National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Fort Davis National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/CHDN/NRR—2014/892

ON THE COVER

Fort Davis National Historic Site. Photo: Nina Chambers

Fort Davis National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/CHDN/NRR—2014/892

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December 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available from Chihuahuan Desert Inventory and Monitoring Network (http://science.nature.nps.gov/im/units/chdn/) and the Natural Resource Publications Management Web site (http://www.nature.nps.gov/publications/nrpm/) on the Internet. To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Struthers, K., P. Valentine-Darby, N. Chambers, R.E. Bennetts, and K. Gallo. 2014. Fort Davis National Historic Site: Natural resource condition assessment. Natural Resource Report NPS/CHDN/NRR—2014/892. National Park Service, Fort Collins, Colorado.

NPS 418/127449, December 2014

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program, administered by National Park Service's (NPS) Water Resources Division, aims to provide documentation about current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. The NRCA for Fort Davis National Historic Site began in 2013, and ten focal study natural resources were chosen for the Historic Site's NRCA. These resources were organized into three categories that ranged in contexts from broader to narrower including landscape-scale, supporting environment (i.e., physical resources), and biological integrity, which included wildlife and vegetation topics.

Fort Davis was authorized by Congress in 1961 (under 75 Stat. 488) and was established as a National Historic Site on July 4, 1963. The Historic Site was set aside to perpetuate and conserve the cultural and natural resources of Fort Davis NHS and to educate the public about the influence of Fort Davis on the development and settlement of the Southwest and the impact of military operations on American Indians. For the most part, the surrounding area still maintains its rural and remote character, which has helped to preserve and protect the Historic Site's natural and cultural resources.

The landscape scale resources chosen for this assessment included viewshed, night sky, and soundscape. Overall, these resources were in relatively good condition. The condition of these three resources alone afford visitors an opportunity to experience life at the Fort through a variety of natural and cultural sights and sounds.

The Historic Site's supporting physical environment resource topics included air quality, geology, and groundwater. The current condition of these resources ranged between good and moderate.

The resource topics related to vegetation included upland vegetation/soils, dry wash and historic cottonwoods, and exotic plants. The upland vegetation/soils and exotic plants were in good and good to moderate condition, respectively. The dry wash area and the cottonwood grove was considered to be in moderate condition.

Finally, the wildlife resource topics included landbirds only, which was considered to be in good condition. There is a relatively high conservation potential at Fort Davis NHS for several breeding landbird species based on their breeding range and the availability of breeding habitat at the Historic Site.

Acknowledgements

We wish to thank Jeff Albright, Program Lead of the Natural Resource Condition Assessment Program, Water Resources Program Center, National Park Service, who provided programmatic insight and guidance on project development and review and Donna Shorrock, Intermountain Region Natural Resource Condition Assessment Coordinator for her guidance and review. The authors are grateful to the staff at the National Park Service Natural Resource Stewardship and Science Directorate for their technical expertise, guidance, and reviews of their respective subjects. We are extremely grateful to all subject matter experts who provided valuable information pertaining to their respective areas of research and expertise. Their input helped to create a relevant, scientifically based document that provided new insights into the communities and processes found and occurring throughout the Historic Site. Finally, we would like to express our gratitude and thanks to Fort Davis NHS staff, whose input and reviews were very appreciated. To all those remaining who reviewed and commented on this report, thank you. Your contributions have increased its professional value.

CHERYL MCINTYRE

Chapter 1: NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement — not replace — traditional issue- and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope;[1]
- employ hierarchical indicator frameworks;[2]
- identify or develop reference conditions/values for comparison against current conditions;[3]
- emphasize spatial evaluation of conditions and GIS (map) products;[4]
- summarize key findings by park areas; and[5]
- follow national NRCA guidelines and standards for study design and reporting products.

NRCAs Strive to Provide…

- Credible condition reporting for a subset of important park natural resources and indicators
- Useful condition summaries by broader resource categories or topics, and by park areas

1. The breadth of natural resources and number/type of indicators evaluated will vary by park.
2. Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures [conditions for indicators] condition summaries by broader topics and park areas
3. NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management "triggers").
4. As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.
5. In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

Important NRCA Success Factors

- Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline
- Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures / indicators) broader resource topics, and park areas
- Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the 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. These staff will be asked to assist with the selection of study indicators;

KIM STRUTHERS

A NRCA is intended to provide useful science-based information products in support of all levels of park planning.

recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What a NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCA Reporting Products…

- Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:
- Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations (near-term operational planning and management)
- Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values (longer-term strategic planning)
- Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public ("resource condition status" reporting)

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference

CHERYL MCINTYRE

A NRCA uses a variety of data to assess the condition of a park's natural resources.

6. An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

7. While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

8. The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

Over the next several years, the NPS plans to fund a NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information on the NRCA program, visit http://www.nature.nps.gov/water/nrca/index.cfm.

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Fort Davis NHS.

Chapter 2: Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Park Purpose and Significance

Fort Davis National Historic Site (NHS) was authorized on September 8, 1961 (under 75 Stat. 488) and established on July 4, 1963. The park's purpose is to:

- Perpetuate and conserve the cultural and natural resources of Fort Davis NHS; and
- Educate the public about the influence of Fort Davis on the development and settlement of the Southwest and the impact of military operations on American Indians.

With its preserved structures, the Historic Site "symbolizes the era of westward migration and the essence of the late 19th century U.S. Army" (NPS 2001). More than 100 historic buildings, ruins, and foundations are preserved, as is the landscape associated with two forts that were active from 1854-1862 and 1867-1891.

The Fort Davis NHS General Management Plan Summary (NPS 2002) presents the following statements on the park's significance:

- Fort Davis is one of the best remaining examples in the Southwest of a typical post-Civil War frontier fort because of the extent of the surviving structures and ruins.
- Fort Davis NHS provides an excellent opportunity for understanding and appreciating the important role played by African Americans in the West, and, specifically, in the frontier army, because Black troops served at the post from 1867 to 1885.
- Fort Davis provided essential troops and supplies to the Victorio Campaign, which ended meaningful resistance of Apache bands in the Trans-Pecos region.
- The historic integrity and character of the military post have not been significantly altered since its establishment. Much of the landscape immediately adjacent to the post has experienced little visible change.

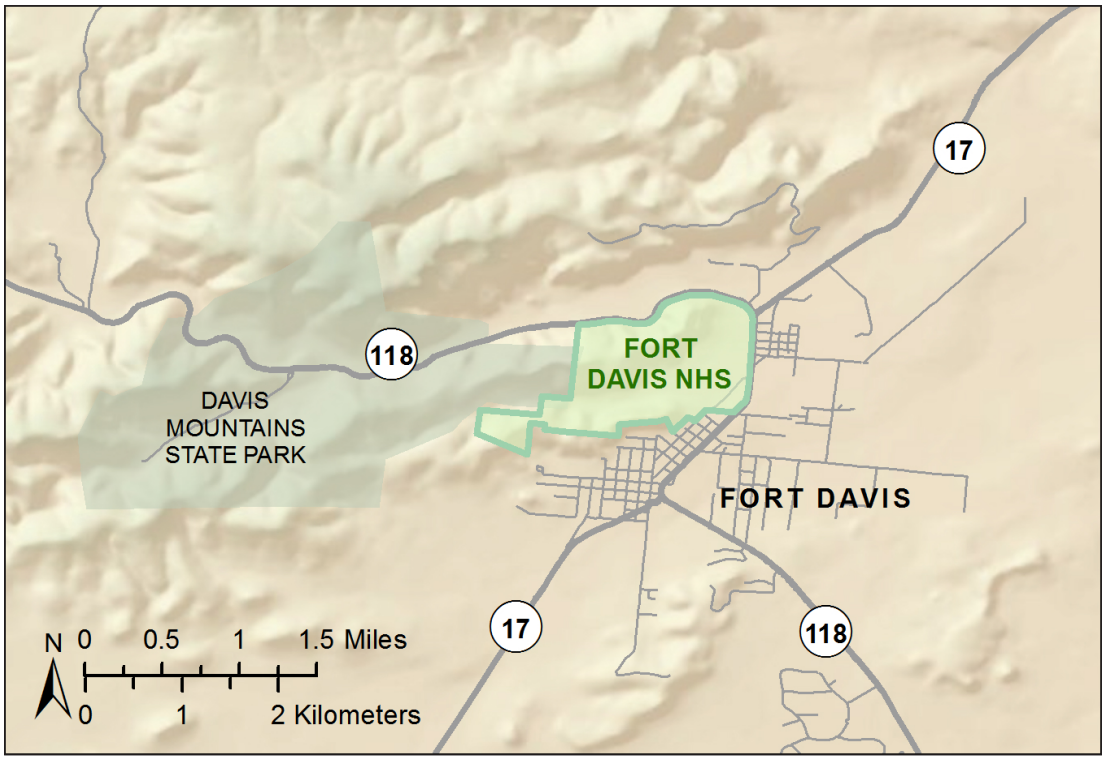

Figure 2.1.2-1. Setting of Fort Davis NHS.

- For Davis was strategically located to defend the Trans-Pecos portion of the San Antonio-El Paso Road and the Chihuahua Trail. This encompassed controlling activities on the southern portions of the Great Comanche War Trail and Mescalero Apache War Trails.

2.1.2. Geographic Setting

Fort Davis NHS, 523 acres (212 hectares) in size, is located at the southeast edge of the Davis Mountains in the Trans-Pecos region of west Texas. The park is in Jeff Davis County, to the north of the town of Fort Davis (Figure 2.1.2-1). The Historic Site is located along State Highways 118 and 17, about 205 miles (330 kilometers) southeast of El, Paso, Texas, and 155 miles (249 kilometers) southwest of Odessa, Texas. The park is bordered by Davis Mountains State Park to the west, and by private land on the other sides. Nearby neighbors include The Nature Conservancy's Davis Mountains Preserve, the University of Texas McDonald Observatory, and the Chihuahuan Desert Research Institute.

The Historic Site experiences an elevation change of 340 feet (104 meters), ranging from about 4,880 feet (1,487 meters) to 5,220 feet (1,591 meters) in elevation (NPS 2002). The nearby Davis Mountains are some of the most rugged in the state. The fifth highest peak in Texas, Mount Livermore (8,382 feet), is about 15 miles (24 km) north of the park. Jeff Davis County receives, on average, about 20 inches of precipitation annually, primarily from June to October (Larkin and Bomar 1983, as cited in Porter et al. 2009). The quantity of precipitation in the spring and summer increases with elevation.

2.1.3. Visitation Statistics

Monthly visitation data for Fort Davis NHS are available for 1979-2013, while annual visitation data date back to 1964. The months receiving the greatest average number of visitors over the recording period were July, March, and April, respectively (NPS Public Use Statistics Office 2013). The total number of visitors each year ranged from 35,130 (in 2011) to 135,800 (in 1966) (Figure 2.1.3-1). The number of visitors in 2013 was 43,277.

2.2. Natural Resources

A summary of the natural resources at Fort Davis NHS is presented in this section and represents information known prior to the completion of this condition assessment.

New data were gathered and compiled throughout this assessment process as a result of meetings, consultations, and literature reviews pertaining to each natural resource topic. Therefore, some of the information presented in section 2.2 may be included in subsequent chapters or omitted depending upon new findings.

Figure 2.1.3-1. Total number of visitors each year to Fort Davis NHS, 1964-2013.

Note that italicized text in the following sections are excerpts from resource descriptions in various reports; sources are noted in each section as appropriate.

2.2.1. Ecological Units and Watersheds

Fort Davis NHS is located within the central part of the Trans-Pecos region of Texas, which encompasses about one-fifth (50,000 square miles [129,500 square kilometers]) of the Chihuahuan Desert. The Historic Site is located within the northern extent of the Chihuahuan Desert Ecoregion (in the Northern Chihuahuan Subregion) (NPS, CHDN 2010).

The Historic Site is situated on the eastern side of the Davis Mountains, the largest mountain range in the Trans-Pecos region. The mountains were formed by volcanic eruptions during the Tertiary period, and they form one of the Trans-Pecos "sky islands".

"The entrance area, or foreground, of the Historic Site features the Chihuahuan Desert grassland community common to the Davis Mountains... It also contains a spring and associated historic grove of cottonwood trees ....The fort is located in the middle of an alluvial floodplain, and natural drainages run through the site. Historic ditches and dikes are maintained for flood control. Behind the main fort area rise the volcanic cliff walls of Hospital Canyon and a rugged, steep escarpment running north/south that forms the prominent backdrop view from the lower elevations. Mixed vegetative cover is found throughout this zone, where desert-scrubland intermixes with cacti and pinyon-juniper woodland..." (Excerpt from NPS 2001).

Fort Davis National Historic Site's northern boundary parallels Limpia Creek, which is a spring fed water resource (Gregory and Hatler 2008). The creek originates on the northeastern flank of Mount Livermore, the highest peak in the Davis Mountains (2,555 m [8,382 ft]), 27 km (17 mi) northwest of the Historic Site. The creek then flows along (but outside) the Historic Site's boundary and runs northeast for 101 km (63 mi) to its mouth on Barrilla Draw in western Pecos County, which feeds into the Pecos River. Limpia Creek's upper reaches cross rugged terrain surfaced by shallow, stony soils. The lower reaches run through flat to rolling country surfaced by shallow, stony clay and sandy loams.

Although Limpia Creek was reportedly an important source of water for the Fort during the 1870s, dry conditions in the late 1880s appeared to have affected both the quantity and quality of the water (Green 1986, as cited in Porter et al. 2009). Limpia Creek was observed in April of 2008 and was described as an intermittent stream with several pools separated by considerable distances of dry stream bed (Porter et al. 2009).

Limpia Creek is located within the Chihuahua Creek-Limpia Creek subwatershed, which

encompasses 51.8 square miles (Heidi Sosinski, SOPN Data Manager, pers. comm., January 13, 2014) (Figure 2.2.1-1).

Climate

The climate of the Davis Mountains is semi-arid, as is typical of the northern Chihuahuan Desert, with annual rainfall averaging 48 centimeters (19 in) across the Davis Mountains. Due to its location and elevation, the park is in a transitional zone between desert grasslands and shrublands and higher elevational vegetative communities (NPS 2001).

The elevation of the site results in relatively mild temperatures, but extremes of more than 35°C (95°F) during the summer are common. Winter temperatures may reach below -6°C (20°F) (NPS 2010).The monthly precipitation and temperature data from 1981-2011 are presented in Figure 2.2.1-2 (NCDC 2012). The driest year on record (102 years) was 2011.

2.2.2. Resource Descriptions

Geology and Soils

Information in italics below is excerpted from McIntyre and Studd (2013).

The Davis Mountains were formed by volcanic eruptions that occurred during the Tertiary geologic period, which began approximately 35 million years ago. Behind the main fort area rise the volcanic cliff walls of Hospital Canyon and a rugged steep escarpment running north-south.... The Sleeping Lion Mountains form the southern ridge of the site. Both the North Ridge Mountains and the Sleeping Lion Mountains are composed of a low-silica rhyolite lava flow that has distinctive exposed columnar jointing patterns commonly referred to as hoodoos. These formations create rugged and boulder-strewn cliffs with strong north and south aspects that influence vegetation patterns through modifying soil water availability and aspect-driven variation in solar radiation (Muldavin et al. 2012).

The valley bottom of Hospital Canyon and the lower elevation flats of the fort site have been described as Quaternary alluvial fan deposits. Soil properties of these four distinct areas have been summarized by Haynie (2000) based on soil survey data collected in 1969 and 1971 for Jeff Davis County (Turner and Jaco 1969, Turner 1977). Soils of both mountain ranges are said to have low water-holding capacity and high rock content, whereas the deeper soils of the military grounds and Hospital Canyon have high water-holding capacities.

Soil map units within the Historic Site are: Bigetty association; Boracho-Espy association, gently sloping; Mainstay-Brewster association, hilly; Musquiz association; Rock outcrop-Brewster association, steep; Rockhouse-Bigetty association; and Santo Tomas-Medley association, gently sloping (NRCS 2012).

Hydrology: Water Quality Monitoring of Limpia Creek

Water quality monitoring of Limpia Creek has discontinued at the sites closest to the Historic Site (USGS 08431800 and USGS 08431700; Storet Stations FODA001- FODA004).

In 1999, the National Park Service's Water Resources Division (WRD) searched water-related data records for the Historic Site and compiled findings into a report titled, *Baseline Water Quality Data Inventory and Analysis*. Porter et al. (2009) summarized these same data.

A recent search (2014) of the same water quality databases reported

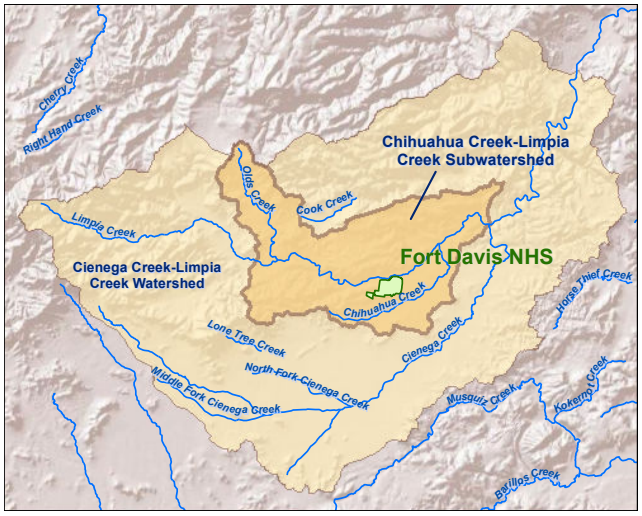

Figure 2.2.1-1. Fort Davis NHS is within the Chihuahua Creek-Limpia Creek Subwatershed of the Cienega Creek-Limpia Creek Watershed.

in NPS-WRD (1999) reveal no additional and/or recent surface water quality monitoring of Limpia Creek (USEPA 2013, USGS 2014).

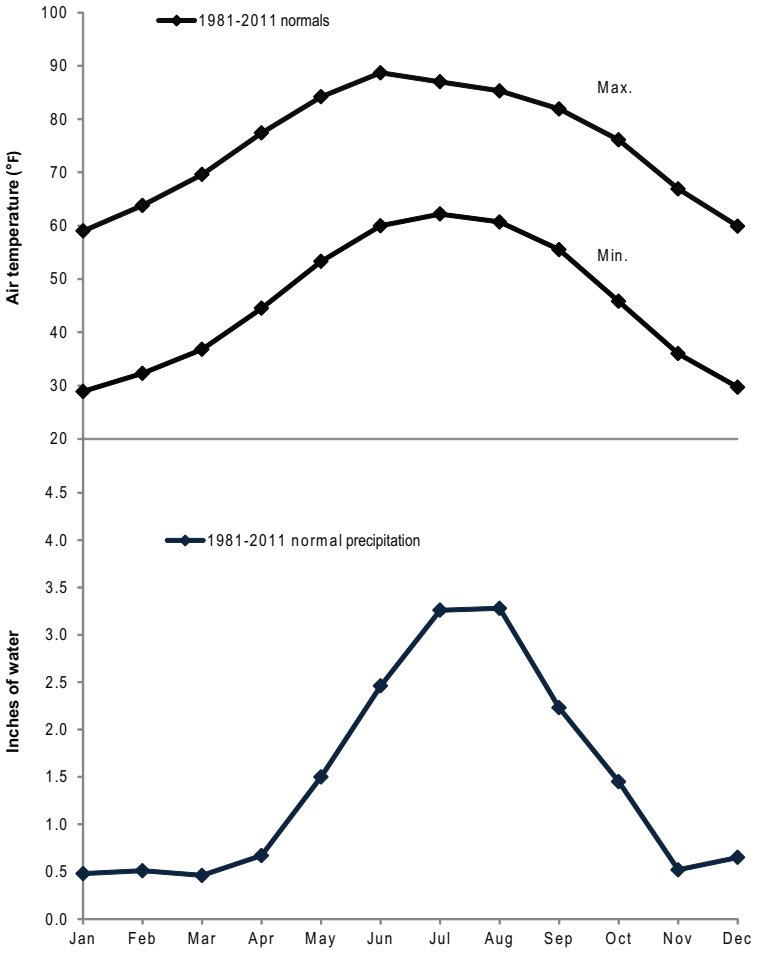

Figure 2.2.1-2. Climate data from 1981-2011 for Fort Davis, Texas (NCDC 2012).

Groundwater

Groundwater flow near the Historic Site is primarily away from the higher-elevation mountainous terrain and toward the areas that are lower in elevation (LBG-Guyton 2001, as cited in Porter et al. 2009). Most groundwater discharge is the result of well withdrawals and springflow. There does not appear to be evidence of extended periods of discharge from groundwater to perennial streams. The Tertiary Volcanics aquifer, which is the only source of water for Fort Davis residents, has been monitored in the area of the Historic Site since 1967 (using the Jeff Davis County observation well). Some information is available from water wells at the Historic Site (Porter et al. 2009).

Air Quality

Fort Davis NHS is designated as a Class II air quality area (NPS, CHDN 2010), in which only limited amounts of new emissions are allowed. There are no NPS (or other) air quality monitoring stations in or near the Historic Site. Therefore, air quality trends cannot be determined. According to the General Management Plan Summary (NPS 2002), the Historic Site will continue to support air quality programs in both the private and public sectors.

Wildlife

*Current inventories or expected distributions indicate that Fort Davis NHS is home to 368 species of plants from 74 families. No fish are found within the boundaries of Fort Davis NHS. However, a number of other vertebrate taxa occur (or in the case of mammals, are expected to occur) here, including 31 species of herps, 15 species of mammals, and 119 species of birds (*Excerpt from NPS, CHDN 2010).

In 2003 and 2004, an inventory was conducted at the Historic Site for reptiles and amphibians (i.e., herpetofauna). Twenty-nine species of herpetofauna were documented


ROBERT SHANTZ

Black-throated Sparrow (*Amphispiza bilineata*), one of the most commonly observed birds at the Historic Site during 2012 monitoring.

NPS: CHERYL MCINTYRE

Vegetation at Fort Davis NHS.

by researchers: five frog and toad species; 12 lizard species; 11 snake species; and one turtle species (Prival and Goode 2005). Of these, one was a state-listed species (the threatened Texas horned lizard [*Phrynosoma cornutum*]). No non-native herpetofauna species were found during the inventory (Prival and Goode 2005).

An inventory of birds in low-elevation riparian habitats in Fort Davis NHS during the migration and breeding seasons of 2004 to 2006 documented a total of 80 species (Meyer and Griffin 2011). All of the species were on previous checklists for the park vicinity. Seventy-two species were observed in Hospital Canyon, including 42 breeding or potentially breeding species. Forty-six species were observed in the Mesquite Grasslands, including 34 breeding or potentially breeding species (Meyer and Griffin 2011). Nineteen of the species were observed only during the 2004-2006 fall or spring migratory seasons.

The Chihuahuan Desert Network (CHDN) began monitoring birds in spring 2010, after a pilot season in 2009. This effort, conducted annually in the breeding season, is part of a collaboration among the Southern Plains, Sonoran Desert, and Chihuahuan Desert Networks. Results of the 2009-2012 monitoring at Fort Davis NHS are discussed in Chapter 4 of this document.

Vegetation

Information in italics below is an excerpt from Muldavin et al. (2012).

The vegetation pattern of Fort Davis NHS has an intricate pattern that reflects its history as an active garrison in two periods between 1854 and 1891. Evergreen oak-dominated woodlands occur on north-facing ridges and in canyons. Chihuahuan foothill semidesert grasslands dominated by grama grasses are found on the southerly slopes intermixed with desert shrublands (often-dense catclaw mimosa, whitethorn acacia, and beebrush). The flats of the eastern foreground area and along the bottom of Hospital Canyon were also dominated by grama grasslands, but these may have a weedy herbaceous component or have been invaded by honey mesquite. This ruderal aspect is likely a legacy of grazing and agricultural practices during the fort's heyday and subsequent private ownership up until

Fort Davis NHS establishment in 1961. The core historic site itself currently has actively manicured, cultural vegetation that includes mowed grasslands and a relic cottonwood grove once used as a picnic ground. Hospital Canyon also supports a remnant dry riparian zone dominated by oaks and netleaf hackberry. The expansion area to the west acquired in 2011 is predominately foothill grasslands along with scattered shrublands and woodlands, but a fire that swept through this portion of the park in spring 2011 may have significantly reduced tree cover. Hence, the vegetation of Fort Davis NHS is dynamic..."

Muldavin et al. (2012) contains a list of plant species observed during their work to create a vegetation map for the Historic Site.

In the spring of 2011, the CHDN implemented monitoring protocols for the upland vegetation and soils monitoring and for the early detection of invasive, non-native plants at the Historic Site. Exotic plants monitoring in 2011 and 2012 led to the observance of 22 exotic species (e.g., horehound [*Marrubium vulgare*], prickly Russian thistle [*Salsola tragus*], and Johnsongrass [*Sorghum halepense*]) (McIntyre and Studd 2013). Most of the plants were found along three vectors: the entrance road, the Old El Paso-San Antonio Road, and were burnt in the Rock House Fire (Reiser et al. 2012 and CHDN unpublished data, as cited in McIntyre and Studd 2013).

Night Sky and Soundscape

Protecting the night sky and soundscape at Fort Davis NHS is important for visitor experience, has cultural and historical significance, and benefits the natural resources of the Historic Site. No formal studies on the Historic Site's night sky have been conducted to date. However, informal studies (quantitative and qualitative) were conducted on night sky for this NRCA, and results are presented in a subsequent chapter.

A recent acoustical study was conducted at the Historic Site for the Natural Sounds and Night Skies Division by the U.S. Department of Transportation's Research and Innovative Technology Administration. Acoustical monitoring systems were used in 2010 at two locations, the North Ridge Trail and Sleeping Lion Mountain (NPS 2013). The purpose of the monitoring at the Historic Site was to characterize existing sound levels and estimate natural ambient sound levels in the two sites, as well as to identify audible sound sources. The results of the report are discussed in a subsequent chapter of the NRCA.

Also see Section 2.2.3, Resource Issues Overview, immediately below, for a discussion related to both viewshed and soundscape.

2.2.3. Resource Issues Overview

At Fort Davis NHS, the main resource concern is maintaining the historic landscape, viewshed, and sounds inside the Historic Site and on private and State lands bordering the park (NPS, CHDN 2010). When visitors enter the Historic Site, the intent is for them to be able to look and listen in all directions and imagine an active military post in the mid to late 19th century. Natural barriers preserve most of the Historic Site's viewshed, but adjacent private land to the northeast could impact the viewshed in the future if it is developed. Aircraft overflights, passing traffic on the highway, and vehicles idling in the parking lot pose minor noise pollution problems. Appendices to the CHDN Vital Signs Monitoring Plan (NPS, CHDN 2010) also list threats to the Historic Site as: deposition from atmospheric pollution; groundwater infiltration from adjacent urban sources; groundwater infiltration from Historic Site facilities; and flood inflows to Hospital Canyon Arroyo.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

In addition to NPS staff recommendations, the Washington (WASO) level programs guided the selection of key natural resources for this condition assessment. This included Chihuahuan Desert Inventory and Monitoring Network (CHDN) Program, Air Resources Division for air quality, and the Natural Sounds and Night Skies Program for the soundscape and night sky sections.

CHDN Program

In an effort to improve overall park management through expanded use of scientific knowledge, the Inventory & Monitoring (I&M) Program was established to collect, organize, and provide natural resource data, as well as information derived from data through analysis, synthesis, and modeling (NPS 2011). The primary goals of the I&M Program are to:

- inventory the natural resources under NPS stewardship to determine their nature and status;
- monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other altered environments;
- establish natural resource inventory and monitoring as a standard practice throughout the National Park System that transcends traditional program, activity, and funding boundaries;
- integrate natural resource inventory and monitoring information into NPS planning, management, and decision making; and
- share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives (NPS 2011).

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Fort Davis NHS is part of the CHDN, which also includes six additional parks. Through a rigorous multi-year, interdisciplinary scoping process, each network selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as 'vital signs', and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources. For the CHDN, core vital signs were identified. Inventories on a wide variety of natural resource topics have been completed, and long-term monitoring protocols are currently underway.

Resource Stewardship Strategy and *State of the Park*

National Parks are encouraged to develop a Resource Stewardship Strategy (RSS) as part of the park management planning process. Indicators of resource condition, both natural and cultural, are selected by the park. After each indicator is chosen, a target value is determined and the current condition is compared to the desired condition. An RSS has not yet been started for Fort Davis NHS, so the NRCA will provide valuable information for the RSS process once underway. Management plans may then be developed based upon information from the RSS and NRCA to outline actions to be taken over the next 15 to 20 years that will help achieve or maintain the desired condition(s) for each indicator. The NRCA will also be useful for the recently launched NPS *State of the Park* (SotP) reporting initiative.

2.3.2. Status of Supporting Science

Available data and reports varied significantly depending upon the resource topic. The existing data used for each indicator to assess condition or to develop reference conditions are described in each indicator summary in Chapter 4. Part of CHDN's mission is to collect, manage, analyze, and report long-term ecological data to support each park in determining the status, condition, and trend of important natural resources (NPS, CHDN 2010). In addition to data from the CHDN Program and research by other scientists and programs, subject matter experts provided significant information pertaining to upland vegetation, exotic plants, and breeding landbird habitat at the Historic Site. Washington level programs, including night sky and air quality also provided a wealth of information for this NRCA.

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NRCA uplands/soils assessment at Fort Davis NHS.

Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the Fort Davis NHS staff and the CHDN, both of the NPS. Stakeholders in this project include the Historic Site's division managers and management staff and CHDN staff. The purpose of the condition assessment is to provide a "snapshot-in-time" evaluation of the condition of a select set of Historic Site natural resources that were identified by the project team. Project findings will aid Historic Site staff in the following objectives:

- Develop near-term management priorities.
- Engage in watershed or landscape scale partnership and education efforts.
- Conduct park planning (e.g., General Management Plan [GMP], compliance, Resource Stewardship Strategy, resource management plans).

The approach we used to select natural resources was to assess the fundamental and important values of the Historic Site as well as to consider broader natural resources as identified by the NPS' Natural Resource Program Center. The resources assessed are limited to natural-based topics, but cultural resources were also taken into consideration within the context of the chosen natural resources.

3.1. Preliminary Scoping

The selection of resources to assess resulted from meetings and subsequent discussions. For a complete list of team members, please refer to Appendix A.

These meetings and discussions focused on:

1. Confirming the purpose of the Historic Site and its related significance statements and related values.
2. Identifying important natural and cultural resources and concerns for each topic.
3. Identifying data sources and gaps for each resource topic.

Certain constraints were placed on this NRCA, including the following:

- Condition assessments are conducted using existing data and information.
- Identification of data needs and gaps is driven by the project framework categories.

- A preliminary study framework was developed as a result of the meetings and discussions, which listed the chosen resources and the degree of assessment (e.g., full or limited) based upon existing data and information.

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available park data, reports, and spatial information from appropriate sources including: Historic site resource staff, scientific literature, NatureBib, NPSpecies, Inventory and Monitoring data, and available third-party sources. Enlist the help of subject matter experts for each resource topic when appropriate and feasible (refer to Appendix A for subject matter experts list).
- Define an appropriate description of reference condition for each of the key natural resource components and indicators so statements of current condition can be developed for the NRCA report.
- Where applicable, develop GIS products and graphic illustrations that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually.
- Conduct analysis of specific existing data sets to develop descriptive statistics about key natural resource indicators.
- Discuss the issue of key natural resource indicators that are not contained within the Historic Site or controlled directly by Historic Site management activities (e.g., viewshed condition). There are important stressors that impact key natural resource components in the Historic Site but are not under NPS jurisdiction.

Historic site staff participated in on-site meetings and staff reviewed interim and final products. Historic site staff, I&M staff, and additional writer/editors data mined information for each assigned resource topic.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

The Historic Site's NRCA utilizes an assessment framework adapted from "The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States", by the H. John Heinz III Center for Science, Economics and the Environment. This framework was endorsed by the National NRCA Program as an appropriate framework for listing resource components, indicators/measures, and resource conditions.

Each NRCA project represents a unique assessment of key natural resource components that are important to the specific park that is being assessed. As a result, the project framework is developed by the project participants to reflect the key resources of the park. For the purpose of this NRCA, ten key Historic Site natural resources were identified and are listed under the "Resource" column in Table 3.2.1-1. This list of focal study resources is not all inclusive of every natural resource at the Historic Site, but it includes natural resources and processes that were of greatest concern at the time of this assessment.

Reference conditions were identified with the intent of providing a benchmark to which the current condition of each indicator/measure could be compared. Generally, this condition represents a historical reference in which modern human activity and disturbance were not major drivers of population and ecological processes. Attempts were made to utilize existing research and documentation to identify reference conditions; however, many of the indicators lack a quantifiable reference condition according to literature and data reviewed for this project. When a specific reference condition for the Historic Site resources was unknown, an attempt was made to include state and federal standards or data from other relevant locations in order to provide some context for interpreting condition.

Table 3.2.1-1. Fort Davis NHS Natural Resource Condition Assessment Framework

Resource	Assessment Level	Indicators and Measures
I. Landscape Condition Context		
Viewshed	Full Assessment	• Scenic and Historic Integrity (2 Measures)
Night Sky	Full Assessment	• Sky Brightness (1 Measure) • Sky Quality (1 Measure)
Soundscape	Full Assessment	• Audibility (1 Measure) • Sound Characteristics (2 Measures)
II. Supporting Environment		
Air Quality	Full Assessment	• Visibility (1 Measure) • Level of Ozone (1 Measure) • Atmospheric Wet Deposition (2 Measures)
Geology	Limited Assessment	• Geologic Integrity
Groundwater	Full Assessment	• Groundwater Elevation (Change in Groundwater Elevation)
III. Biological Integrity		
Vegetation		
Dry Wash and Historic Cottonwoods	Limited Assessment	• Dry Wash: (2 Measures) • Cottonwood Stand Health (1 Measure)
Upland Vegetation and Soils	Full Assessment	• Soil/Site Stability and Hydrologic Function (3 measures) • Biotic Integrity (5 measures)
Exotic Plants	Full Assessment	• Prevalence of Exotic Plants (2 Measures) • Potential to Alter Native Plant Communities (1 Measures)
Wildlife		
Breeding Landbirds	Full Assessment	• Species Occurrence (3 Measures)

3.2.2. Reporting Areas

Since the Historic Site is relatively small, the reporting area was treated as one unit and encompassed the entire acreage within the Historic Site's boundary. Due to the nature of some of the focal study resources, areas outside of the Historic Site's boundary were included in the assessment to determine overall condition within the Historic Site (e.g., viewshed, air quality).

3.2.3. General Approach and Methods

This study involved reviewing existing literature and data for each of the resources listed, and, where appropriate, analyzing the data to provide summaries or to create new spatial representations. After gathering data regarding current condition of indicators and measures, a qualitative statement was developed comparing the current condition(s) at the Historic Site to the reference condition(s) when possible.

Data Mining

Data and literature were found in multiple forms: NPS reports and monitoring plans (park, regional, and national level), other reports from various state and federal agencies, published and unpublished research documents, non-governmental organization reports, databases, and tabular data. Spatial data were provided by the Historic Site, the CHDN, and by the Natural Resource Program Center. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality pertaining to the indicators identified in the project framework. All reasonably accessible and relevant data were used to conduct this assessment.

Subject Matter Experts

Several researchers and subject matter experts were consulted while developing this assessment. Consultations ranged from

on-site visits to personal communication, and reviews of resource sections. A full list of the team of experts can be found in Appendix A.

Data Analyses and Development

Data analysis and development/writing tasks were performed for specific resources based on the data mining process and recommendations provided by NPS staff. Data analyses and development were resource specific, and the methodology for individual analyses can be found within each section of chapter four.

Geographic Information System (GIS) technology was utilized to graphically depict the status and distribution of considered resources when possible.

Final Assessments

Final assessments were made by incorporating comments provided by subject matter experts, reviewers, and Historic Site staff during the review of draft chapters. Additionally, continued contact with Historic Site staff to address questions and comments pertaining to each resource topic was maintained throughout the data analysis and report writing phase to ensure accurate representation of staff knowledge. The final assessments represent the most relevant and timely data available for each resource topic based on the recommendations and insights provided by Historic Site staff, researchers, subject matter experts, and assessment writers.

Indicator/Measures Assessment Format

Indicator assessments are presented in a standard format that is consistent with *State of the Park* reporting (NPS 2012). The major components are as follows:

The condition/trend/level of confidence graphic provides a visual representation for each resource indicator and is intended to give readers a quick interpretation of the authors' assessments of condition. The level of confidence ranges from high-low and indicates how confident we are with the data used to determine condition. The written statements of condition, located under the "*Condition and Trend*" heading in each resource topic section, provides a more in-depth description of each indicator and associated measure(s)' condition. Figure 3.2.3-1 shows the condition/trend/confidence level scorecard used to describe each indicator/measure.

Circle colors provide indication of condition based upon the chosen indicators/measures and reference conditions. Red circles signify that a resource is of significant concern; yellow circles signify that a resource is in moderate condition; and green circles denote that an indicator is currently in good condition. A circle without any color, (which is almost always associated with the low confidence symbol-dashed line), signifies that there is insufficient information to make a statement about condition of the indicator, therefore, condition is unknown. We include an indicator condition and overall rationale summary table at the end of each resource topic's section.

Arrows inside the circles signify the trend of the indicator/measure condition. Upward pointing arrows signify that the indicator is improving; right pointing arrows signify that the indicator's condition is currently unchanging; double arrows indicate and unchanging condition, and downward pointing arrows indicate that the indicator's condition is deteriorating. No arrow denotes that the trend of the indicator's condition is currently unknown. Figure 3.2.3-2 is an example of a final condition graphic used in the indicator assessments.

Background and Importance

This section provides information regarding the relevance of the resource to the Historic Site. This section also explains the characteristics of the resource that help the reader understand subsequent sections of the document.

Data and Methods

This section describes the existing datasets used for evaluating the indicators/measures. Methods used for processing or evaluating the data are also discussed where applicable. The indicators/measures are listed in this section as well, describing how we measured

Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	An open (uncolored) circle indicates that current condition is unknown or indeterminate; this condition status is typically associated with unknown trend and low confidence				

Figure 3.2.3-1. Condition, trend, and level of confidence key used in the Fort Davis NHS NRCA.

Figure 3.2.3-2. An example of a good condition, unchanging trend, and high confidence level graphic used in NRCAs.

or qualitatively assessed the natural resource topic.

Reference Conditions
This section explains the reference conditions that were used to evaluate the current condition for each indicator. Additionally, explanations of available data and literature that describe the reference conditions are located in this section.

Condition and Trend
This section provides a summary of the condition and trend of the indicator/measure at the Historic Site based on available literature, data, and expert opinions. This section highlights the key elements used in defining the condition and trend designation, represented by the condition/trend graphic, located at the beginning of each resource topic.

The level of confidence and key uncertainties are also included in the condition and trend section. This provides a summary of the unknown information and uncertainties due to lack of data, literature, and expert opinion, as well as our level of confidence about the presented information.

Sources of Expertise
Individuals who were consulted for the focal study resources are listed in this section. A short paragraph describing their background is also included.

Literature Cited
This section lists all of the referenced sources. A DVD is included in the final report with copies of all literature cited unless the citation was from a book. When possible, links to websites are also included.

3.3. Literature Cited

The H. John Heinz III Center for Science, Economics and the Environment. 2008. The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States. Washington, D.C.

National Park Service. 2012. A Call to Action: Preparing for a Second Century of Stewardship and Engagement. Washington, D.C. 28pp.

Chapter 4: Natural Resource Conditions

In this chapter, we present the background and importance, methods, and condition assessment for each focal study resource that we considered for Fort Davis NHS. In many cases, we did not have a quantitative measure for the indicators but tried to present meaningful categorical measures qualitatively that reflect the condition. We also explained why each indicator was chosen and what we considered as a good, moderate or significant concern reference condition for each indicator. We provide a summary of all focal study resource indicators and their page numbers for explanations of our methods and natural resource conditions in Table 4.1.

Table 4.1. Page numbers where the description, methods, and condition for each indicator are presented within this chapter.

Resource	Indicator	Description/ Methods	Condition
I. Landscape Condition Context			
Viewshed	Scenic and Historic Integrity (2 measures)	25	31
Night Sky	Sky Brightness (1 measure)	38	41
	Sky Quality (1 measure)	39	41
Soundscape	Audibility (1 measure)	48	54
	Sound Characteristics (2 measures)	49	55
II. Supporting Environment			
Air Quality	Visibility Haze Index (1 measure)	63	65
	Level of Ozone (1 measure)	64	65
	Atmospheric Wet Deposition in Total N and Total S (2 measures)	64	66
Geology	Geologic Integrity (1 measure)	72	73
Groundwater	Groundwater Elevation (1 measure)	78	79
III. Biological Integrity			
Vegetation			
Dry Wash and Historic Cottonwoods	Dry Wash (2 measures)	85	85
	Cottonwood Stand Health (1 measure)	85	87
Upland Vegetation and Soils	Soil/Site Stability and Hydrologic Function (3 measures)	91	95
	Biotic Integrity (5 measures)	91	96
Exotic Plants	Potential to Alter Native Plant Communities (1 measures)	107	110
	Prevalence of Exotic Plants (2 measures)	109	110
Wildlife			
Breeding Landbirds	Species Occurrence (3 measures)	120	126

4.1. Viewshed

Indicators/Measures

- Scenic and Historic Integrity (2 measures)

Condition – Trend - Confidence

Good - Unchanging - High

4.1.1. Background and Importance

The conservation of scenery is established in the National Park Service (NPS) Organic Act ("…to conserve the scenery and the wildlife therein…"), reaffirmed by the General Authorities Act, as amended, and addressed generally in the NPS Management Policies (Section 1.4.6 and 4.0) (Johnson et al. 2008). Although no management policy currently exists exclusively for scenic or viewshed management and preservation, parks are required to protect scenic and viewshed quality as one of their most fundamental resources. According to Biel (2005), aesthetic conservation, interchangeably used with scenic preservation, has been practiced in the NPS since the early twentieth century. Aesthetic conservation strove to protect scenic beauty for park visitors to better experience the values of the park. The need for scenic preservation management is as relevant today as ever, particularly with the pervasive development pressures that challenge park stewards to conserve scenery today and for future generations.

Fort Davis National Historic Site (NHS) is located within approximately 212 ha (523 ac) nestled in a box canyon near Limpia Creek on the eastern side of the Davis Mountains, the most extensive mountain range in Texas. The historic Fort includes both restored historic buildings and building ruins (Figure 4.1.1-1).

The Fort was occupied from 1854 to 1891. Named in honor of U.S. Secretary of War Jefferson Davis, who later became president of the Confederacy, Fort Davis served as a key post in western Texas where soldiers helped to open the area to settlement and protect emigrants, freighters, mail coaches, and travelers along the San Antonio–El Paso Road, the southern-most route to California.

The Fort was recognized early on for its beautiful setting. In 1855, Second Lietutenant Zenas R. Bliss, of the Eigth U.S. Infantry, arrived at Fort Davis and wrote (NPS 2013):

NPS/CHERYL MCINTYRE

Figure 4.1.1-1. View including the historic buildings and ruins at Fort Davis National Historic Site.

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Figure 4.1.1-2. One of the values of a viewshed, particularly one with such historic significance, is the potential to visualize that site as it once might have been to gain a "sense of place" in that historic context. Restored buildings add to the experience by allowing visitors to imagine the everyday life of Fort inhabitants.

JONATHIN HORSLEY

Figure 4.1.1-3. A view of Fort Davis NHS from a hiking trail above.

The Post was the most beautifully situated of any that I have ever seen. It was in a narrow canyon with perpendicular sides, the walls of which were about 200 feet in height.

Visitor Experience

Inherent in virtually every aspect of this assessment is how features on the visible landscape influence the enjoyment, appreciation, and understanding of the Historic Site by visitors. The indicators we use for condition of the viewshed are based on studies related to perceptions people hold toward various features and attributes of the viewsheds. We also focus on how the historic integrity of the viewshed enhances the opportunity for visitors to better understand the historical significance that the Historic Site had in shaping our country.

From a cultural and historical perspective, the views are not just about the scenery, but rather an important way to better understand life in a frontier Fort.

Historians consider Fort Davis to be one of the best remaining examples of a frontier military post in the American Southwest. When the National Park Service acquired the property in the early 1960s, Fort Davis had been abandoned for nearly 70 years. An intensive restoration effort stabilized structures, restored buildings, and refurnished barracks with period antiques, museum-quality replicas, and custom-made items (Figure 4.1.1-2). In this way, visitors can explore the restored and refurnished buildings to get a sense of what life was like, see the remains (ruins) of other buildings that made up the Fort, and experience the natural setting in a condition similar to the way it was at the time the Fort was occupied. In addition, hiking trails within the historic site connect with trails in adjacent Davis Mountains State Park, where visitors can get an aerial view of the Fort (Figure 4.1.1-3).

4.1.2. Data and Methods

Viewsheds are considered in this assessment within two interrelated contexts: natural scenic integrity and historic integrity. Impacts that degrade one aspect likely degrade the

other as well. For example, modern structures or roadways visible on the landscape may detract from the natural scenic integrity of the viewshed, and diminish the sense of place that a historically authentic landscape evokes. Depending on the context, scenic and historic integrity may be distinct, or there may be so little practical difference that they are the same. In the case of Fort Davis National Historic Site, there is so much overlap that we treat them together. We qualitatively assess how features on the landscape contribute (or not) to the scenic and historic integrity of the site.

Indicator
Scenic and Historic Integrity

The overall indicator of viewshed condition we use in this assessment is a combination of scenic and historic integrity. For this overall indictor we used two measures (intactness and conspicuousness) from key vantage points (Table 4.1.2-1). Each of these measures are described in greater detail below.

Scenic integrity is defined as the state of naturalness or, conversely, the state of disturbance created by human activities or alteration (USFS 1995). This focuses on the features of the landscape related to human influence.

Historic integrity is the authenticity of a site's historic identity, evidenced by the survival of physical characteristics that existed during its historic period. Historic integrity is based on those features of the cultural and natural landscape, from the perspective of an observer, that contribute to the sense of place and enhance the visitor experience. In this assessment, we focus on those features that have a visual impact and contribute to the history of Fort Davis. We evaluate features as contributing, enhancing the scenic and historic features of the landscape, or noncontributing, detracting from the scenic and historic integrity.

We assess scenic and historic integrity by evaluating specific human-made features that can be seen from key vantage points and whether or not those features are contributing or noncontributing to the scenic and/or historic integrity of the view. For noncontributing features, we further assess the characteristics that make them more or less conspicuous; which influences the level of impact that they might have. We then supplement this assessment with a Geographic Information System (GIS)-based map showing areas that are or are not visible from key vantage points. The GIS analysis provides spatial orientation of key features.

Viewshed Vantage Points

The three main vantage points within the Historic Site used in this analysis were *Sleeping Lion*, from a trail along the western edge of the Fort; *the Barracks*, from behind the barracks buildings, looking south over the ruins and toward town; and *The Overlook*, a high vantage point looking down onto the Fort from a hiking trail (Figure 4.1.2-1). These sites capture what visitors experience, including scenic quality and historic context.

Sleeping Lion – The Sleeping Lion vantage point is a view from a small hiking trail that winds up the canyon wall along the west side of the Historic Site. From there, the entire Fort is visible, from a somewhat

Table 4.1.2-1. Indicators and measures of viewshed and why these are important to the resource condition.

Indicators of Condition	Measures	Why are these indicators/measures important to resource condition?
Scenic and Historic Integrity	Intactness of View	Intactness represents how much the viewshed has been altered from its reference state, which in turn influences scenic quality as well as the sense of place in an historic context.
	Conspicuousness of non-contributing features	Non-contributing features that are more conspicuous tend to detract more from the scenic quality and/or the sense of place in an historic context.

Figure 4.1.2-1. Location of vantage points used in this assessment.

higher-than-ground-level perspective. The feeling visitors have when they leave the parking lot and cross the footbridge into the Fort, is that they have gone back in time. This view captures that feeling.

The Barracks– As visitors explore the buildings and grounds of the Fort, the southern view overlooks the ruins of the old stables and looks toward the town of Fort Davis.

The Overlook – Hiking trails up the canyon are popular among visitors for aerial views looking down on the Fort. From this vantage point, visitors can take in the entire Fort and its setting.

Measure
Intactness

The extent of intactness provides a measure of the degree to which the viewshed is unaltered from its original (reference) state, particularly the extent to which intrusive or disruptive elements may diminish the character of the scene (USFS 1995, Johnson et al. 2008).

We used a series of panoramic images to portray the viewshed from an observer's perspective from each vantage point. These images were taken using a Canon PowerShot digital camera and the GigaPan Epic 100 system, a robotic camera mount coupled with stitching software (Figure 4.1.2-2). A series of images are automatically captured and the individual photographs are stitched into a single high-resolution panoramic image. These photographs provide a means of illustrating the indicators related to viewshed integrity.

We recognize that visitor perceptions of an altered landscape are highly subjective, and there is no completely objective way to measure this. Research has shown, however, that there are certain landscape types and characteristics that people tend to prefer over others. In general, there is a wealth of research demonstrating that people tend to prefer natural over human-modified landscapes (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). In the case of park units set aside for their historical significance, human-made structures that have historical significance also add value to the historical context and contribute to the sense of place. Therefore, human-made features that are consistent

Figure 4.1.2-2. The GigaPan system takes a series of images that are stitched together to create a single panoramic image.

with the historical context of the Historic Site are likewise considered consistent with the goals of scenic and historic integrity. Human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) that do not contribute to the historic context are often perceived as detracting from the scenic and historic character of the viewshed.

Despite this generalization for natural landscape preferences, studies have shown that not all human-made structures or features have the same impact on visitor preferences. Visitor preferences can be influenced by a variety of factors, including cultural background, familiarity with the landscape, and their environmental values (Kaplan and Kaplan 1989, Virden and Walker 1999, Kaltenborn and Bjerke 2002, Kearney et al. 2008).

Measure

Conspicuousness of Noncontributing Features

Substantial research has demonstrated that human-made features on a landscape are perceived more positively when they are considered in harmony with the landscape (e.g., Kaplan and Kaplan 1989, Gobster 1999, Kearney et al. 2008). For example, Kearney et al. (2008) showed that survey respondents tended to prefer development that blended with the natural setting through use of colors, smaller scale, and vegetative screening. For this indicator, we focused on four characteristics, or groups of characteristics, that have been demonstrated to contribute to the conspicuousness of man-made features: (1) distance from a given vantage point, (2) size, (3) color and shape, and (4) movement and noise. A general relationship between these characteristics and their influence on conspicuousness is presented in Table 4.1.2-2 and more detailed descriptions of these human-made features are presented below.

Distance – The impact that individual human-made features have on perception is substantially influenced by the distance from the observer to the feature(s). Viewshed assessments using distance zones or classes often define three classes: foreground, middle ground, and background (Figure 4.1.2-3). For this assessment, we have used the distance classes that have been recently used by the National Park Service:

Table 4.1.2-2. Characteristics that influence how less conspicuous human-made features are within a viewshed and the general effect.

Characteristic	Less Conspicuous	More Conspicuous
Distance	Distant from the vantage point	Close to the vantage point
Size	Small relative to the landscape	Large relative to the landscape
Color and Shape	Colors and shapes that blend into the landscape	Colors and shapes that contrast with the landscape
Movement and Noise	Lacking movement or noise	Exhibits obvious movement or noise

Figure 4.1.2-3. An example of approximate distance classes used in this assessment.

- Foreground = 0-½ mile from vantage point
- Middle ground = ½-3 miles from vantage point
- Background = 3-60 miles from vantage point. Over time, different agencies have adopted minor variations in the different specific distances use to define these zones, but the overall logic and intent has been consistent.

The foreground is the zone where visitors should be able to distinguish variation in texture and color, such as the relatively subtle variation among vegetation patches, or some level of distinguishing clusters of tree boughs. Large birds and mammals would likely be visible throughout this distance class, as would small or medium-sized animals at the closer end of this distance class (USFS 1995). Within the middle ground there is often sufficient texture or color to distinguish individual trees or other large plants (USFS 1995). It is also possible to still distinguish larger patches within major plant community types (such as grasslands), provided there is sufficient difference in color shades at the farther distance. Within the closer portion of this distance class, it still may be possible to see large birds when contrasted against the sky, but other wildlife would be difficult to see without the aid of binoculars or telescopes. The background distance class is where texture tends to disappear and colors flatten. Depending on the actual distance, it is sometimes possible to distinguish among major vegetation types with highly contrasting colors (for example, forest and grassland), but any subtle differences within these broad land cover classes would not be apparent without the use of binoculars or telescopes, and even then may be difficult.

Size

Size is another characteristic that may influence how conspicuous a given feature dominates the landscape, and how it is perceived. For example, Kearney et al. (2008) found human preferences were lower for human-made developments that tended to dominate the view, such as large, multi-storied buildings) and were more favorable toward smaller, single family dwellings. In another study, Brush and Palmer (1979) found that farms tended to be viewed more favorably than views of towns or industrial sites, which ranked very low on visual preference. This is consistent with other studies that have reported rural family dwellings, such as farms or ranches, as quaint and contributing to rural character (Schauman 1979, Sheppard 2001, Ryan 2006), or as symbolizing good stewardship (Sheppard 2001).

Table 4.1.2-3. A matrix describing the six size classes used for visible human-made features.

	Low Volume	Substantial Volume
Low Height	Single family dwelling (home, ranch house)	Small towns, complexes
Substantial Height	Radio and cell phone towers	Wind farms, oil derecks
Substantial Length	Small roads, wooden power lines, fence lines	Utility corridors, highways

We considered the features on the landscape surrounding Fort Davis NHS as belonging to one of six size classes (Table 4.1.2-3), which reflect the preference groups reported by studies. Using some categories of perhaps mixed measures, we considered size classes within the context of height, volume, and length.

Color and Shape

Studies have shown that how people perceive a human-made feature in a rural scene depends greatly on how well it seems to fit or blend in with the environment (Kearney et al. 2008, Ryan 2006). For example, Kearney et al. (2008) found preferences for homes that exhibit lower contrast with their surroundings as a result of color, screening vegetation, or other blending factors (see Figure 4.1.2-4). It has been shown that colors lighter in tone or higher in saturation relative to their surroundings have a tendency to attract attention (contrast with their surroundings), whereas darker colors (relative to their surroundings) tend to fade into the background (Ratcliff 1972), O'Conner 2008). This is consistent with the findings of Kearney et al. (2008) who found that darker color was one of the factors contributing to a feature blending in with its environment and therefore preferred. Some research has indicated that color can be used to offset other factors, such as size, that may evoke a more negative perception (O'Conner 2009). Similarly, shapes of features that contrast sharply with their surroundings may also have an influence on how they are perceived. This has been a dominant focus within visual resource programs of land management agencies (Ribe 2005). In forest management, negative perceptions related to the contrasting shapes of forest harvest with their surroundings (for example, clear cuts) was so strong that it was explicitly addressed in the National Forest Management Act of 1976 calling for "cuts shaped and blended to the extent practicable with the natural terrain" (16 USCA 1604g3Fiii). The Visual Resource Management Program of the BLM (BLM 1980) similarly places considerable

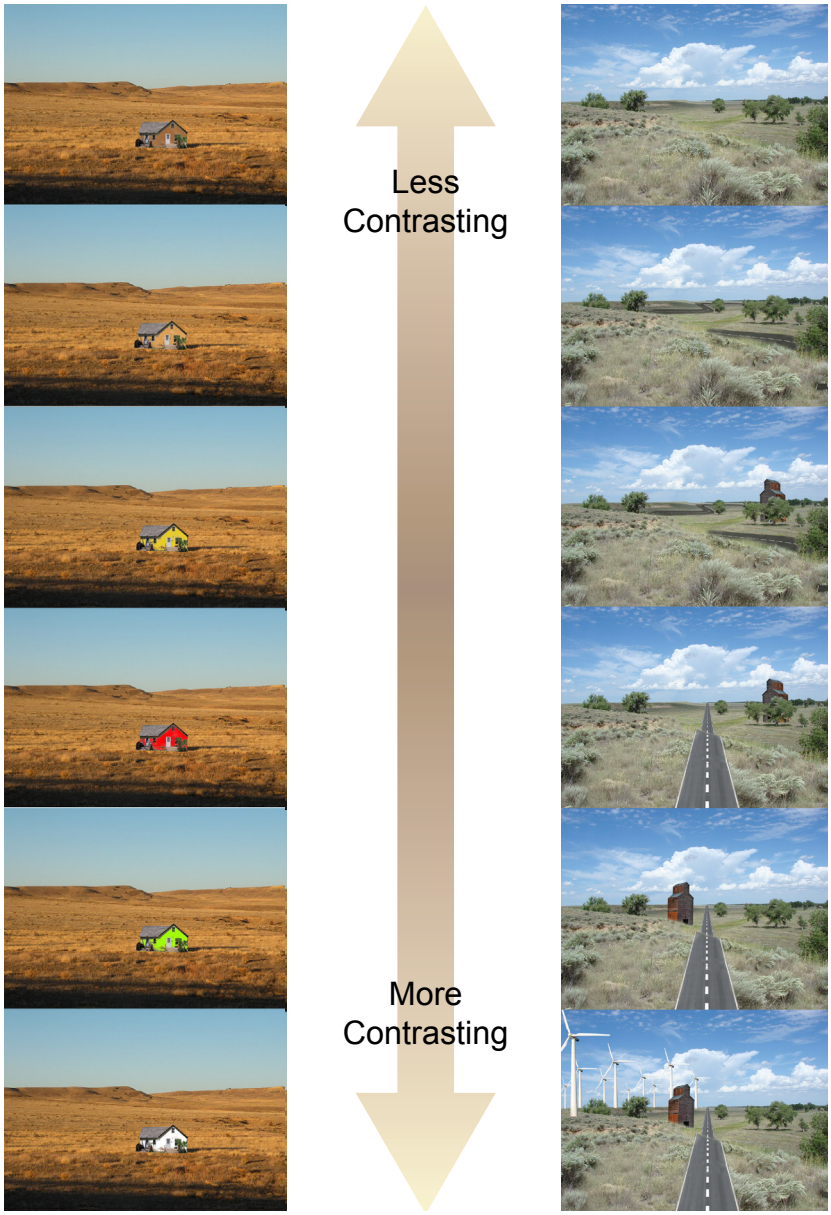


Figure 4.1.2-4. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.

focus on design techniques that minimize visual conflicts with features such as roads and power lines by aligning them with the natural contours of the landscape. Based on these characteristics of contrast, we considered the color of a feature in relative harmony with the landscape if it closely matched the surrounding environment, or if the color tended to be darker relative to the environment. We considered the shape of a feature in relative harmony with the landscape if it was not in marked contrast to the environment.

