera	*Microtendipes sp.*		0	17	130	1174	23	0	0	0	17	56	40	29
Diptera	*Nanocladius sp.*		0	0	0	0	0	0	0	0	0	22	0	6
Diptera	*Nostococladius sp.*		0	0	11	11	0	0	0	0	0	0	0	0
Diptera	*Odontomesa sp.*		0	0	0	6	0	0	0	0	0	0	0	0
Diptera	*Odontomyia sp.*		0	0	0	0	0	0	0	0	6	6	11	12
Diptera	*Oreogeton sp.*		6	17	0	0	0	0	0	0	0	0	0	6
Diptera	*Orthocladius sp.*		1316	1265	487	1037	397	8	187	135	2494	494	11	261
Diptera	*Pagastia sp.*		11	17	6	28	6	0	0	45	0	85	0	96
Diptera	*Paracladopelma sp.*		0	0	0	17	0	0	0	0	0	0	0	0
Diptera	*Parakiefferiella sp.*		0	0	0	0	0	0	0	0	0	96	0	6
Diptera	*Parametriocnemus sp.*		0	12	0	0	0	0	0	23	119	23	17	0
Diptera	*Paraphaenocladius sp.*		0	0	0	0	0	0	0	6	0	6	0	0

			Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
Order/Phylum	**Species**	**Water Quality Sensitivity**	**P1**	**P2**	**P3**	**P4**	**P5**	**DC1[1]**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Diptera	*Paratanytarsus sp.*		0	0	17	23	0	0	0	0	0	0	0	0
Diptera	*Paratendipes sp.*		0	0	0	0	0	0	0	17	0	0	0	6
Diptera	*Parochlus kiefferi*		0	0	0	0	0	0	0	34	0	0	0	0
Diptera	*Pericoma sp.*		6	0	0	0	0	16	0	0	0	0	0	0
Diptera	*Phaenopsectra sp.*		0	11	0	28	0	0	0	0	17	0	17	40
Diptera	*Polypedilum spp.*		23	23	11	80	17	0	11	0	0	0	0	0
Diptera	*Potthastia sp.*		0	6	0	0	0	0	0	0	0	0	0	0
Diptera	*Prodiamesa sp.*		0	0	0	0	0	0	23	0	0	0	0	0
Diptera	*Pseudochironomus sp.*		0	0	0	0	0	0	6	0	6	0	0	0
Diptera	*Pseudodiamesa sp.*		0	0	0	0	0	0	0	28	6	0	0	0
Diptera	*Rheocricotopus sp.*		0	0	0	11	0	0	0	114	51	6	0	57
Diptera	*Rheotanytarsus sp.*		17	6	34	63	11	0	0	0	63	408	68	545
Diptera	*Simulium sp.*	opportunistic	79	222	266	63	908	336	2064	6662	878	487	6	351
Diptera	*Stempellina sp.*		0	0	0	6	0	0	0	0	0	0	0	0
Diptera	*Stictochironomus sp.*		0	0	0	0	0	0	0	0	0	6	0	0
Diptera	*Synorthocladius sp.*		0	0	0	0	0	0	0	0	0	17	0	0
Diptera	*Tanytarsus sp.*		39	6	12	119	0	0	788	0	28	6	0	0
Diptera	*Thienemannimyia sp.*		6	0	0	11	0	0	0	0	11	11	6	57
Diptera	*Thienimeniella sp.*		0	0	0	0	0	0	0	0	57	0	0	0
Diptera	*Tipula sp.*		119	40	74	46	91	0	0	295	29	182	108	40
Diptera	*Tipulidae*		0	0	0	0	0	8	0	0	0	0	0	0
Diptera	*Tvetenia sp.*		12	85	34	6	0	0	11	1242	1032	431	0	102
Diptera	*Zavrelimyia sp.*		0	0	0	0	0	0	11	0	0	0	0	0
Ephemeroptera	*Ameletus sp.*	intermediately tolerant	17	0	11	6	0	0	0	0	0	0	0	0
Ephemeroptera	*Baetis insignificans*	intermediately tolerant	0	0	0	0	0	40	0	0	0	0	0	0

Order/Phylum	Species	Water Quality Sensitivity	Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
			P1	P2	P3	P4	P5	DC1[1]	G1	G2	G3	G4	G5	G6
Ephemeroptera	*Baetis tricaudatus*	intermediately tolerant	1293	3005	3407	1469	2847	872	210	2279	3708	953	227	2126
Ephemeroptera	*Drunella doddsi*	intermediately tolerant	6	11	0	0	12	0	0	0	0	0	0	0
Ephemeroptera	*Drunella grandis*	intermediately tolerant	182	107	522	407	171	0	0	0	0	0	0	0
Ephemeroptera	*Epeorus longimanus*	intermediately tolerant	578	221	45	40	74	96	108	0	11	0	0	0
Ephemeroptera	*Ephemerella inermis*	intermediately tolerant	255	318	993	805	1570	16	0	0	0	0	0	6
Ephemeroptera	*Nixe simplicoides*	intermediately tolerant	34	11	34	57	79	160	312	0	0	0	0	0
Ephemeroptera	*Paraleptophlebia sp.*	intermediately tolerant	97	0	45	6	6	328	0	0	6	0	11	17
Ephemeroptera	*Rhithrogena undulata*	intermediately tolerant	958	606	488	159	1310	0	0	0	0	0	0	0
Ephemeroptera	*Tricorythodes sp.*	intermediately tolerant	6	6	40	45	6	0	0	0	79	295	119	692
Hemiptera	*Ambrysus mormon*		0	0	0	6	0	0	0	0	0	6	113	153
Hemiptera	*Circadellidae*		0	0	6	0	0	0	0	12	0	0	0	0
Lepidoptera	*Petrophila sp.*		0	6	0	0	6	0	6	0	0	0	0	17
Mollusca	*Ferrissia sp.*		0	0	0	6	0	0	0	0	0	0	0	0
Mollusca	*Gyraulus sp.*		23	6	23	6	0	0	0	6	0	0	28	23
Mollusca	*Lymnaea sp.*		0	0	6	28	0	0	0	0	0	0	0	0
Mollusca	*Physella sp.*		0	0	28	17	6	0	0	844	0	11	45	170
Mollusca	*Sphaeriidae*		0	0	0	0	0	0	11	0	0	0	0	0
Nematomorpha	*Gordius sp.*		0	0	6	0	0	0	6	0	0	0	0	0
Odonata	*Aeshna sp.*		0	0	0	0	0	0	0	28	6	0	0	0
Odonata	*Argia sp.*		0	0	0	0	0	0	0	74	34	34	68	545
Odonata	*Ophiogomphus sp.*		0	6	6	0	0	0	0	0	0	0	0	0
Platyhelminthes	*Turbellaria*		0	0	11	28	0	0	0	0	0	266	742	1638
Plecoptera	*Amphinemura*		0	0	0	0	0	700	34	0	0	0	0	0

			Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
Order/Phylum	Species	Water Quality Sensitivity	P1	P2	P3	P4	P5	DC1[1]	G1	G2	G3	G4	G5	G6
Plecoptera	*Amphinemura sp.*		0	0	0	0	0	180	102	0	0	0	0	0
Plecoptera	*Capniidae*		0	0	6	6	0	0	0	17	822	6	23	0
Plecoptera	*Chloroperlidae A*		108	0	0	0	147	0	0	0	0	0	0	0
Plecoptera	*Chloroperlidae B*		17	23	0	0	0	0	11	0	0	0	0	0
Plecoptera	*Claassenia sabulosa*	sensitive	12	28	18	6	51	0	0	0	0	0	0	0
Plecoptera	*Hesperoperla pacifica*	sensitive	34	6	23	17	6	120	0	0	0	0	0	0
Plecoptera	*Isogenoides elongatus*	sensitive	108	6	136	159	256	8	0	0	0	0	0	0
Plecoptera	*Isoperla sp.*		12	90	220	238	488	40	0	0	181	6	0	0
Plecoptera	*Paraleuctra sp.*		11	6	0	0	0	0	0	0	6	0	0	0
Plecoptera	*Plumiperla diversa*		0	0	0	0	0	0	17	0	0	0	0	0
Plecoptera	*Podmosta delicatula*		618	1803	675	499	1469	56	0	0	108	6	0	11
Plecoptera	*Pteronarcella badia*	sensitive	1639	1559	2631	776	2040	16	0	0	0	0	0	0
Plecoptera	*Pteronarcys californica*	sensitive	686	555	1734	913	2341	0	0	0	0	0	0	0
Plecoptera	*Suwallia sp.*		0	0	0	0	0	48	0	0	0	0	0	0
Plecoptera	*Sweltsa sp.*		34	810	107	125	97	0	0	0	199	0	0	0
Plecoptera	*Taenionema sp.*		56	346	204	34	147	0	0	0	0	0	0	0
Plecoptera	*Zapada cinctipes*		0	0	6	0	0	0	0	0	0	0	0	0
Trichoptera	*Anagapetus sp.*		17	125	754	74	68	0	0	0	0	0	0	0
Trichoptera	*Brachycentrus americanus*		278	221	3033	1802	969	0	0	0	0	11	0	0
Trichoptera	*Ceraclea sp.*		29	23	34	131	0	8	0	0	0	0	23	0
Trichoptera	*Cheumatopsyche sp.*		0	0	0	0	0	0	0	0	0	11	0	0
Trichoptera	*Chimarra sp.*		0	0	0	0	0	0	0	0	0	0	0	17
Trichoptera	*Clistoronia sp.*		0	0	0	0	0	0	164	68	238	641	28	113
Trichoptera	*Dolophilodes sortosa*		0	0	0	0	0	8	0	0	0	0	0	0
Trichoptera	*Glossosoma sp.*		0	0	0	6	0	0	0	0	0	0	0	0
Trichoptera	*Helicopsyche borealis*		0	6	0	204	0	0	0	0	0	40	182	23
Trichoptera	*Hydropsyche oslari*	tolerant	2523	3839	5166	3148	4513	520	516	294	789	2217	306	1021
Trichoptera	*Hydroptila sp.*		0	0	0	0	0	16	0	11	358	28	79	130
Trichoptera	*Lepidostoma sp.*		317	386	130	426	136	624	34	0	91	17	0	6
Trichoptera	*Limnephilidae*		0	0	0	0	0	16	17	0	0	0	0	0
Trichoptera	*Micrasema sp.*		0	0	0	0	0	64	0	0	0	0	0	0

			Sample Sites (Jacobi and Jacobi 1998)											
			Pecos River					Glorieta Creek						
Order/Phylum	**Species**	**Water Quality Sensitivity**	**P1**	**P2**	**P3**	**P4**	**P5**	**DC1[1]**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Trichoptera	*Nectopsyche sp.*		0	0	6	0	0	0	0	0	0	0	0	0
Trichoptera	*Ochrotrichia sp.*		0	0	437	40	0	0	0	0	51	386	261	301
Trichoptera	*Polycentropus sp.*		0	0	0	11	0	0	0	0	0	0	0	0
Trichoptera	*Psychomyia sp.*		0	0	63	215	23	0	0	0	0	0	0	0
Trichoptera	*Psychoronia sp.*		0	221	0	0	0	0	0	0	0	0	0	0
Trichoptera	*Rhyacophila brunea cpx.*		0	0	0	0	0	56	0	0	0	0	0	0
Trichoptera	*Rhyacophila coloradensis*		73	23	6	17	6	0	0	0	0	0	0	0
Trichoptera	*Rhyacophila valuma*		34	17	0	0	0	0	0	0	0	0	0	0
Trichoptera	*Rhyacophila verrula*		17	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	*Stactobiella sp.*		0	0	0	0	0	0	0	0	0	0	363	119

[1] Sample site on Dalton Creek, used when Glorieta Creek was not flowing.