Movement and Noise

Motion and sound can both have an influence on how a landscape is perceived (Hetherington et al. 1993), particularly by attracting attention to a particular area of a viewshed. Movement and noise parameters can be perceived either positively or negatively, depending on the source and context. For example, the motion of running water generally has a very positive influence on perception of the environment (Carles et al. 1999), whereas noise from vehicles on a highway may be perceived negatively. In Carles et al.'s 1999 study, sounds were perceived negatively when they clashed with aspirations for a given site, such as tranquility. We considered the conspicuousness of the impact of movement and noise to be consistent with the amount present (that is, little movement or noise was inconspicuous, obvious movement or noise was conspicuous).

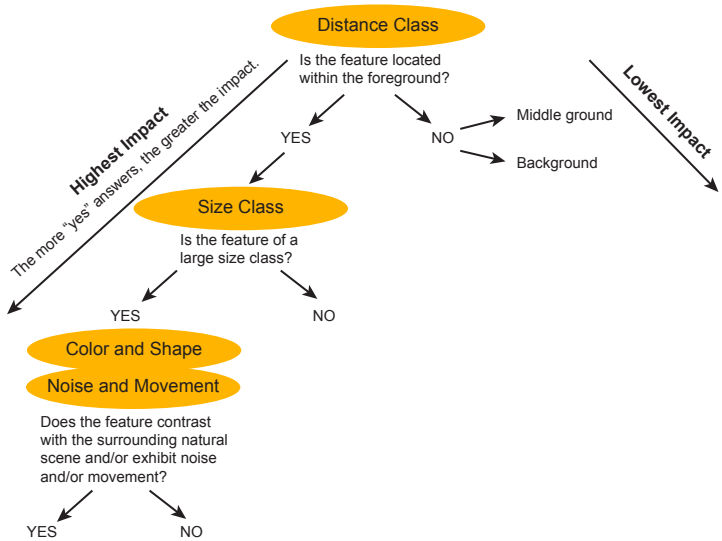


Figure 4.1.2-5. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

Hierarchical Relationship among Conspicuousness Measures

The above-described characteristics do not act independently with respect to their influence on the conspicuousness of features; rather, they tend to have a hierarchical effect. For example, the color and shape of a house would not be important to the integrity of the Historic Site's viewshed if the house was located too far away from the vantage point. Thus, distance becomes the primary characteristic that affects the potential conspicuousness. Therefore, we considered potential influences on conspicuousness in the context of a hierarchy based on the distance characteristics having the most impact on the integrity of the viewshed, followed by the size characteristic, then both the color and shape, and movement and noise characteristic (Figure 4.1.2-5).

GIS Viewshed Analyses

We supplement our assessment with a GIS anaysis to provide spatial context for these measures.

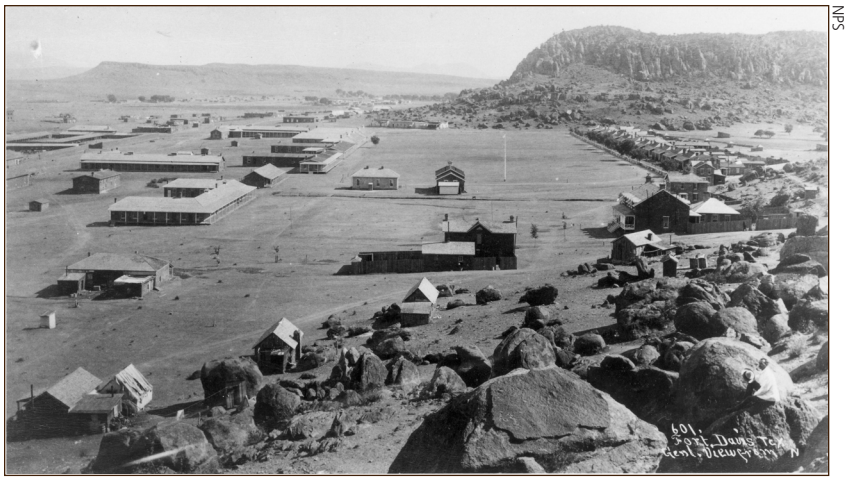
Viewshed analyses were conducted to depict the total visible area seen from each of the three key vantage points. Aerial maps of each of the vantage points were generated based on digital elevation models (DEMs) to predict the area visible from a given vantage point taking into account changes in elevation and other obstructions such as tree, mountain, or building heights. We limited this approach to an area of 30 km (18.6 mi) from Historic Site since features at greater distances have relatively less impact on scenic or historic integrity than those in greater proximity.

Ground verification indicated that the initial viewshed analyses tended to underestimate the visible area. Consequently, we adjusted the analyses by experimenting with different offsets that adjust the height of the observer or the surrounding landscape. After several iterations, we found that a 10 m offset for the surrounding landscape provided the best depiction of the visible area from each vantage

point. Complete details of the viewshed analysis process are listed in Appendix B.

4.1.3. Reference Conditions

The indicators and measures of viewshed condition at Fort Davis are all inter-related and are intended to provide information about how well the views maintain their scenic quality and their ability to evoke a sense of place in an historic context. As previously discussed, the scenic and historic integrity at Fort Davis NHS overlap considerably. From the historic perspective, the reference state is based on a particular period relevant to the site—in this case, the time of the Fort's occupation (1854-1891). Figure 4.1.3-1 is a historic photo from 1885.



NPS

Figure 4.1.3-1. Historic photo of Fort Davis from 1885.

The basis for determining condition in an assessment such as this is a comparison between current condition and some reference. For Fort Davis NHS we used a qualitative reference state for the scenic and historic integrity of the viewshed (Table 4.1.3-1). Embedded within these reference conditions is both the intactness and conspicuousness of features that do not contribute to the scenic and historic integrity relative to that period.

4.1.4. Condition and Trend

We considered the views at Fort Davis NHS to be in moderate to good condition depending on the vantage point (Table 4.1.4-1). The landscape surrounding the Historic Site has some non-contributing features, but the main views of the Fort have high scenic and historic integrity. Overall, the condition of the viewshed is good (Table 4.1.4-2).

The views from the Sleeping Lion vantage point are framed largely by the canyon and look over the Fort, with the parade grounds and historic Fort buildings prominent. From this vantage point, the entrance road, parking lot, and some buildings associated with the Town of Fort Davis are visible, but are not conspicuous within the visitor's view of the Fort (Figure 4.1.4-1).

Table 4.1.3-1. Qualitative reference condition classes used for scenic and historic integrity within the viewshed at Fort Davis NHS.

Class	Scenic & Historic Integrity
High Integrity (Good Condition)	Some non-contributing features or developments may be visible, but the vast majority of the landscape is dominated by natural or historic features. The integrity of the historic context is well preserved such that an observer can easily visualize the historic aspect of the viewshed. As such, the features that contribute to the historic integrity are well preserved (even as ruins) and the noncontributing features are generally absent or are sufficiently inconspicuous so as to not detract from the historic sense of place.
Moderate Integrity (Moderate Concern)	Non-contributing features or developments occupy a moderate portion of the landscape and/or are moderately conspicuous, but sufficient intactness retains much of its integrity. The integrity of the historic context is also largely preserved such that an observer can visualize the historic aspect of the viewshed.
Low Integrity (Significant Concern)	The vast majority of the landscape is dominated by non-contributing features or developments that are conspicuous enough that little integrity or "sense of place" remains. The integrity of the historic context is essentially lost either from the contributing factors not being well preserved or the noncontributing features overwhelming the potential to visualize the historic aspect of the viewshed.

Table 4.1.4-1. Summary of viewshed condition assessed at each vantage point.

Vantage Point	Non-contributing Features	Assessment	Condition
Sleeping Lion Vantage Point (Figure 4.1.4-1)	Park road, trail Parking lot Buildings	The views from the Sleeping Lion vantage point are framed largely by the canyon and look over the Fort, with the parade grounds and historic Fort buildings prominent. From this vantage point, the entrance road, parking lot, and some buildings associated with the Town of Fort Davis are visible, but are not conspicuous within the visitor's view of the Fort.	Good
The Barracks Vantage Point (Figure 4.1.4-2)	Town (largely shielded) Hillside road Hillside homes	The Barracks vantage point looks toward town and away from the majority of the Historic Site (visitors have to be behind the barracks buildings to see this view). In the foreground are the ruins of the stables and other Fort buildings. In the middle ground are views of the Town of Fort Davis, though trees largely shield the streets and buildings from view. In the middle ground to background a road winding up a hillside may catch a visitor's eye, which leads to hillside homes, that are somewhat conspicuous.	Good to Moderate
The Overlook (Figure 4.1.4-3)	Town of Fort Davis (buildings, homes, roads)	The Overlook provides a "birds-eye" view of the Fort within the landscape context of the canyon, the mountain ranges, and the nearby town. Because the Town of Fort Davis coincided with the Fort since its establishment, seeing the Fort in the context of town (which has retained some historic character) does not strike us as inconsistent, however, the light colors of building and roofs make them conspicuous.	Good to Moderate

Table 4.1.4-2. Indicators and measures of viewshed condition, their corresponding assigned condition class, and the rational for assigning that condition class.

Indicators of Condition	Measures	Condition	Rationale for Condition
Scenic and Historic Integrity	Intactness of View	Good	Views within the Historic Site to the north, west, and east are framed by the box canyon and maintain a high degree of integrity. The views are dominated by natural features of the canyon and historic features of the Fort buildings (both restored and ruins) and parade grounds. Non-contributing features exist, but they do not dominate the view. The sense of place is largely retained.
	Conspicuousness of non-contributing features	Moderate	Non-contributing features to the south and east are mostly shielded by vegetation. The view to the east of the parking lot and town buildings are fairly conspicuous. The town of Fort Davis existed during the time of the Fort, but has certainly grown over time, and the light-colored buildings contrast more and are conspicuous. To the west, there is a road that winds up a hill to homes on the hillside, and those are also somewhat conspicuous. Views from ground level are mostly shielded from non-contributing features. Once the vantage point rises (as in Sleeping Lion and the Overlook), more terrain is visible, and the non-contributing features become more conspicuous.

Figure 4.1.4-1. Views of the Fort from the Sleeping Lion vantage point are largely framed by the canyon walls and prominently feature the Fort historic buildings and parade grounds. Notice the non-contributing features to the southeast (lower image) including the parking lot and entrance road, the town is largely shielded by vegetation, though some light-colored buildings are conspicuous.

The Barracks vantage point toward town and away from the majority of the Historic Site (visitors have to be behind the barracks buildings to see this view). In the foreground are the ruins of the stables and other Fort buildings. In the middle ground are views of the Town of Fort Davis, though trees largely shield the streets and buildings from view. In the middle ground to background a road winding up a hillside may catch a visitor's eye, which leads to hillside homes, though these are not terribly conspicuous (Figure 4.1.4-2).

The overlook provides a "birds-eye" view of the Fort within the landscape context of the canyon, the mountain ranges, and the nearby town. Because the Town of Fort Davis coincided with the Fort since its establishment, seeing the Fort in the context of town (which has retained some historic character, as well) does not strike us as inconsistent with historic character, however, development since the historic town, the light colors of building and roofs make them somewhat conspicuous (Figure 4.1.4-3).

Viewshed

Indicator	Measures
Scenic and Historic Integrity	Intactness of View Conspicuousness of non-contributing features

Overall Condition

Based on this assessment, the viewshed condition at Fort Davis NHS is considered good and unchanging. While some non-contributing features are conspicuous from higher vantage points, the natural and historic features are largely intact and from a ground-based view, non-contributing features are less conspicuous. Because the Historic Site is adjacent to the state park, much of the viewshed is likely to remain protected.

GIS-based Assessment

For our GIS-based analysis, we estimated the areas visible or not visible from the Fort Davis vantage points. Distant views to the north and west (and somewhat to the east) are limited by topography, whereas views to the south are

Figure 4.1.4-2. Views from the Barracks vantage point to the south feature historic Fort building ruins, while the Town of Fort Davis is visible, it is mostly screened by vegetation. Non-contributing features include the hillside road (top left) and large building (lower right).

Figure 4.1.4-3. Views from the Overlook vantage point provide a "bird's-eye" perspective of the Fort's location in the canyon and adjacent to town. Notice that as the vantage points gain elevation, the non-contributing features (such as light colored buildings in town, colored roofs, and roads) become more conspicuous.

limited by vegetation and the Town of Fort Davis (Figure 4.1.4-4).

It is important to keep in mind that these estimates of visible area are approximations based on digital evaluation models. Although we have checked them on the ground to verify that they are approximately correct, it should not be assumed that they are exactly correct for the purposes of planning specific projects. Such cases may require further verification, and adjustment if necessary, for the specific context intended.

4.1.5. Sources of Expertise

For assessing the condition of this resource, we relied primary on literature on this topic. Heidi Sosinski provided GIS expertise.

Key Uncertainties

How a view is perceived is quite subjective and will always have an element of uncertainty. We have tried to base our assessment on the findings of an extensive body of literature, and have tried to be transparent with our assessment, such that those that disagree can make an argument based on our approach.

Another element of uncertainty is our GIS analysis. This analysis is based on digital elevation models and does not take into account visibility limitations from vegetation, etc. An offset was used to try to approximate the visible area, but the map needs to be groundtruthed, which was not completed in this analysis. It should not be assumed that our analysis is exactly correct for the purposes of planning specific projects. Such cases may require further verification, and adjustment if necessary, for the specific context intended.

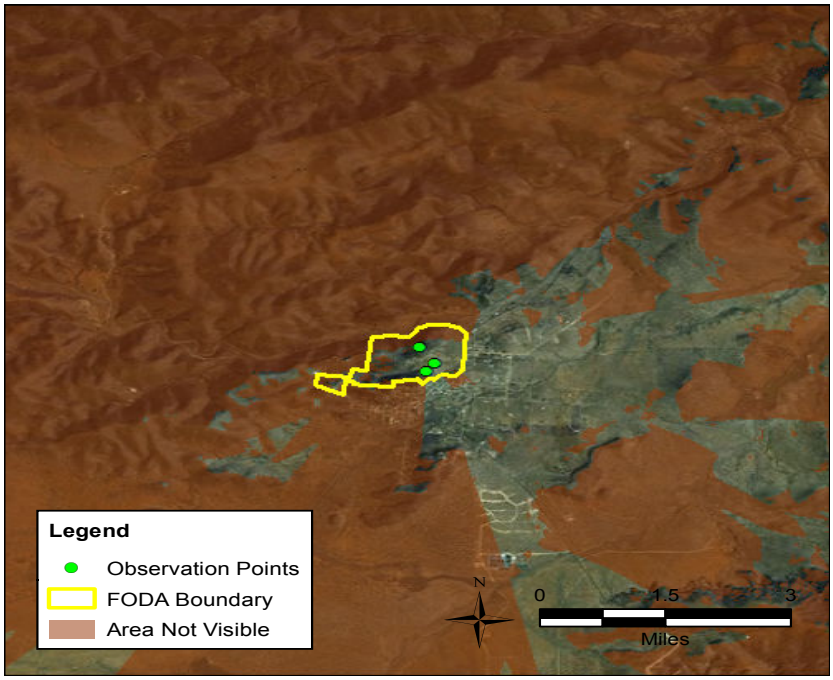


Figure 4.1.4-4. Cumulative area visible and not visible from the three Fort Davis vantage points based on GIS analysis.

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4.2. Night Sky

Indicators/Measures

- Sky Brightness (1 measure)
- Sky Quality (1 measure)

Condition – Trend – Confidence Level

Good - Insufficient Data - Medium

4.2.1. Background and Importance

Natural dark skies are a valued resource within the NPS, reflected in NPS management policies (NPS 2006) which highlight the importance of a natural photic environment to ecosystem function, and the importance of the natural lightscape for aesthetics. The NPS Natural Sounds and Night Skies Division makes a distinction between a *lightscape*—which is the human perception of the nighttime scene, including both the night sky and the faintly illuminated terrain, and the *photoic environment*—which is the totality of the pattern of light at night at all wavelengths (Moore et al. 2013).

Lightscapes are an aesthetic and experiential quality that are integral to natural and cultural resources (Moore et al. 2013). A 2007 visitor survey conducted throughout Utah national parks found that 86% of visitors thought the quality of park night skies was "somewhat important" or "very important" to their visit. Additionally, in an estimated 20 national parks, stargazing events are the most popular ranger-led program (NPS 2010).

The values of night skies goes far beyond visitor experience and scenery. The photic environment affects a broad range of species, is integral to ecosystems, and is a natural physical process (Moore et al. 2013). Natural light intensity varies during the day--night (diurnal) cycle, the lunar cycle, and the seasonal cycle. Organisms have evolved to respond to these periodic changes in light levels in ways that control or modulate movement, feeding, mating, emergence, seasonal breeding, migration, hibernation, and dormancy. Plants also respond to light levels by flowering, vegetative growth, and their direction of growth (Royal Commission on Environmental Pollution 2009). Given the effects of light on living organisms, it is likely that the introduction of artificial light into the natural light/darkness regime will disturb the normal routines of many plants and animals (Royal Commission on Environmental Pollution 2009), as well as diminish stargazing recreational opportunities offered to national park visitors.

MCDONALD OBSERVATORY

Figure 4.2.1-1. McDonald Observatory, located nearby to Fort Davis NHS.

Fort Davis National Historic Site (NHS) is primarily a cultural resource park, and the cultural significance of dark night skies should be recognized as part of the cultural landscape. Visitors to Fort Davis NHS can visit the nearby McDonald Observatory (Figure 4.2.1-1), a research unit of The University of Texas- Austin, one of the world's leading centers for astronomical research, public education, and outreach. The observatory offers a wide variety of public programs during the daytime, such as solar viewing, lectures, and visitor center tours, as well as nighttime star parties. Outreach programs are geared toward teachers and students in kindergarten to 12th grade classrooms. The observatory also produces the StarDate radio program, StarDate magazine, and the StarDate website (http://www.stardate.org).

Protecting the night sky resources at Fort Davis NHS benefits the natural resources, is important for visitor experience, has cultural and historical significance, and is important within the cultural context of the Historic Site.

4.2.2. Data and Methods

The NPS Natural Sounds and Night Skies Division goals of measuring night sky brightness are to describe the quality of the lightscape, quantify how much it deviates from natural conditions, and how it changes with time due to changes in natural conditions, as well as artificial lighting in areas within and outside of the national parks (Duriscoe et al. 2007).

Based on new guidance (Moore et al. 2013), the NPS Natural Sounds and Night Skies Division recommends that the all-sky Anthropogenic Light Ratio (ALR) as the best single parameter for characterizing the overall sky condition. Additional indicators and measures may be considered in an assessment of night sky condition, but the ALR measure is the primary data source for condition assessment (see Table 4.2.2-1).

We conducted a supplemental rapid assessment of the Historic Site's night sky condition on June 25, 2013 using the Bortle Dark Sky Scale, a qualitative assessment commonly used by amateur astronomers to evaluate the potential quality for star gazing. This rapid assessment is supplementary and is intended only to illustrate the night sky condition.

Measure

Sky Brightness (Anthropogenic Light Ratio)

The anthropogenic light ratio (ALR) is the average anthropogenic sky luminance presented as a ratio over natural conditions. It is a useful metric to average the light flux over the entire sky (measuring all that is above the horizon and omitting the terrain). Recent advances in modeling of the natural components of the night sky allow the separation of anthropogenic light from natural features, such as the Milky Way. This metric is a convenient and robust measure. It is most accurately obtained from ground-based measurements with the NPS Night Skies Program's photometric system, however, it can also be modeled with moderate

Table 4.2.2-1. Indicators and measures of the night sky and why they are important to resource condition.

Indicator	Measure	Description
Sky Brightness	Anthropogenic Light Ratio	The all-sky anthropogenic light ratio describes light due to man-made sources compared to light from a natural dark sky. Understanding the lightscape and sources of light is helpful to managers to maintain dark skies for the benefit of wildlife and people alike.
Sky Quality	Bortle Scale Class	The Bortle Dark Sky classification system describes the quality of the dark night sky by the celestial bodies and night sky features an observer can see. Observing the stars has been an enjoyable human pastime for centuries.

confidence when such measurements are not available. No ground-based measures were taken for Fort Davis NHS; modeling data are reported here.

CCD camera images assess brightness, including maximum sky brightness, minimum sky brightness, and two measures of integrated sky brightness. The maximum sky brightness is typically found in the core of urban light domes (i.e., the semicircular-shaped light along the horizon caused by the scattering of urban light). The minimum sky brightness is typically found at or near the zenith (i.e., straight overhead). The integrated night sky brightness is calculated from both the entire celestial hemisphere as well as a measure of the integrated brightness masked below 20° altitude to avoid site-to-site variations introduced by terrain and vegetation blocking.

Measure
Bortle Dark Sky Scale

The Bortle Dark Sky Scale (Appendix C) was proposed by John Bortle (Bortle 2001) based on 50 years of astronomical observations. Bortle's qualitative approach uses a nine-class scale that requires a basic knowledge of the night sky and no special equipment (Bortle 2001, Moore 2001, White et al. 2012, Table 4.2.2-2). The Bortle scale uses both stellar objects and familiar descriptors to distinguish among the different classes. Another advantage of the Bortle scale is that it is suitable for conditions ranging from the darkest skies to the brightest urban areas (Moore 2001, Figure 4.2.2-1).

4.2.3. Reference Conditions

The ideal night sky reference condition, regardless of how it's measured, is one devoid of any light pollution. However, results from night sky data collection throughout more than 90 national parks suggest that a pristine night sky is very rare (NPS 2010). A natural night sky has an average brightness across the entire sky of 80 nL (nanolamberts, a measure of luminance), and includes features such as the Milky Way, Zodiacal light, airglow, and other starlight. This is figured into the ratio, so that an ALR reading of 0.0 would indicate pristine natural conditions where the anthropogenic component was 0 nL. A ratio of 1.0 would indicate that anthropogenic light was 100% brighter than the natural light from the night sky. For a summary of condition assessment categories for all night sky indicators, see Table 4.2.3-1.

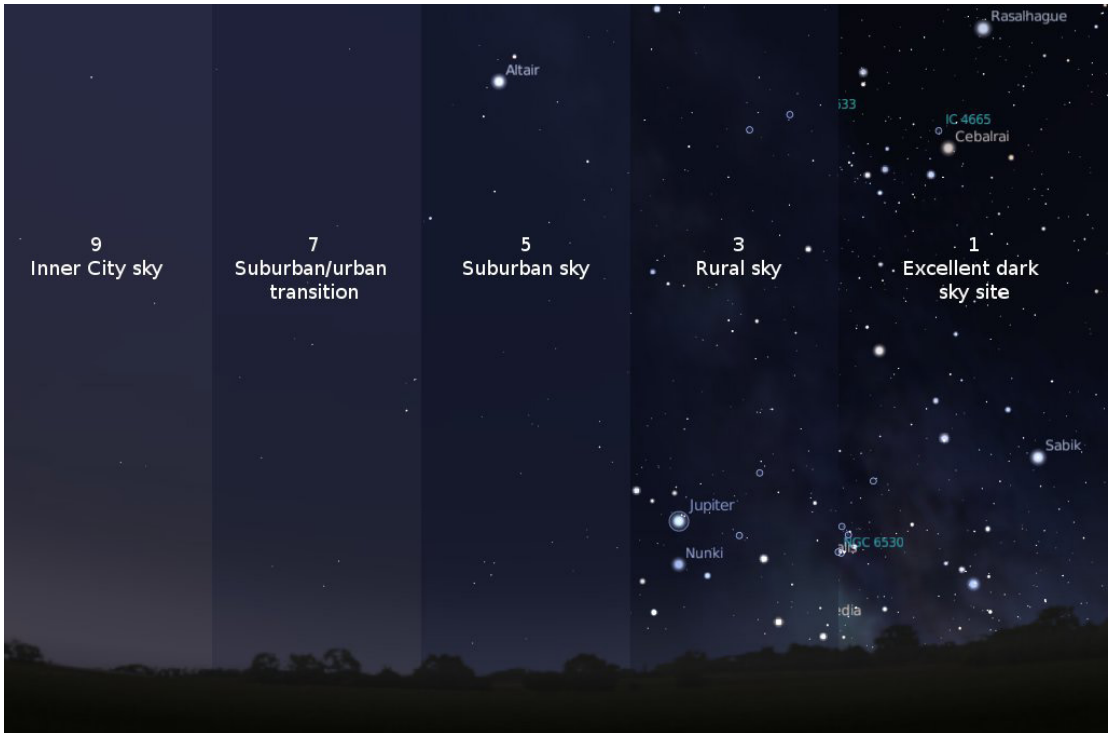


IMAGE GENERATED FROM STELLARIUM (WWW.STELLARIUM.ORG)

Figure 4.2.2-1. Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

Table 4.2.2-2. Bortle Dark Sky Scale.*

Bortle Scale	Milky Way (MW)	Astronomical Objects	Zodiacal Constellations	Airglow and Clouds	Nighttime Scene
Class 1 Excellent Dark Sky Site	MW shows great detail, and appears 40° wide in some parts; Scorpio-Sagittarius region casts an obvious shadow	Spiral galaxies (M33 and M81) are obvious objects; the Helix nebula is visible with the naked eye	Zodiacal light is striking as a complete band, and can stretch across entire sky	The horizon is completely free of light domes, very low airglow	Jupiter and Venus annoy night vision, ground objects are barely lit, trees and hills are dark
Class 2 Typical Dark Site	MW shows great detail and cast barely visible shadows	The rift in Cygnus star cloud is visible; the Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares	Zodiacal band and gegenschein are visible	Very few light domes are visible, with none above 5° and fainter than the MW; airglow may be weakly apparent, and clouds still appear as dark voids	Ground is mostly dark, but object projecting into the sky are discernible
Class 3 Rural Sky	MW still appears complex; dark voids and bright patches and a meandering outline are visible	Brightest globular clusters are distinct, pinwheel galaxy visible with averted vision	Zodiacal light is easily seen, but band of gegenschein is difficult to see or absent	Airglow is not visible, and clouds are faintly illuminated except at zenith	Some light domes evident along horizon, ground objects are vaguely apparent
Class 4 Rural-Suburban Transition	MW is evident from horizon to horizon, but fine details are lost	Pinwheel galaxy is a difficult object to see; deep sky objects such as M13 globular cluster, Northern Coalsack dark nebula, and Andromeda galaxy are visible	Zodiacal light is evident, but extends less than 45° after dusk	Clouds are just brighter than the sky, but appear dark at zenith	Light domes are evident in several directions (up to 15° above the horizon), sky is noticeably brighter than terrain
Class 5 Suburban Sky	MW is faintly present, but may have gaps	The oval of Andromeda galaxy is detectable, as is the glow in the Orion nebula, Great rift in Cygnus	Only hints of zodiacal light may be glimpsed	Clouds are noticeably brighter than sky	Light domes are obvious to casual observers, ground objects are easily seen
Class 6 Bright Suburban Sky	MW only apparent overhead, and appears broken as fainter parts are lost to sky glow	Cygnus, Scutum, and Sagittarius star fields just visible	Zodiacal light is not visible; constellations are seen, and not lost against a starry sky	Clouds appear illuminated and reflect light	Sky from horizon to 35° glows with grayish color, ground is well lit
Class 7 Suburban-Urban Transition	MW may be just barely seen near the zenith	Andromeda galaxy (M31) and Beehive cluster (M44) are rarely glimpsed	Zodiacal light is not visible, and brighter constellations are easily seen	Clouds are brilliantly lit	Entire sky background appears washed out, with a grayish or yellowish color
Class 8 City Sky	MW not visible	Pleiades are easily seen, but few other objects are visible	Zodiacal light not visible, constellations are visible but lack key stars	Clouds are brilliantly lit	Entire sky background has uniform washed out glow, with light domes reaching 60° above the horizon
Class 9 Inner City Sky	MW not visible	Only the Pleiades are visible to all but the most experienced observers	Only the brightest constellations are discernible	Clouds are brilliantly lit	Entire sky background has a bright glow, ground is illuminated

*Table 4.2.2-1 also incorporates the Bortle Dark Sky Scale Key for the Summer Sky for Latitudes 30° to 50° N, White et al. 2012.

Table 4.2.3-1. Night sky condition class summary.

Good	ALR <0.33 (<26 nL average anthropogenic light in sky)	1-3
Significant concern	ALR >2.0 (>156 nL average anthropogenic light in sky)	5-9

*at least half of the park's geographic area should meet the standard described

Anthropogenic Light Ratio

The threshold for night skies in good condition is an ALR <0.33 and the threshold for a moderate condition is ALR 0.33-2.0. An ALR >2.0 suggests significant concern (Moore et al. 2013).

Bortle Dark Sky Scale

A night sky with a Bortle Dark Sky Scale class 1 is considered in the best possible condition (Bortle 2001); unfortunately, a sky that dark is so rare that few observers have ever witnessed it (Moore 2001). Non-urban park skies with a Bortle class 3 or darker are considered to be in good condition, class 4 of moderate condition, and class 5 are considered poor condition. At class 4 and higher, many night-sky features are obscured from view due to artificial lights (either within or outside the park). Skies class 7 and higher have a significantly degraded aesthetic quality that may introduce ecological disruption (Moore et al. 2013). It is important to note that such degraded conditions may be restored toward a more natural state by modifying outdoor lighting, depending on the surrounding conditions that exist outside the park.

4.2.4. Condition and Trend

Modeling data provided by the NPS Night Skies Program show an ALR of 0.08 indicating good condition (the models have an error of ±0.1 ALR).

The qualitative Bortle Scale assessment estimated the night sky quality to class 2, consistent with a dark sky, which indicates good condition (see Table 4.2.4-1).