Appendix E: Terrestrial Invertebrate Species

Table E-1. Arthropod species in Pecos National Historical Park

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Arachnida	Araneae	Agelenidae	*agelenid*	funnel weaver spider	X	X			X	
Arachnida	Araneae	Araneidae	*Neoscona arabesca*		X		X		X	
Arachnida	Araneae	Corinnidae	*Castianeira sp. (1)*		X				X	
Arachnida	Araneae	Corinnidae	*Trachelas sp. (1)*		X		X		X	
Arachnida	Araneae	Dictynidae	*Dictyna coloradensis*		X				X	
Arachnida	Araneae	Gnaphosidae	*Callilepis imbecilla*		X				X	
Arachnida	Araneae	Gnaphosidae	*Drassodes gosiutus*		X				X	
Arachnida	Araneae	Gnaphosidae	*Drassodes saccatus*		X				X	
Arachnida	Araneae	Gnaphosidae	*Drassyllus dromeus*		X				X	
Arachnida	Araneae	Gnaphosidae	*Drassyllus sp. (1)*		X				X	
Arachnida	Araneae	Gnaphosidae	*Gnaphosa brumalis*		X				X	
Arachnida	Araneae	Gnaphosidae	*Gnaphosa frontinalis*		X				X	
Arachnida	Araneae	Gnaphosidae	*Gnaphosa muscorum*		X				X	
Arachnida	Araneae	Gnaphosidae	*Herpyllus sp. (1)*		X				X	
Arachnida	Araneae	Gnaphosidae	*Micaria pulicaria*		X		X		X	
Arachnida	Araneae	Gnaphosidae	*Micaria sp. (1)*		X	X			X	
Arachnida	Araneae	Gnaphosidae	*Zelotes fratris*		X		X		X	
Arachnida	Araneae	Gnaphosidae	*Zelotes lasalanus*		X				X	
Arachnida	Araneae	Linyphiidae	*Grammonota sp. (1)*		X		X		X	
Arachnida	Araneae	Linyphiidae	*Pityohyphantes sp. (1)*		X				X	
Arachnida	Araneae	Liocranidae	*Agroeca sp. (1)*				X		X	
Arachnida	Araneae	Liocranidae	*Phrurotimpus sp. (1)*		X				X	
Arachnida	Araneae	Lycosidae	*Allopecosa kochii*		X	X			X	
Arachnida	Araneae	Lycosidae	*Allocosa morelsiana*		X				X	
Arachnida	Araneae	Lycosidae	*Allocosa utahana*		X	X			X	
Arachnida	Araneae	Lycosidae	*Geolycosa sp. (1)*			X			X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Arachnida	Araneae	Lycosidae	*Hogna carolinensis*			X			X	
Arachnida	Araneae	Lycosidae	*Pardosa distincta*				X		X	
Arachnida	Araneae	Lycosidae	*Pardosa falcifera*				X		X	
Arachnida	Araneae	Lycosidae	*Pardosa orophila*		X	X			X	
Arachnida	Araneae	Lycosidae	*Pardosa steva*		X				X	
Arachnida	Araneae	Lycosidae	*Pardosa sp. (1)*		X				X	
Arachnida	Araneae	Lycosidae	*Schizocosa retrorsa*		X				X	
Arachnida	Araneae	Lycosidae	*Trochosa terricola*				X		X	
Arachnida	Araneae	Lycosidae	*Varacosa sp. (1)*		X				X	
Arachnida	Araneae	Mimetidae	*Mimetus sp. (1)*		X				X	
Arachnida	Araneae	Oxyopidae	*Oxyopes scalaris*		X				X	
Arachnida	Araneae	Philodromidae	*Philodromus sp. (1)*		X	X			X	
Arachnida	Araneae	Philodromidae	*Thanatus sp. (1)*		X	X			X	
Arachnida	Araneae	Philodromidae	*Tibellus oblongus*				X		X	
Arachnida	Araneae	Pholcidae	*Psilochorus sp. (1)*		X				X	
Arachnida	Araneae	Salticidae	*Evarcha hoyi*			X	X		X	
Arachnida	Araneae	Salticidae	*Habronattus sp. (1)*		X	X			X	
Arachnida	Araneae	Salticidae	*Metaphidippus arizonensis*			X			X	
Arachnida	Araneae	Salticidae	*Metaphidippus mimus*				X		X	
Arachnida	Araneae	Salticidae	*Phidippus sp. (1)*			X			X	
Arachnida	Araneae	Salticidae	*Sitticus sp. (1)*		X				X	
Arachnida	Araneae	Salticidae	*Tylogonus arizonensis*		X				X	
Arachnida	Araneae	Tetragnathida	*Tetragnatha laboriosa*				X		X	
Arachnida	Araneae	Tetragnathida	*Tetragnatha versicolor*				X		X	
Arachnida	Araneae	Theridiidae	*Euryopis scriptipes*		X				X	
Arachnida	Araneae	Theridiidae	*Lactrodectus hesperus*	black widow spider	X	X			X	
Arachnida	Araneae	Theridiidae	*Steatoda albomaculata*		X				X	
Arachnida	Araneae	Theridiidae	*Steatoda apacheana*		X				X	
Arachnida	Araneae	Theridiidae	*Steatoda washona*		X	X			X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Arachnida	Araneae	Thomisidae	*Minumenops coloradensis*		X	X	X		X	
Arachnida	Araneae	Thomisidae	*Xysticus apachecus*		X				X	
Arachnida	Araneae	Thomisidae	*Xysticus auctificus*		X	X			X	
Arachnida	Opilones	Sclerosomatidae	*sclerosomatid (1)*	harvestmen	X				X	
Arachnida	Solifugae	Eremobatidae	*Eremobates sp. (1)*		X				X	
Malacostraca	Amphipoda	Hyalellidae	*Hyalella azteca**					X	X	
Malacostraca	Isopoda	Armadillidiidae	*Armadillidium vulgare*				X		X	
Diplopoda	Julida	Parajulidae	*Apacheius sp. (1)*		X				X	
Chilopoda	Lithobiomorpha	Lithobiidae	*Nadabius mesechinus*		X				X	
Chilopoda	Scolopendramorpha	Scolopendridae	*Scolopendra viridis*		X	X			X	
Hexapoda	Collembola	Entomobryidae	*Tomocerus vulgaris*		X		X		X	
Hexapoda	Microcoryphia	Machilidae	*Mesomachilis hearticus*		X				X	
Hexapoda	Microcoryphia	Meinertillidae	*Machilinus aurantiacus*		X				X	
Hexapoda	Ephemeroptera	Baetidae	*Baetis sp. (1)*				X	X	X	
Hexapoda	Ephemeroptera	Ephemerellidae	*Drunella proserpina*				X	X	X	
Hexapoda	Ephemeroptera	Ephemerellidae	*Ephemerella infrequens*				X	X	X	
Hexapoda	Ephemeroptera	Heptgeniidae	*Epeorus sp. (1)*				X	X	X	
Hexapoda	Ephemeroptera	Siphlonuridae	*Siphlornurus sp. (1)*				X	X	X	
Hexapoda	Ephemeroptera	Tricorythidae	*Tricorythodes sp. (1)**				X	X	X	
Hexapoda	Odonata	Aeshnidae	*Aeschna palmata*				X	X	X	
Hexapoda	Odonata	Libellulidae	*Libellula pulchella*	tenspot skimmer			X	X	X	
Hexapoda	Odonata	Libellulidae	*Libellula quadrimaculata*	fourspot skimmer			X	X	X	
Hexapoda	Odonata	Libellulidae	*Sympetrum pallipes*				X	X	X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Odonata	Calopterygidae	*Hetaerina americana*	American ruby-spot			X	X	X	
Hexapoda	Odonata	Coenagrionidae	*Amphiagrion abbreviatum*				X	X	X	
Hexapoda	Odonata	Coenagrionidae	*Argica sp. (1)*				X	X	X	
Hexapoda	Odonata	Coenagrionidae	*Ischnura sp. (1)*				X	X	X	
Hexapoda	Odonata	Lestidae	*Lestes sp. (1)*				X	X	X	
Hexapoda	Plecoptera	Chloroperlidae	*chloroperlid (1)*	green stoneflies			X	X	X	
Hexapoda	Plecoptera	Pteronarcyidae	*Pteronarcella badia**				X	X	X	
Hexapoda	Plecoptera	Pteronarcyidae	*Pteronarcys californica**	salmon-fly			X	X	X	
Hexapoda	Plecoptera	Perlodidae	*Isoperla patricia*				X	X	X	
Hexapoda	Plecoptera	Perlodidae	*Isoperla sp. (1)**				X	X	X	
Hexapoda	Plecoptera	Leuctridae	*Paraleuctra vershina*				X	X	X	
Hexapoda	Mantodea	Mantida	*Litaneutra minor*		X	X			X	
Hexapoda	Mantodea	Mantida	*Yersiniops solitarium*		X	X			X	
Hexapoda	Orthoptera	Acrididae	*Ageneotettix deorum*			X			X	
Hexapoda	Orthoptera	Acrididae	*Arphia conspersa*			X			X	
Hexapoda	Orthoptera	Acrididae	*Arphia pseudonietana*			X			X	
Hexapoda	Orthoptera	Acrididae	*Allocara ellioti*			X			X	
Hexapoda	Orthoptera	Acrididae	*Camnula pellucida*			X			X	
Hexapoda	Orthoptera	Acrididae	*Chortophaga viridifasciata*				X		X	
Hexapoda	Orthoptera	Acrididae	*Conozoa sulcifrons*				X		X	
Hexapoda	Orthoptera	Acrididae	*Cordillacris crenulata*			X			X	
Hexapoda	Orthoptera	Acrididae	*Dissosteira carolina*			X	X		X	
Hexapoda	Orthoptera	Acrididae	*Encoptolophus costalis*			X	X		X	
Hexapoda	Orthoptera	Acrididae	*Eritettix simplex*			X			X	
Hexapoda	Orthoptera	Acrididae	*Hesperotettix viridis*			X			X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus aridus*		X	X			X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus bivitattus*				X		X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
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Hexapoda	Orthoptera	Acrididae	*Melanoplus confusus*			X	X		X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus femurrubrum*				X		X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus packardii*			X			X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus occidentalis*			X			X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus sanguinipes*			X	X		X	
Hexapoda	Orthoptera	Acrididae	*Melanoplus splendidus*		X				X	
Hexapoda	Orthoptera	Acrididae	*Mestobregma plattei*		X				X	
Hexapoda	Orthoptera	Acrididae	*Opeia obscura*			X			X	
Hexapoda	Orthoptera	Acrididae	*Phlibostroma quadrimaculatum*			X			X	
Hexapoda	Orthoptera	Acrididae	*Psoloessa delicatula*			X			X	
Hexapoda	Orthoptera	Acrididae	*Spharagemon campestris*			X			X	
Hexapoda	Orthoptera	Acrididae	*Trachyrachis coronata*			X			X	
Hexapoda	Orthoptera	Acrididae	*Trimerotropis cincta*		X				X	
Hexapoda	Orthoptera	Acrididae	*Trimerotropis fraturcula*		X				X	
Hexapoda	Orthoptera	Acrididae	*Trimerotropis gracilis*		X				X	
Hexapoda	Orthoptera	Acrididae	*Trimerotropis pallidipennis*		X	X			X	
Hexapoda	Orthoptera	Acrididae	*Trimerotropis pistrinaria*		X				X	
Hexapoda	Orthoptera	Acrididae	*Xanthippus corallipes*			X			X	
Hexapoda	Orthoptera	Tettirigidae	*Paratettix aztecus*				X	X	X	
Hexapoda	Orthoptera	Gryllacrididae	*Ceuthophilus pallidus*		X	X			X	
Hexapoda	Orthoptera	Gryllacrididae	*Ceuthophilus utahensis*		X				X	
Hexapoda	Orthoptera	Gryllacrididae	*Stenopelmatus fuscus*		X				X	
Hexapoda	Orthoptera	Gryllacrididae	*Styracosceles neomexicanus*		X				X	