Local and Regional Context

Fort Davis NHS is located in Fort Davis, Texas, about 175 miles southeast of El Paso (Figure 4.2.4-1). Fort Davis is a small town with a population of 1,201; El Paso is the largest relatively close city with a population of 800,647 (U.S. Census Bureau 2010).

In order to protect the quality of the night sky around McDonald Observatory, the West Texas Dark Sky Preserve (Figure 4.2.4-2) was formed through city and county ordinances that specify outdoor lighting guidelines (e.g., Marfa Outdoor Lighting Ordinance, http://www.texasida.org/Marfa%20ordinance.pdf, accessed 16 September 2013).

Table 4.2.4-1. Summary of night sky indicators and measures, and assessment of night sky condition at Fort Davis National Historic Site.

Indicator	Measure	Condition	Description
Sky Brightness	Anthropogenic Light Ratio (0.08)	Good	This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS. The night sky around Fort Davis is largely protected from light domes from cities and towns, resulting in good condition.
Sky Quality	Bortle Scale Class (2)	Good	Star gazing at Fort Davis NHS is very good for observing the constellations, Milky Way, and other celestial bodies. Local point sources are minimal.

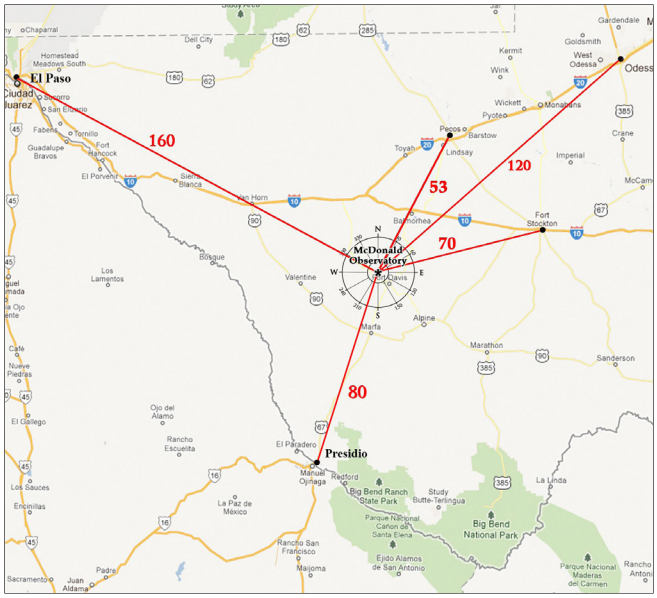


Figure 4.2.4-1. Location of McDonald Observatory (about 16 miles northwest of Fort Davis NHS) in relation to nearby cities.

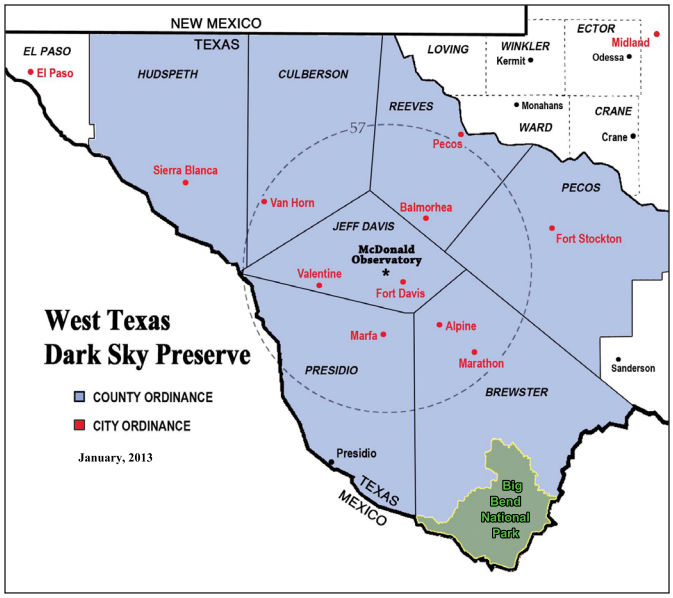
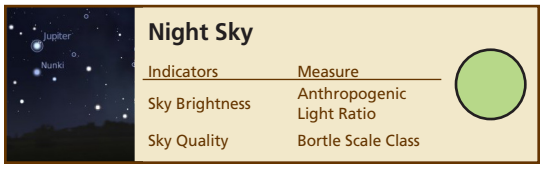


Figure 4.2.4-2. The West Texas Dark Sky Preserve protects the night sky around McDonald Observatory (and Fort Davis NHS) through city and county ordinances.



Overall Condition

Quantitative modeling of sky brightness (all-sky anthropogenic light ratio) and a qualitative assessment of sky quality (the Bortle Dark Sky Scale) were used to assess the condition of the night sky. These indicators are summarized and interpreted in Table 4.2.4-2. The overall condition of the Historic Site's night sky is good, and is likely to remain in good condition due to local protection through outdoor lighting ordinances.

Key Uncertainties

The Bortle Dark Sky Scale estimates have inherent uncertainties and error. The principle drawback of the Bortle Scale is that it relies upon human visual observers. Differences in visual acuity, experience and knowledge, as well as time and effort expended can influence the estimates (Bortle 2001, Moore 2001). This assessment should be interpreted as interim until ground-based

Table 4.2.4-2. Summary of the night sky indicators and their contributions to the overall night sky Natural Resource Condition Assessment.

Indicator	Description of How the Indicator Contributes to the Overall Resource Condition	General Contribution of this Indicator to the Overall Resource Condition
Anthropogenic Light Ratio	Anthropogenic light ratio (ALR) is a quantitative measure that presents the ratio of the average anthropogenic sky luminance to the average natural sky luminance.	Based on modeling conducted by the NPS Night Sky Program, the condition of the night sky at the monument is in good condition. This method is the primary consideration for condition.
Bortle Dark Sky Scale	This is a qualitative measure that uses a scale divided into nine classes. It is a relatively easy measure to use for night sky conditions and requires no special equipment. The scale is based on observing features of the night sky including the Milky Way, constellations, and the nighttime scene.	The monument's night sky was assessed to be consistent with truly dark skies and is considered to be in good condition.

measures of all-sky ALR are taken (C. Moore, NPS, pers. comm.).

4.2.5. Sources of Expertise

Chad Moore, Natural Sounds and Night Skies Division, part of the NPS Natural Resource Stewardship & Science Directorate provided information pertaining to night sky data collection methodology and interpretation of results. Moore earned a master's degree in earth science in 1996 and began working for the NPS shortly thereafter. Moore is the Night Skies Program manager, a small team of scientists that measure, restore, and promote the proper management of the night sky resource. He and team member, Dan Duriscoe have developed an automated all-sky camera capable of precise measurement of light pollution. Since 2001 the team has collected sky quality inventories at over 110 U.S. national parks.

Thanks to Bill Wren at McDonald Observatory for information and images contributed to this chapter.

4.2.6. Literature Cited

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4.3. Soundscape

Indicators/Measures

- Audibility (1 measure)
- Sound Level (2 measures)

Condition - Trend - Confidence Level

Moderate - Insufficient Data - Medium

4.3.1. Background and Importance

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. An unimpaired acoustical environment is an important part of overall NPS visitor experience and enjoyment, as well as vitally important to overall ecosystem health.

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet they can offer. In a 1998 survey of the American public, 72% of respondents 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 et al. 1995) (Figure 4.3.1-1). Despite this desire for quiet environments, noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

Sound also plays a critical role in intraspecies communication, courtship and mating, predation and predator avoidance, and effective use of habitat. Studies have shown that wildlife can be adversely affected by sounds 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 fact that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds

Figure 4.3.1-1. Bird vocalizations contribute to natural sounds in our national parks.

(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, USDA 1992, Anderssen et al. 1993, NPS 1994).

A park's 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) (2006) require preservation of parks' natural soundscapes and restoration of degraded soundscapes to natural conditions wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscapes from noise (i.e., any unwanted sound). Although the management policies currently refer to the term soundscape as the aggregate of all natural sounds that occur in a park, differences exist between the physical sound sources and human perceptions of those sound sources. The physical sound resources (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of their audibility, at a particular location, is referred to as the acoustical environment, while the human perception of that acoustical environment is defined as the soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

Sound Characteristics

Humans and wildlife perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. Sound is measured in terms of frequency (pitch) and amplitude (loudness) (Templeton and Sacre 1997, Harris 1998).

Frequency, measured in Hertz (Hz), describes the cycles per second of a sound wave and is perceived by the ear as pitch. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz and are most sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency sounds are more readily absorbed by the atmosphere or scattered by obstructions than low frequency sounds. Low frequency sounds diffract more effectively around obstructions. Therefore, low frequency sounds travel farther.

Besides the pitch of a sound, we also perceive the amplitude (or loudness) of a sound, which is measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in SPL can have significant effects on the acoustical environment. For instance, a 6 dB reduction in background noise level would produce a 4x increase in listening area (Figure 4.3.1-2). Changes in the background noise level cause a change in listening opportunity. These lost opportunities will approach a halving of alerting distance and a 75% reduction of listening area for each 6 dB increase in affected band level (Barber et al. 2010).

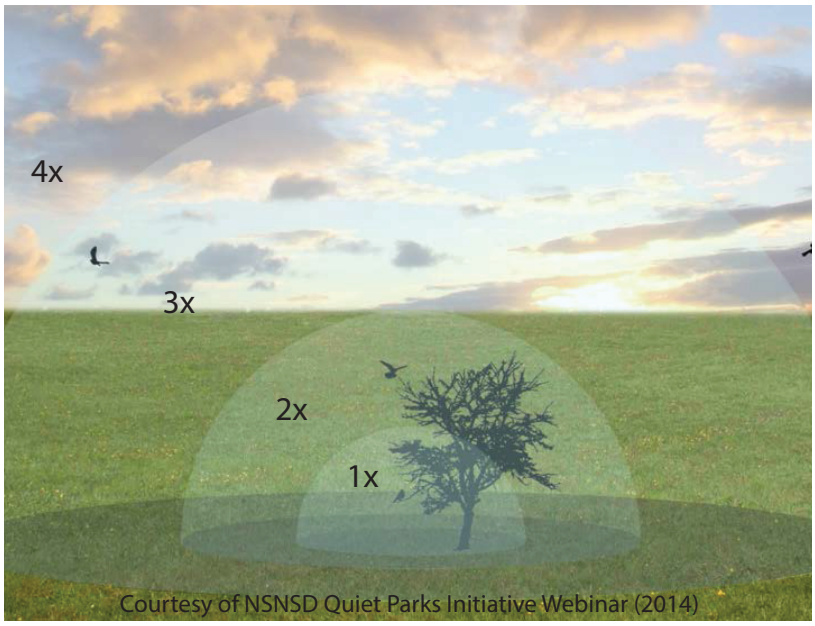


Figure 4.3.1-2. A 6 dB reduction in background noise level would produce a 4x increase in listening area (NSNSD 2014).

SPL is commonly summarized in terms of dBA (A-weighted

SPL). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate the variation in human hearing sensitivity.

4.3.2. Data and Methods

A formal acoustical monitoring study was conducted by Volpe National Transportation Systems Center personnel for Fort Davis NHS. Two acoustical monitoring systems were used in the Historic Site to characterize existing sound levels, estimate natural ambient sound levels, and identify audible sound sources (NPS 2013). The measurements were intended to represent the soundscape of the Historic Site during the summer season only. A number of tables and figures were presented in the NPS (2013) report but primarily focused on aircraft noises since the original acoustical monitoring request was intended for developing an Air Tour Management Plan (NPS 2013).

For the purposes of this condition assessment, Randy Stanley, Physical Scientist / Acoustic Specialist, with the NPS Intermountain Region Office, obtained the original data from Volpe National Transportation Systems Center (Volpe 2010). This provided an opportunity to include all sound categories collected during the acoustical monitoring study in this condition assessment. It's important to note that while the NPS (2013) report includes sound level data for a 24-hour period, sound classification data were only analyzed for the daytime period of 7am-7pm per contract specifications. The daytime data were useful for the condition assessment since:

- the 7am-7pm period represents the most likely time frame when visitors are at the Historic Site, and
- the 7am-7pm period provides the "worst case" soundscape scenario since most of the Site's activity occurs within the daytime hours.

Data Collection

The following description of the Acoustical Monitoring data collection methodology (in italics) was taken from NPS (2013).

Larson Davis 831 sound level meters (SLM) were employed .... at the Historic Site. The Larson Davis SLM is a hardware-based, real-time analyzer which constantly records one second sound pressure level (SPL) and 1/3 octave band data, and exports these data to a portable storage device (thumb drive). These Larson Davis-based sites met American National Standards Institute (ANSI) Type 1 standards.

Each ... sampling station at the Historic Site consisted of: a microphone with environmental shroud, preamplifier, multiple 12V NiMH rechargeable battery packs, anemometer, MP3 recorder, meteorological data logger, and photo voltaic panels.

Each acoustic sampling station collected:

- *Sound level data in the form of A-weighted decibel readings (dBA) every second*
- *Continuous digital audio recordings*
- *One third octave band data every second ranging from 12.5 Hz – 20,000 Hz*
- *Meteorological data.*

In characterizing natural and non-natural acoustic conditions in a park, knowledge of the intensity, duration, and distribution of the sound sources is essential. Thus, during sound-level data collection, FAA and NPS have agreed that periods of observer logging "in situ" (i.e., on site and in real-time) and/or post measurements using high-quality digital recordings will be conducted in order to discern the type, timing, and duration of different sound sources. In situ observer logging takes full advantage of human binaural hearing capabilities, allows identification of sound source origin, simultaneous sound sources, and directionality, and closely matches the experience of park visitors. Off-site audio playback observer logging allows for sampling periodically throughout the entire measurement period (e.g., 10 seconds every 2 minutes) and repeated playback of the recordings (e.g. when the sound is difficult to identify).

Monitoring Site Locations

Two sites were chosen for the study- the North Ridge Trail site and the Sleeping Lion Mountain site (Figure 4.3.2-1). The

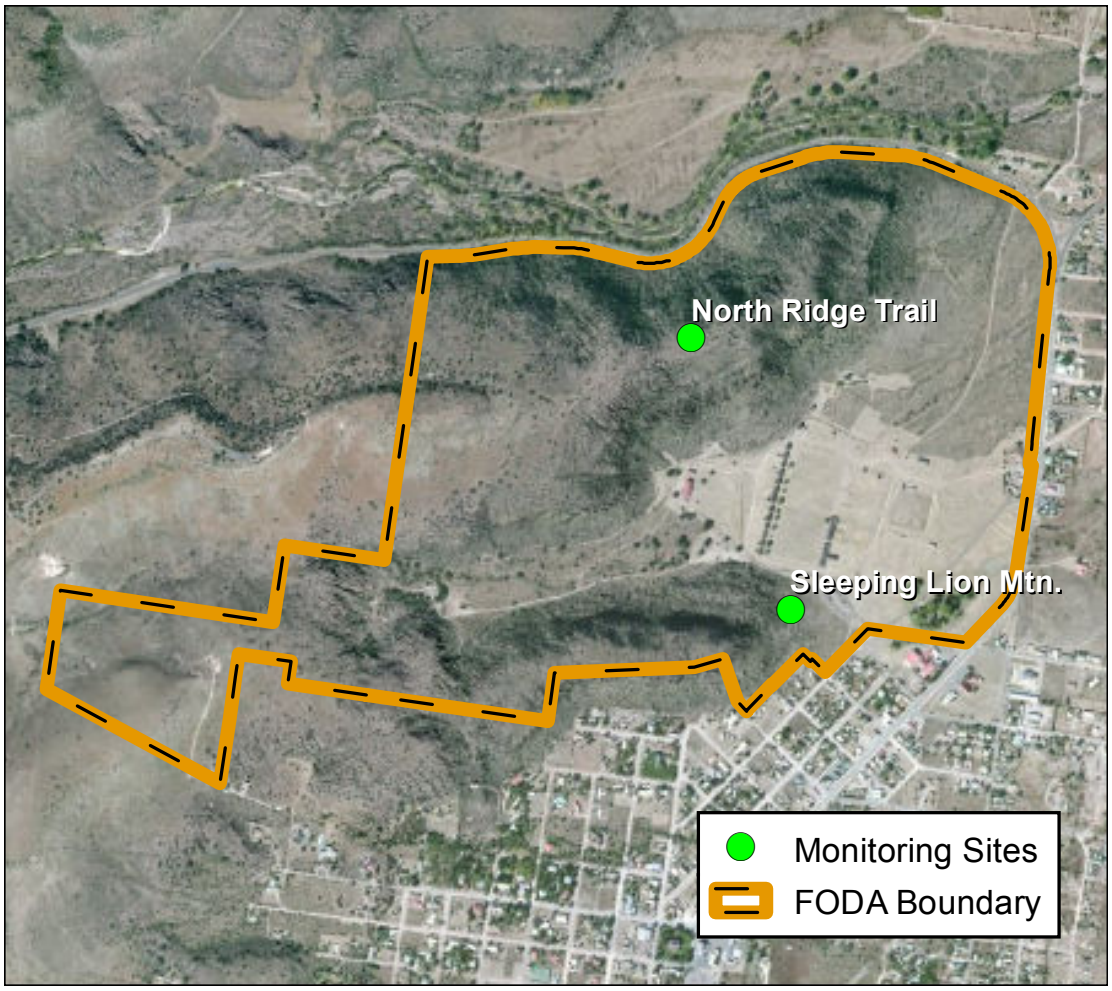


Figure 4.3.2-1. Locations of 2010 acoustical monitoring sites at Fort Davis NHS.

Figure 4.3.2-2. Acoustical monitoring site - North Ridge Trail (NPS 2013).

North Ridge Trail site was located to the north of the Fort grounds (i.e., historic core) on a high ridge described as a rocky area with grasses and scrub (NPS 2013) (Figure 4.3.2-2). The National Land Cover Database (NLCD) classification for the site is shrubland, and its elevation is 1,595 m (5,233 ft). The site overlooked a paved road with a nearby intersection. Data anaylzed for the sound classification included eight days of monitoring (7am - 7pm) at the site.

Figure 4.3.2-3. Acoustical monitoring site- Sleeping Lion Mountain (NPS 2013).

The Sleeping Lion Mountain site, on Sleeping Lion Mountain, overlooked the historic core from the south (Figure 4.3.2-3). Also classified as shrubland, the site was grassy and contained large rocks and was located several hundred feet from the visitor parking lot. Its elevation was 1,516 m (4,974 ft). Data anaylzed for the sound classification included eight days of monitoring (7am - 7pm) at the site.

Table 4.3.2-1. Indicators and measures used to assess the soundscape at Fort Davis NHS.

Indicator	Measure	Definition
Audibility	% Time Audible	The percent of time that a particular sound may be detected by the human ear is the measure for audibility. This measure was obtained from results of the Acoustical Monitoring study using observer logging. For determining condition, we focused on the percent of time that noise was heard as opposed to natural sounds. Unfortunately, in some cases the report results did not distinguish among some noise categories (e.g., besides the aircraft category, there was an "other human" category, which did not distinguish between sound sources [to distinguish culturally-relevant sounds vs. noise]).
Sound Level	Amplitude (on-site monitoring)	Loudness or amplitude of a sound is typically measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. Amplitude was assessed using the results of the Acoustical Monitoring study. As with our other measures, we focused primarily on the loudness of noise(s) for the purposes of assessing condition.
	Amplitude (Mennitt et al. (2013) modeled sound levels)	"Using long-term sound pressure level measurements from hundreds of sites across the contiguous United States, geospatial models were developed to predict sound levels. These sound models incorporated spatial representations of biological, geophysical, climatic, and anthropogenic factors to assess expected contributions to the existing sound pressure level from both anthropogenic and natural sources, which enable mapping of sound pressure levels at regional and national scales" (cited from Mennitt et al. 2013). This sound level information supplements the on-site listening results from NPS (2013).

The primary indicators we used to assess the soundscape condition were audibility and sound level, with one and two measures, respectively (Table 4.3.2-1).

Indicators/Measures
Audibility (% Time Audible)

Audibility of sounds was obtained from results of the Acoustical Monitoring study using observer logging. For determining condition, we focused on the percent of time that noise was heard as opposed to natural sounds. By obtaining the original data, we were able to distinguish among the different noise categories that were originally grouped as an "other human" category in the NPS (2013) report. For example, traffic noises could not be distinguished separately from other noise sources.

Indicators/Measures
Sound Level (2 measures)

Sound levels were assessed in two ways (1) using sound models created by Mennitt et al. (2013) to provide quantitative parkwide/regional sound levels, and (2) using the results of the Acoustical Monitoring study.

Mennitt et al. (2013) created sound level models at regional and national scales. The model used spatial, meteorological, and actual sound level measurements from 100s of sites (primarily located in the west) to model sound levels for natural and existing conditions, as well as to model the impact of the sound levels based on the difference between the modeled natural and existing sound levels. We used the results from this model to provide an additional quantitative assessment of sound level at Fort Davis NHS.

Context for Evaluating Sounds

Whether or not a given sound contributes to or detracts from the soundscape condition depends largely on whether or not that sound is appropriate for the context. Like many other parks, Fort Davis NHS was established because of its historic significance. Its designated purposes include the preservation and conservation of the cultural and natural resources of the Fort, the education of the public about the influence of the Fort on the development/settlement of the Southwest, and the impact of military operations on Native Americans. As such, sounds that contribute to the education and enjoyment of the Historic Site's visitors, even though they

are not natural, are considered appropriate to the soundscape (e.g., bugle calls).

If this were a wilderness setting, natural versus anthropogenic sounds might be a pertinent distinction for how a sound is perceived. However, the context and setting at Fort Davis NHS is quite different in that there are elements of the historic context as well as an educational context. Thus, in addition to the natural sounds that contribute to the sense of place of the natural setting, the anthropogenic sounds that might have been heard during the 1854 to 1891 period the Fort was active also contribute to its present-day soundscape. For example, sounds produced by gatherings of people or by a small arms demonstration contribute to the understanding and appreciation of the historic context and enjoyment of the park. Thus, for the purposes of this assessment, we would consider sounds that were consistent with the historic context to be contributing to soundscape condition.

In contrast, some sounds, such as low flying aircraft, vehicles, or excessive human voices, may detract from the "sense of place" of the site's historic context and consequently be perceived negatively as noise, detracting from the soundscape condition.

For these reasons, we considered sound types within the context of belonging to two classes: (1) natural, cultural, and recreational-appropriate sounds, and (2) noise (any unwanted sound). The first class was considered as having a neutral or positive influence on soundscape condition; whereas excessive noise, especially in locations where noise is unexpected due to designated use, was considered to have a negative effect, contributing to a more impacted soundscape condition. Some common examples of expected sounds at the Historic Site are listed in Table 4.3.2-2.

Additionally, the locations where the sounds were heard, based upon the Historic Site's designated resource opportunity areas/ management prescription zones, affected the soundscape condition. Each resource opportunity area/management prescription zone has designated activities and common sound types. These factors were taken into consideration throughout this assessment. The areas consisted of two management prescriptions for three Resource Opportunity Areas [ROAs], which were identified in the Historic Site's General Management Plan (GMP) (NPS 2002).

4.3.3. Reference Conditions

Studies identifying effects of noise on human health and well being and effects of noise on wildlife serve as guides for the quality of visitor soundscape experience, and the reference conditions were developed with these effects in mind (Table 4.3.3-1).

We considered the soundscape to be in good condition if sounds heard were consistent with Historic Site designated activities, if no excessive sound/noise levels were present in any area of the Historic Site, regardless of

Table 4.3.2-2. Types of sounds expected at Fort Davis NHS.

Natural, Cultural, and Recreational Sounds	Noises
• Birds • Insects • Other Wildlife • Wind • Rustling Leaves • Rain/Thunder • Living History Sounds (e.g., small arms demonstration, bugle calls, and audio Retreat Parade) • Interpretive Programs • Visitor Conversations	• Planes • Automobiles/Horns • Tires on Pavement • Maintenance (e.g., mowing, etc.) • Raised Voices/Yelling

Table 4.3.3-1. Reference conditions used to assess the soundscape at Fort Davis NHS.

Indicator	Measure	Good	Moderate	Significant Concern
Audibility	% Time Audible	Dominant sounds are consistent with Historic Site's designated purpose. Natural ambient sounds such as wind, leaves rustling, birds singing, thunder claps, etc. and sounds related to cultural and visitor activities are expected. Some sources of noise (e.g., automobiles) are acceptable in the developed areas provided they are consistent with the expectations for that location and are audible for a small percentage of the time.	The dominant sounds are generally consistent with the park's designated purpose, but noise occurs more frequently and noise from the parking area/adjacent highway, etc., begin to infiltrate into the Historic Core and Undeveloped Landscape. A historic sense of place is still maintained, but is periodically interrupted by audible noises.	A high percentage of the audible sounds heard are from noise such that the historic and natural sense of place is compromised; therefore, the education and enjoyment of visitors is compromised.
Sound Level	Amplitude (loudness)	Visitors typically maintain quiet to normal conversation levels (e.g., 40-50 dB), and interpreters talking to larger groups rarely exceed 55-60 dB. There is a sightly higher tolerance for noise levels in the Historic Interpretive/Developed zone (especially the Foreground ROA), but they should rarely exceed 60 dB. The natural sound level for the Historic Site modeled by Mennitt et al. (2013) was 29.6-31.3 dBA.	Noise > 55 dB is beginning to be heard in both management zones so as to cause occasional interference with normal conversation and annoyance among some visitors. Noise greater than approximately 65 dB is still quite rare.	The historic and natural sense of place is compromised due to frequently loud noise. Communication among interpreters and visitors is frequently interrupted by loud noise impacting visitor enjoyment and educational experience. Noise levels that might interfere with wildlife behavior and auditory signals disrupt conversation or evoke annoyance (e.g., exceeding 55-60 dB) may occur.

designated use, and if noise-free intervals were common.

We considered a moderate condition soundscape to be one where the designated uses for a higher activity area (e.g. parking lot) began to infiltrate into lower use zones (e.g., historic), noise-free intervals became only moderately common, and noise levels began to be heard throughout the Historic Site.

A significant concern soundscape condition occurs when noises became incongruent with Historic Site designated activities/purpose and/or are disruptive, regardless of the area within the park. Also, noises generated by military overflights, fast moving traffic, etc., dominated the types of sounds heard.

These reference conditions are evaluated within the context of two categories: (1) the effects of noise on the quality of visitor experience, and (2) the effect of location where noise is heard.

Effects of Noise on Human Health (serves as a reference to help assess visitor soundscape experience)

There have been numerous studies on the effects of noise on human health, and probably the most commonly studied effects are cardiovascular. The World Health Organization (Berglund et al. 1999) suggests that even prolonged exposure to noise levels below 75dB will not result in noise-induced hearing loss. They also conclude that prolonged exposure to air and road traffic noises above 65-70 dB are associated with cardiovascular effects, but this is from exposure times that far exceed what is likely to be encountered during a Historic Site visit. The threshold levels for responses such as raising of blood pressure are much lower (i.e., 35 dBA in sleeping humans; Haralabidis et al. 2008). However, these human health responses, at the levels of noise exposure at Fort Davis NHS are not likely to cause any physical damage. Thus, for the most part, noise levels exceeding thresholds for damage to human health are not of high concern at

the Historic Site. The most likely exception to this is for park staff operating machinery (e.g., mowers, tractors, etc.). Although damage to human health is not of high concern, this does not imply that there are no physiological responses to noise.

Effects of Noise on Wildlife (serves as a reference to assess visitor soundscape experience)

Research has indicated that the effects of noise on wildlife populations can vary widely among species and conditions, although birds have probably been most widely studied. Most effects fall into one of three categories: (1) behavioral and/or physiological effects, (2) damage to hearing from acoustic over-exposure, and (3) interference with communication (Dooling and Popper 2007). Since birds are probably more resistant to hearing loss or damage from noises than are humans (Dooling and Popper 2007), the threshold identified for damage to human hearing should be adequate to also account for damage to wildlife hearing. Similarly, the noise levels that interfere with human communication are also similar to the thresholds identified for interference with communication and/or annoyance.

For example, Dooling and Popper (2007) suggest that it is unlikely that a traffic noise level below an overall level of about 50-60 dBA would have much of an effect on acoustic communication or the biology of a bird in a quiet suburban area (see also Kaseloo 2006). Because the thresholds for wildlife appear to be similar to the thresholds we identified for human health and because the responses by wildlife are varied and complex, we have assumed for the purposes of this assessment that a degraded condition for visitors would also likely have potential impacts to birds, specifically.

Effects of Noise on the Quality of Visitor Experience

An essential component of the designated purpose of Fort Davis NHS relative to the soundscape is to provide for visitor enjoyment and education. A key element of this is maintaining a sense of place for the Fort such that visitors can visualize being back in time experiencing the sights and sounds of the mid to late 1800s. From the historic setting of the Fort, with natural sounds from the wind, leaves rustling, or birds singing, to the historic sounds of the day-to-day activities of life at the Fort, all are part of the education and enjoyment of being transported back in time. However, it is difficult to imagine being in the 1800s while a jet is flying overhead or a car horn is honking. Thus, we consider condition of the soundscape relative to a visitor being able to gain a sense of place in the Fort's setting and an enjoyable educational experience. Condition is deteriorated when noise interrupts normal conversation, when such noise is frequent enough or loud enough to detract from the sense of place, and/or to be annoying to visitors trying to appreciate the historic context of the Historic Site.

Additionally, the U.S. Environmental Protection Agency (USEPA) uses a speech interference threshold (52 dBA) for speaking in a raised voice to an audience at 10 meters (USEPA 1974). This threshold addresses the effects of noise on interpretive programs in parks. Also, a threshold of 60 dBA provides a basis for estimating impacts on normal voice communications at 1 meter (USEPA 1974). Hikers and visitors viewing scenic vistas and walking throughout the Fort grounds would likely be conducting such conversations.

Effect of Location (Resource Opportunity Area / Management Zone) on Reference Condition

Inherent in our condition assessment is how sounds are perceived by visitors and whether or not the sounds contribute to or detract from visitor education and enjoyment of the Historic Site. Whether or not sounds are perceived negatively depends not only on the types of sounds heard but also where they are heard. For example, a visitor is probably going to be less disturbed by noises from vehicles if they are in the parking lot than if they are along the nature trail above the Fort. Consequently, we take into consideration where sounds are heard within the Historic Site and the expectations of different sounds based on management zones as defined in the General Management Plan (NPS 2002) when considering the condition of the soundscape (Table 4.3.3-2 and Figure 4.3.3-1).

Table 4.3.3-2. Activities and associated sounds expected within each resource opportunity area / management prescription zone (NPS 2002) that influence the reference condition within that zone.

Management Prescription / Zone (Degree of Human Activity)	Typical Activities and Associated Sounds
Historic Interpretive / Developed (High Activity)	This prescription / zone consists of the bulk of the Historic Core and a portion of the Foreground Resource Opportunity Areas (ROA). The Historic Core ROA is central to the park both geographically and figuratively. This area contains the most of the Fort's historic structures and features and was the location of most of the Fort's day-to-day activities. This area includes military sites and sounds that assist visitors in imagining what it would have been like at the Fort when it was an active military post. The Historic Interpretive / Developed management prescription / zone encompasses the areas of the park where modern development and/or intensive use alter the natural environment substantially. This is the area with the highest levels of use in the park. The dominant sounds may be natural sounds when human-created sounds are absent; however, typical sounds consistent with designated activities include normal conversation voices, voices from group gatherings, periodic use of motorized tools and heavy equipment (from maintenance equipment), and bugle calls and dress retreat parade recordings. The latter are used to help cover up the modern noises from the parking area and the adjacent highway (NPS 2013).
Undeveloped Landscape (Low to Medium Activity)	This prescription / zone encompasses the majority of the Historic Site except for those areas discussed above. This zone consists of the Natural Backdrop ROA, as well as some of the Historic Core and Foreground ROAs. This zone includes the two cliff walls of Hospital Canyon and the rugged, steep escarpment that runs north and south. Trails on the ridges provide visitors with views of the Fort, the Davis Mountains, and flat areas to the east. This zone contains a mix of vegetation and most of the hiking and natural viewing opportunities in the park. The area is also vital to the Fort's natural setting, "ensuring that the Fort maintains it late 19th century appearance." This prescription / zone includes other areas of the Historic Site (e.g., the historic cottonwood grove). The zone has one main, unpaved service road, but public access is limited to foot traffic on established trails. No development is allowed other than that associated with trails, visitor safety, and stabilization. Example sounds might include normal conversation voices, low-level vehicle sounds from the service road, occasional maintenance equipment noise, and natural sounds from wildlife.

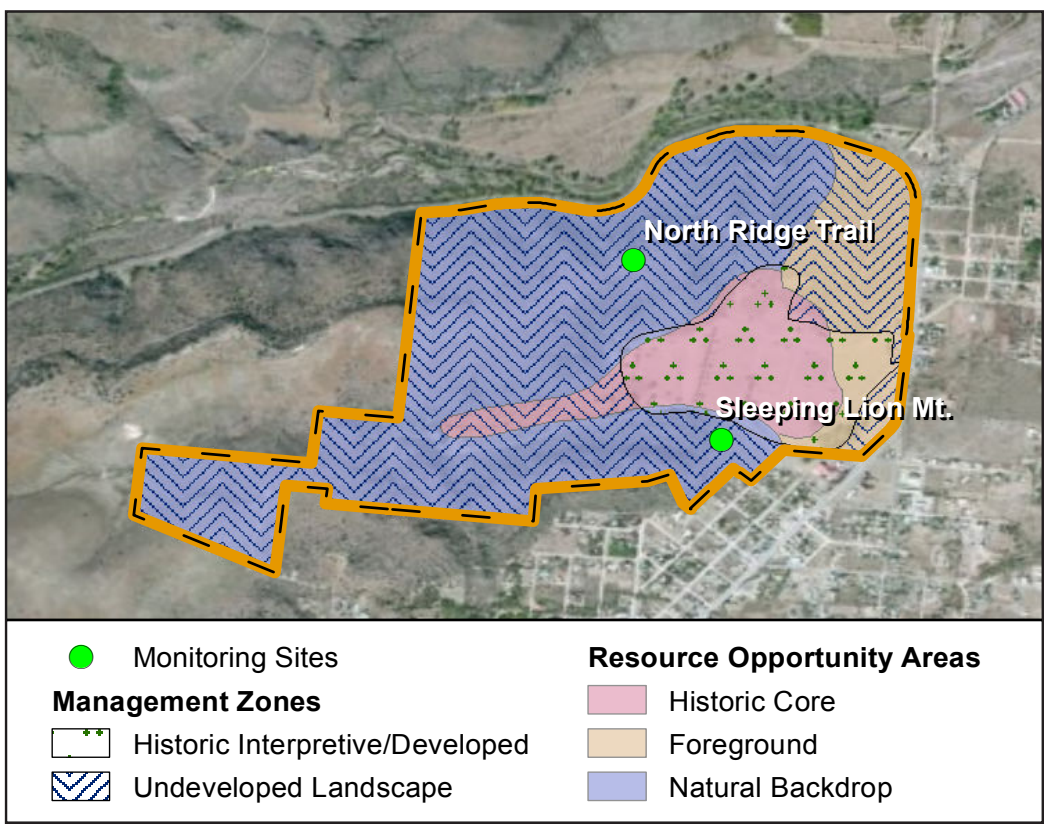


Figure 4.3.3-1. Resource Opportunity Areas and Management Prescription Zones at Fort Davis NHS as defined in the General Management Plan (2002). Also shown are the two acoustical monitoring sites.

The monitoring sites were located within the Historic Site's Natural Backdrop Resource Opportunity Area and the Undeveloped Land management prescription/zone. The North Ridge Trail was located farther away from the Historic Core and from the town of Fort Davis, Texas than the Sleeping Lion Mountain location. The Sleeping Lion location was located near Texas State Highway 17/118 and closer to the Historic Core and the town of Fort Davis.

4.3.4. Condition and Trend

Audibility

A combination of in-situ logging and office listening of audio files collected at the acoustical monitoring sites provided an indication of the amount of time that certain sound sources were present at each site during daytime hours (NPS 2013).

Sounds audible during the acoustical monitoring were assigned to major sound categories including:

- fixed-wing aircraft and helicopters,
- jets,
- vehicles,
- natural (including noise free, insects, wind, and birds).

At the North Ridge Trail, traffic noise was the predominant sound heard (88.9% of the mean time audible based on eight days of monitoring). Jets, prop planes, and helicopter noises were heard for a mean percent time audibility of 0.38%. Other noises heard included motors, domestic animals, voices, music, and artifacts, which resulted from equipment interference, all totaling only 2.6% mean time audible. The predominant natural sounds (including noise free periods) were heard 89.3% of the mean time audible, with wind, bird vocalizations, and insects comprising the majority of natural sounds.

At the Sleeping Lion Mountain site aircraft, vehicles, people talking, construction activities, and domestic animals were frequent sources of sounds. Due to the monitoring site's close proximity to the parking area (100 m away) and park structures, maintenance activities, construction, domestic animals, and conversations were heard more frequently. On the other hand, traffic noise was heard less frequently (43.4% mean time audible) at this location compared to the North Ridge Trail location.

Aircraft was also heard more frequently at the Sleeping Lion Mtn. site (8.2% mean time audible) compared to the North Ridge Trail, however, this may be a result of only one shared monitoring day (October 11, 2010). Although the mean percent time audibility for aircraft throughout that day at the North Ridge Trail was 0.38% compared to 19.4% at Sleeping Lion Mtn.

While considered as contributing to the Historic Site's soundscape condition, amplified recordings were played over the public address system every 15 minutes during Fort operating hours (NPS 2013). While this sound contributes to the Historic Site's soundscape, we cannot separate it from the "people-voices" data collection category. This provided a slightly worse condition perspective as a result. It's worthwhile noting that the Historic Site recordings could be heard at both monitoring locations, although more frequently heard at the Sleeping Lion Mtn. site.

Wind and wind related sounds, birds, insects, and noise-free periods comprised the majority of the natural sounds heard at the Sleeping Lion Mtn. site. These sounds were audible 92%of the mean percent time, which was slightly higher than the audible natural sounds at the North Ridge Trail location.

At both sites, noises were heard for more than 50% of the 7am-7pm hours. This is of concern, but it should also be noted that, in a park as small as Fort Davis NHS, neither site is very far from the Historic Core or the exterior boundaries of the park. It is not surprising that cultural sounds from the Fort (bugle calls and recordings broadcast over the public address system) are audible at both sites. However, the

General Management Plan Summary (NPS 2002) also states that the bugle calls and recordings are used "to help cover up or drown out modern sounds from the parking area and the adjacent highway." So, although these sounds (i.e., bugle calls and recordings) are compatible with activities in the Historic Core, they may be louder than otherwise desirable due to noise issues with the traffic and vehicle-related noises (e.g., horns, beeping, doors shutting, etc.).

Overall, aircraft noise comprised a relatively small proportion of the noises heard at the Historic Site. The closest commercial airport is located in Midland, about 170 miles (274 km) to the northeast. For private aircraft, there are two not-too-distant airports- Alpine Municipal Airport, located on State Highway 118 about 25 miles south of Fort Davis NHS, and the Marfa Municipal Airport, on State Highway 17, about 18 miles south of Fort Davis NHS.

Based on the percent time audible measure for noises heard at both monitoring locations, especially traffic noise at the North Ridge Trail, we consider the soundscape condition to be of moderate -significant concern .

Amplitude (on-site monitoring)
The Acoustical Monitoring report (NPS 2013) contains estimates of sound levels for: the daytime and nighttime (overall median values by site for one season [summer]); 24-hour periods (L_{50}); hourly periods (L_{50}); and daytime natural ambient conditions. We refer the reader to the 2013 report for these specific values. We will discuss the results in a more general context here.

Sound levels (measured in dBA) were generally higher at Sleeping Lion Mountain than at the North Ridge Trail site, during both day and night, with the overall median daytime sound levels (i.e., L_{50}) recorded during the summer at 35.2 dBA and 26.6 dBA, respectively (NPS 2013). In the context of the 24-hour L_{50} sound levels, louder days correlated with higher wind conditions at both sites. Based on the hourly data, louder sound levels occurred during the night and early morning at both sites, and the frequency data suggested that insect activity occurred during the nighttime hours. Other than the mention of insect activity, little information was provided on the types of sounds heard during the nighttime hours.

One product of the NPS (2013) modeling efforts is shown in Figure 4.3.4-2. This figure shows the ambient sounds levels at the Historic Site and within a 1/2-mile buffer around the Historic Site's boundary. Within or immediately adjacent to the park, sound levels are highest along the roads bordering the Historic Site (i.e., Texas State Roads 118, 17, and intersection of 17/118). Sound levels in these areas ranged from 45 to <65 dBA (orange shades and brown).

Most of the Historic Core ROA was within the 40 to <45 dBA sound level. Based on this model's results, a visitor would not be exposed to the loudest sounds throughout the area while visiting the Historic Site. Sound levels below 45 dBA (the yellow area) are less than the threshold addressing the effects of noise on interpretive programs and the threshold for estimating impacts on normal voice communications at 1 meter, 52 and 60 dBA, respectively.

Based on this, we would consider the condition of the soundscape, with respect to amplitude from the on-site listening results to be in good to moderate condition. However, taking into consideration the need to use dress retreat parade recordings to help cover up the modern noises from the parking area and adjacent highway (NPS 2002, as described previously), we consider the condition to be moderate.

Amplitude (Mennitt et al. (2013) sound model)
The model results for the natural ambient and existing sound levels for the Historic Site ranged from 29.6-31.3 dBA and 34.2-36.2 dBA, respectively (Mennitt et al. 2013 and E. Lynch, NSNSD, pers. comm.-provided the model sound level values). Mennitt et al. (2013) suggest that in a natural environment, the average summertime L_{50}, which is the sound level exceeded half of the time (and is a fair representation of expected conditions) is not expected to exceed 41 dBA. The modeled

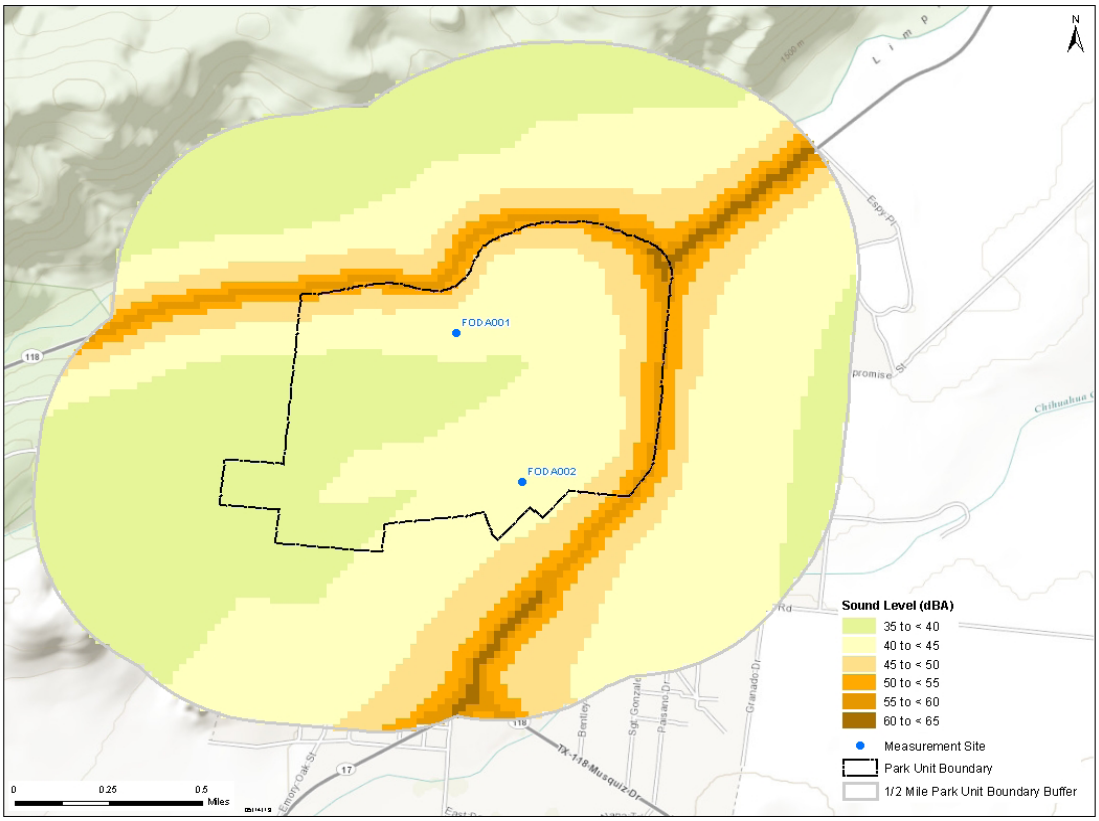
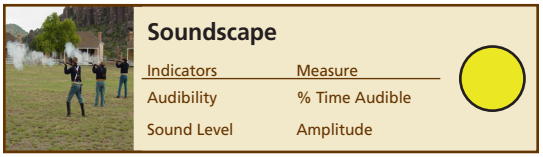


Figure 4.3.4-2. Graphic showing sound levels (dBA) at Fort Davis NHS and vicinity during the summer season, as well as location of monitoring sites (NPS 2013).

sound levels for all noise sources surrounding the Historic Site was 34.2-36.2 dBA, suggesting a soundscape that is in good condition (refer to Appendix D for sound level maps). Note that this model's sound levels are lower than the NPS (2013) modeled results previously discussed.

However, the difference between the Historic Site's modeled natural sound level and existing sound level (i.e., impact) ranges between 4.6-4.9 dBA. According to Mennitt et al. (2013), "an impact of 3dBA suggests that anthropogenic noise is noticeable at least 50% of the hour or more." NSNSD also provides soundscape reference conditions for the purposes of *The State of the Park* reports, which categorizes parks into urban versus non-urban. If we consider the Historic Site to be a non-urban park, the threshold for significant concern is an impact level that is greater than three. If we consider the Historic Site to be an urban park, the threshold for significant concern is interpreted to be an impact level greater than 12 dBA. We consider Fort Davis NHS to fit somewhere between urban and non-urban, which results in a good to moderate condition for sound level impact using the Mennitt et al. (2013) sound level model results.



Overall Condition and Trend

For assessing the condition of the Historic Site's soundscape, we used two indicators and three measures, which are summarized in Table 4.3.4-1. Overall, we consider the soundscape at the Historic Site to be in moderate condition, with an unknown trend.

Level of Confidence and Key Uncertainties

The John A. Volpe National Transportation Systems Center of the USDOT conducted the 2010 acoustical monitoring for NPS' NSNSD to evaluate the condition of the Historic Site's soundscape. Based on the expertise, we are confident that the findings accurately reflected the condition of the Historic Site's soundscape in the areas monitored at the time of the monitoring. However, there are

Table 4.3.4-1. Summary of the soundscape indicators/measures and their contribution to the overall soundscape condition.

Indicators of Condition	Measures	Condition	Rationale for Condition
Audibility	% Time Audible	Moderate - Significant Concern	The mean percent time audible (during the day) of all non-natural sounds was 91.9% and 71.5% of the time at N. Ridge Trail and Sleeping Lion Mtn., respectively, indicating that noises could be heard more than half of the 7am-7pm monitoring period. This warranted moderate - significant concern, especially given the prevalence of audible traffic noise at the North Ridge Trail, which is in the natural backdrop resource opportunity area as identified in the Historic Site's GMP (NPS 2002).
Sound Level	Amplitude (on-site monitoring)	Moderate	The loudest sounds heard occurred at night (compared to day) at both sites. Measured sound levels were generally higher at Sleeping Lion Mtn. (closer to the Fort and parking lot and highway). Louder days correlated with higher wind conditions. Modeled sound levels showed that levels are highest (45 to <65 dBA) along the roads bordering the park (i.e., State Road 118, 17, and 17/118) (NPS 2013). The Historic Core is exposed to lower sound levels, so a visitor would not be exposed to the loudest areas for most of the time they are in the park. However, again, because there is a need to use dress retreat parade recordings to help cover up the modern noises from the parking area and adjacent highway (NPS 2002), we consider the condition to be moderate.
	Amplitude (Mennitt et al. (2013) modeled sound level impact)	Good-Moderate	The modeled impact sound level for the Historic Site ranged between 4.6-4.9 dBA. This range is within a threshold for good to moderate concern when evaluating a park classified somewhere between a non-urban and urban park using NSNSD thresholds.

some key uncertainties that make our overall confidence in the assessment only moderate.

First, the monitoring was only conducted in one season, the summer season. Second, the information in the monitoring report was not presented in the form most useful for our purposes. In the report, there is no detailed listing of the types of sounds and/or noises in the "other human" category. This information would have enabled more of a determination as to whether sounds recorded at the two monitoring sites were from cultural activities or other, undesirable sounds (e.g., vehicle/road noise). Finally, it would have been useful to have a monitoring station in the Fort area itself so we could assess whether noise is affecting visitor education/interpretation activities in the immediate Fort area.

4.3.5. Sources of Expertise

The NPS Natural Sounds and Night Skies Division (NSNSD) scientists help parks manage sounds in a way that balances the various expectations of park visitors with the protection of park resources. They provide technical assistance to parks in the form of acoustical monitoring, data collection and analysis, and in developing acoustical baselines for planning and reporting purposes.

Emma Lynch, Acoustical Resource Specialist with the NSNSD, provided an NRCA soundscape template, which we largely used to develop Fort Davis NHS' soundscape assessment and provided an expert review of this section. The assessment is also based on the 2010 Acoustical Monitoring report that was conducted by USDOT in conjunction with NSNSD. For more information, see http://www.nature.nps.gov/sound/. Finally, NSNSD provided the sound model results and maps, which are included in Appendix D.

Randy Stanley, Physical Scientist / Acoustic Specialist, with the NPS Intermountain Region Office, obtained the original acoustical monitoring data from Volpe National Transportation Systems Center, which provided an opportunity to include all sound categories collected during study in this condition assessment.

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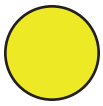
4.4. Air Quality

Indicators/Measures

- Visibility (1 measure)
- Level of Ozone (1 measure)
- Atmospheric Wet Deposition in Total N and Total S (2 measures)

Condition – Trend – Confidence



Moderate - See Report - Medium

4.4.1. Background and Importance

Under the direction of the NPS' Organic Act, Air Quality Management Policy 4.7.1 (NPS 2006), and the Clean Air Act (CAA) of 1970 (U.S. Federal Register 1970), the NPS has a responsibility to protect air quality and any air quality related values (e.g., scenic, biological, cultural, and recreational resources) that may be impaired from air pollutants.

One of the main purposes of the CAA is "to preserve, protect, and enhance the air quality in national parks" and other areas of special national or regional natural, recreational, scenic or historic value. The CAA includes special programs to prevent significant air quality deterioration in clean air areas and to protect visibility in major national parks and wilderness areas (NPS-ARD 2012a).

Different categories of air quality areas have been established through the authority of the CAA: Class I, II, and III. Like most National Park Service areas, Fort Davis National Historic Site is designated as a Class II airshed (Figure 4.4.1-1).

These classes are allowed different levels of permissible air pollution, with Class I receiving the greatest protection and strictest regulation. The CAA gives federal land managers responsibilities and opportunities to participate in decisions being made by regulatory agencies that might affect air quality in the federally protected areas they administer (NPS-ARD 2012b).

It's important to note that even though the CAA affords Class I areas the greatest

CHERYL MCINTYRE

Figure 4.4.1-1. Fort Davis National Historic Site is a Class II airshed.

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Figure 4.4.1-2. A hazy day at Fort Davis National Historic Site.

protection against air quality deterioration, NPS management policies do not distinguish between the level of protection afforded to any unit of the National Park System (NPS 2006).

Air Quality Standards

Air quality is deteriorated by many forms of pollutants that either occur as primary pollutants, emitted directly from sources such as power plants, vehicles, wildfires, and wind-blown dust, or as secondary pollutants, which result from atmospheric chemical reactions. The CAA requires the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) (40 CFR part 50) to regulate these air pollutants that are considered harmful to human health and the environment (EPA 2012a). The two types of NAAQS are primary and secondary, with the primary standards establishing limits to protect human health, and the secondary standards establishing limits to protect public welfare from air pollution effects, including decreased visibility, damage to animals, crops, vegetation, and buildings (EPA 2012a).

The NPS' Air Resources Division (NPS-ARD) air quality monitoring program uses EPA's NAAQS, natural visibility goals, and ecological thresholds as benchmarks to assess current conditions of visibility, ozone, and atmospheric deposition throughout park service areas.

Visibility affects how well (acuity) and how far (visual range) one can see (NPS-ARD 2002), but air pollution can degrade visibility. Both particulate matter (e.g. soot and dust) and certain gases and particles in the atmosphere, such as sulfate and nitrate particles, can create haze and reduce visibility.

Visibility can be subjective and value-based (e.g. a visitor's reaction viewing a scenic vista while observing a variety of forms, textures, colors, and brightness) (Figure 4.4.1-2) or it can be measured objectively by determining the size and composition of particles in the atmosphere that interfere with a person's ability to see landscape features (Malm 1999). The viewshed section (4.1) of this assessment addresses the subjective aspects of visibility, whereas, this section addresses measurements of particles and gases in the atmosphere affecting visibility.

Ozone is a gaseous constituent of the atmosphere produced by reactions of nitrogen oxides (NO_x) from vehicles, powerplants, industry, and fire and volatile organic compounds from industry, solvents,

and vegetation in the presence of sunlight (Porter and Biel 2011). It is one of the most widespread air pollutants (NPS-ARD 2003), and the major constituent in smog. Ozone can be harmful to human health, and it is also phytotoxic, causing foliar damage to plants (NPS-ARD 2003). The foliar damage requires the interplay of several factors, including the interaction of the plant to the ozone, the level of ozone exposure, and the exposure environment. The highest ozone risk exists when the species of plants are highly sensitive to ozone, the exposure levels of ozone significantly exceed the thresholds for foliar injury, and the environmental conditions, particularly adequate soil moisture, foster gas exchange and the uptake of ozone by plants (Kohut 2004).

Ozone penetrates leaves through stomata (openings) and oxidizes plant tissue, which alters the physiological and biochemical processes (NPS-ARD 2012c). Once the ozone is inside the plant's cellular system, the chemical reactions can cause cell injury or even death (NPS-ARD 2012c), but more often reduces the plant's resistance to insects and diseases, reduces growth, and reduces reproductive capability (NPS-ARD 2012d).

Air pollutants can be deposited to ecosystems through rain and snow (wet deposition) or dust and gases (dry deposition). Nitrogen and sulfur air pollutants are commonly deposited as nitrate, ammonium, and sulfate ions and can have a variety of effects on ecosystem health, including acidification, fertilization or eutrophication, and accumulation of toxins (NPS-ARD 2010a). Atmospheric deposition can also change soil pH, which in turn, affects microorganisms, understory plants, and trees (NPS-ARD 2010a). Certain ecosystems are more vulnerable to nitrogen or sulfur deposition than others, including high-elevation ecosystems in the western United States, upland areas in the eastern part of the country, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands (NPS-ARD 2010b). Increases in nitrogen have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. Nitrogen may also increase water use in plants like big sagebrush (Inouye 2006).

According to the EPA, in the United States, roughly two thirds of all SO_2 and one quarter of all NO_x come from electric power generation that relies on burning fossil fuels. Sulfur dioxide and nitrogen oxides are released from power plants and other sources, and ammonia is released by agricultural activities, feedlots, fires, and catalytic converters. In the atmosphere these transform to sulfate, nitrate, and ammonium and can be transported long distances across state, national, and international borders, impacting resources, including at Fort Davis National Historic Site (EPA 2012b).

4.4.2. Data and Methods

The approach we used for assessing the condition of air quality within the Historic Site's airshed was developed by the NPS-ARD for use in Natural Resource Condition Assessments (NPS-ARD 2010b, 2010c). Interpolated values generated by NPS-ARD, averaged over five years were used to assess condition. NPS-ARD used all available data from NPS, EPA, state, tribal, and local monitors to generate the interpolated values across the contiguous U.S., with a specific value assigned to the center of each park. These values provided estimates for visibility, ozone, and atmospheric wet deposition in the absence of onsite monitoring. Even though the data are derived from all available monitors, the data from the closest monitor will "outweigh" the rest.

Indicators/Measures
Visibility

Visibility is monitored by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program (NPS-ARD 2010a). The NPS-ARD assesses visibility based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions; (i.e., those

estimated for a given area in the absence of human-caused visibility impairment, EPA-454/B003-005). Group 50 is defined as the mean of the visibility observations falling within the range of the 40th through the 60th percentiles, as expressed in terms of a Haze Index in deciviews (dv). A factor of the haze index is light extinction, which is used as an indicator to assess the quality of scenic vista and is proportional to the amount of light lost due to scattering or absorption by particles in the air as light travels a distance of one million meters (NPS-ARD 2003). The haze index for visibility condition is calculated as follows:

Visibility Condition/Haze Index (dv) = current Group 50 visibility – estimated Group 50 visibility (under natural conditions)

The deciview scale scores pristine conditions as a zero and increases as visibility decreases (NPS-ARD 2010b).

Indicators/Measures
Level of Ozone

Ozone is monitored as part of the NPS Gaseous Pollutant Monitoring Program, in partnership with the EPA's CASTNet Program (Porter and Biel 2011). The assessment for ozone levels at the Historic Site was made by referencing NPS ARD's five-year interpolated values.

Indicators/Measures
Atmospheric Wet Deposition in Total N and Total S

Atmospheric deposition can be monitored in both wet and dry forms, but for the purposes of this assessment, we will use wet deposition monitoring data only because most areas of the country do not have dry deposition data available, including the Historic Site.

Atmospheric wet deposition is monitored across the United States as part of the National Atmospheric Deposition Program/ National Trends Network (NADP/NTN; NPS-ARD 2003). The values for wet deposition condition are expressed as the average amount of nitrogen (N) or sulfur (S) in kilograms deposited over a one-hectare area in one year (kg/ha/yr) (NPS-ARD 2003).

4.4.3. Reference Conditions

The reference conditions against which current air quality indicators are assessed are identified by NPS ARD (2010b) for NRCAs and listed in Table 4.4.3-1.

Visibility

A visibility condition estimate of less than 2 dv above estimated natural conditions indicates a "good" condition, estimates ranging from 2-8 dv above natural conditions indicate "moderate" condition, and estimates greater than 8 dv above natural conditions indicate "significant concern." Although the dv ranges of these categories were selected somewhat subjectively, the NPS-ARD chose them to reflect the variation in visibility conditions across the monitoring network as closely as possible.

Ozone

The ozone standard set by the EPA at a level to protect human health, 75 parts per billion (ppb) averaged over an eight-hour period, is used as a benchmark for rating current ozone condition. The three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor in an area must not exceed 75 ppb in order to be in compliance with the EPA standard.