Class	Order	Family	Scientific Name	Common Name	Habitat: Wood-land	Habitat: Grass-land	Habitat: Riparian	Habitat: Aquatic	Parmenter and Lightfoot (1996)[1]: Observed	Museum of South-western Biology[2]: Collection
Hexapoda	Orthoptera	Gryllacrididae	*Udeopsylla robusta*			X			X	
Hexapoda	Orthoptera	Gryllidae	*Cycloptilium comprehendens*		X	X			X	
Hexapoda	Orthoptera	Gryllidae	*Gryllus sp. (1)*		X	X			X	
Hexapoda	Orthoptera	Gryllidae	*Oecanthus californicus*			X	X		X	
Hexapoda	Orthoptera	Tettigoniidae	*Arethea gracilipes gracilipes*			X			X	
Hexapoda	Orthoptera	Tettigoniidae	*Capnobotes occidentalis*		X				X	
Hexapoda	Orthoptera	Tettigoniidae	*Conocephalus fasciatus*				X		X	
Hexapoda	Orthoptera	Tettigoniidae	*Scudderia furcata*				X		X	
Hexapoda	Phasmida	Heteronemiidae	*Parabacillus coloradus*			X			X	
Hexapoda	Phasmida	Heteronemiidae	*Pseudosermyle straminae*			X			X	
Hexapoda	Dermaptera	Forficulidae	*Forficula auricularia*	European earwig			X		X	
Hexapoda	Isoptera	Rhinotermitidae	*Reticulitermes flavipes*		X	X			X	
Hexapoda	Thysanoptera	Thripidae	*Frankliniella tritici*		X	X	X		X	
Hexapoda	Hemiptera	Anthocoridae	*Orinus tristicolor*		X	X	X		X	
Hexapoda	Hemiptera	Alydidae	*Alydus eurinus*		X	X			X	
Hexapoda	Hemiptera	Alydidae	*Stachyocnemus apicalis*		X	X			X	
Hexapoda	Hemiptera	Berytidae	*Neides muticus*		X	X			X	
Hexapoda	Hemiptera	Coreidae	*Leptoglossus clypealis*		X				X	
Hexapoda	Hemiptera	Corixidae	*Sigara alternata*					X	X	
Hexapoda	Hemiptera	Corixidae	*Sigara omani*					X	X	
Hexapoda	Hemiptera	Cydnidae	*Pangaeus bilineatus*		X	X			X	
Hexapoda	Hemiptera	Gelastocoridae	*Gelastocoris oculatus*				X	X	X	
Hexapoda	Hemiptera	Gerridae	*Gerris marginatus*					X	X	
Hexapoda	Hemiptera	Gerridae	*Gerris remigis*					X	X	
Hexapoda	Hemiptera	Lygaeidae	*Lygaeus kalmii*			X			X	
Hexapoda	Hemiptera	Lygaeidae	*Lygaeus sp. (1)*			X	X		X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Hemiptera	Lygaeidae	*Nysius niger*		X	X			X	
Hexapoda	Hemiptera	Lygaeidae	*Emblethis vicarius*		X	X			X	
Hexapoda	Hemiptera	Lygaeidae	*Geocoris nanus*		X	X			X	
Hexapoda	Hemiptera	Lygaeidae	*Sphaerobius insigns*		X	X			X	
Hexapoda	Hemiptera	Miridae	*Lygus lineolaris*			X			X	
Hexapoda	Hemiptera	Miridae	*mirid (9)*	plant bugs	X	X	X		X	
Hexapoda	Hemiptera	Nabidae	*Nabicula subcoleoptrata*			X	X		X	
Hexapoda	Hemiptera	Nabidae	*Nabis alternata*			X	X		X	
Hexapoda	Hemiptera	Notnectidae	*Notonecta kirbyi*					X	X	
Hexapoda	Hemiptera	Naucoridae	*Ambrysus mormon**					X	X	
Hexapoda	Hemiptera	Pentatomidae	*Banasa dimidiata*			X			X	
Hexapoda	Hemiptera	Pentatomidae	*Brochymena barberi*		X				X	
Hexapoda	Hemiptera	Pentatomidae	*Rhytipiloma belfragei*			X			X	
Hexapoda	Hemiptera	Pentatomidae	*Rhytipiloma osborni*			X			X	
Hexapoda	Hemiptera	Pentatomidae	*Thyanta rugulosa*		X	X			X	
Hexapoda	Hemiptera	Pentatomidae	*Thyanta casta*		X	X			X	
Hexapoda	Hemiptera	Phymatidae	*Phymata fascinata*		X	X			X	
Hexapoda	Hemiptera	Rhopalidae	*Leptocoris trivittatus*	boxelder bug			X		X	
Hexapoda	Hemiptera	Rhopalidae	*rhopalid (3)*	scentless plant bugs		X	X		X	
Hexapoda	Hemiptera	Reduviidae	*Apiomerus crassipes*		X	X			X	
Hexapoda	Hemiptera	Reduviidae	*Melanolestes abdominalis*		X				X	
Hexapoda	Hemiptera	Reduviidae	*Sinea diadema*		X	X			X	
Hexapoda	Hemiptera	Saldidae	*Saldula sp. (1)*				X	X	X	
Hexapoda	Hemiptera	Scutellaridae	*Homoaeus aenifrons*				X		X	
Hexapoda	Hemiptera	Tingidae	*Acalypta sp. (1)*			X	X		X	
Hexapoda	Hemiptera	Tingidae	*Atheas mimeticus*		X	X			X	
Hexapoda	Hemiptera	Tingidae	*Corythuca mollicula*			X			X	
Hexapoda	Hemiptera	Veliidae	*Microvelia sp. (1)*					X	X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Homoptera	Cercopidae	*Apherophora irrorata*		X				X	
Hexapoda	Homoptera	Cercopidae	*cercopid (2)*	spittle bugs		X	X		X	
Hexapoda	Homoptera	Cicadidae	*Okanagana synodica*			X			X	
Hexapoda	Homoptera	Cicadidae	*Platypedia mohavensis*		X				X	
Hexapoda	Homoptera	Cicadellidae	*cicadellid (15)*	leafhopper s	X	X	X		X	
Hexapoda	Homoptera	Dictyopharidae	*Scolops sp. (1)*			X			X	
Hexapoda	Homoptera	Membracidae	*membracid (3)*	treehoppe rs		X	X		X	
Hexapoda	Homoptera	Psyllidae	*psyllid (1)*	jumping plant lice		X			X	
Hexapoda	Neuroptera	Chrysopidae	*Chrysopa sp. (1)*		X	X	X		X	
Hexapoda	Neuroptera	Hemerobiidae	*Micromus variolosus*		X				X	
Hexapoda	Neuroptera	Myrmeleontidae	*Brachynemurus sackeni*		X				X	
Hexapoda	Neuroptera	Myrmeleontidae	*Eremoleon nigribasis*		X				X	
Hexapoda	Neuroptera	Myrmeleontidae	*Myrmeleon sp. (1)*		X				X	
Hexapoda	Neuroptera	Raphidiidae	*Raphicila modesta*		X		X		X	
Hexapoda	Coleoptera	Anthicidae	*Anthicus sp. (1)*			X			X	
Hexapoda	Coleoptera	Buprestidae	*Acmaeodera rubronotata*		X				X	
Hexapoda	Coleoptera	Buprestidae	*Chrysobothris woogatei*		X				X	
Hexapoda	Coleoptera	Cantharidae	*Podabrus sp. (3)*			X			X	
Hexapoda	Coleoptera	Carabidae	*Agonum placidum*				X		X	
Hexapoda	Coleoptera	Carabidae	*Amara ellipsis*		X				X	
Hexapoda	Coleoptera	Carabidae	*Amara carinata*		X				X	
Hexapoda	Coleoptera	Carabidae	*Amara littoralis*			X	X		X	
Hexapoda	Coleoptera	Carabidae	*Calathus advena*				X		X	
Hexapoda	Coleoptera	Carabidae	*Calleida viridis*				X		X	
Hexapoda	Coleoptera	Carabidae	*Carabus serratus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Chlaenius lithophilus*				X		X	

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Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Coleoptera	Carabidae	*Cyclotrachelus constrictus*		X				X	
Hexapoda	Coleoptera	Carabidae	*Cyclotrachelus substriatus*		X				X	
Hexapoda	Coleoptera	Carabidae	*Cyclotrachelus torvus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Cymindus punctigera*		X				X	
Hexapoda	Coleoptera	Carabidae	*Dicaelus laevipennis*				X		X	
Hexapoda	Coleoptera	Carabidae	*Discoderus robustus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Harpalus pennsylvanicus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Lebia viridis*				X		X	
Hexapoda	Coleoptera	Carabidae	*Lebia vittata*			X			X	
Hexapoda	Coleoptera	Carabidae	*Pasimachus californicus*		X				X	
Hexapoda	Coleoptera	Carabidae	*chloroperlid*				X	X	X	
Hexapoda	Coleoptera	Carabidae	*Pasimachus elongatus*			X			X	
Hexapoda	Coleoptera	Carabidae	*Pterotichus luculandus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Pterotichus adstictus*				X		X	
Hexapoda	Coleoptera	Carabidae	*Pterotichus permundas*		X				X	
Hexapoda	Coleoptera	Carabidae	*Rhadine umbra*		X				X	
Hexapoda	Coleoptera	Carabidae	*Synbchus dubius*				X		X	
Hexapoda	Coleoptera	Carabidae	*Tachyta sp. (1)*				X		X	
Hexapoda	Coleoptera	Cerambycidae	*Mecas sp. (1)*			X			X	
Hexapoda	Coleoptera	Cerambycidae	*Megacyllene robiniae*		X				X	
Hexapoda	Coleoptera	Cerambycidae	*Moneilema sp. (1)*		X	X			X	
Hexapoda	Coleoptera	Cerambycidae	*Monochamus maculosus*		X				X	
Hexapoda	Coleoptera	Cerambycidae	*Tragosoma desparium*		X				X	
Hexapoda	Coleoptera	Chrysomelidae	*Altica torquata*		X	X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Altica sp. (2)*		X	X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Chalepus sp. (1)*				X		X	
Hexapoda	Coleoptera	Chrysomelidae	*Chaetocnema sp.*							X