The NPS-ARD rates ozone condition as "good" if the ozone concentration is less than or equal to 60 ppb, "moderate" if the ozone

Table 4.4.3-1. Reference conditions for air quality indicators.

Air Quality Indicator	Significant Concern	Moderate	Good
Visibility	>8 dv	2-8 dv	< 2 dv
Ozone	≥ 76 ppb	61-75 ppb	≤ 60 ppb
Wet deposition (total N and total S)	>3 kg/ha/yr	1-3 kg/ha/yr	< 1 kg/ha/yr

Source: NPS-ARD 2010b

concentration is between 61 and 75 ppb, and of "significant concern" if the concentration is greater than or equal to 76 ppb.

Wet Deposition

The NPS-ARD considers parks with less than 1 kg/ha/yr of atmospheric wet deposition of nitrogen or sulfur compounds to be in "good" condition, those with 1-3 kg/ha/yr to be in "moderate" condition, and parks with wet deposition greater than 3 kg/ha/yr to be of "significant concern."

4.4.4. Condition and Trend

Condition for all air quality indicators are listed in Table 4.4.4-1. Air quality trends were not evaluated for ozone or atmospheric wet deposition since there are no nearby monitors to provide the necessary data. Although conditions can be assessed with interpolated data, trends analyses require data from a nearby monitor. An ozone monitor is considered representative if it is located within 10 km (6 miles) of a park; a deposition sampler is considered representative if it is within 16 km (10 miles) of a park, and a visibility monitor is considered representative if it is within 100 km (60 miles) of a park (Ellen Porter, NPS_Air Resources Division, pers. comm.). Trend data from the Cedar Bluff IMPROVE (visibility) monitoring site will be used to determine the visibility trend at the Historic Site.

Visibility

All visibility data used to assess condition were derived from NPS ARD Air Atlas interpolated five-year average values (2006-2010) (NPS-ARD 2012e). The 5-year interpolated values average for the Historic Site's visibility condition fell within the moderate condition rating, which indicates visibility is degraded from the good reference condition of <2 dv above the natural condition. The visibility trend for Fort Davis NHS was derived from the Cedar Bluff IMPROVE monitoring site. From 2000-2009, visibility improved on the haziest days, while visibility on the clearest days showed no trend (NPS-ARD 2013).

Ozone

Ozone data for the Historic Site were derived from the five-year interpolated values average (2006-2010) (NPS-ARD 2012f), which resulted in a moderate ozone condition ranking for Fort Davis NHS.

Four ozone-sensitive plant species are found within the Historic Site (NPS-ARD 2006), and all four species are ozone bioindicators (Porter 2003), which is more of a concern if ozone levels are ≥ 76 ppb (Table 4.4.4-2). Additionally, an ozone risk assessment was conducted by Kohut (2004) for Chihuahuan Desert Network parks, including the Historic Site. The overall risk was judged to be low because although ozone levels were somewhat elevated, environmental conditions likely limited ozone uptake at times. The ozone level difference between NPS-ARD and Kohut (2004) is most likely due to the fact that Kohut (2004) considered environmental conditions that affect plant response to ozone, whereas, NPS-ARD's approach considers more recent ozone conditions but not environmental conditions (e.g., soil moisture levels). We

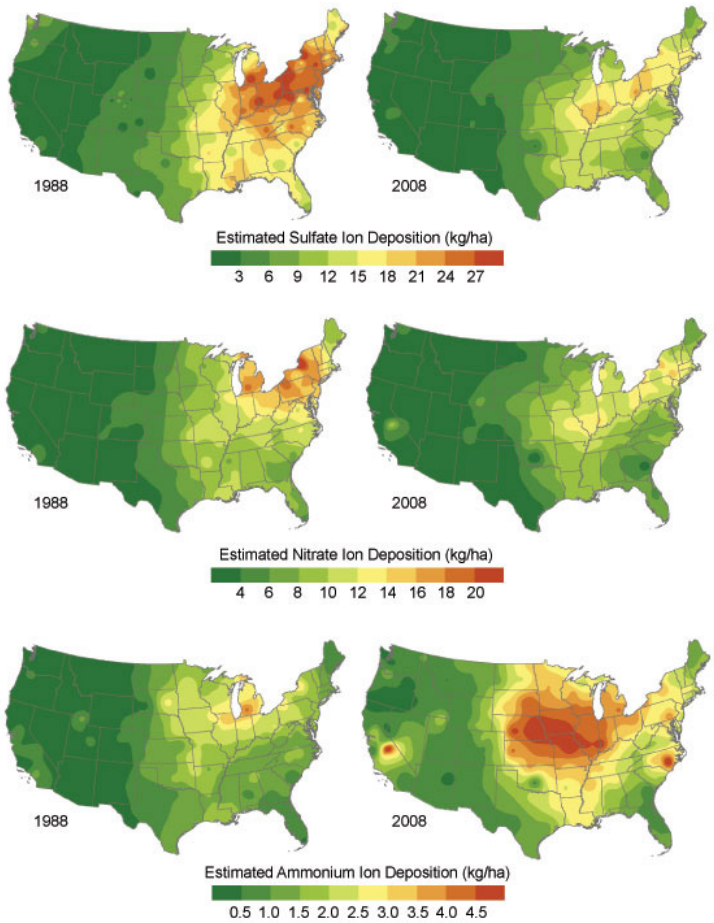
Table 4.4.4-1. Condition results for air quality indicators at Fort Davis NHS.

2006-2010	Moderate (68.8)	Moderate (6.2)	Moderate (1.7)	Moderate (1.2)

Source: D. NPS-ARD (2012 e,f,g) Air Quality Estimate Tables

Table 4.4.4-2. Ozone sensitive plants found at Fort Davis NHS (NPS-ARD 2006, Porter 2003).

Scientific Name	Common Name	Bioindicator
Apocynum androsaemifolium	Spreading dogbane	Yes
Artemisia ludoviciana	Silver wormwood	Yes
Prunus serotina	Black cherry	Yes
Rhus trilobata	Skunkbush	Yes



HTTP://WWW.NATURE.NPS.GOV/AIR/MONITORING/WETMON.CFM.

Figure 4.4.4-1. Change in wet deposition levels From 1988-2008 throughout the United States.

based the current ozone condition at the Historic Site on the most recent data (2006-2010).

Wet Deposition

The data for atmospheric wet deposition condition were derived from NPS-ARD's 2006-2010 interpolated values (NPS-ARD 2012g). The average value for total nitrogen and total sulfur resulted in moderate condition ratings.

Sullivan et al. (2011a), studied the risk from acidification for acid pollutant exposure and ecosystem sensitivity for Chihuahuan Desert parks, including the Historic Site. Pollutant exposure included the type of deposition (i.e., wet, dry, cloud, fog), the oxidized and reduced forms of the chemical, if applicable, and the total quantity deposited. The ecosystem sensitivity considered the type of terrestrial and aquatic ecosystems present at the Historic Site and their inherent sensitivity to the atmospherically deposited chemicals. These risk rankings for Fort Davis NHS were considered very low for acid pollutant exposure and low for ecosystem sensitivity to acidification. In general, arid ecosystems have been found to be very sensitive to nitrogen deposition, which can promote invasions of annual grasses, with subsequent displacement of native forbs and shrubs and increased fire risk (E. Porter, NPS-ARD, pers. comm.).

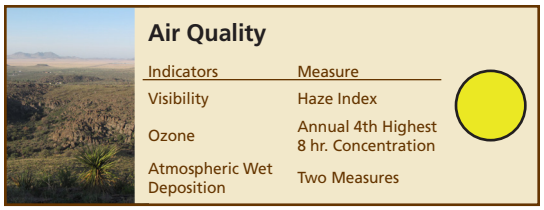
Sullivan et al. (2011b), also developed risk rankings for nutrient N pollutant exposure and ecosystem sensitivity to nutrient N enrichment, and were ranked as very low and very high, respectively.

In general, nitrate, sulfate, and ammonium deposition levels have changed over the past 20 years throughout the United States (Figure 4.4.4-1). Regulatory programs that mandated a reduction in emissions have proven effective for decreasing both sulfate and nitrate ion deposition primarily through reductions from electric utilities, vehicles, and industrial boilers, although a rise in ammonium ion deposition has occurred in large part due to the agricultural and livestock industries (NPS-ARD 2012h). A new study conducted by Lehmann and Gay (2011), indicated a decrease in sulfate concentrations from 1985-2009 in the area surrounding the Historic Site, and a statistically significant increase in nitrate concentrations.

It seems reasonable to expect a continued improvement in sulfate deposition levels because of Clean Air Act requirements, however, at this time, ammonium levels are not regulated by the EPA and may continue to rise as a result (NPS-ARD 2010a).

Table 4.4.4-3. Summary of the air quality indicators/measures and their contributions to the overall air quality Natural Resource Condition Assessment.

Indicator	Measure(s)	Condition	Condition Rationale
Visibility	Haze Index	Moderate	For 2006–2010, estimated average visibility in the Historic Site was 6.2 deciviews above natural conditions, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. From 2000-2009, the visibility trend improved on the haziest days, while visibility on the clearest days showed no trend.
Level of Ozone	Annual 4th-Highest 8-hour Concentration	Moderate	The estimated ozone level for 2006–2010 at the Historic Site was 68.8 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. Ozone-sensitive plants in the Historic Site include four species, all of which are bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitor stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr	Moderate	For 2006–2010, estimated wet nitrogen deposition was 1.7 kilograms per hectare per year, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitor stations.
	Total S in kg/ha/yr	Moderate	For 2006–2010, estimated wet sulfur deposition was 1.2 kilograms per hectare per year, therefore, the resource is in good condition based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitor stations.



Overall Condition and Trend

For assessing the condition of air quality, we used three air quality indicators. Our indicators/measures for this resource were intended to capture different aspects of air quality, and a summary of how they contributed to the overall condition is summarized in Table 4.4.4-3.

We consider the overall condition of air quality at Fort Davis National Historic Site to be of a moderate concern with a medium confidence level due to the interpolated values.

Trends cannot be derived for any of the air quality indicators since air quality monitoring sites are not located near enough to be representative of the conditions at the Historic Site and on-site monitoring does not occur.

Level of Confidence/Key Uncertainties

The key uncertainty of the air quality section is knowing the effect(s) of air pollution, especially nitrogen deposition, on ecosystems at Fort Davis NHS.

4.4.5. Sources of Expertise

The National Park Service's Air Resources Division oversees the national air resource management program for the NPS. Together with parks and NPS regional offices, they monitor air quality in park units; provide air quality analysis and expertise related to all air quality topics.

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4.5. Geology

Indicators/Measures

- Geologic Integrity

Condition - Trend - Confidence

Good - Insufficient Data - Low

This section is extracted from the Geologic Resources Evaluation Scoping Summary (KellerLynn 2008) for Fort Davis National Historic Site. For more information, go to http://www.nature.nps.gov/geology/inventory

4.5.1. Background and Importance

Geologic resources serve as the foundation of ecosystems and yield important information needed for science-based decision making in National Park System units. Geology is a major determinant of topography, water and soil chemistry, fertility of soils, stability of hill slopes, and flow styles of surface water and groundwater. These factors, in turn, influence biology, including the distribution of habitats and the locations of threatened and endangered species. Geology also influences human settlement patterns and how people use natural resources—for farming, ranching, industry, construction, hunting, fishing, and recreation.

Fort Davis National Historic Site (NHS) covers approximately 212 ha (523 ac). The site is located in a box canyon (Figure 4.5.1-1) near Limpia Creek on the eastern side of the Davis Mountains, the most extensive mountain range in Texas.

From 1854 to 1891 when the Fort was occupied, trees from the surrounding hills provided wood for fuel, the river and springs provided water, and grass was plentiful for forage. Although most of the buildings at the Fort are adobe, the nearby cliffs of red volcanic tuff provided material for foundations, as well as stone for the officers' quarters. The source for building materials was the Tertiary volcanics that flank the flat, bajada-like terrain where the Fort's parade grounds and buildings rest.

Named in honor of U.S. Secretary of War Jefferson Davis, who later became president of the Confederacy, Fort Davis served as a key post in western Texas where soldiers helped to open the area to settlement and protect emigrants, freighters, mail coaches,

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Figure 4.5.1-1. Fort Davis National Historic Site is located in a box canyon, surrounded on three sides by rocky cliffs.

NINA CHAMBERS

Figure 4.5.1-2. Many of the buildings at Fort Davis NHS have been restored and refurbished, such as these officer barracks.

and travelers along the San Antonio–El Paso Road. When the National Park Service acquired the property in the early 1960s, Fort Davis had been abandoned for nearly 70 years. An intensive restoration effort stabilized structures, restored buildings, and refurnished barracks with period antiques, museum-quality replicas, and custom-made items (Figure 4.5.1-2).

Historians consider Fort Davis to be one of the best remaining examples of a frontier military post in the American Southwest. Visitors can take self-guided tours of the restored and refurnished buildings. In addition, hiking trails within the historic site connect with trails in adjacent Davis Mountain State Park. The exposed igneous rock in the canyon walls records the volcanic activity that formed the Davis Mountains 40–20 million years ago.

4.5.2. Data and Methods

This limited assessment summarizes the findings from a geologic resource evaluation scoping summary conducted by the National Park Service Geologic Resources Division (KellerLynn 2008). The scoping included meetings with park staff and geologic experts to identify geologic issues, features, and processes. For more information about the Geologic Resources Division, visit http://www.nature.nps.gov/geology/.

4.5.3. Reference Conditions

In parks that do not have a geologic resource focus, that is, they do not have significant canyons or volcanoes or other prominent geologic features, no specific indicators or measures have been identified by which to assess geologic condition. In these cases, we use professional judgment and qualitative assessment of general geologic integrity to assign condition class and level of confidence. Table 4.5.3-1 clearly states how condition is assessed, and this assessment is reviewed by staff in the NPS Geologic Resources Division.

Good condition is assigned to parks where no concerns or issues about geologic resources have been identified. Geologic resources and processes are in a generally natural state and function.

Moderate condition is assigned to parks if there are some areas of moderate concern either inside the park, or outside the park that may impact it. Examples of this could be moderate disturbance due to soil erosion or mining exploration in the region.

Table 4.5.3-1. Qualitative description for determining condition of geologic resources.

Class	Description
Good Condition	No concerns or issues about geologic resources have been identified. Geologic resources and processes are in a generally natural state and function.
Moderate Concern	Some areas of moderate concern either inside the park, or outside the park that may impact it. Examples of this could be moderate disturbance due to soil erosion or mining exploration in the region.
Significant Concern	Areas of concern have been identified in assessments conducted by the NPS Geologic Resources Division or significant activities are occurring outside the park that have the potential to impact park resources.

Significant concern is assigned to parks that have identified areas of concern in assessments conducted by the NPS Geologic Resources Division or have significant impacts occurring inside or outside the park that have the potential to impact park resources.

Level of confidence is assessed depending on the level of information we have on which to base the condition assessment. A Geologic Resources Inventory Report produced by the NPS Geologic Resources Division, or similar report produced by the U.S. Geological Survey or state geologic survey specifically focused on a park's geology, results in a high confidence level for the assessment. A Geologic Resources Scoping Report (or the equivalent) provides a moderate level of confidence. If a Scoping Summary is all that is available and little is known or available about the geologic resources, then a low confidence level is assigned.

4.5.4. Condition and Trend

Specific indicators and measures related to soil erosion are presented in section 4.9 on grasslands. Based on the level of assessment that has been completed to date, no specific areas of geologic concern have been identified, therefore, the condition is considered good, but with a low level of confidence until further assessment is conducted.

The following discussion on geologic issues and geologic processes are excerpts summarized from the geologic scoping summary (KellerLynn 2008).

Geologic Issues

Geologic issues are those that may warant attention from resource managers at Fort Davis NHS as they are relevant for maintenance of facilities, mitigation of hazardous conditions, and protection of resources.

Disturbed Lands

Disturbed lands are those park lands where the natural conditions and processes have been directly impacted by mining, development (e.g., facilities, roads, dams, abandoned campgrounds, and user trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use. The NPS Disturbed Lands Restoration Program, administered by the Geologic Resources Division, usually does not consider lands disturbed by natural phenomena (e.g., landslides, earthquakes, floods, hurricanes, tornadoes, and fires) for restoration unless influenced by human activities. Most disturbances are not in keeping with the mandates of the National Park Service, but some may be of historical significance. For example, the cultural landscape at the Fort was much more denuded than today.

Disturbances at Fort Davis NHS may include groundwater mining. In the late 1800s, well levels were 12 m (40 ft); they are approximately 52 m (170 ft) now (KellerLynn 2008). In addition, the Fort once hosted a spring that no longer produces. Park managers are monitoring groundwater levels and are investigating whether this drawdown is related to development. Another concern for development is protecting the site's viewshed (see section 4.1).

Commercial logging of ponderosa pine occurs in the Davis Mountains, but resulting erosion and sedimentation does not affect Fort Davis NHS. The sand and gravel resources in the


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Figure 4.5.4-1. Depressions in rock surrounding Fort Davis NHS act as tinajas that catch rainwater and runoff.

vicinity of Fort Davis are very fine-grained and not suitable for industrial use; historically they may have been used for making mortar, however.

Climate Change

Climate change has the potential to impact park resources such as scenery, environmental quality, and natural and cultural resources. Drought cycles at Fort Davis NHS may change as a result of climate disruption, which would affect the regularity of dust storms. The region has been experiencing a drought since the 1990s, with the driest year on record occurring in 2011; another such long-term drought occurred during the 1950s.

Eolian Features and Processes

Fort Davis NHS has no significant dunes or loess deposits; however, in the spring, dust storms are common, primarily as a result of disturbed agricultural fields. Not uncommon during these times are "mud storms" when precipitation mixed with dust "rains" out of the air.

Geologic Features and Processes

Fluvial Processes

Arroyos have cut the bajada-like alluvial plain on which Fort Davis NHS sits. During the monsoon, water pours off the volcanic cliffs and flows onto Historic Site property. Typically, flows last for a few hours. Some have caused flooding; for example, in 1990 storm flow impacted some buildings at Fort Davis NHS. At the western end of the national historic site, tinaja-like depressions hold water that pours off the cliffs during storms (Figure 4.5.4-1).

Hillslope Features and Processes

The cliffs in the vicinity of the Fort are a minimal threat for rockfall hazards. Some colluvial debris has formed deposits at the base of these cliffs, but the volcanic rock (i.e., rhyolites or ignimbrites) show few signs of instability.

Seismic Features and Processes

Visitors and staff sometimes feel seismic shaking at Fort Davis NHS. Notable seismic activity occurred in the 1950s, diverting Limpia Creek. Although this event changed the hydrologic pattern, it left no other surface expression. In spring 1995 a 5.0-magnitude earthquake on the Richter scale occurred near Marathon, Texas (epicenter east of Alpine, Texas); this is the most significant recent earthquake in the vicinity of the Historic Site (Collins et al. 1996, Collins and Raney 1997, Henry and Price 1985).

At 5:40am on August 16, 1931 the largest earthquake known to have occurred in

Table 4.5.4-1. Qualitative description for determining condition of geologic resources.

Indicator of Condition	Measure	Condition	Rationale for Condition
Geologic Integrity	None	Moderate	The integrity of the geologic resources at Fort Davis NHS is intact, there are no geologic concerns, and a resource evaluation scoping report was completed for this site.

Texas took place near Valentine (latitude 30.6 degrees and longitude -104.2 degrees), with a recorded magnitude of 3.5 or above. All the buildings were damaged and even the tombstones in the local cemetery were rotated.

Volcanic Features and Processes

Volcanic activity surrounding Fort Davis NHS ended 20 million years ago; however, most of rock types are volcanic: rhyolite, tuff, basalt, and sedimentary deposits between flows. Some may be particularly interesting and enjoyable to interpret, for example, ignimbrites—rock formed by the widespread emplacement of ash flows and swiftly flowing nuées ardentes. In addition, the Davis Mountain volcanic field and Buckhorn Caldera express a violent geologic past and may be of interest to visitors.

Overall Condition

Table 4.5.4-1 describes the overall condition for Fort Davis NHS. The condition of the geologic resources at is good, with a low level of confidence.

4.5.5. Sources of Expertise

The National Park Service's Geologic Resources Division conducts geologic inventories and resource evaluations, and produces digital geologic maps in close partnership with the Inventory and Monitoring Program, park staff, and partners.

This section is based entirely on a scoping summary report (KellerLynn 2008) produced by the Geologic Resources Division, and was reviewed by Bruce Heise, Geologist at the National Park Service Geological Resources Division.

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4.6. Groundwater

Indicators/Measures

- Groundwater Elevation (Change in groundwater elevation)

Condition - Trend - Confidence

Moderate - Insufficient Data - Low

4.6.1. Background and Importance

Groundwater resources provide approximately 60% of Texas' water supply needs statewide (Texas Water Development Board 2013a). The entire state is divided into groundwater management areas, with Fort Davis National Historic Site (NHS) located in District 4.

National Park Service (NPS) Management Policy 4.6.1 states that the NPS will perpetuate surface waters and groundwater as integral components of park aquatic and terrestrial ecosystems (NPS 2006). It is the policy of the NPS to determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution or other types of degradation of park waters by human activities occurring within and outside of parks.

Aquifer in the Vicinity of Fort Davis NHS

Fort Davis NHS' groundwater resource is located within a minor aquifer of igneous origin that covers the majority of Jeff Davis County (Texas Water Development Board 2013a) (Figure 4.6.1-1). A complex series of Tertiary volcanic rocks create an aquifer thickness between 2,000-3,000 feet within a region encompassing the Historic Site (George et al. 2011).

Tensional forces in the earth's crust created downfaulted basins, which eventually filled with sedimentary and volcanic alluvial deposits, creating the Alluvium and Tertiary Volcanics Aquifer where the Historic Site wells are located. Groundwater recharge to this aquifer results from precipitation

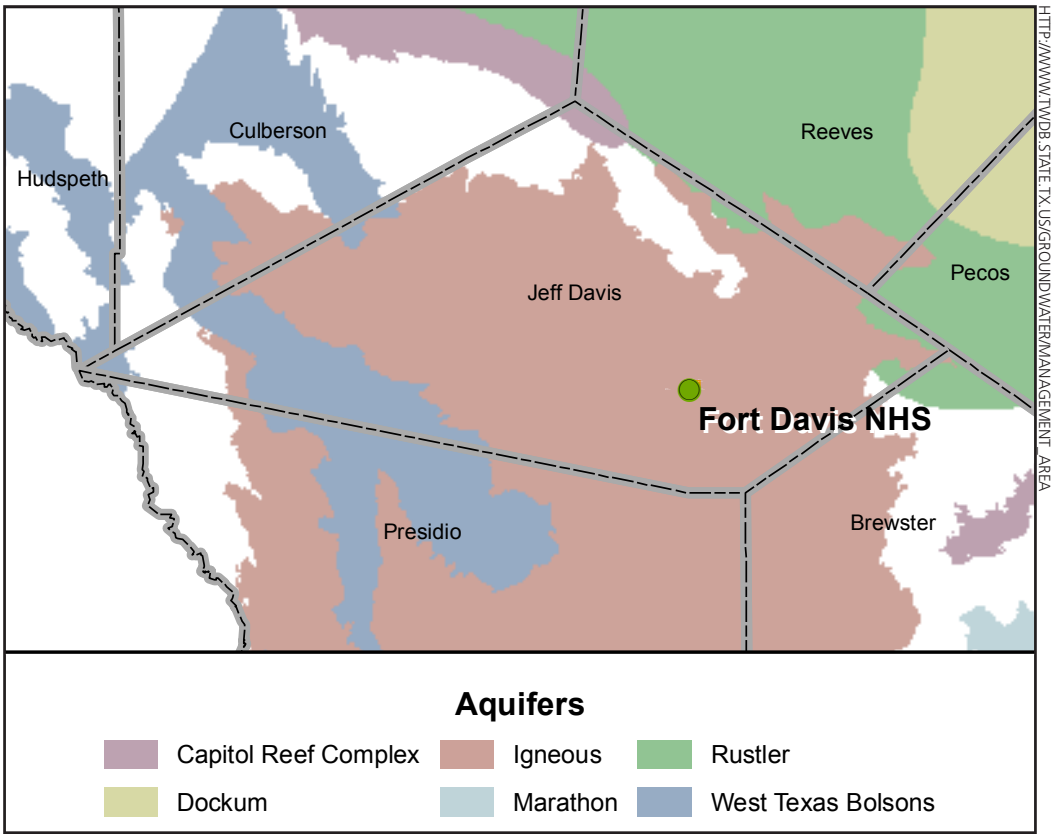


Figure 4.6.1-1. Fort Davis NHS' groundwater resource is located in the Igneous aquifer, which covers most of Jeff Davis County.

percolating through fractures, especially when intersecting streambeds (Porter et al. 2009) and primarily flows from the higher elevations to the lower elevations (LBG-Guyton 2001 as cited in Porter et al. 2009). Most of the groundwater uses are from well withdrawals and springflow (Porter et al. 2009).

This igneous aquifer is complex near the Historic Site due to the extensive faulting and fracturing, both vertically and horizontally, of the volcanic rock. As a result, groundwater levels can vary by several hundreds of feet between closely spaced wells. This variance can also result from the rugged topography and/or the from the variable porosity and storage capacity of the volcanic rocks comprising the aquifer (LBG-Guyton 2001 as cited in Porter et al. 2009).

4.6.2. Data and Methods

Indicators/Measures
Groundwater Elevation (Change in groundwater elevation)

Water Use at Fort Davis NHS

Three groundwater wells are located within the Historic Site's boundary (Figure 4.6.2-1). The maintenance area well is primarily used for landscape watering purposes (NPS, Fort Davis NHS Draft Watering Plan for Cultural Landscape Cottonwood Grove n.d.). According to Superintendent John Morlock, the park has been watering the historic cottonwoods, which includes the state champion tree, since 1988 and uses ~6 million gallons of water per year. Mr. Morlock drafted a watering plan for the cultural landscape cottonwood grove (n.d.) to improve efficiency of water use by watering during the height of the growing season to "supplement summer rains and maintain soil moisture during fall and winter months."

The church camp well is only used in the summer for constructing adobe bricks for the Historic Site's building restoration efforts, and the oak grove well is abandoned (John Morlock, Fort Davis NHS Superintendent, pers. comm., January 15, 2013). Two of the wells (church camp and oak grove) are in the Texas Water Development Board (TWDB) groundwater database but lack specific water level measurements for both wells (TWDB 2013b).

To determine water level within the aquifer we used measurements from two wells outside the Historic Site's boundary (State Well IDs #5225309 and #5225308) to serve as likely proxies for the groundwater level at the Historic Site. Groundwater level

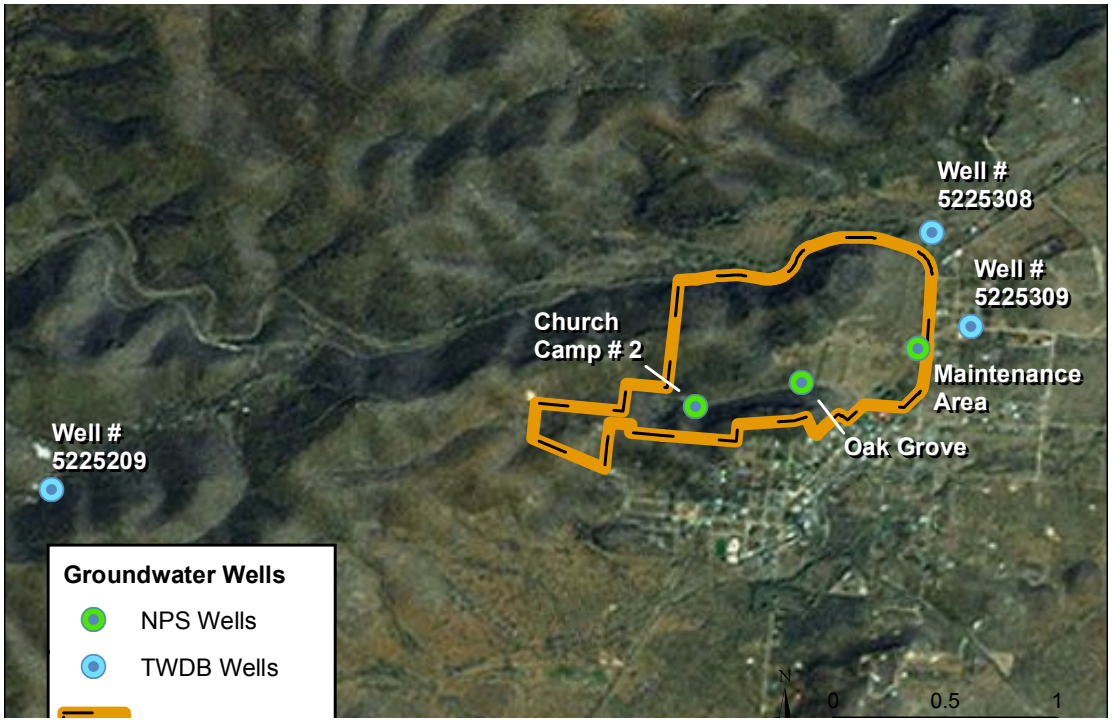


Figure 4.6.2-1. Groundwater well locations at Fort Davis NHS and within the surrounding area.

measurements were retrieved from the Texas Water Development Board Groundwater Database Reports for both proxy wells (TWDB 2013b,c).