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Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Coleoptera	Chrysomelidae	*Coleothorpa axillaris*							X
Hexapoda	Coleoptera	Chrysomelidae	*Cryptocephalus amatus apicedens*			X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Cryptocephalus sp. (1)*			X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Diabrotica unidecempunctata*			X	X		X	
Hexapoda	Coleoptera	Chrysomelidae	*Disonycha alternata*			X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Galeruca popenoei*							X
Hexapoda	Coleoptera	Chrysomelidae	*Glyptina sp.*							X
Hexapoda	Coleoptera	Chrysomelidae	*Monoxia sp.*							X
Hexapoda	Coleoptera	Chrysomelidae	*Ophraella notulata*			X			X	
Hexapoda	Coleoptera	Chrysomelidae	*Pachybrachis bivittatus*							X
Hexapoda	Coleoptera	Chrysomelidae	*Pachybrachis hepaticus*							X
Hexapoda	Coleoptera	Chrysomelidae	*Pachybrachis sp.*							X
Hexapoda	Coleoptera	Chrysomelidae	*Phyllotreta pusilla*			X	X		X	
Hexapoda	Coleoptera	Cicindelidae	*Cicindela punctulata*			X	X		X	
Hexapoda	Coleoptera	Cleridae	*Phyllobaenus sp. (1)*			X			X	
Hexapoda	Coleoptera	Cleridae	*Trichodes ornatus*		X	X			X	
Hexapoda	Coleoptera	Cleridae	*Trichodes sp. (1)*		X				X	
Hexapoda	Coleoptera	Coccinellidae	*Brachiacantha uteella*			X			X	
Hexapoda	Coleoptera	Coccinellidae	*Coccinella trifasciata*		X	X	X		X	
Hexapoda	Coleoptera	Coccinellidae	*Epilachra varivestis*		X				X	
Hexapoda	Coleoptera	Coccinellidae	*Hippodamia convergens*		X	X	X		X	
Hexapoda	Coleoptera	Coccinellidae	*Hippodamia parenthesis*		X		X		X	
Hexapoda	Coleoptera	Coccinellidae	*Macronaemia episcopalis*		X	X			X	
Hexapoda	Coleoptera	Cryptophagidae	*Cryptophagus sp. (1)*		X				X	
Hexapoda	Coleoptera	Curculionidae	*curculionid (14)*	weevils	X	X	X		X	
Hexapoda	Coleoptera	Dermestidae	*Dermestis sp. (1)*		X	X			X	
Hexapoda	Coleoptera	Dytiscidae	*Agabus sp. (1)*					X	X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Coleoptera	Dytiscidae	*Deronectus striatellus*					X	X	
Hexapoda	Coleoptera	Dytiscidae	*Laccophilus maculosus*					X	X	
Hexapoda	Coleoptera	Dytiscidae	*Theronectus nigrofasciatus*					X	X	
Hexapoda	Coleoptera	Elateridae	*Ctenicera conjungens*				X		X	
Hexapoda	Coleoptera	Elateridae	*Ctenicera glauca*		X				X	
Hexapoda	Coleoptera	Elateridae	*Limonius lanai*		X				X	
Hexapoda	Coleoptera	Elmidae	*Optioservus divergens*					X	X	
Hexapoda	Coleoptera	Haliplidae	*Haliplus sp. (1)*					X	X	
Hexapoda	Coleoptera	Histeridae	*Hypocaccus sp. (1)*		X				X	
Hexapoda	Coleoptera	Histeridae	*Saprinus sp. (1)*		X				X	
Hexapoda	Coleoptera	Hydrophyllidae	*Tropisternus lateralis*					X	X	
Hexapoda	Coleoptera	Lampyridae	*Lucidota sp. (1)*			X	X		X	
Hexapoda	Coleoptera	Lampyridae	*Pyropyga sp. (1)*		X				X	
Hexapoda	Coleoptera	Leptodiridae	*Catops sp. (1)*		X				X	
Hexapoda	Coleoptera	Meloidae	*Epicauta sp. (1)*			X			X	
Hexapoda	Coleoptera	Melyridae	*Collops bipunctatus*			X	X		X	
Hexapoda	Coleoptera	Melyridae	*Collops parvus*				X		X	
Hexapoda	Coleoptera	Melyridae	*Collops quadrimaculatus*		X				X	
Hexapoda	Coleoptera	Melyridae	*Eudasytes sp. (1)*			X			X	
Hexapoda	Coleoptera	Melyridae	*Malachius sp. (1)*			X			X	
Hexapoda	Coleoptera	Melyridae	*Trichochrous sp. (1)*		X				X	
Hexapoda	Coleoptera	Mordellidae	*Anapsis rufa*				X		X	
Hexapoda	Coleoptera	Mordellidae	*Anapsis sp. (1)*			X	X		X	
Hexapoda	Coleoptera	Nitidulidae	*Thalycra kiltoni*		X				X	
Hexapoda	Coleoptera	Nitidulidae	*Thalycra murrayi*		X				X	
Hexapoda	Coleoptera	Phalacridae	*pahalacrid (1)*	shining mold beetles		X			X	
Hexapoda	Coleoptera	Phalacridae	*Diplotaxis anxius*		X				X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Coleoptera	Scarabaeidae	*Diplotaxis brevicollis*		X				X	
Hexapoda	Coleoptera	Scarabaeidae	*Diplotaxis carbonata*		X				X	
Hexapoda	Coleoptera	Scarabaeidae	*Diplotaxis corvinus*		X				X	
Hexapoda	Coleoptera	Scarabaeidae	*Diplotaxis subangulata*		X	X			X	
Hexapoda	Coleoptera	Scarabaeidae	*Euphoria inda*	bumble flower beetle	X	X	X		X	
Hexapoda	Coleoptera	Scarabaeidae	*Ligyrus gibbosus*		X	X			X	
Hexapoda	Coleoptera	Scarabaeidae	*Orthophagus sp. (1)*			X			X	
Hexapoda	Coleoptera	Scarabaeidae	*Phyllophaga wickhami*		X		X		X	
Hexapoda	Coleoptera	Scarabaeidae	*Phyllophaga sp. (1)*		X		X		X	
Hexapoda	Coleoptera	Scarabaeidae	*Polyphylla decimlineata*		X		X		X	
Hexapoda	Coleoptera	Scarabaeidae	*Rhyssemus sp. (1)*			X			X	
Hexapoda	Coleoptera	Scarabaeidae	*Serica anthracina*		X		X		X	
Hexapoda	Coleoptera	Scarabaeidae	*Xylorhyctes jamaicensis*		X		X		X	
Hexapoda	Coleoptera	Scolytidae	*scolotid (1)*	bark beetles	X				X	
Hexapoda	Coleoptera	Silphidae	*Heterosilpha ramosa*		X	X	X		X	
Hexapoda	Coleoptera	Silphidae	*Nicrophorus guttulus*		X	X	X		X	
Hexapoda	Coleoptera	Staphylinidae	*staphylinid (5)*	rove beetles	X	X	X		X	
Hexapoda	Coleoptera	Tenebrionidae	*Blapstinus pimalis*			X			X	
Hexapoda	Coleoptera	Tenebrionidae	*Eleodes extricatus*		X	X			X	
Hexapoda	Coleoptera	Tenebrionidae	*Eleodes obscurus*		X				X	
Hexapoda	Coleoptera	Tenebrionidae	*Eleodes obsoletus*		X				X	
Hexapoda	Coleoptera	Tenebrionidae	*Eleodes sponsus*		X				X	
Hexapoda	Coleoptera	Tenebrionidae	*Eleodes tricostatus*			X			X	
Hexapoda	Coleoptera	Tenebrionidae	*Iphthiminus serratus*		X				X	
Hexapoda	Coleoptera	Tenebrionidae	*Neobaphion planipennis*		X				X	
Hexapoda	Coleoptera	Togidae	*Trox sp. (1)*		X	X	X		X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Diptera	Anthomyiidae	*Hemichlora sp. (1)*		X				X	
Hexapoda	Diptera	Anthomyiidae	*anthomyiid (4)*	anthomyiid flies	X	X	X		X	
Hexapoda	Diptera	Asilidae	*Backomyia sp. (1)*		X				X	
Hexapoda	Diptera	Asilidae	*Efferia argyrosoma*		X	X			X	
Hexapoda	Diptera	Asilidae	*Efferia kelloggi*			X	X		X	
Hexapoda	Diptera	Asilidae	*Proctocanthella leucopogon*			X			X	
Hexapoda	Diptera	Asilidae	*Proctocanthus micans*			X			X	
Hexapoda	Diptera	Asilidae	*Stenopogon inquinatus*			X			X	
Hexapoda	Diptera	Asilidae	*Stichopogon trifasciatus*		X				X	
Hexapoda	Diptera	Atharicidae	*Atherix sp. (1)*				X	X	X	
Hexapoda	Diptera	Bibionidae	*Bibio sp. (1)*				X		X	
Hexapoda	Diptera	Bombiliidea	*bombyliid (2)*	bee flies	X	X			X	
Hexapoda	Diptera	Calliphoridae	*Calliphora vicina*		X				X	
Hexapoda	Diptera	Calliphoridae	*calliphorid (2)*	blow flies		X	X		X	
Hexapoda	Diptera	Chironomidae	*chironomid (1)*	midge			X	X	X	
Hexapoda	Diptera	Chloropidae	*chloropid (2)*	frit flies		X	X		X	
Hexapoda	Diptera	Conopidae	*conopid (2)*	thick-headed flies		X			X	
Hexapoda	Diptera	Culicidae	*culicid (2)*	mosquitos			X	X	X	
Hexapoda	Diptera	Dolichopodidae	*dolichopodid (1)*	long-legged flies	X		X		X	
Hexapoda	Diptera	Drosophilidae	*Drosophila sp. (1)*				X		X	
Hexapoda	Diptera	Heleomyzidae	*Allomyella sp. (1)*		X				X	
Hexapoda	Diptera	Heleomyzidae	*heleomyzid (1)*	heleomyzid flies			X		X	
Hexapoda	Diptera	Micropesidae	*micropezid (1)*	stilt-legged flies	X				X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Diptera	Muscidae	*Musca sp. (3)*		X		X		X	
Hexapoda	Diptera	Muscidae	*muscid (1)*	muscid flies	X				X	
Hexapoda	Diptera	Mycetophilidae	*Mycoma sp. (1)*		X				X	
Hexapoda	Diptera	Pipunculidae	*pipunculid (1)*	big-headed flies		X			X	
Hexapoda	Diptera	Psycodidae	*psycodid (1)*				X		X	
Hexapoda	Diptera	Rhagionidae	*Chrysopilus sp. (1)*				X		X	
Hexapoda	Diptera	Sarcophagidae	*Amaurosaura sp. (1)*		X				X	
Hexapoda	Diptera	Sarcophagidae	*Orthellia sp. (1)*		X		X		X	
Hexapoda	Diptera	Sarcophagidae	*Plethochauta sp. (1)*				X		X	
Hexapoda	Diptera	Sarcophagidae	*Sercophaga aldrichi*			X	X		X	
Hexapoda	Diptera	Sarcophagidae	*sarchophagid (2)*	flesh flies		X	X		X	
Hexapoda	Diptera	Sciaridae	*sciarid (1)*	dark-winged fungus gnats			X		X	
Hexapoda	Diptera	Sciomyzidae	*sciomyzid (4)*	marsh flies			X		X	
Hexapoda	Diptera	Sepsidae	*Sepsis sp. (1)*		X		X		X	
Hexapoda	Diptera	Simulidae	*simulid (1)*	black flies			X	X	X	
Hexapoda	Diptera	Syrphidae	*Copestylum caudatum*			X	X		X	
Hexapoda	Diptera	Syrphidae	*syrphid (2)*	flower flies		X	X		X	
Hexapoda	Diptera	Tabanidae	*tabanid (3)*	deer flies			X		X	
Hexapoda	Diptera	Tachinidae	*Peleteria malleotla*				X		X	
Hexapoda	Diptera	Tachinidae	*tachinid (1)*	tachinid flies		X			X	
Hexapoda	Diptera	Tephritidae	*tephritid (2)*	fruit flies	X	X			X	
Hexapoda	Diptera	Therevidae	*therevid (2)*	stiletto flies	X				X	
Hexapoda	Diptera	Tipulidae	*tipulid (2)*	crane flies			X	X	X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Trichoptera	Brachycentridae	*Brachycentrus americanus**				X	X	X	
Hexapoda	Trichoptera	Hydropsychidae	*Hydropsyche sp. (1)*				X	X	X	
Hexapoda	Trichoptera	Lepidostomatidae	*Lepidostoma sp. (1)**				X	X	X	
Hexapoda	Lepidoptera	Arctiidae	*Bertholdia trigona*		X		X		X	
Hexapoda	Lepidoptera	Arctiidae	*Estimgene acraea*		X		X		X	
Hexapoda	Lepidoptera	Danaidae	*Danaus plexippus*	monarch butterfly	X	X	X		X	
Hexapoda	Lepidoptera	Geometridae	*Nacophora perfidaria*		X		X		X	
Hexapoda	Lepidoptera	Geometridae	*Pherne sp. (1)*				X		X	
Hexapoda	Lepidoptera	Geometridae	*Semiothisa colorata*		X		X		X	
Hexapoda	Lepidoptera	Hesperiidae	*Erynnis meridianus*	meridian duskywing	X	X			X	
Hexapoda	Lepidoptera	Hesperiidae	*Erynnis sp. (1)*		X	X			X	
Hexapoda	Lepidoptera	Lasiocampidae	*Malacosoma disstria*				X		X	
Hexapoda	Lepidoptera	Lycaenidae	*Hemiargus isola*	Reakert's blue	X	X			X	
Hexapoda	Lepidoptera	Lycaenidae	*Lycaeides idas*	northern blue		X			X	
Hexapoda	Lepidoptera	Lycaenidae	*Lycaeides melissa*	melissa blue	X	X			X	
Hexapoda	Lepidoptera	Lycaenidae	*Strymon melinus*	common hairstreak	X	X			X	
Hexapoda	Lepidoptera	Noctuidae	*Abagrotis trigona*				X		X	
Hexapoda	Lepidoptera	Noctuidae	*Euxoa sp. (1)*		X		X		X	
Hexapoda	Lepidoptera	Noctuidae	*Matigramma rubrosuffus*		X				X	
Hexapoda	Lepidoptera	Noctuidae	*Peridroma saucia*		X				X	
Hexapoda	Lepidoptera	Noctuidae	*Synedoida inepta*		X				X	
Hexapoda	Lepidoptera	Noctuidae	*Ululoche disticha*		X				X	
Hexapoda	Lepidoptera	Noctuidae	*Ululoche sp. (1)*				X		X	
Hexapoda	Lepidoptera	Notodontidae	*Furcula scolopendrina*				X		X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Lepidoptera	Nymphalidae	*Basilarchia weidemeyeri*	Weidemeyer's admiral			X		X	
Hexapoda	Lepidoptera	Nymphalidae	*Euptoieta claudia*	variegated fritillary		X			X	
Hexapoda	Lepidoptera	Nymphalidae	*Nymphalis antiopa*	mourning cloak			X		X	
Hexapoda	Lepidoptera	Nymphalidae	*Thessalia fulvia*	fulvous checker-spot		X			X	
Hexapoda	Lepidoptera	Nymphalidae	*Vanessa cardui*	painted lady		X			X	
Hexapoda	Lepidoptera	Papilionidae	*Papilio bairdii*	Baird's swallowtail	X	X			X	
Hexapoda	Lepidoptera	Papilionidae	*Papilio multicaudata*	two-tailed swallowtail	X		X		X	
Hexapoda	Lepidoptera	Papilionidae	*Papilio rutulus rutulus*	W. tiger swallowtail			X		X	
Hexapoda	Lepidoptera	Pieridae	*Colias eurytheme*	orange sulfur		X			X	
Hexapoda	Lepidoptera	Pieridae	*Nathalis iole*	dainty sulfur	X	X			X	
Hexapoda	Lepidoptera	Pieridae	*Neophasia menapia menapia*	pine white	X				X	
Hexapoda	Lepidoptera	Pieridae	*Pontia occidentalis occidentalis*	W. white		X			X	
Hexapoda	Lepidoptera	Pieridae	*Pontia protodice*	checkered white	X	X			X	
Hexapoda	Lepidoptera	Saturniidae	*Automeris io*	io moth			X		X	
Hexapoda	Lepidoptera	Saturniidae	*Coloradia pandora davisi*	pandora moth	X		X		X	
Hexapoda	Lepidoptera	Saturniidae	*Glovaria arizonensis*	glovaria moth	X		X		X	
Hexapoda	Lepidoptera	Satyridae	*Cercyonis pegala*	wood nymph	X				X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	**Order**	**Family**	**Scientific Name**	**Common Name**	**Wood-land**	**Grass-land**	**Riparian**	**Aquatic**	**Observed**	**Collection**
Hexapoda	Lepidoptera	Sphingidae	*Hyles lineata*	white-lined sphinx	X	X	X		X	
Hexapoda	Lepidoptera	Sphingidae	*Manduca quinquinmaculata*	five-spotted hawkmoth			X		X	
Hexapoda	Hymenoptera	Anthophoridae	*Melissocles confusa*			X			X	
Hexapoda	Hymenoptera	Anthophoridae	*anthophorid (1)*	digger bees		X			X	
Hexapoda	Hymenoptera	Apidae	*Apis mellifera*	honey bee	X	X	X		X	
Hexapoda	Hymenoptera	Apidae	*Bombus affinius*		X	X			X	
Hexapoda	Hymenoptera	Apidae	*Bombus fervidus*		X	X			X	
Hexapoda	Hymenoptera	Apidae	*Bombus nevadensis*		X	X			X	
Hexapoda	Hymenoptera	Braconidae	*braconid (2)*	braconid wasps			X		X	
Hexapoda	Hymenoptera	Chrysididae	*Omalus sp. (1)*				X		X	
Hexapoda	Hymenoptera	Eumenidae	*eumanid (1)*	eumenid wasps	X				X	
Hexapoda	Hymenoptera	Formicidae	*Camponotus vicinus*	carpenter ant	X				X	
Hexapoda	Hymenoptera	Formicidae	*Crematogaster cerasi*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Dorymyrmex insana*	army ant	X				X	
Hexapoda	Hymenoptera	Formicidae	*Formica fusca*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Formica laeviceps*		X	X			X	
Hexapoda	Hymenoptera	Formicidae	*Formica neoclara*		X		X		X	
Hexapoda	Hymenoptera	Formicidae	*Formica obtusopilosa*			X			X	
Hexapoda	Hymenoptera	Formicidae	*Formica podzolica*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Lasius crypticus*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Leptothorax crassipilis*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Manica mutica*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Monomorium minimum*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Myrmecocystus mendax*		X				X	

Class	Order	Family	Scientific Name	Common Name	Habitat: Wood-land	Grass-land	Riparian	Aquatic	Parmenter and Lightfoot (1996)[1] Observed	Museum of South-western Biology[2] Collection
Hexapoda	Hymenoptera	Formicidae	*Myrmecocystus mexicanus*	honeypot ant	X				X	
Hexapoda	Hymenoptera	Formicidae	*Myrmica emeryana*				X		X	
Hexapoda	Hymenoptera	Formicidae	*Myrmica incompleta*				X		X	
Hexapoda	Hymenoptera	Formicidae	*Myrmica lobifrons*		X	X			X	
Hexapoda	Hymenoptera	Formicidae	*Neivamyrmex nigrescens*	army ant	X				X	
Hexapoda	Hymenoptera	Formicidae	*Pheidole sp. (1)*		X				X	
Hexapoda	Hymenoptera	Formicidae	*Pogonomyrmex occidentalis*	W. harvester ant		X			X	
Hexapoda	Hymenoptera	Formicidae	*Tapinoma sessile*		X				X	
Hexapoda	Hymenoptera	Halictidae	*Agapostemon texana*			X			X	
Hexapoda	Hymenoptera	Ichneumonidae	*ichneumonid (3)*	Ichneumon wasps	X	X			X	
Hexapoda	Hymenoptera	Megachilidae	*Anthidium maculifrons*			X			X	
Hexapoda	Hymenoptera	Megachilidae	*Megachile sp. (1)*		X	X			X	
Hexapoda	Hymenoptera	Mutillidae	*Dasymutilla sp. (1)*		X	X			X	
Hexapoda	Hymenoptera	Pompilidae	*pompilid (4)*	spider wasps	X	X			X	
Hexapoda	Hymenoptera	Scoliidae	*Triscolia ardens*				X		X	
Hexapoda	Hymenoptera	Specidae	*Amophila azteca*		X	X			X	
Hexapoda	Hymenoptera	Specidae	*Amophila pruinosa*			X			X	
Hexapoda	Hymenoptera	Specidae	*Amophila sp. (1)*		X	X			X	
Hexapoda	Hymenoptera	Specidae	*Bembix sp. (1)*		X	X			X	
Hexapoda	Hymenoptera	Specidae	*Chalybion californicum*	blue mud-dauber			X		X	
Hexapoda	Hymenoptera	Specidae	*Sceliphron caementarium*	mud-dauber			X		X	
Hexapoda	Hymenoptera	Tenthredinidae	*tenthredinid (1)*	sawflies			X		X	
Hexapoda	Hymenoptera	Tiphiidae	*Brachycistis sp. (1)*		X	X			X	
Hexapoda	Hymenoptera	Vespidae	*Mischocyttarus flavitarsis*	paper wasp	X		X		X	

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of South-western Biology[2]
Class	Order	Family	Scientific Name	Common Name	Wood-land	Grass-land	Riparian	Aquatic	Observed	Collection
Hexapoda	Hymenoptera	Vespidae	*Vespula pennsylvanica*	yellowjacket	X		X		X	

* An asterisk associated with the Scientific Name indicates the same observation is included in the benthic invertebrate table.
(n) A number in parenthesis next to the Scientific Name indicates the number of taxon included in the record of observation.
[1] Parmenter and Lightfoot. 1996. A field survey of the faunal resources of the Pecos Unit, Pecos National Historical Park, Pecos, New Mexico.
[2] Museum of Southwestern Biology. 2010. Arctos: Multi-Institution, Multi-Collection Museum Database. [http://arctos.database.museum/SpecimenSearch.cfm]. Last accessed 2010-06-30.

Table E-2. Mollusc species in Pecos National Historical Park

					Habitat				Parmenter and Lightfoot (1996)[1]	Museum of Southwestern Biology[2]
Class	Order	Family	Scientific Name	Common Name	Woodland	Grassland	Riparian	Aquatic	Observed	Collection
Gastropoda	Lymnophila	Lymnaeidae	*Lymnea sp. (1)*					X	X	
Gastropoda	Lymnophila	Physidae	*Physa virgata*					X	X	
Gastropoda	Stylomanatophora	Polygyridae	*Ashmunella thompsoniana*				X		X	

* An asterisk associated with the Scientific Name indicates the same observation is included in the benthic invertebrate table.
(n) A number in parenthesis next to the Scientific Name indicates the number of taxon included in the record of observation.
[1] Parmenter and Lightfoot. 1996. A field survey of the faunal resources of the Pecos Unit, Pecos National Historical Park, Pecos, New Mexico.
[2] Museum of Southwestern Biology. 2010. Arctos: Multi-Institution, Multi-Collection Museum Database. [http://arctos.database.museum/SpecimenSearch.cfm]. Last accessed 2010-06-30.

Appendix F: Bird Species

Table F-1. Bird species in Pecos National Historical Park

Common Name	Scientific Name	Habitat Type			
		Grassland	Piñon-Juniper	Ponderosa Pine	Riparian
Canada Goose	*Branta canadensis*				X
Mallard	*Anas platyrhynchos*				X
Northern Bobwhite	*Colinus virginianus*				X
Great Blue Heron	*Ardea herodias*	X			X
Green Heron	*Butorides virescens*				X
Turkey Vulture	*Cathartes aura*	X		X	X
Cooper's Hawk	*Accipiter cooperii*				X
Red-tailed Hawk	*Buteo jamaicensis*		X		X
American Kestrel	*Falco sparverius*				X
Killdeer	*Charadrius vociferus*	X			
Spotted Sandpiper	*Actitis macularius*				X
Eurasian Collared-Dove	*Streptopelia decaocto*	X	X	X	X
White-winged Dove	*Zenaida asiatica*		X		X
Mourning Dove	*Zenaida macroura*	X	X	X	X
Great Horned Owl	*Bubo virginianus*				X
Lesser Nighthawk	*Chordeiles acutipennis*				X
Common Nighthawk	*Chordeiles minor*	X			X
Black-chinned Hummingbird	*Archilochus alexandri*	X	X		X
Broad-tailed Hummingbird	*Selasphorus platycercus*	X	X		X
Ladder-backed Woodpecker	*Picoides scalaris*				X
Downy Woodpecker	*Picoides pubescens*				X
Hairy Woodpecker	*Picoides villosus*		X		X
Northern Flicker	*Colaptes auratus*	X	X	X	X
Olive-sided Flycatcher	*Contopus cooperi*		X		X
Western Wood-pewee	*Contopus sordidulus*	X	X	X	X
Willow Flycatcher	*Empidonax traillii*				X
Gray Flycatcher	*Empidonax wrightii*	X	X		X
Cordilleran Flycatcher	*Empidonax occidentalis*		X		X
Black Phoebe	*Sayornis nigricans*				X
Say's Phoebe	*Sayornis saya*	X			
Ash-throated Flycatcher	*Myiarchus cinerascens*	X	X		X
Cassin's Kingbird	*Tyrannus vociferans*	X	X	X	X
Western Kingbird	*Tyrannus verticalis*	X	X		
Plumbeous Vireo	*Vireo plumbeus*	X	X	X	X
Warbling Vireo	*Vireo gilvus*	X	X		X
Steller's Jay	*Cyanocitta stelleri*		X		X
Western Scrub-jay	*Aphelocoma californica*	X	X	X	X
Pinyon Jay	*Gymnorhinus cyanocephalus*	X	X	X	X
American Crow	*Corvus brachyrhynchos*	X	X		X
Common Raven	*Corvus corax*	X	X	X	X
Violet-green Swallow	*Tachycineta thalassina*	X	X		X
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	X	X		X
Bank Swallow	*Riparia riparia*				X
Cliff Swallow	*Petrochelidon pyrrhonota*	X	X		X
Barn Swallow	*Hirundo rustica*	X	X		X

Common Name	Scientific Name	Habitat Type			
		Grassland	Piñon-Juniper	Ponderosa Pine	Riparian
Black-capped Chickadee	*Poecile atricapillus*		X		
Mountain Chickadee	*Poecile gambeli*	X	X		X
Juniper Titmouse	*Baeolophus ridgwayi*	X	X	X	X
Bushtit	*Psaltriparus minimus*	X	X		X
White-breasted Nuthatch	*Sitta carolinensis*	X	X		X
Rock Wren	*Salpinctes obsoletus*				X
Canyon Wren	*Catherpes mexicanus*		X		X
Bewick's Wren	*Thryomanes bewickii*		X	X	X
House Wren	*Troglodytes aedon*		X		X
Blue-gray Gnatcatcher	*Polioptila caerulea*				X
Western Bluebird	*Sialia mexicana*	X			X
Mountain Bluebird	*Sialia currucoides*	X			X
American Robin	*Turdus migratorius*	X	X	X	X
Gray Catbird	*Dumetella carolinensis*				X
Northern Mockingbird	*Mimus polyglottos*	X	X	X	X
Cedar Waxwing	*Bombycilla cedrorum*				X
Orange-crowned Warbler	*Vermivora celata*				X
Virginia's Warbler	*Vermivora virginiae*		X		X
Yellow Warbler	*Dendroica petechia*		X		X
Yellow-rumped Warbler	*Dendroica coronata*		X		X
Black-throated Gray Warbler	*Dendroica nigrescens*	X	X		X
Grace's Warbler	*Dendroica graciae*		X		
MacGillivray's Warbler	*Oporornis tolmiei*		X		X
Common Yellowthroat	*Geothlypis trichas*				X
Wilson's Warbler	*Wilsonia pusilla*		X		X
Yellow-breasted Chat	*Icteria virens*		X	X	X
Green-tailed Towhee	*Pipilo chlorurus*				X
Spotted Towhee	*Pipilo maculatus*	X	X	X	X
Canyon Towhee	*Pipilo fuscus*	X			
Rufous-crowned Sparrow	*Aimophila ruficeps*		X		
Chipping Sparrow	*Spizella passerina*	X	X	X	X
Vesper Sparrow	*Pooecetes gramineus*	X	X		
Lark Sparrow	*Chondestes grammacus*	X		X	
Song Sparrow	*Melospiza melodia*	X	X		X
White-crowned Sparrow	*Zonotrichia leucophrys*				X
Dark-eyed Junco	*Junco hyemalis*				X
Hepatic Tanager	*Piranga flava*	X	X	X	X
Western Tanager	*Piranga ludoviciana*		X		X
Black-headed Grosbeak	*Pheucticus melanocephalus*	X	X	X	X
Blue Grosbeak	*Passerina caerulea*		X		X
Indigo Bunting	*Passerina cyanea*				X
Red-winged Blackbird	*Agelaius phoeniceus*	X			X
Western Meadowlark	*Sturnella neglecta*	X	X		X
Brewer's Blackbird	*Euphagus cyanocephalus*	X	X		X
Great-tailed Grackle	*Quiscalus mexicanus*				X
Brown-headed Cowbird	*Molothrus ater*	X	X		X
Bullock's Oriole	*Icterus bullockii*	X			X
House Finch	*Carpodacus mexicanus*	X	X	X	X
Red Crossbill	*Loxia curvirostra*	X	X		X

Common Name	Scientific Name	Habitat Type			
		Grassland	Piñon-Juniper	Ponderosa Pine	Riparian
Pine Siskin	*Spinus pinus*	X		X	
Lesser Goldfinch	*Spinus psaltria*	X	X		X
American Goldfinch	*Spinus tristis*				X

Appendix G: Special Status Species

Table G-1. Special status species template used for National Environmental Policy Act compliance, Santa Fe County (Glorieta Battlefield Unit)

Pecos National Historical Park

Special Status Species Template Used for NEPA Compliance

Santa Fe County (Glorieta Battlefield Unit)

Federal and State of New Mexico Special Status Species - Santa Fe County **December 8, 2009**

AGENCY STATUS DEFINITIONS

U.S. Fish and Wildlife Service (FWS)

(E) Endangered - A species in danger of extinction throughout all or a significant portion of its range.
(T) Threatened - A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
(C) Candidate - Candidate Species (taxa for which the FWS has sufficient information to propose that they be added to list of endangered and threatened species, but the listing action has been precluded by other higher priority listing activities).
(P) Proposed - Any species of fish, wildlife or plant that is proposed in the Federal Register to be listed under section 4 of the Act. This could be either proposed for endangered or threatened status.
(S) Species of Concern - A taxon for which further biological research and field study are needed to resolve their conservation status OR are considered sensitive, rare, or declining on lists maintained by Natural Heritage Programs, State wildlife agencies, other Federal agencies, or professional/academic scientific societies.

State of New Mexico

(e) Endangered - The taxon is listed as threatened or endangered under provisions of the Federal Endangered Species Act (16 U.S.C. Sections 1531 et seq.), or is considered proposed under the tenets of the act [10-29-85,]; or the taxon is a rare plant across its range within the state, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in New Mexico. [10-29-85, 8-31-95]
(t) Threatened - As defined in the Wildlife Conservation Act [17-2-37 to 17-2-46 NMSA (New Mexico Statutes Annotated) 1978]: "THREATENED SPECIES"' means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range in New Mexico; the term may also include any species of fish and wildlife appearing on the United States list of endangered native and foreign fish and wildlife as set forth in Section 4 of the Endangered Species Act of 1973 as threatened species..
(s) Sensitive taxa (informal) - Taxa which deserve special consideration in management and planning, and are NOT listed threatened or endangered by the state of New Mexico. These may include taxa that are listed as threatened, endangered or sensitive by other agencies; taxa with limited protection; and taxa without any legal protection.
(soc) Species of Concern - A New Mexico plant species, which should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

STATUS: New Mexico t – Threatened, e – Endangered, s – Sensitive, soc – Species of Concern
Federal T – Threatened, E – Endangered, C – Candidate, P – Proposed, S – Species of Concern

PROJECT AREA HABITAT: HN – Habitat NOT found in Project Area; HF – Habitat FOUND in project area

Affect: N – No Effect, NL – If present, likely to affect but not likely to adversely effect, LA – Likely to adversely effect

	Species	Status	Species Habitat	Unit Habitat	Affect	Notes (Survey Results) *Results listed below apply generally to most proposed actions that may take place within the unit, however results in this column must be reviewed and adjusted to each proposed action on an individual basis*
1	Bat, Big-eared, Townsend's, Pale *Corynorhinus townsendii pallescens*	s/S	Semi-desert shrublands, pinon-juniper woodlands, and open montane forests. Frequently associated with caves and abandoned mines for day roosts and hibernacula but will also use abandoned buildings and crevices on rock cliffs for refuge.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
2	Bat, Myotis, Fringed *Myotis thysanodes thysanodes*	s	Mountainous pine, oak, and pinon-juniper to desert scrub but seem to prefer grassland areas at intermediate elevations. Roost in caves, mine tunnels, rock crevices, and old buildings. Extensive use of both live and dead trees in pinyon-juniper habitats.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
3	Bat, Myotis, Long-legged *Myotis volans interior*	s	Inhabitant of forested areas, where it prefers high, open woods and mountainous terrain. Rare in the Trans-Pecos. Probably only a summer resident. Roosts in buildings, rock crevices, and trees.	HN	N	Unlikely that the proper roosting habitat is present in the unit. Myotis volans is usually found at higher elevations in ponderosa pine and higher vegetation types.
4	Bat, Myotis, Small-footed, W. *Myotis ciliolabrum melanorhinus*	s	Relatively common in ponderosa pine forests and pinon-juniper woodlands. Roost in trees, buildings, rock face crevices, and ground fissures. Caves and mines used as night roosts. Probably hibernate singly in local mines and caves. Commonly associated with willows along stream sides in cottonwood and rabbitbrush riparian habitats.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.