Additional surrounding groundwater wells were considered to also serve as proxies for the Historic Site's groundwater condition assessment, but upon review of topographic maps, aerial images, and knowledge of local geology, we determined that the direction of groundwater most likely flows east-slightly northeast, moving from the higher elevations to lower elevations (Mike Martin, NPS Water Resources Division Hydrologist, pers. comm., January 14, 2013 and Porter et al. 2009), and the additional wells to the north and south were located on the other sides of the bedrock outcroppings, decreasing the likelihood of hydrologic connection to the Historic Site's wells (Mike Martin, NPS Water Resources Division Hydrologist, pers. comm., January 14, 2013).

4.6.3. Reference Conditions

The reference conditions by which Fort Davis NHS' groundwater resource was assessed are listed in Table 4.6.3-1.

4.6.4. Condition and Trend

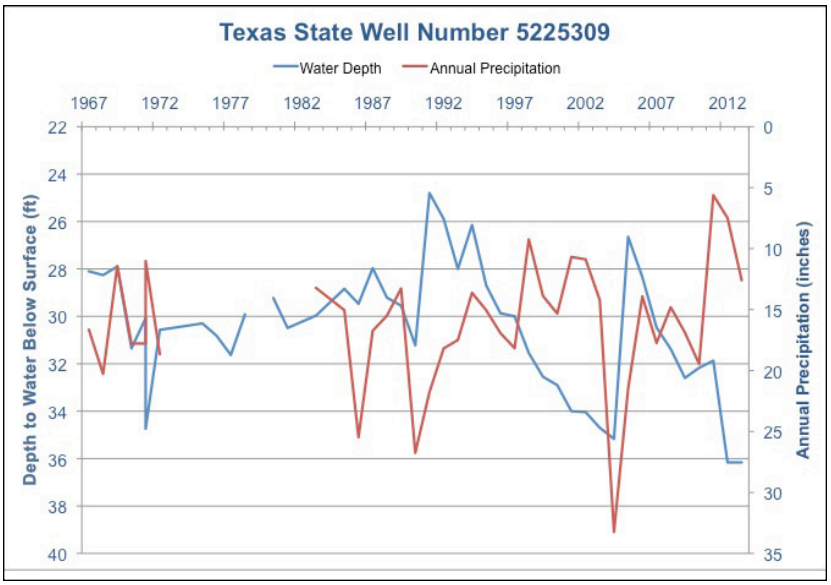
Porter et al. (2009) used three wells surrounding the Historic Site in their groundwater evaluation report for the park (State Well IDs 5225308, 5225309, and 5225209; see Figure 4.6.2-1). While it may be possible due to the faulting and fracturing of the regional volcanic rocks, it is unlikely that there is any substantial hydrologic communication between well #5225209 and the Historic Site wells, especially due to the depth of this well, distance from the Historic Site, and geologic terrain (Mike Martin, NPS Water Resources Division Hydrologist, pers. comm., January 14, 2013). Even if there is a connection, the rate would be so small as to be considered negligible. As a result, the groundwater levels for this well were omitted from the discussion below. The graphs shown in Figure 4.6.4-1 show the depth of groundwater levels below the surface and the amount of precipitation for the two wells used and proxies and (State Well IDs 5225308 and 5225309) included in Porter et al. (2009). Additional information pertaining to both park and proxy wells are summarized in Table 4.6.4-1.

<u>Proxy Well # 5225309</u>

This privately owned and purportedly unused well is within the same aquifer (Alluvium and Tertiary Volcanics) as the Historic Site's wells and is located just to the east of the park's boundary, approximately 1,188 feet (362 m) from the park's maintenance area well. The groundwater level records for this well span from 1967-2013, with depths to water levels ranging from a high of 24.8 feet in 1991 to a low of 36.16 feet in 2012 and 2013 (Texas Water Development Board. 2013b). In general, it appears as if the groundwater

Table 4.6.3-1. Reference condition classes for assessing groundwater condition at Fort Davis National Historic Site.

Condition Class	Description
Good	A good reference condition is one where groundwater level supports Historic Site resources. We expect variability that reflects annual variation in environmental conditions (e.g., rainfall, evapotranspiration, pumping), but lacks an overall long-term decreasing water level trend. Natural systems, when well supported by the local water table, are generally resilient enough to maintain viability through natural variations in hydrology, including through periods of drought.
Moderate	A moderate condition is when groundwater levels fluctuate around a water table elevation that only provides marginal support for the Historic Site resources. In this scenario prolonged drought or excessive withdrawals could result in water level decline over time.
Significant Concern	A significant concern condition is when water levels are so low in the aquifer that there is either no hydrologic support and/or there are adverse impacts to Historic Site resources.



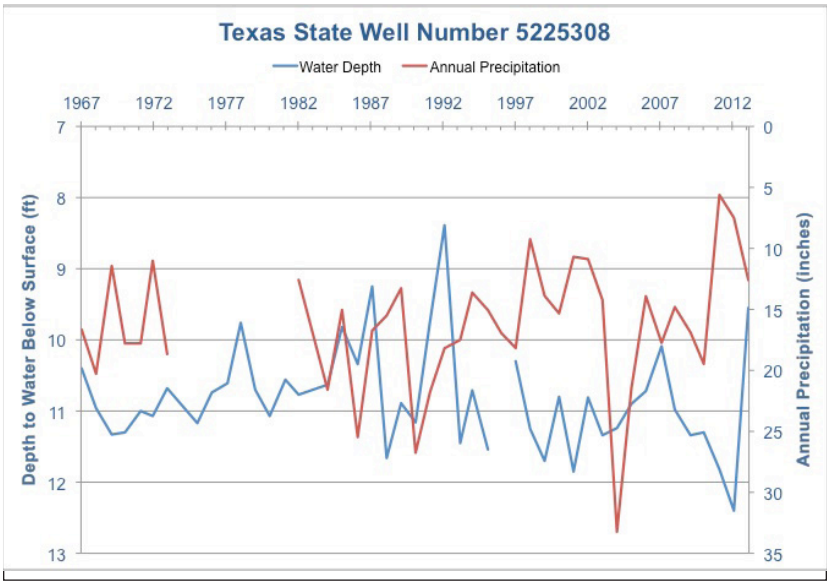
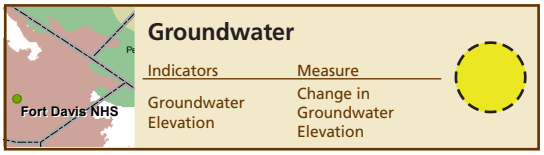


Figure 4.6.4-1. Depth to water below surface for two wells used as proxies to assess groundwater condition within the Historic Site and annual precipitation data for corresponding well level measurement years.

levels have been quite variable, with an overall downward trajectory, especially since 1991 (with the exception of an increase from 2005-2006). The well record does not indicate a date when the well became unused so it is difficult to interpret the reason(s) for the decline, which may be a function of excessive withdrawals and/or drought conditions in an already arid southwest environment. Annual precipitation data were obtained from the National Weather Service Weather Forecast Office (2014) for the same years as those that groundwater level measurements were available for well #5225309 and plotted on the same graph.

Well # 5225308

This privately owned and also purportedly unused well is within the Volcanics aquifer and is located northwest of well #5225309, by approximately 2,359 feet (719 m). The groundwater level records for this well span from 1967-2013, with depths to water levels ranging from a high of 8.39 feet in 1992 to a low of 12.4 feet in 2012 (Texas Water Development Board. 2013c). In general, it appears as if the groundwater levels have remained stable, with the exception of a 3.06 foot decline between 1992 and 1993. The topological gradient between this well and well #5225309 is relatively similar to the change in water table gradients, possibly indicating a hydrologic connection. Annual precipitation data were obtained from the National Weather Service Weather Forecast Office (2014) for the same years as those that groundwater level measurements were available for well #5225308 and plotted on the same graph.



Overall Condition/Trend

For assessing the condition of the groundwater resource at the Historic Site, we chose one indicator (change in groundwater elevation), which is summarized in Table 4.6.4-2.

In general, it appears as if the groundwater level within the Alluvium and Tertiary Volcanic Aquifer near the Historic Site has been declining. It's worth mentioning that there have been no significant water level declines in wells measured by the TWDB throughout the Volcanics Aquifer (George et al. 2011). So if there is in fact inter-aquifer connection between the Volcanics and Alluvium and Tertiary Volcanics aquifers, the declining level in the Alluvium and Tertiary Volcanics aquifer may be less of an overall concern. However, at this time, we consider the groundwater resource at the Historic Site to be in moderate condition, with an unknown trend due to lack of additional information. We also assigned a low confidence level since we do not know the cause of decline.

Table 4.6.4-1. Summary of groundwater wells within and surrounding Fort Davis NHS.

Texas State Well ID#	Aquifer	Well Depth (ft.)	Location and Summary
5225306 (Oak Grove)	Alluvium and Tertiary Volcanics	140	This well is located within the Historic Site and abandoned. This well was drilled in 2000.
5225307 (Church Camp/ Hospital Canyon Well)	Tertiary Volcanics	205	This well is located within the Historic Site and used to make adobe bricks for historic building restoration purposes. This well was drilled in 2000.
No Number (Maintenance Area Well)	Alluvium and Tertiary Volcanics	245	This well is located within the Historic Site and used for watering the cottonwood grove located within the cultural landscape. This well was drilled in 2000.
5225309[1]	Alluvium and Tertiary Volcanics	50	This well is privately owned and located just outside the Historic Site's boundary directly east, approximately 1,188 feet from the maintenance area well. Water level records from this well were used as a proxy to determine the Historic Site's groundwater resource condition.
5225308[1]	Volcanics	95	This well is privately owned and located outside the Historic Site's boundary to the northeast, approximately 2,746 feet from the maintenance area well. Water level records from this well were also used as a proxy to determine the Historic Site's groundwater resource condition.
5225209[1]	Volcanics	392	This well is located within the Davis Mountains State Park to the west of the Historic Site but was not used for the purposes of this assessment.

[1]These wells were included in Fort Davis NHS' groundwater assessment conducted by Porter et al. (2009).
Well information was derived from State of Texas (2000) well reports.

Table 4.6.4-2. Indicator, measure, and rationale of groundwater condition.

Indicator of Condition	Measure	Condition	Rationale for Condition
Groundwater Elevation	Change in Groundwater Elevation	Moderate	The groundwater level records for well #5225309, which is located in the same aquifer as two of the Historic Site's wells, indicate a rather variable fluctuation in water table elevation, with apparent decline (but indeterminate trend). Well #5225308, located in the Volcanics Aquifer, may be hydrologically connected to the park's wells and does not exhibit significant water level declines according to George et al. (2011). Overall, we consider the Historic Site's groundwater condition to be moderate.

Key Uncertainties

There are numerous factors that may affect the trend of the water table elevation in the Alluvium and Tertiary aquifer. One of the greatest uncertainties is the natural hydrologic input, which affects the groundwater elevations. In addition, the effects of drought and significant groundwater withdrawals, especially within an arid environment where the Historic Site is located, may also impact the overall groundwater condition and decline. The driest year on record (102 years) was in 2011. At this point, a more thorough understanding of the groundwater dynamics is needed to provide better insight for management decisions.

4.6.5. Source of Expertise

Michael Martin, a hydrologist with the NPS Water Resources Division, provided guidance on relevancy of surrounding groundwater wells to the Historic Site's groundwater

resource, as well as provided interpretation of water level records for overall condition assessment.

Michael Martin has his Masters of Science in Watershed Science. Specialty areas include open channel flow, geomorphology, flood analysis, wetlands hydrology, geochemistry, and water quality.

4.6.6. Literature Cited

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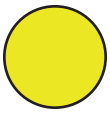
4.7. Dry Wash and Historic Cottonwoods

Indicators/Measures

- Dry Wash (2 Measures)
- Historic Cottonwood Grove (1 Measure)

Condition - Trend - Confidence



Moderate - Insufficient Data - Medium

4.7.1. Background and Importance

There are two features of the Fort Davis National Historic Site that we address in this section- the dry wash and the historic cottonwood grove (Figure 4.7.1-1).

Dry Wash

The watershed above the Historic Site is approximately 0.6 square miles and is oblong in shape, measuring less than 2 miles long by less than one-half mile wide. Intense thunderstorms, characteristic of this region, are capable of producing high-magnitude runoff events. Furthermore, given the small size of the watershed and the rapid runoff rate of the bedrock, the Fort location is very likely within a flash flood zone (excerpted from Martin 1999).

A dry wash is a dry channel that serves as a transitory stream or river during flash flood events. A dry wash channel's flood conveyance capacity depends upon the amount of flow and the channel's ability to accommodate the flow without overbank flooding. Changes to a channel can occur with great frequency and intensity given the type of landform where it exists (i.e., a steep slope that transports water and sediment via a feeder channel then deposits the sediment load when it reaches a topographic break, usually at the base of a mountain or valley side). The deposited sediment forms an alluvial fan where the incised channel ends and the flow laterally expands often forming several distributary channels (Blair and McPherson 1994).

The Fort's historic structures are located on an alluvial fan directly below the fan-head valley, which is a little over one-half mile long

NINA CHAMBERS

Figure 4.7.1-1. Historic grove of cottonwood trees at Fort Davis NHS (left of center and above parking lot in photo).

(Martin 1999). The Fort and surrounding grounds occupy approximately two-thirds of the upper alluvial fan and is located within the Regulatory Floodplain (Martin 2008).

Two ditches were dug during the Fort period to alleviate flooding of the structures and parade ground, one to the north side of the Fort that served as overflow relief for the second main south ditch (Figure 4.7.1-2). These ditches were created to serve as incised channels, directing water away from the Fort's structures, along with levees that were also built to serve as flood control features.

After the active Fort period, several impoundments were constructed within the small watershed. One rock dam is located inside the Historic Site's boundary, but several are located farther upstream on private land. Silt has accumulated behind the dam that is located in the Historic Site, and according to engineers, the structure is showing signs of failure. The Historic Site is concerned that a failure of the dam would result in a massive wash of silt that could adversely affect vegetation and the drainage pattern downslope (Folts-Zettner 2013).

Historic Cottonwood Grove

The historic cottonwood (*Populus deltoides*) grove was planted by officers' wives during the Fort period to provide a picnic and meeting area, which is located on the alluvial fan close to the Historic Site's eastern boundary. Although cottonwoods of all age groups are found along nearby Limpia Creek (to the north of the Historic Site's boundary), the cottonwoods in the Historic Site are not growing in a natural setting but are nonetheless a contributing feature to the Site's cultural landscape. The grove contains the first- and second-largest Rio Grande cottonwoods in the state and supplemental water is frequently and strategically applied to maintain the health of these historically significant trees (NPS n.d.).

4.7.2. Data and Methods

This limited assessment is based on a rapid field assessment conducted by Tomye Folts-Zettner of the Southern Plains Inventory and Monitoring Network and Cheryl McIntyre of the Chihuahuan Desert Network in June 2013. We also reviewed two memoranda from Michael Martin, a hydrologist with the Water Resources Division of NPS, concerning a flood hazard assessment and

Figure 4.7.1-2. Location of features associated with the dry wash and cottonwood grove.

a flood mitigation plan for the Historic Site (Martin 1999 and Martin 2008, respectively).

Indicators/Measures
Dry Wash (Channel Formation/Sediment Accumulation and Stability)

Dry Wash
The upper dry wash and the hand-dug ditches' abilities to withstand water flow was assessed based upon bank stability and channel formation/sediment accumulation. Water flow within a channel is a dynamic process dependent upon several physical characteristics governed by landform and location, such as slope, depth of channel, and stabilizing vegetation -all of which may serve to dissipate the velocity of the water flow. This energy dissipation decreases the potential for erosion and increases the likelihood of the hand-dug ditches to serve as primary channels during rain events.

Indicators/Measures
Historic Cottonwood Grove (Age Structure)

Historic Cottonwood Grove
The historic cottonwood grove was assessed using one indicator (cottonwood grove health), with one measure (age structure). Age class distribution, or age structure, is often associated with vigor of a system, and multiple age classes of vegetation are necessary to provide natural recruitment and replacement. Intact systems may be able to recover from a severe flooding event, and the older age classes can usually persist even within degraded conditions.

4.7.3. Reference Conditions

Reference conditions for the dry wash and historic cottonwood grove are listed in Table 4.7.3-1.

4.7.4. Condition and Trend

Dry Wash
The head, or origin, of the wash is on private property, but it can be seen at a distance from Davis Mountains State Park. This land is steeply sloped grassland that is used for grazing, and it burned during the 2011 wildfire. There are at least two shallow impoundments present in this section. From a distance, the grass cover appears to be in good condition, which would help stabilize the soils and reduce sediment runoff during heavy rains.

The next segment of the wash alternates between state and federal property, and it is too steep for access to assess the top portion.

Table 4.7.3-1. Reference condition classes for assessing the dry wash and historic cottonwood grove conditions at Fort Davis National Historic Site.

Condition Class	Good	Moderate	Significant Concern
Dry Wash	We considered the dry washes/ditches to be in good condition if they appeared to be stabilized with minimal sediment build-up.	We considered the dry washes/ditches to be in moderate condition if they appeared to be relatively stabilized and contained only a moderate amount of sediment.	We considered the dry washes/ditches to be of significant concern if they appeared to be destabilized and contained a high amount of sediment that would prevent the ability to effectively convey flood waters.
Historic Cottonwood Grove	We considered the cottonwood grove to be in good condition if it contained multiple age classes of trees, and recruitment occurred naturally.	A moderate condition was when there was some lack of multiple age classes or natural conditions to encourage the persistence of trees and the recruitment of new trees.	A significant concern condition existed if the age class distribution was skewed toward all old or all young trees, and/or a substantial proportion of the trees were in poor health.

The next wash segment assessed, which was located between the failing dam and Church Camp on park property (now used for maintenance storage) showed little sign of erosion and had very good native vegetation growing in the dry wash channel and along the banks. A week prior to the June 2013 field assessment, a large amount of water flowed through the wash, but no vegetation appeared to be uprooted. The dominant vegetation growing in this area of the channel included bulb panicgrass (*Panicum bulbosum*) and streambed bristlegrass (*Setaria leucopila*), both of which are native perennials. Terraces were also vegetated, and there was a well formed canopy of Emory oak (*Quercus emoryi*) and net-leaf hackberry (*Celtis laevigata*). This was the most naturalized section of the dry wash within the Historic Site.

Below Church Camp, the channel was less confined and began forming the alluvial fan. The alluvial soils in this section of the channel showed signs of erosion and incision in places, and the bottom portion of the wash was not as vegetated. The vegetation canopy was more open and dispersed. Shrubs and early successional forbs (denoting disturbance) were more abundant, along with more bare ground. All of these conditions are typical in an alluvial fan environment but don't necessarily support the maintenance of primary channel formation.

During the second fort period (1867-1891) and midway between Church Camp and the Fort hospital, the army constructed a series of dikes and ditches to alleviate fort flooding (NPS 2002). These ditches now serve as the dry wash areas, which are historically significant to the site. One wash was channelized into a hand-dug ditch (the south channel), and a second wash/ditch (the north channel) branches off at a higher gradient to prevent excessive water flow to the south channel. The north ditch (with dikes at the Fort) eventually rejoins the south channel beyond the main Fort. These channels have long stretches of straight runs with little to no stabilizing vegetation (typical characteristics for channels on an alluvial fan).

The ditches/channels were comprised of bare ground, which is likely consistent with Fort-period conditions. Erosion was also observed in these areas. Typical of a dynamic, highly disturbed, and bare ground environment, exotic grasses and forbs (primarily Johnsongrass (*Sorghum halepense))* were becoming established.

Beyond the Fort, and during a high rain event, excess water spreads out into a wide, grassy depression, flowing through the historic cottonwood grove and picnic area and eventually passing out of the Historic Site, under Highway 118 to join Limpia Creek. The grass cover throughout this area was rather thick and is mowed regularly by Historic Site staff. There was minimal to no erosion evident, most likely due to the lack of slope and energy dissipation that occurs across the alluvial fan.

Using the two measures of channel formation and slope stability we consider the dry wash (overall) to be in moderate condition. There are varying degrees of erosion/slope stability and channel formation, with the upper washes being in better condition than the lower washes. This is primarily due to vegetation cover, which provides bank stability, and the steeper slope affords more channel incision to occur. Also, the hand-dug channels/ditches are located on the alluvial fan, which doesn't typically have well confined channels.

A concern for the lower portion of the channel is the potential for the failing dam to break, which would rapidly release accumulated sediment, most likely overloading the current hand-dug ditch/wash diversion channels.

In 2013, Historic Site staff began the process of incrementally notching the failing dam, with a goal of gradually releasing the sediment that has built up behind it (Figure 4.7.4-1). Barring any extreme rainfall events, a partial notch combined with the grass roots holding the sediment should ensure a slow release of sediment that will not harm the established vegetation and channels. Once the sediment load behind the dam is somewhat reduced, a second, deeper notch in the dam will be made to continue the incremental release process.

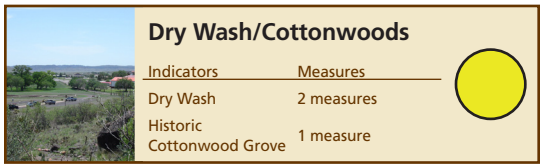

NPS

Figure 4.7.4-1. The notch in the failing dam (shown in the upper center of the photo) was made by park staff in 2013 to manage the potential sediment release incrementally.

Historic Cottonwood Grove

One indicator (grove health), with one measure (age structure) was used to assess the condition of the historic cottonwood grove. The first- and second-largest Rio Grande cottonwoods in the state are in decline, due primarily to their age.

Cottonwood trees are known to live approximately 70-120 years; a typical age is 70 years, and a 120-year-old tree would be considered very old (Northern State University 2013). There are younger trees in the grove, so the historic setting will be preserved, but these have been planted and were not recruited naturally. No new, young trees have naturally recruited into the stand because conditions are not conducive for their natural establishment. Overall, It appears that the cottonwood grove is not self-sustaining and requires maintenance in order to perpetuate. Additionally, the area has become off-limits to visitors for safety reasons due to the potential for falling branches. We consider the historic cottonwood grove to be in moderate condition.



Overall Condition

Taking into account the two indicators with their measures, we consider the overall condition of the dry washes and historic cottonwood grove to be moderate. The indicators and measures are summarized in Table 4.7.4-1.

4.7.5. Sources of Expertise

This section was based on the rapid field assessment conducted by Tomye Folts-Zettner, a biologist with SOPN specializing in vegetation, with a background in Natural Resource Management and Rangeland Ecology, by Cheryl McIntyre, a physical scientists with CHDN, and grassland expert Tim Seastedt with University of Colorado at Boulder. Supporting information included two memoranda and personal communication with Michael Martin, a hydrologist with the Water Resources Division.

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Martin, M. 1999. Memorandum to Fort Davis National Historic Site Superintendent

Table 4.7.4-1. Indicators and measures of dry wash and cottonwood grove condition, their corresponding assigned condition classes, and the rationale for assigning conditions.

Indicators of Condition	Measures	Condition	Rationale for Condition
Dry Wash	Channel Formation	Moderate	Upper areas of the wash had good channel formation, including some sinuosity, which will help dissipate flow energy during rain events. Below Church Camp, the channel became less confined and began the formation of an alluvial fan, typical of a semi-arid environment. The alluvial soils in this section of the channel showed signs of erosion. There was minimal channel formation beyond the Fort. There is concern regarding the failing dam within the Historic Site and the potential to fill the channels with sediment, decreasing the ability to convey flood waters.
	Bank Stability	Moderate	Expected species (bulb panicgrass and bristlegrass) were present in the bed and on the banks (Emory oak and net-leaf hackberry), providing stability within the upper washes. Lower areas of the wash were less vegetated and early successional forbs were more prevalent. At still lower portions of the wash (where the ditches are present), exotic grasses and forbs were present and in some areas vegetation was absent.
Cottonwood Grove Health	Age Structure	Moderate	The historic cottonwood grove does not have a wide distribution of age classes. No new, young trees are naturally recruiting into the grove because conditions are not conducive for their natural establishment, Younger trees have been planted to maintain the historic setting but will require routine maintenance and resources to persist.

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4.8. Upland Vegetation and Soils

Indicators/Measures

- Soil/Site Stability (3 measures)
- Biotic Integrity (5 measures)

Condition – Trend – Confidence

Good - Insufficient Data - High

Much of this section is excerpted from a recent report on terrestrial vegetation and soils by McIntyre and Studd (2013).

4.8.1. Background and Importance

Despite its relatively small size, Fort Davis NHS supports 22 different associations of plants (Table 4.8.1-1; Muldavin et al. 2012). These plant associations are typical of the broadly defined desert grassland/shrub-steppe borderlands of New Mexico, Texas, and northern Mexico (Apacherian-Chihuahuan region) and the desert scrub groups of the Chihuahuan Desert (NatureServe 2012 via usnvc.org). Many areas of the park exhibit characteristics of both regions, having rich and diverse perennial grass, shrub, and succulent cover (Figure 4.8.1-1). Topographic and edaphic variation drive the majority of these differences across these species' ranges with the colluvial slopes, ridges, and upper bajadas supporting scrub communities, and lower slopes and flatlands containing the semi-desert grasslands and steppe communities.

Historic Context

The rugged canyon and scenic beauty of the area feature prominently in historic accounts, and the first structures of the Fort were built with oak, pine, and cottonwood from the surrounding mountains.

4.8.2. Data and Methods

This assessment is primarily based on recent reports of Fort Davis NHS terrestrial vegetation and soils (McIntyre and Studd 2013; Muldavin et al. 2012) and supplemented with a rapid field assessment conducted June 25-26, 2013. McIntyre and Studd (2013) present results from upland monitoring based on ten permanent field monitoring sites that were established in 2011 (Figure

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Figure 4.8.1-1. Vegetation at Fort Davis NHS is characteristic of the Chihuahuan Desert and Apacherian-Chihuahuan region.

Table 4.8.1-1. Plant associations (based on the National Vegetation Classification Standard) identified at Fort Davis NHS (Muldavin et al. 2012).

NVC Plant Association	Primary Class	Area (hectares / acres)
Pinchot's Juniper/Sideoats Grama Woodland	Woodland	5.4 ha / 13.2 ac
Gray Oak/Emory Oak Woodland	Woodland	32.2 ha / 79.6 ac
Emory Oak/Netleaf Hackberry Woodland	Woodland	3.9 ha / 9.7 ac
Emory Oak/Tanglehead-Bullgrass Woodland	Woodland	6.4 ha / 15.8 ac
Mescal Bean-Wright's Beebrush Shrubland	Shrubland	4.0 ha / 10.0 ac
Whitethorn Acacia-Texas Pricklypear Shrubland	Shrubland	3.1 ha / 7.7 ac
Catclaw Mimosa/Grama Grass Shrubland	Shrubland	13.2 ha / 32.5 ac
Catclaw Mimosa-Whitebrush/Grama Grass Shrubland	Shrubland	17.5 ha / 43.4 ac
Catclaw Mimosa-Whitebrush-Pricklypear Shrubland	Shrubland	7.4 ha / 18.3 ac
Honey Mesquite/Blue Grama Shrubland	Shrubland	12.9 ha / 31.8 ac
Black Grama/Texas Sacahuista Semi-desert Grassland	Grassland	3.7 ha / 9.2 ac
Sideoats Grama/Tanglehead Semi-desert Grassland	Grassland	2.5 ha / 6.3 ac
Mixed Grama Grass Semi-desert Grassland	Grassland	5.3 ha / 13.1 ac
Blue Grama/Ruderal Semi-desert Grassland	Grassland	13.2 ha / 32.6 ac
Sideoats Grama/Sotol Semi-desert Grassland	Grassland	6.3 ha / 15.7 ac
Blue Grama/Sideoats Grama Texas Sacahuista Semi-desert Grassland	Grassland	7.5 ha / 18.4 ac
Rockland/Scarp/Cliff	Sparse Vegetation	25.4 ha / 62.9 ac
Upland Barren Soil/Disturbed Ground	Sparse Vegetation	1.8 ha / 4.5 ac
Cottonwood/Ruderal Herbaceous Vegetation Woodland	Managed Landscape	1.5 ha / 3.7 ac
Johnsongrass/Ruderal Herbaceous Vegetation	Managed Landscape	0.4 ha / 1.0 ac
Urban/Built-up Vegetation and Residential Vegetation	Managed Landscape	24.5 ha / 60.5 ac

4.8.2-1), approximately six months after the Rock House fire, as well as a review of previous studies. Their results only apply to approximately 40% of Fort Davis NHS and excludes areas within Fort Davis NHS with slopes greater than 45 degrees, and that are near roads, trails, buildings, or washes, and the Fort itself (Figure 4.8.2-1; McIntyre and Studd 2013). Their monitoring objectives are to determine the status of and detect trend over five-year intervals in vegetation cover, vegetation frequency, soil cover, biological soil crusts, and surface soil stability. The rapid grassland assessment focused on biological integrity and soil/site stability as defined by Pellant et al. (2005) as follows:

Soil/Site Stability - The capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.