5	Bat, Myotis, Yuma *Myotis yumanensis yumanensis*	s	Usually associated with permanent sources of water, typically rivers and streams. Occurs in riparian, arid shrublands and deserts, and forest areas. Roost in bridges, buildings, cliff crevices, caves, mines, & trees.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. Needs permanent water nearby, which is not present at the creek If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
6	Blazing Star, Springer’s *Mentzelia springeri*	soc	Volcanic pumice and unconsolidated pyroclastic ash in piñon-juniper woodland and lower montane coniferous forest; 2,150-2,450 m (7,000-8,000 ft).	HN	N	Habitat not present at this site.
7	Canadian Lynx *Lynx canadensis*	C	Lynx usually live in mature boreal forests with dense undergrowth but can also be found in more open forests, rocky areas or tundra.	HN	N	Habitat not present at this site.
8	Chub, Rio Grande *Gila pandora*	s	Cool water reaches the Rio Grande & Pecos Rivers (& tributaries) in northern NM.	HN	N	Habitat not present at this site.
9	Cholla, Santa Fe *Opuntia viridiflora*	e/S	The Santa Fe cholla is known from only three areas, Fort Marcy Park in Santa Fe, near Pojoaque, and near Chimayo	HF	NL	Surveys conducted in 2007 and 2009 by research personnel from Natural Heritage New Mexico failed to identify the presence of this species in this unit.
10	Cuckoo, Yellow-billed *Coccyzus americanus*	s/C	The western yellow-billed cuckoo is an obligate riparian nester—they only breed in streamside forests, especially those dominated by willow and cottonwood stands. Habitat occurs within relatively large patches, usually 25-100 acres in extent.	HN	N	Habitat in the park is marginal because of the relatively small riparian land area and little habitat of this type exists in the project area. Due to the absence of suitable habitat for this species, the proposed action will not affect this species or its habitat.
11	Dodder, Santa Fe *Cuscuta fasciculata*	soc	Unknown; presumably in disturbed areas on other weeds, at about 7,000 ft. Species of *Cuscuta* are parasites and are therefore dependent on their hosts for survival.	unknown	unknown	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.

12	Eagle, Bald *Haliaeetus leucocephalus alascanus*	t	Winter residents and occasional nesters in New Mexico. Requires fish-producing waters and large riparian trees to successfully nest and produce young. During the winter months they congregate in areas with high fish densities and waterfowl. The Bald Eagle is known to winter in the Pecos River drainage and individuals have been seen along the Pecos River in the Park in winter months. Bald eagles may use large cottonwood trees in the riparian areas along the Pecos River or Glorieta Creek.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
13	Falcon, Peregrine *Falco peregrinus anatum*	t/S	Douglas fir, Hemlock-Sitka spruce, redwood, ponderosa pine, larch/white pine, lodgepole pine, fir-spruce, aspen (hardwoods), chaparral, and pinyon-juniper forest types. Breed on cliffs in wooded/forested habitats, with large "gulfs" of air nearby where they can forage. Hunt in croplands, meadows, river bottoms, marshes and lakes.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
14	Falcon, Peregrine, Arctic *Falco peregrinus tundrius*	t/S	Douglas fir, Hemlock-Sitka spruce, redwood, ponderosa pine, larch/white pine, lodgepole pine, fir-spruce, aspen (hardwoods), chaparral, and pinyon-juniper forest types. Breed on cliffs in wooded/forested habitats, with large "gulfs" of air nearby where they can forage. Hunt in croplands, meadows, river bottoms, marshes and lakes.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
15	Ferret, Black-footed *Mustela nigripes*	E	Black-footed ferrets are obligates of prairie dog towns. No wild populations are known to reside in New Mexico. No prairie dog towns are located in or near the park, therefore there is no potential for ferret habitat in the Park.	HN	N	Due to the absence of suitable habitat for this species, the proposed action will not affect the Black-footed Ferret or its habitat.
16	Flycatcher, Willow, SW. *Empidonax traillii extimus*	e/E	The southwestern willow flycatcher breeds in dense riparian habitats along rivers, streams, or other wetlands. The vegetation can be dominated by dense growths of willows (*Salix* sp.) or other shrubs and medium-sized trees. One of the most important characteristics of the habitat appears to be the presence of dense vegetation, usually throughout all vegetation layers present.	HN	NL	The park would support marginal habitat along riparian corridors for the species, however the unit contains little of this habitat. Due to the absence of suitable habitat for this species, the proposed action will not affect the Southwestern willow flycatcher or its habitat.

17	Fox, Red *Vulpes vulpes fulva; macroura*	s	Common in open woodlands, pasturelands, riparian, and agricultural lands. Favors mixture of vegetation types occurring in small mosaics with good development of ground cover. Do well on margins of urbanized areas. Common in open space and other undeveloped areas adjacent to cities.	HF	NL	Not likely present in this habitat. Status and threats to the red fox are so poorly known in the state that little can be said as to their need for special protection. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
18	Goshawk, Northern *Accipiter gentilis atricapillus; apache*	s/S	Locally in mature, closed canopied coniferous forests of mountains and high mesas. Known to use Juniper and Wetland habitats. Large trees (> 18 " dia.) supply large snags and downed logs important to Goshawk prey, perches and nest sites.	HN	NL	Habitat not present at this site.
19	Hummingbird, Violet-crowned *Amazilia violiceps ellioti*	t	Riparian woodlands at low to moderate elevations. In New Mexico, the violet-crowned hummingbird seeks only well-developed riparian areas of the Guadalupe Canyon in summer	HN	N	Habitat not present at this site.
20	Larkspur, Sapello Canyon *Delphinium sapellonis*	soc	Canyon bottoms and aspen groves in lower and upper montane coniferous forest; 2,450-3,500 m (8,000-11,500 ft).	HN	N	Habitat not present at this site.
21	Marmot, Yellow-bellied *Marmota flaviventris luteola; obscura*	s	Common above 8,000 ft in alpine tundra, subalpine and montane meadows. Range into foothills and canyon country on either side of mountains where rock outcrops or boulders exist along with suitably productive and succulent vegetation.	HN	N	Habitat not present at this site or elevation.
22	Marten, American *Martes americana origenes*	t	Spruce-fir forests and marginal Alpine habitat.	HN	N	Habitat not present at this site.
23	Milk vetch, cyanic *Astragalus cyaneus* A. Gray	soc	Dry hillsides and gullied banks, in sandy or gravelly soils, commonly in piñon-juniper woodland; 6,900-7,300 ft. This plant is relatively common within its limited range.	HF	NL	Presence is possible. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
24	Milk vetch, Flint Mountains *Astragalus siliceus*	soc	Calcareous knolls and rocky areas in rolling shortgrass prairie; 6,000-6,500 ft.	HN	N	Habitat not present at this site.

25	Milk vetch, Santa Fe *Astragalus feensis*	soc	Sandy benches and gravelly hillsides in piñon-juniper woodland or plains-mesa grassland; 5,100-6,000 ft. Relatively common within its range.	HN	N	Habitat not present at this site.
26	Minnow, Rio Grande Silvery *Hybognathus amarus*	E	The Rio Grande silvery minnow has historically been distributed over thousands of miles of the Rio Grande and Pecos Rivers. Today, somewhere between 70 - 95% of this last remnant population of silvery minnow is located in the short stretch of the Rio Grande River between San Acacia Dam and Elephant Butte Reservoir.	HN	N	This habitat does not occur within the unit. Due to the absence of suitable habitat for this species, the proposed action will not affect the Rio Grande Silvery Minnow or its habitat.
27	Mountainsnail, Socorro *Oreohelix neomexicana*	s	Occurs in vicinity of limestone cliffs in thick, moist litter derived mainly from fallen leaves of pinyon pine, one-seeded juniper, and various shrubs.	HN	N	Habitat not present at this site.
28	Mouse, New Mexican Meadow Jumping *Zapus hudsonius luteus*	C	Species lives in various habitats that have some herbaceous cover, but moist grassland is preferred and heavily wooded areas are avoided. Grassy fields and thick vegetated areas bordering streams, ponds, or marshes generally support greater numbers. Mice may prefer habitats with high humidity. It nests in dry soils, but uses moist, streamside, dense riparian / wetland vegetation up to an elevation of about 8,000 feet. It appears to only utilize two riparian community types: 1) beaked sedge and reed canary grass alliances; and 2) riparian areas along perennial streams that are composed of willows and alders. It especially uses microhabitats of patches or stringers of tall dense sedges on moist soil along the edge of permanent water.	HN	N	Suitable habitat for the New Mexican meadow jumping mouse is not located within the unit; therefore the proposed action will not affect the New Mexican meadow jumping mouse or its habitat.
29	Muhly, Navaho *Muhlenbergia arsenei*	soc	On limestone rock outcrops in piñon-juniper woodland; 4,600-6,500 ft.	HN	N	Habitat not present at this site.
30	Owl, Boreal *Aegolius funereus*	t	Primarily a bird of high elevation, mature and old-growth spruce-fir forests.	HN	N	Habitat not present at this site.

31	Owl, Spotted, Mexican *Strix occidentalis lucida*	s / T	Nesting and roosting habitat is composed of mixed conifer and/or Douglas-fir vegetation types. Understory characteristics demonstrate multi-layered, uneven-aged conifer and hardwoods ranging in age from 20-70 years. Live trees are 8 inches dbh or greater with at least 40% canopy closure and are located on slopes of 40% or greater. Dead and down attributes include a variety of age class of snags and presence of large down logs.	HN	N	Suitable habitat for the Mexican spotted owl is not located within the unit; therefore the proposed action will not affect the Mexican spotted owl or its habitat.
32	Owl, Western Burrowing *Athene cunicularia hypugaea*	S	Breeds in North America and spends its non-breeding time primarily south of the United States. Uncommon to fairly common in open grassland areas, particularly in or adjacent to white-tailed prairie dog towns. Nest and roost in burrows, such as those excavated by prairie dogs (*Cynomys* spp.). Burrowing owls in New Mexico inhabit grasslands and open shrubland and woodland at lower (2800 - 5500 ft) and middle (5000 - 7500 ft) elevations.	HF	NL	Habitat within the unit Unlikely that the proper roosting habitat is present in the unit near NM Highway 50 could support this species. No suitable burrows, owls or owl sign were observed during a 2008 survey performed by Marron & Associates, Inc. (Marron 2008) and no prairie dog towns exist in or near the park, therefore the proposed action is not likely to affect the Western Burrowing Owl or its habitat.
33	Peaclam, Lilljeborg's *Pisidium lilljeborgi*	t	Characteristic of lakes, occurring at higher latitudes and altitudes. Surrounding habitats include rocky talus, stands of Engelmann spruce and subalpine fir, and grass-sedge-forb communities.	HN	N	Habitat not present at this site.
34	Plover, Mountain *Charadrius montanus*	s/S	Strongly associated with sites of heaviest grazing pressure to the point of excessive surface disturbance. Attracted to man-made landscapes (e.g., sod farm, cultivated fields) that mimics natural habitat associations, or sites with grassland characteristics (alkali flats, other agricultural lands). Nesting sites dominated by short vegetation and bare ground, often with manure piles or rocks nearby.	HN	N	Habitat not present at this site.
35	Prairie Dog, Gunnison's *Cynomys gunnisoni gunnisoni*	s	Grasslands from low valleys to montane meadows.	HF	N	There are no prairie dog towns in or near the park.
36	Ptarmigan, White-tailed *Lagopus leucurus altipetens*	e	Alpine tundra and timberline habitats, which in New Mexico are mainly above 10000 feet.	HN	N	Habitat not present at this site.

37	Raspberry, Santa Fe *Rubus aliceae*	soc	Montane coniferous forest with *Pinus flexilis* and *Juniperus communis*; other parameters unknown.	HN	N	Habitat not present at this site.
38	Ringtail *Bassariscus astutus arizonensis*	s	Montane habitats, but also in lowlands in rough, rocky country. Sycamore, and rabbitbrush riparian habitats and in the steep cliffs and arroyos that drain to the east. Particularly associated with rocky habitat types in New Mexico.	HF	NL	Ringtail has been documented in the park. If present at the project site, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
39	Shrike, Loggerhead *Lanius ludovicianus excubitorides*	s	Agricultural lands on prairies to montane meadows, nesting in sagebrush areas, desert scrub, pinyon-juniper woodlands, and woodland edge. Open country interspersed with improved pastures, grasslands, and hayfields is primary shrike habitat throughout its range.	HF	NL	Presence is possible, but usually found in more grassland, shrubland habitats. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
40	Skunk, Spotted Western *Spilogale gracilis*	s	Sycamore, cottonwood, and rabbitbrush riparian habitats.	HF	NL	Presence is possible. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
41	Stickleaf, Todilto *Mentzelia todiltoensis*	soc	Outcrops of gypsum in the Todilto Formation; 5,600-5,840 ft.	HN	N	Habitat not present at this site.
42	Stickseed, New Mexico *Hackelia hirsuta*	soc	Dry sites of shaley or igneous soils in lower to upper montane coniferous forest, usually with Gambel oak; 2,350-3,100 m (7,700-10,200 ft).	HN	N	Habitat not present at this site.
43	Sucker, Rio Grande *Catostomus plebeius*	S	Found in the Rio Grande, the tributary streams of the Rio Grande, and the Rio Hondo (of the Pecos drainage) along with its headwater tributary streams. It lives in small to large, middle elevation (2000-2600 m) streams usually over gravel and/or cobble, but also in backwaters and in pools below riffles. It is rarely found in waters with heavy loads of silt and organic detritus	HN	N	Numerous fish surveys within the park have failed to confirm the presence of the Rio Grande sucker. Habitat not present in this unit.

44	Sparrow, Baird's *Ammodramus bairdii*	t/S	Migrant in NM, occurring primarily in the eastern plains and southern lowlands, & may winter in some locales. Grassland species.	HN	N	Habitat not present at this site.
45	Swift, Black *Cypseloides niger borealis*	s	High inaccessible cliffs with exposed rock near permanent water. Forage aerially over all wetland and aquatic types.	HN	N	Habitat not present at this site.
46	Trout, Rio Grande Cutthroat *Oncorhynchus clarki virginalis*	C	Rio Grande cutthroat trout lives in clean, cold mountain streams, preferably of moderate (6 % or less) gradient. *Virginalis* typically requires high oxygen content in its stream habitat, low summer water temperatures, and clean gravel for its spawning beds. It requires riffle areas for food production and habitat for young, and pools for overwintering, and summer rest, and the number of pools and riffles should be roughly equal. Vegetation in the riparian zone needs to be abundant enough to provide shade and cover.	HN	N	Numerous fish surveys within the park have failed to confirm the presence of the Rio Grande cutthroat in the Pecos River and suitable habitat may not be present. No suitable habitat exists on Glorieta Creek. Due to the absence of suitable habitat for this species within the park, the proposed action will not affect the Rio Grande cutthroat trout or its habitat.
47	Tern, Least *Sterna antillarum athalassos*	e	Colonially-nesting water bird. Prefer a flat, sandy substrate essentially devoid of vegetation, on which they place their nest scrapes. Provision of proper breeding conditions is essential, this involving level, sparsely-vegetated ground near water, relative freedom from terrestrial predators and human disturbance, and an adequate prey base.	HN	N	Habitat not present at this site.
48	Tufted sand verbena *Abronia bigelovii*	soc	Hills and ridges of gypsum in the Todilto Formation, 5,700-7,400 f).	HN	N	Habitat not present at this site.
49	Vireo, Gray *Vireo vicinior*	t	Open woodlands/shrublands featuring evergreen trees and shrubs of various kinds. In NM, the gray vireo is most often found in arid juniper woodlands on foothills and mesas, these most often associated with oaks and usually in habitat with a well-developed grass component Occurs in NM only in the warmer months (April-September).	HF	NL	Habitat not present at the Pigeons Ranch Sub Unit. At Canyoncito Sub Unit, presence is possible. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
50	Vole, Heather *Phenacomys intermedius intermedius*	s	Stands of spruce, fir, lodgepole, aspen, and ponderosa pine, and grassy meadows in montane forests, subalpine forests, and alpine tundra	HN	N	Habitat not present at this site.

Table G-2. Special status species template used for National Environmental Policy Act compliance, San Miguel County (Pecos Unit)

Pecos National Historical Park

Special Status Species Template Used for NEPA Compliance

San Miguel County (Pecos Unit)

Federal and State of New Mexico Special Status Species – San Miguel County

January 17, 2011

AGENCY STATUS DEFINITIONS

U.S. Fish and Wildlife Service (FWS)

(E) Endangered - A species in danger of extinction throughout all or a significant portion of its range.
(T) Threatened - A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
(C) Candidate - Candidate Species (taxa for which the FWS has sufficient information to propose that they be added to list of endangered and threatened species, but the listing action has been precluded by other higher priority listing activities).
(P) Proposed - Any species of fish, wildlife or plant that is proposed in the Federal Register to be listed under section 4 of the Act. This could be either proposed for endangered or threatened status.
(S) Species of Concern - A taxon for which further biological research and field study are needed to resolve their conservation status OR are considered sensitive, rare, or declining on lists maintained by Natural Heritage Programs, State wildlife agencies, other Federal agencies, or professional/academic scientific societies.

State of New Mexico

(e) Endangered - The taxon is listed as threatened or endangered under provisions of the Federal Endangered Species Act (16 U.S.C. Sections 1531 et seq.), or is considered proposed under the tenets of the act [10-29-85,]; or the taxon is a rare plant across its range within the state, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in New Mexico. [10-29-85, 8-31-95]
(t) Threatened - As defined in the Wildlife Conservation Act [17-2-37 to 17-2-46 NMSA (New Mexico Statutes Annotated) 1978]: "THREATENED SPECIES"' means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range in New Mexico; the term may also include any species of fish and wildlife appearing on the United States list of endangered native and foreign fish and wildlife as set forth in Section 4 of the Endangered Species Act of 1973 as threatened species..
(s) Sensitive taxa (informal) - Taxa which deserve special consideration in management and planning, and are NOT listed threatened or endangered by the state of New Mexico. These may include taxa that are listed as threatened, endangered or sensitive by other agencies; taxa with limited protection; and taxa without any legal protection.
(soc) Species of Concern - A New Mexico plant species, which should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

STATUS: New Mexico t – Threatened, e – Endangered, s – Sensitive, soc – Species of Concern
Federal T – Threatened, E – Endangered, C – Candidate, P – Proposed, S – Species of Concern

PROJECT AREA HABITAT: HN – Habitat NOT found in Project Area; HF – Habitat FOUND in project area

Affect: N – No Effect, NL – If present, likely to affect but not likely to adversely effect, LA – Likely to adversely effect

Species		Status	Species Habitat	Unit Habitat	Affect	Notes (Survey Results) ***Results listed below apply generally to most proposed actions that may take place within the unit, however results in this column must be reviewed and adjusted to each proposed action on an individual basis***
1	Bat, Big-eared, Townsend's, Pale *Corynorhinus townsendii pallescens*	s/S	Semi-desert shrublands, pinon-juniper woodlands, and open montane forests. Frequently associated with caves and abandoned mines for day roosts and hibernacula but will also use abandoned buildings and crevices on rock cliffs for refuge.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
	Bat, Myotis, Brown, Little *Myotis lucifugus carissima*	s	This species occurs in New Mexico in mixed shrub habitats at lower elevations below the mesas (elevation less than 6700 ft. or 2043 m). Broom snakeweed is the dominant plant species. Rubber rabbitbrush and fourwing saltbush are interspersed with sparse stand of big sagebrush. Some small areas are dominated by blue grama grass, western wheatgrass, cheatgrass, and squirreltail grass. Bare ground is prevalent in some areas. Little brown myotis roost in trees, caves, mines, rocky cliffs, wood piles, and man-made structures	HN	N	Habitat not present at this site.

	Bat, Myotis, Brn., Little, Occult *Myotis lucifugus occultus*	s	This species occurs in New Mexico in mixed shrub habitats at lower elevations below the mesas (elevation less than 6700 ft. or 2043 m). Broom snakeweed is the dominant plant species. Rubber rabbitbrush and fourwing saltbush are interspersed with sparse stand of big sagebrush. Some small areas are dominated by blue grama grass, western wheatgrass, cheatgrass, and squirreltail grass. Bare ground is prevalent in some areas. Little brown myotis roost in trees, caves, mines, rocky cliffs, wood piles, and man-made structures	HN	N	Habitat not present at this site.
2	Bat, Myotis, Fringed *Myotis thysanodes thysanodes*	s	Mountainous pine, oak, and pinon-juniper to desert scrub but seem to prefer grassland areas at intermediate elevations. Roost in caves, mine tunnels, rock crevices, and old buildings. Extensive use of both live and dead trees in pinyon-juniper habitats.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
3	Bat, Myotis, Long-legged *Myotis volans interior*	s	Inhabitant of forested areas, where it prefers high, open woods and mountainous terrain. Rare in the Trans-Pecos. Probably only a summer resident. Roosts in buildings, rock crevices, and trees.	HN	N	Unlikely that the proper roosting habitat is present in the unit. Myotis volans is usually found at higher elevations in ponderosa pine and higher vegetation types.
4	Bat, Myotis, Small-footed, W. *Myotis ciliolabrum melanorhinus*	s	Relatively common in ponderosa pine forests and pinon-juniper woodlands. Roost in trees, buildings, rock face crevices, and ground fissures. Caves and mines used as night roosts. Probably hibernate singly in local mines and caves. Commonly associated with willows along stream sides in cottonwood and rabbitbrush riparian habitats.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.

5	Bat, Myotis, Yuma *Myotis yumanensis yumanensis*	s	Usually associated with permanent sources of water, typically rivers and streams. Occurs in riparian, arid shrublands and deserts, and forest areas. Roost in bridges, buildings, cliff crevices, caves, mines, & trees.	HF	NL	Unlikely that the proper roosting habitat is present in the unit. Needs permanent water nearby, which is not present at the creek If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
	Black-Hawk, Common *Buteogallus anthracinus anthracinus*	t	Desert Riparian Deciduous Woodland, Marsh. Woodlands, especially of cottonwoods, that occurs where desert streams provide sufficient moisture for a narrow band of trees and shrubs along the margins. Common black hawks are found in riparian woodlands at lower elevations (2800 - 5500 ft)	HN	N	Habitat not present at this site.
	Butterfly, New Mexico silverspot *Speyeria nokomis nitocris*	S	Found in streamside meadows and open seepage areas with an abundance of violets in generally desert landscapes. Colonies often isolated.	HN	N	Habitat not present at this site.
8	Chub, Rio Grande *Gila pandora*	s	Cool water reaches the Rio Grande & Pecos Rivers (& tributaries) in northern NM.	HF	NL	The proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
10	Cuckoo, Yellow-billed *Coccyzus americanus*	s/C	The western yellow-billed cuckoo is an obligate riparian nester—they only breed in streamside forests, especially those dominated by willow and cottonwood stands. Habitat occurs within relatively large patches, usually 25-100 acres in extent.	HN	N	Habitat in the park is marginal because of the relatively small riparian land area and little habitat of this type exists in the project area. Due to the absence of suitable habitat for this species, the proposed action will not affect this species or its habitat.

12	Eagle, Bald *Haliaeetus leucocephalus alascanus*	t	Winter residents and occasional nesters in New Mexico. Requires fish-producing waters and large riparian trees to successfully nest and produce young. During the winter months they congregate in areas with high fish densities and waterfowl. The Bald Eagle is known to winter in the Pecos River drainage and individuals have been seen along the Pecos River in the Park in winter months. Bald eagles may use large cottonwood trees in the riparian areas along the Pecos River or Glorieta Creek.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
13	Falcon, Peregrine *Falco peregrinus anatum*	t/S	Douglas fir, Hemlock-Sitka spruce, redwood, ponderosa pine, larch/white pine, lodgepole pine, fir-spruce, aspen (hardwoods), chaparral, and pinyon-juniper forest types. Breed on cliffs in wooded/forested habitats, with large "gulfs" of air nearby where they can forage. Hunt in croplands, meadows, river bottoms, marshes and lakes.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
14	Falcon, Peregrine, Arctic *Falco peregrinus tundrius*	t/S	Douglas fir, Hemlock-Sitka spruce, redwood, ponderosa pine, larch/white pine, lodgepole pine, fir-spruce, aspen (hardwoods), chaparral, and pinyon-juniper forest types. Breed on cliffs in wooded/forested habitats, with large "gulfs" of air nearby where they can forage. Hunt in croplands, meadows, river bottoms, marshes and lakes.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
15	Ferret, Black-footed *Mustela nigripes*	E	Black-footed ferrets are obligates of prairie dog towns. No wild populations are known to reside in New Mexico. No prairie dog towns are located in or near the park, therefore there is no potential for ferret habitat in the Park.	HN	N	Due to the absence of suitable habitat for this species, the proposed action will not affect the Black-footed Ferret or its habitat.
	Fleabane, Pecos *Erigeron subglaber*	soc	Rocky, open meadows in subalpine coniferous forest; 3,050-3,500 m (10,000-11,500 ft).	HN	N	Habitat not present at this site.

16	Flycatcher, Willow, SW. *Empidonax traillii extimus*	e/E	The southwestern willow flycatcher breeds in dense riparian habitats along rivers, streams, or other wetlands. The vegetation can be dominated by dense growths of willows (*Salix* sp.) or other shrubs and medium-sized trees. One of the most important characteristics of the habitat appears to be the presence of dense vegetation, usually throughout all vegetation layers present.	HN	NL	The park would support marginal habitat along riparian corridors for the species, however the unit contains little of this habitat. Due to the absence of suitable habitat for this species, the proposed action will not affect the Southwestern willow flycatcher or its habitat.
17	Fox, Red *Vulpes vulpes fulva; macroura*	s	Common in open woodlands, pasturelands, riparian, and agricultural lands. Favors mixture of vegetation types occurring in small mosaics with good development of ground cover. Do well on margins of urbanized areas. Common in open space and other undeveloped areas adjacent to cities.	HF	NL	Not likely present in this habitat. Status and threats to the red fox are so poorly known in the state that little can be said as to their need for special protection. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
	Fox, Swift *Vulpes velox velox*	s/S	Swift and kit foxes are grassland and desert species, most common where soft soils support large populations of rodents, especially kangaroo rats, on which these little foxes prey. Shelter is sought in underground burrows, neither rocks nor vegetation being essential for burrow construction	HN	NL	Habitat not present at this site.
18	Goshawk, Northern *Accipiter gentilis atricapillus; apache*	s/S	Locally in mature, closed canopied coniferous forests of mountains and high mesas. Known to use Juniper and Wetland habitats. Large trees (> 18 " dia.) supply large snags and downed logs important to Goshawk prey, perches and nest sites.	HN	NL	Habitat not present at this site.
19	Hummingbird, Broad-billed *Cynanthus latirostris magicus*	t	The species summers regularly in Guadalupe Canyon (Hidalgo Co.), which is the key habitat area for the species in the state. Vagrants have been reported from near Los Alamos, Bandelier National Monument (Sandoval Co.), Las Vegas, Truth or Consequences, Las Cruces, and Carlsbad Caverns National Park. Broad-billed hummingbirds inhabit riparian woodlands at lower elevations (2800 - 5500 ft).	HN	N	Habitat not present at this site.

	Hummingbird, White-eared *Hylocharis leucotis borealis*	t	Hylocharis leucotis borealis is accidentally transient in areas of desert scrub/rocky slopes, juniper Savannah, pinon/juniper woodland, and Ponderosa/oak forests. White-eared hummingbirds inhabit evergreens and riparian woodlands at middle elevations (5000 - 7500 ft)	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
	Ipomopsis, Holy Ghost *Ipomopsis sancti-spiritus*	e/E	It grows on relatively dry, steep, west to southwest-facing slopes in open ponderosa pine or mixed conifer forest at 2,400-2,500 m (7,730-8,220 ft). The geologic substrate is partly weathered Terrero limestone. This plant appears to grow best in bare mineral soils with its highest densities on disturbed sites such as road cuts.	HN	N	Habitat not present at this site.
20	Larkspur, Sapello Canyon *Delphinium sapellonis*	soc	Canyon bottoms and aspen groves in lower and upper montane coniferous forest; 2,450-3,500 m (8,000-11,500 ft).	HN	N	Habitat not present at this site.
	Lily, Pecos mariposa *Calochortus gunnisonii*	soc	Meadows and aspen glades in upper montane coniferous forest; 2,900-3,400 m (9,500-11,200 ft).	HN	N	Habitat not present at this site.
21	Marmot, Yellow-bellied *Marmota flaviventris luteola; obscura*	s	Common above 8,000 ft in alpine tundra, subalpine and montane meadows. Range into foothills and canyon country on either side of mountains where rock outcrops or boulders exist along with suitably productive and succulent vegetation.	HN	N	Habitat not present at this site or elevation.
22	Marten, American *Martes americana origenes*	t	Spruce-fir forests and marginal Alpine habitat.	HN	N	Habitat not present at this site.
	Milkweed, Dwarf *Asclepias uncialis var. uncialis*	S	The plant is typically found in sandy or rocky semi-arid shortgrass prairies on plains, open hills, or low slopes. The plant has also been found scattered in pinyon-juniper woodlands. Most often, the milkweed is found on bare soil between patches of vegetation, or even in areas with noticeable disturbance. d scattered in pinyon-juniper s. Most often, the milkweed is found on between patches of vegetation, or even ith noticeable disturbance. It has been rowing at elevations from 3900 to 6250	HN	N	Habitat not present at this site.

	Minnow, Plains *Hybognathus placitus*	s	The plains minnow inhabits clear to turbid rivers and creeks with sandy bottoms. In New Mexico, it occurs along main channels of major streams and a short distance up tributary streams	HF	NL	Numerous fish surveys within the park have failed to confirm the presence of the suckermouth minnow.
	Minnow, Suckermouth *Buteogallus anthracinus anthracinus*	t	This minnow is found in the Dry Cimarron River, the Canadian drainage (Cimarron to Conchas Lake), and in the upper Pecos River from Sumner Lake to Fort Sumner (Propst et al. 1985). All of these constitute key habitat areas, although possibly the occurrences in the Pecos River are not natural. The species inhabits mainly sand, gravel, and rubble-bottomed riffles in small to moderate-sized streams.	HF	NL	Numerous fish surveys within the park have failed to confirm the presence of the suckermouth minnow.
27	Mountainsnail, Socorro *Oreohelix neomexicana*	s	Occurs in vicinity of limestone cliffs in thick, moist litter derived mainly from fallen leaves of pinyon pine, one-seeded juniper, and various shrubs.	HN	N	Habitat not present at this site.
28	Mouse, New Mexican Meadow Jumping *Zapus hudsonius luteus*	C	Species lives in various habitats that have some herbaceous cover, but moist grassland is preferred and heavily wooded areas are avoided. Grassy fields and thick vegetated areas bordering streams, ponds, or marshes generally support greater numbers. Mice may prefer habitats with high humidity. It nests in dry soils, but uses moist, streamside, dense riparian / wetland vegetation up to an elevation of about 8,000 feet. It appears to only utilize two riparian community types: 1) beaked sedge and reed canary grass alliances; and 2) riparian areas along perennial streams that are composed of willows and alders. It especially uses microhabitats of patches or stringers of tall dense sedges on moist soil along the edge of permanent water.	HN	N	Suitable habitat for the New Mexican meadow jumping mouse is not located within the unit; therefore the proposed action will not affect the New Mexican meadow jumping mouse or its habitat.
	Muskrat, Pecos River *Ondatra zibethicus ripensis*	s/S	Muskrats occur in marshes and drainage ditches along the Rio Grande, Pecos, and San Juan rivers.	HN	N	Habitat not present at this site.
30	Owl, Boreal *Aegolius funereus*	t	Primarily a bird of high elevation, mature and old-growth spruce-fir forests.	HN	N	Habitat not present at this site.

31	Owl, Spotted, Mexican *Strix occidentalis lucida*	s / T	Nesting and roosting habitat is composed of mixed conifer and/or Douglas-fir vegetation types. Understory characteristics demonstrate multi-layered, uneven-aged conifer and hardwoods ranging in age from 20-70 years. Live trees are 8 inches dbh or greater with at least 40% canopy closure and are located on slopes of 40% or greater. Dead and down attributes include a variety of age class of snags and presence of large down logs.	HN	N	Suitable habitat for the Mexican spotted owl is not located within the unit; therefore the proposed action will not affect the Mexican spotted owl or its habitat.
32	Owl, Western Burrowing *Athene cunicularia hypugaea*	S	Breeds in North America and spends its non-breeding time primarily south of the United States. Uncommon to fairly common in open grassland areas, particularly in or adjacent to white-tailed prairie dog towns. Nest and roost in burrows, such as those excavated by prairie dogs (*Cynomys* spp.). Burrowing owls in New Mexico inhabit grasslands and open shrubland and woodland at lower (2800 - 5500 ft) and middle (5000 - 7500 ft) elevations.	HF	NL	Habitat within the unit Unlikely that the proper roosting habitat is present in the unit near NM Highway 50 could support this species. No suitable burrows, owls or owl sign were observed during a 2008 survey performed by Marron & Associates, Inc. (Marron 2008) and no prairie dog towns exist in or near the park, therefore the proposed action is not likely to affect the Western Burrowing Owl or its habitat.
	Paper Pondshell *Utterbackia imbecillis*	e	Paper-shell mussels are strictly aquatic bivalves that inhabit mud, sand, and gravel substrates of lakes and rivers. This species is known in recent time only in the lower Canadian Rriver (San Miguel Co.), where a population inhabits Conchas Reservoir -- which is this clam's key habitat area in the state.	HN	N	Habitat not present at this site.
	Fingernailclam, Lake *Musculium lacustre*	t	Raymond's pea-clam occurs in northern New only from upper Cieneguilla Creek (Colfax Co.), near the Angel Fire Recreation Area.	HN	N	Habitat not present at this site.
	Fingernailclam, Long *Musculium transversum*	t	The wide pea-clam occurs in a variety of habitat types, with sloughs, rivers, and large lakes being among the most frequently. This species is found in the Arkansas River drainage and in Cabra Springs (San Miguel Co.).	HN	N	Habitat not present at this site.

	Pelican, Brown *Pelecanus occidentalis carolinensis*	e	The brown pelican is usually found in marine habitats in warmer waters in North America; except for the lower Colorado Basin and vicinity, it only rarely occurs inland There are records from 13 New Mexico counties, with most from large lakes or along major rivers	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
34	Plover, Mountain *Charadrius montanus*	s/P	Strongly associated with sites of heaviest grazing pressure to the point of excessive surface disturbance. Attracted to man-made landscapes (e.g., sod farm, cultivated fields) that mimics natural habitat associations, or sites with grassland characteristics (alkali flats, other agricultural lands). Nesting sites dominated by short vegetation and bare ground, often with manure piles or rocks nearby.	HN	N	Habitat not present at this site.
35	Prairie Dog, Gunnison's / Black Tail *Cynomys gunnisoni gunnisonii/ Cynomys ludovicianus*	s/S	Grasslands from low valleys to montane meadows.	HF	N	There are no prairie dog towns in or near the park.
36	Ptarmigan, White-tailed *Lagopus leucurus altipetens*	e	Alpine tundra and timberline habitats, which in New Mexico are mainly above 10000 feet.	HN	N	Habitat not present at this site.
38	Ringtail *Bassariscus astutus arizonensis*	s	Montane habitats, but also in lowlands in rough, rocky country. Sycamore, and rabbitbrush riparian habitats and in the steep cliffs and arroyos that drain to the east. Particularly associated with rocky habitat types in New Mexico.	HF	NL	Ringtail has been documented in the park. If present at the project site, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
39	Shrike, Loggerhead *Lanius ludovicianus excubitorides*	s	Agricultural lands on prairies to montane meadows, nesting in sagebrush areas, desert scrub, pinyon-juniper woodlands, and woodland edge. Open country interspersed with improved pastures, grasslands, and hayfields is primary shrike habitat throughout its range.	HF	NL	Presence is possible, but usually found in more grassland, shrubland habitats. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.

	Skunk, Hog-nosed, Common *Conepatus leuconotus mearnsi*	s	They are found in sycamore, cottonwood, and rabbitbrush riparian habitats	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
42	Stickseed, New Mexico *Hackelia hirsuta*	soc	Dry sites of shaley or igneous soils in lower to upper montane coniferous forest, usually with Gambel oak; 2,350-3,100 m (7,700-10,200 ft).	HN	N	Habitat not present at this site.
44	Sparrow, Baird's *Ammodramus bairdii*	t/S	Migrant in NM, occurring primarily in the eastern plains and southern lowlands, & may winter in some locales. Grassland species.	HN	N	Habitat not present at this site.
45	Swift, Black *Cypseloides niger borealis*	s	High inaccessible cliffs with exposed rock near permanent water. Forage aerially over all wetland and aquatic types.	HN	N	Habitat not present at this site.
46	Trout, Rio Grande Cutthroat *Oncorhynchus clarki virginalis*	s/C	Rio Grande cutthroat trout lives in clean, cold mountain streams, preferably of moderate (6 % or less) gradient. *Virginalis* typically requires high oxygen content in its stream habitat, low summer water temperatures, and clean gravel for its spawning beds. It requires riffle areas for food production and habitat for young, and pools for overwintering, and summer rest, and the number of pools and riffles should be roughly equal. Vegetation in the riparian zone needs to be abundant enough to provide shade and cover.	HN	N	Numerous fish surveys within the park have failed to confirm the presence of the Rio Grande cutthroat in the Pecos River and suitable habitat may not be present. No suitable habitat exists on Glorieta Creek. Due to the absence of suitable habitat for this species within the park, the proposed action will not affect the Rio Grande cutthroat trout or its habitat.
	Tern, Black *Chlidonias niger surinamensis*	S	Black terns are found near water at lower (2800 - 5500 ft) and middle (5000 - 7500 ft) elevations. Desert Riparian Deciduous Woodland, Marsh. Woodlands, especially of cottonwoods, that occur where desert streams provide sufficient moisture for a narrow band of trees and shrubs along the margins.	HF	NL	If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.

47	Tern, Least *Sterna antillarum athalassos*	e	Colonially-nesting water bird. Prefer a flat, sandy substrate essentially devoid of vegetation, on which they place their nest scrapes. Provision of proper breeding conditions is essential, this involving level, sparsely-vegetated ground near water, relative freedom from terrestrial predators and human disturbance, and an adequate prey base.	HN	N	Habitat not present at this site.
49	Vireo, Gray *Vireo vicinior*	t	Open woodlands/shrublands featuring evergreen trees and shrubs of various kinds. In NM, the gray vireo is most often found in arid juniper woodlands on foothills and mesas, these most often associated with oaks and usually in habitat with a well-developed grass component Occurs in NM only in the warmer months (April-September).	HF	NL	Habitat not present at the Pigeons Ranch Sub Unit. At Canyoncito Sub Unit, presence is possible. If present, the proposed action could affect a population of the species, but would be so small and localized to a small area of the park, that it would have few measurable consequences.
50	Vole, Heather *Phenacomys intermedius intermedius*	s	Stands of spruce, fir, lodgepole, aspen, and ponderosa pine, and grassy meadows in montane forests, subalpine forests, and alpine tundra	HN	N	Habitat not present at this site.

Note: The Townsend's big-eared bat has been detected on the main unit of the park, in Baca Cave (See Table 3.16-1).

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National Park Service
U.S. Department of the Interior

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