Biotic Integrity -The capacity of the biotic community to support ecological processes within the normal range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic

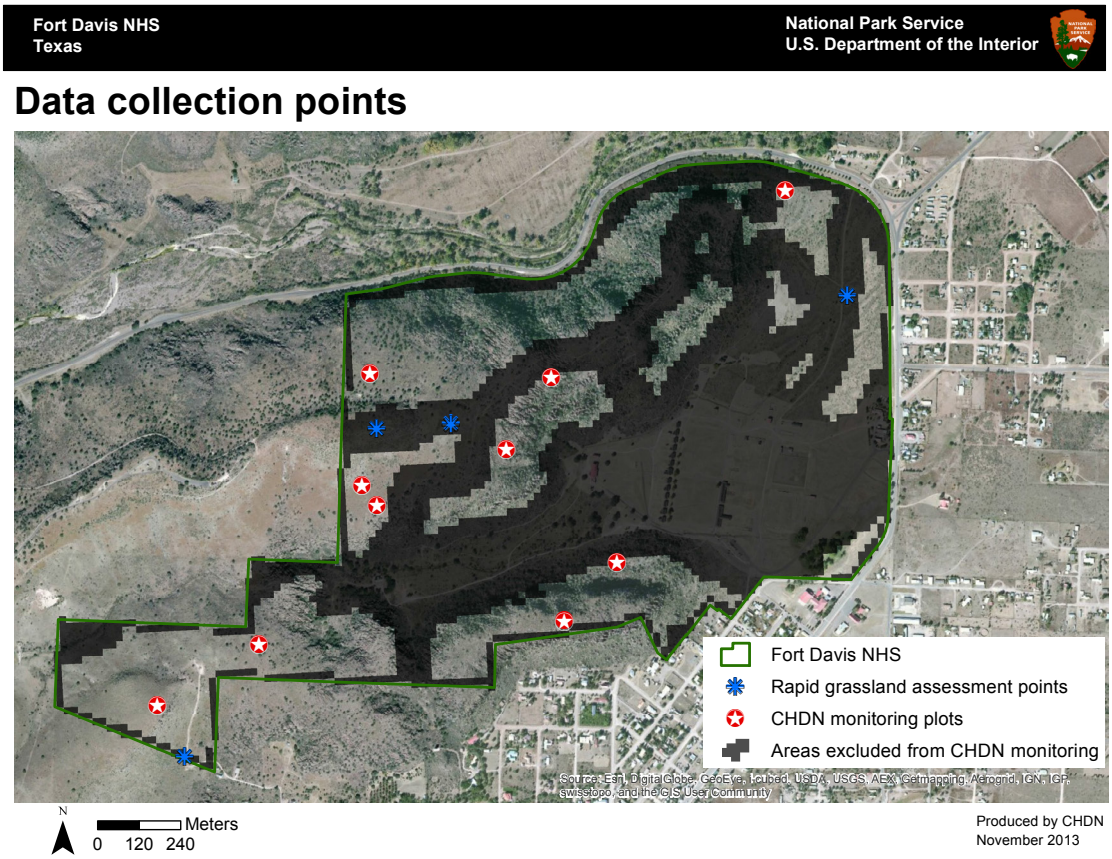

Figure 4.8.2-1. Location of plots for terrestrial vegetation and soils monitoring at Fort Davis NHS.

community includes plants, animals, and microorganisms occurring both above and below ground.

In combination, the measures from each of these indicators provide the basis for this assessment. We have summarized the indicators and measures in Table 4.8.2-1.

Indicator
Biotic Integrity

The assessment for the biotic integrity of grasslands was made via a combination of a field assessment by grassland expert Tim Seastedt (University of Colorado at Boulder) and data collected as part of the Chihuahuan Desert Network's ongoing upland and soils monitoring. In collaboration with network and park staff, qualitative indicators of rangeland health (presented in Pellant et al. 2005) were assessed by experts at four sites in the field. We then used data collected through monitoring to augment the opinions by our experts and to provide a more quantitative baseline for future assessment. These data were collected by the Chihuahuan Desert Inventory and Monitoring Network (McIntyre and Studd 2013).

Indicator
Soil/Site Stability and Hydrologic Function

Soil Cover

The amount of total cover (soil cover and vegetation cover) is the single most important dynamic factor affecting water erosion (Herrick et al. 2005). Most soil loss occurs in "unprotected" areas with uncovered bare soils (Davenport et al. 1998), whereas rock, gravel, vegetation, biological soil crusts, and even plant debris (litter and duff) can "armor" the soil, slowing the flow of water and permitting increased infiltration of water into the soil profile (Belnap et al. 2007).

Biological Soil Crust

Biological soil crusts (or "biocrusts") are composed of a community of cyanobacteria, algae, lichens, and bryophytes. Lichens are a composite, symbiotic organism composed of a fungus and either a cyanobacteria or a green

Table 4.8.2-1. Indicators and measures of upland vegetation and soils and why these are important to the resource condition.

Indicators of Condition	Measures	Why are these indicators/measures important to resource condition?
Soil/Site Stability	Soil Cover	Soil cover is the most important dynamic factor affecting water erosion. Most soil loss occurs in areas with uncovered, bare soils; soil cover slows water flow and provides resistance to erosion and greater stability.
	Biological Soil Crust	Biological soil crusts provide key ecosystem functions, such as increasing water and wind erosion resistance, contributing organic matter, and fixing atmospheric nitrogen.
	Soil Surface Stability	Site stability is the resistance of a site to localized wind and water erosion of soils, with tremendous consequences for park ecosystems and the protection of finite aboveground and subsurface cultural resources.
Biotic Integrity	Species Composition and Landscape-scale Diversity	The extent to which landscape-scale diversity reflects spatial pattern of soils and disturbance. This measure describes the degree to which the current condition is consistent with natural condition and variation.
	Local-scale Diversity	The extent to which species composition within a site (e.g., ecological site) deviates substantially from the expected native species compliment either from exotics or native species.
	Response of Annual Species to Disturbance	The extent to which annual species persist in sites not recently disturbed, compared to undisturbed and recently disturbed sites. How an ecosystem responds to disturbance is an important measure of resilience and integrity.
	Proportion of Functional Groups	The relative proportions of functional groups relative to what would be expected based on site characteristics (e.g., lack of forbs, excessive shrub density, etc.). This is another measure of natural variability and integrity.
	Proportion of C3 and C4 Species	The relative proportions of C3 and C4 plants relative to what would be expected based on site characteristics is another way to measure biotic integrity.

algae. Bryophytes are small, non-vascular plants, including mosses and liverworts.

Biocrusts provide key ecosystem functions, such as increasing water and wind erosion resistance, contributing organic matter, and fixing atmospheric nitrogen. They contribute fixed carbon to soil through decaying and leaching processes (Lange 2003). Some cyanobacteria and cyanolichens have the ability to fix atmospheric nitrogen. This process reduces atmospheric nitrogen (N_2) to ammonia (NH_4^+), which is usable by vascular plants (Belnap 2003). Biocrusts can be the dominant source of nitrogen for desert ecosystems. The distribution and species composition of biological soil crusts is influenced by climate, soil chemistry and disturbance (Belnap et al. 2001).

Soil Surface Stability

Site stability is the resistance of a site to localized wind and water erosion of soils—with tremendous consequences for park ecosystems and the protection of finite aboveground and subsurface cultural resources. During the rapid assessment, signs of erosion (such as rills, gullies, plant pedestals, and other evidence) and soil cover were described.

Species Composition and Landscape-scale Diversity

Daubenmire (1974) suggested that plant communities integrate all impinging environmental conditions and, hence, the classification and description of plant associations provides a framework for understanding the ecological composition and structure of a given landscape (Muldavin et al. 2012). The local species composition generally reflects local conditions of soils, moisture, disturbance, and other factors. As such, we would expect the diversity across a broader region to generally reflect the variation in these site characteristics; however, it is not reasonable to expect a one-to-one correspondence between local communities and their corresponding sites, because a multitude of factors can

influence the local expression of vegetation communities at a given site. Rather, with this measure we are trying to determine if some reasonable level of landscape diversity exists and that it generally corresponds to changes in ecological conditions.

Local-scale Species Composition
The intent behind this measure is to see if the species composition is generally consistent with what might be expected for the site, given the local conditions (soils, disturbance, moisture, etc). We considered this two ways: First, was the degree to which the local species consisted of native vs exotic species? Details about which exotic species are present and their effect on the site are presented in greater detail in section 4.10; here we provide an initial indicator of the extent of invasion by exotic species by looking at the proportion of native and exotic species. Second, we looked at the species composition of the native species relative to what might be expected for that site. This was based on a combination of Natural Resources Conservation Service Ecological Site Descriptions and expert opinion.

Response of Annual Species to Disturbance
It is generally expected that the number of annual species at a given site would be higher immediately following a disturbance, and would shift toward an increasing number of perennials as time passes since a disturbance. The persistence of annuals after a disturbance could indicate some basis for concern. For example, roadside areas that are frequently and unnaturally disturbed might be expected to have a greater persistence of annual species compared to interior sites.

Relative Proportion of Functional Groups
The composition of functional groups can have a dramatic effect of grassland ecosystems and their associated processes (Tilman et al. 1997, Pellant et al. 2005). Tilman et al. (1997) found that functional composition and functional diversity were principal factors explaining plant productivity, plant percent nitrogen, plant total nitrogen, and light penetration. They further concluded that habitat modifications and management practices that change functional diversity and functional composition would likely have a dramatic effect on ecosystem processes.

Relative Proportion of C3 and C4 Species
In the Chihuahuan Desert, C3 (cool season) plants use moisture from winter rains, while C4 (warm season) plants respond most to monsoon summer rainstorms. C4 plants use carbon dioxide more efficiently and grow much faster under high temperatures than most C3 plants. Therefore, the proportion of C3 and C4 species can dramatically influence how these communities respond to climate change and carbon dioxide levels. High species diversity in Chihuahuan ecosystems is in part related to the different life forms and the combination of C3 and C4 plants that are adapted for using water at different times of the year (Kemp 1983).

4.8.3. Reference Conditions

Table 4.8.3-1 presents a summary of how condition is assessed for each measure; discussion and description for each follows below.

Soil/Site Stability
Pellant et al. (2005) described general reference conditions they considered to be an optimal functional state under natural disturbance regimes (Table 4.8.3-1). We considered the condition of soils as "good" if the current condition reflected natural conditions or only slight modifications. The "moderate" ranking was assigned if the departure from optimal fell within Pellant et al.'s (2005) "moderate" class. And finally, we considered the condition of soils as a "significant concern" if the departure from optimal was of significant scale.

Biotic Integrity
The measures we used for biotic integrity are moderately robust for the potentially substantial seasonal and annual variation that plant communities often exhibit. Condition is based on the relative departure from what might be expected for the site under "natural" or undisturbed conditions (see descriptions in Table 4.8.3-1). We recognize that seasonal and annual variation in such things as rainfall and disturbance can result in dramatic shifts that are still within an acceptable range of

Table 4.8.3-1. Reference conditions used to assess upland vegetation and soils.

Indicator	Measure	Significant Concern	Moderate	Good
Soil/Site Stability	Soil Cover	Significantly to extremely reduced throughout the site. Stabilization agents (biological soil crust, vegetation, or rock) are absent or present only in isolated patches.	Significantly reduced in at least half the sites examined.	Matches that expected for the site (or a minority of sites have slight reduction). Soil surface is stabilized by organic matter decomposition, rock, vegetation, or biological soil crust.
	Biological Soil Crust	Greatly reduced occurrence of biological soil crust, or extensive signs of disturbance or degradation of soil crusts.	Biological soil crusts show signs of disturbance or reduction compared to what is expected in natural ecosystems.	Biological soil crust is present in the form and extent expected in natural ecosystems.
	Soil Surface Stability	Evidence of significant soil erosion, such as rills, gullies, pedetals.	Moderate evidence of soil erosion, or significant evidence in only some of the sites examined.	Little to no evidence of soil erosion; soil stability in natural condition.
Biotic Integrity	Species Composition and Landscape-scale Diversity	Significant lack of spatial landscape heterogeneity that does not reflect the expected diversity for the soil types and sites.	Moderate lack of spatial landscape heterogeneity that does not fully reflect the spatial pattern of soils and disturbance.	Landscape-scale diversity reflects spatial pattern of soils and disturbance.
	Local-scale Species Composition	Species composition deviates substantially from the native species compliment that would typically occur at such sites. Such a deviation could also be either from exotics or native species.	Species composition moderately deviates from the expected native species compliment either from exotics or native species in such a way that that does reflect typical types of natural disturbance (e.g., fire).	Species composition reflects expected native species compliment consistent with the site characteristics (e.g., from ESDs). Species composition need not reflect expected climax communities if their current state reflects typical types of natural disturbance (e.g., fire).
	Response of Annual Species to Disturbance	Substantially higher proportion of annual species than expected in sites not recently disturbed.	Proportion of perennial species is moderately lower that what might be expected given the site and time since disturbance.	Proportion of perennial species is approximately what would be expected given the site and time since disturbance.
	Relative Proportion of Functional Groups	Proportions of functional groups differ substantially from what might be expected based on- site characteristics (e.g., lack of forbs, excessive shrub density, etc.).	Proportions of functional groups exhibit moderately departure from what might be expected given the site and disturbance history.	Proportions of functional groups (e.g., grasses, forbs, and shrubs) are consistent with what might be expected given the site characteristics.
	Relative Proportion of C3 and C4 Species	Sites dominated by C4 species traditionally dominated by C3 species.	Higher than expected proportion of C4 species given the ecological site and disturbance history.	A mix and natural variability of C3 (cool season) and C4 (warm season) species for the site (to maximize resilience).

natural variation, and that our assessment is qualitative.

4.8.4. Condition and Trend

Overall, the condition of the upland vegetation and soils at Fort Davis NHS is good. Table 4.8.4-1 summarizes the rationale for the condition assessment, and each of the indicators and measures are described below.

Soil/Site Stability

The results from the Chihuahuan Desert Network's monitoring indicated that the overall current condition of the soils at Fort Davis NHS is good, with slight to moderate signs of erosion (Table 4.8.4-1). Soil and site stability is relatively high, suggesting the park is fairly resistant to erosion or altered water and nutrient cycles (McIntyre and Studd 2013).

Soil Cover

Soil cover was dominated (at least 50%) by gravel, rock, or bedrock on all CHDN vegetation monitoring plots except one; nine of the ten monitoring sites had 35-90% rock fragment cover. On average, approximately 9% of the soil surface was bare soil without vegetative cover, and an additional 9% was bare soil under vegetation. Litter, woody

debris, and duff covered 6-25% of the soil surface. Plant bases averaged approximately 11% cover of the soil surface and plant base cover ranged from 1% to 35% on individual plots (McIntyre and Studd 2013).

Biological Soil Crusts
Biocrusts (light cyanobacteria, dark cyanobacteria, lichen, and moss) accounted for approximately 3% of the soil surface cover on the monitoring sites. All morphological groups of soil crust were encountered, but lichen and cyanobateria cover was sparse. Mosses accounted for most cover, though they were less extensive than gelatinous lichens, which were ubiquitous but highly variable (McIntyre and Studd 2013).

Soil Surface Stability
All Chihuahuan Desert Network monitoring sites had an average surface soil stability rating of at least "somewhat stable" (McIntyre and Studd 2013). On average, samples collected under vegetation tended to have higher stability values than those collected in open spaces, although this was not seen on all plots (McIntyre and Studd 2013).

Surface soil samples consisted of sandy loams or loams with at least 10% rock fragments. Six plots showed signs of erosion. Rills were observed on four sites and gullies were observed on two. Only one plot showed modest amounts of sheet erosion (McIntyre and Studd 2013).

The rapid field assessment visited four separate sites, all of which were assessed to be in good condition regarding soil stability, little to no evidence of erosion, and the presence of soil crust or other stabilizing cover.

Biotic Integrity
Terrestrial vegetation and soils at Fort Davis NHS are within the range of natural variability. The grassland systems appear to be in good

Table 4.8.4-1. Indicators and measures of upland vegetation and soils condition, their corresponding assigned condition class, and the rational for assigning that condition class.

Indicators of Condition	Measures	Condition	Rationale
Soil/Site Stability	Soil Cover	Good	Total cover of the sites is very high with little exposed bare soil (bare soil without vegetative cover averaged less than 10%). Litter and woody debris cover ranges from 6% to 25%. Gravel, rocks, and bedrock dominate and protect the soil surface..
	Biological Soil Crust	Good	A variety of biological soil crusts were found, with mosses, lichens, and some cyanobacteria documented. The presence and extent of the crusts indicate good condition.
	Soil Surface Stability	Moderate	Overall, the soil aggregate stability of the sites is moderate; some signs of erosion were present, but soils are considered to be fairly stable. Field assessments noted the good condition and stability of the sites and soils.
Biotic Integrity	Species Composition and Landscape-scale Diversity	Good	Species composition is consistent with expected species based on spatial patterns of soils and disturbance; vegetation communities reflect the natural range of variation.
	Local-scale Diversity	Good	Species composition is consistent with expected species; field notes indicate the lack of exotics (all native species), high diversity, and vigorous growth.
	Response of Annual Species to Disturbance	Good	The extent to which annual species persist in sites not recently disturbed, compared to undisturbed and recently disturbed sites. How an ecosystem responds to disturbance is an important measure of resilience and integrity.
	Proportion of Functional Groups	Good	The relative proportions of functional groups are consistent with what would be expected; there was a good diversity of grasses, forbs, subshrubs, and shrubs.
	Proportion of C3 and C4 Species	Good	The relative proportions of C3 and C4 plants are consistent with what would be expected based on site characteristics; all sites had C4 grasses and C3 shrubs.

condition with high overall vegetative cover, a high ratio of perennial to annual species, and a near lack of non-native grasses on CHDN uplands monitoring plots (McIntyre and Studd 2013), but there are plenty of non-natives elsewhere throughout the Historic Site as described in the exotics section.

Species Composition and Landscape-scale Diversity

The plant associations at Fort Davis NHS are typical of the broadly defined desert grassland/shrub-steppe borderlands of New Mexico, Texas, and northern Mexico (Apacherian-Chihuahuan region) and the desert scrub groups of the Chihuahuan Desert (NatureServe 2012 via usnvc.org). Many areas exhibit characteristics of both regions, having rich and diverse perennial grass, shrub, and succulent cover. Topographic and edaphic variation drive the majority of these differences across these species' ranges with the colluvial slopes, ridges, and upper bajadas supporting scrub communities, and lower slopes and flatlands containing the semi-desert grasslands and steppe communities (McIntyre and Studd 2013).

Haynie (2000) conducted a botanical survey and analysis of both historical and current vegetation patterns at Fort Davis NHS (Muldavin et al. 2012). That effort resulted in a classification of six main plant communities:

1. Grama grasslands dominated by blue grama, sideoats grama, cane bluestem, Johnsongrass, and deergrass.

2. Mixed desert scrub dominated by whitethorn acacia and catclaw mimosa.

3. Sotol scrub with sotol, yucca, sumac, mimosa, and other shrubs with a grassy understory.

4. Sandy arroyo scrub characterized by brickellbush, hackberry, willows, and little walnut.

5. Canyon scrub characterized by Texas mountain laurel, sumac, Mexican buckeye, Texas persimmon, and littleleaf tree.

6. Montane chaparral dominated by oaks, evergreen sumac, and other shrubs and grasses.

With the exception of sandy arroyo scrub and canyon scrub, these communities had historical correlates based on paired photo-point comparisons. The mixed desert scrub and the montane chaparral communities have expanded since the mid-1800s, perhaps as a function of decreased precipitation, fire suppression, or cattle grazing (Haynie 2000, Muldavin et al. 2012).

The rapid grassland assessment concluded the landscape-scale diversity to be good and consistent with expected conditions. Figure 4.8.4-1 shows rapid assessment site #4 as an example of good landscape-scale diversity.

Shrub Encroachment — Chihuahuan Desert Network monitoring data, which only applies to 40% of the park, (McIntyre and Studd 2013) indicate that the vegetation of Fort Davis NHS currently represents a transition between desert scrub and semiarid grassland and steppe biomes. Previous studies aimed at evaluating vegetative change at the Historic Site (Nelson 1981, Haynie 2000) expressed specific concerns about shrub encroachment into grasslands and associated loss of semidesert grassland. Nelson (1981) estimated an increase of approximately 40% in brush cover from light to medium density between 1880 and the 1980s, but did not indicate substantial boundary expansions for these existing shrubland areas. This increase was predominantly seen along the hills and ridges of North Ridge. Nelson also noted a departure from historical grass composition in the grassland to the east, specifically an increase in Bouteloua gracilis (blue grama) dominance. Haynie (2000) suggested that the mixed-desert scrub and chaparral communities had expanded. Muldavin and others (2012) also remarked on the vulnerability of semi-desert grasslands to invasions and point out that Fort Davis NHS, while small, is part of a limited network of southwestern reserves that support semidesert grasslands.

Chihuahuan Desert Network monitoring data suggest that vegetation at Fort Davis

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Figure 4.8.4-1. Photo of site #4 from the rapid grassland assessment showing an example of good condition and landscape-scale diversity.

NHS is currently fairly stable, consisting of semi-desert grasslands and shrub savannas, but that brush encroachment could become an issue in future. The within-plot frequency of mesquite is low, but the parkwide extent of mesquite is high, which indicates that mesquite is well distributed. Although mesquite distribution in the northeastern grasslands of the park represents a deviation from the historical landscape of the 1800s, mesquite does not appear to have substantially increased in the three decades since Nelson's 1981 study (McIntyre and Studd 2013).

Local-scale Species Composition

Recent upland monitoring results (McIntyre and Studd 2013) showed that vegetative cover was greatest in the "field layer" (<0.5 m height) and accounted for 22-88% of cover. Perennial grasses, shrubs, and succulents accounted for the majoring of cover with annuals and perennial herbaceous species mixed in. Snags (dead perennial species) were an important component of the field layer, contributing up to 8% cover. Subcanopy vegetation (0.5-2.0 m high) was dominated by shrubs and short-statured trees. Trees such as mesquite, juniper, and oak were sparsely distributed, and catclaw mimosa was widely distributed. Canopy (>2.0 m in height) was sparsely distributed and dominated by juniper, mesquite and oak (also found in the subcanopy stratum.

Monitoring results (McIntyre and Studd 2013) indicated that vegetation communities fell into three general categories: mesquite-herbaceous, semi-desert grassland, and mimosa shrub-steppe. Mimosa shrub-steppe is characterized by the abundance of catclaw mimosa in combination with little bluestem, sideoats grama, and sotol. Semi-desert grassland is distinctive for the presence of junco, in addition to sumacs, whitethorn acacia, yerba de pasmo, oaks, and a strong grassland component including blue grama and sideoats grama. Mesquite-herbaceous lacked the dominant species found in other classifications, and included a mix of mesquite, sideoats grama, slender muhly, Texas sacahuista, and annual forbes and grasses (McIntyre and Studd 2013).

The rapid grasslands assessment consistently noted condition of local-scale diversity as good, even considering recent impacts of drought in the area. Sites visited in the field were dominated by mesquite, grama grasses, Texas sacahuista, acacia, prickly pear, and catclaw mimosa. Field notes mention the lack of exotics (all native species), high diversity, and vigorous growth (Figure 4.8.4-2).

Exotic vs Native Species — One of the major threats to grasslands and other plant communities is exotic species. Invasive species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), and changes in water availability (D'Antonio and Mahall 1991).

Unlike many other southwestern grassland systems, Fort Davis NHS currently has a distinct lack of non-native grass species, indicating a stable and presumably resilient system. No exotic plants were found on the Chihuahuan Desert Network vegetation and soils monitoring plots (McIntyre and Studd 2013) and few exotic plants were noted during the rapid assessment of grasslands. It is possible that non-native species occur on some of the upland monitoring sites, but went undetected during the 2011 sampling period due to drought and recent fire (McIntyre and Studd 2013). The Chihuahuan Desert Network also conducts early detection exotic plant monitoring along roads and trails and in areas burned by the 2011 Rock House fire (Reiser et al. 2012) and has detected 25 exotic plant species since 2011.

Response of Annual Species to Disturbance

The proportion of annual and perennial species provides an indication of the stability of the site. It is generally expected that the proportion of annual species at a given site would be higher immediately following a disturbance, but would shift toward an increased proportion of perennials as time passes since a disturbance.

The Rock House Fire swept through Fort Davis NHS and the Davis Mountains in April 2011. Approximately 100 acres in the western portion of the site were affected with low- to moderate-severity burns (Sirotnak and Bennett 2011). The initial post-fire assessment described the overall effects of the fire as having fully consumed many woody species while leaving perennial bunch grasses relatively intact (unburned root crowns). Sirotnak and Bennett (2011) expected vigorous regrowth of grasses, sotol, and forbs, and high mortality of yuccas and cacti. In savanna areas, the scattered juniper trees suffered scorch heights of approximately 5-8 feet and should recover well with only slight damage sustained to canopies (Sirotnak and Bennett 2011).

With any major change in disturbance, such as fire or flooding, the risk of non-native plant

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Figure 4.8.4-2. Photo of site #1 from the rapid grassland assessment showing an example of good condition and local-scale diversity.

invasion increases and can in turn facilitate more disturbance by way of positive feedback mechanisms (Brooks et al. 2004). Invasion by non-natives can be facilitated by the transport of seed on fire suppression tools or vehicles, or may simply result from the opening of niche space, allowing new or existing (yet suppressed) plant species to take hold or spread. The Chihuahuan Desert Network has temporarily included the area burned. During the 2011 fall sampling period, only two species were recorded along any of the burned area transects: *Portulaca oleracea* and *Tribulus terrestris*. Both species are found commonly throughout the site (Reiser et al. 2012). During the 2012 surveys, four additional species were observed on the burned area transects: *Amaranthus blitoides*, *Convolvulus arvensis*, *Euphorbia davidii*, and *Euphorbia dentata* (Table 4.8.4-2). Surveys during 2013 identified three additional species on the burned area transects: *Chenopodium album*, *Eragrostis cilianensis*, and *Salsola kali* (Table 4.8.4-2). No indication is given that these species were responding positively to the fire.

Based on the rapid grassland assessment, all sites were in good condition related to the proportion of annual and perennial plants. The annuals detected on the sites were native, and looking at the area that had burned in 2011, indicated good condition and recovery (Figure 4.8.4-3). Although the Chihuahuan Desert Network monitoring plots within the burned area may have some vegetation differences due to the effects of the recent burn, these differences were not statistically significant (McIntyre and Studd 2013).

Relative Proportion of Functional Groups
The proportions of functional groups observed in the rapid grassland assessment were consistent with the vegetation communities described in the monitoring report (McIntyre and Studd 2013). All observed sites included a good diversity of grasses, forbs, subshrubs, and shrubs (Figure 4.8.4-4).

Relative Proportion of C3 and C4 Species –
During the rapid grassland assessment, the subject experts found no major concern about the proportion of C3 and C4 species. All the sites examined had healthy populations of C4 grasses and C3 shrubs. The grasses were quite robust and thriving, especially those in the burned area (Figure 4.8.4-5).

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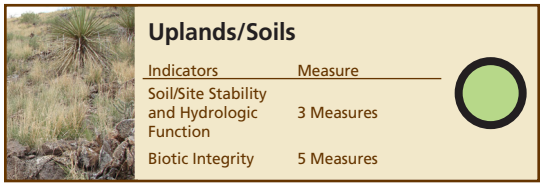
Figure 4.8.4-3. Photo of site #4 from the rapid grassland assessment indicates good recovery of the site after the 2011 fire.

Table 4.8.4-2. Non-native species recorded at Fort Davis NHS in 2011 and 2012 (McIntyre and Studd 2013; Chihuahuan Desert Network unpublished data).

Scientific name	Common name	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Alternanthera pungens	khakiweed			X			
Amaranthus blitoides	mat amaranth				X*		
Amaranthus retroflexus	redroot amaranth				X		
Bothriochloa ischaemum	King Ranch bluestem		X	X	X	X	X
Bromus catharticus	rescuegrass			X			
Chenopodium album	lambsquarters	X	X		X	X*	X
Convolvulus arvensis	field bindweed			X*			
Cynodon dactylon	Bermudagrass	X	X	X	X	X	X
Dactylis glomerata	orchard grass				X		
Eragrostis barrelieri	Mediterranean lovegrass					X	X
Eragrostis cilianensis	stinkgrass		X		X	X*	X*
Erodium cicutarium	redstem stork's bill			X		X	
Euphorbia davidii	David's spurge				X*		
Euphorbia dentata	toothed spurge				X*		
Marrubium vulgare	horehound	X		X	X	X	X
Portulaca oleracea	little hogweed		X*	X	X*		X*
Salsola kali	Russian thistle				X	X*	X*
Salsola tragus	prickly Russian thistle	X	X		X		
Setaria pumila	yellow bristlegrass			X			
Sisymbrium irio	London rocket					X	
Sorghum halepense	Johnsongrass	X	X	X	X	X	X
Stellaria media	common chickweed				X		
Taraxacum officinale	common dandelion		X	X		X	
Tribulus terrestris	puncturevine		X*		X*	X*	X
Ulmus pumila	Siberian elm					X	X

Records marked with an "*" indicate the species was observed along one of the Rock House Fire area.



Overall Condition

For assessing the condition of grasslands, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the condition of the Historic Site's grasslands, upland vegetation communities, and soils. Grassland condition can be assessed from many different angles, but we chose two main categories for this resource. A summary of how they contributed to the overall grassland condition is summarized in Table 4.8.4-3. Based on the indicators, data, and expert opinion, we consider the overall condition of the grasslands at Fort Davis NHS to be in good condition.

Level of Confidence/Key Uncertainties

Overall, our confidence in this assessment is high, although as is generally the case, there are uncertainties. Some of the key uncertainties for the grassland assessment include annual variability, the effect of drought conditions, and the effect of recovery from disturbance.

Annual variability in rainfall, temperatures, and diseases can have a dramatic effect on some indicators (e.g., plant species composition), which in turn, affects our interpretation of grassland condition. This assessment was conducted, at least in part, during drought conditions. The driest year on record (102 years) occurred in 2011. The stress from drought conditions has likely influenced some of our indicators, but this influence

TOMYE FOLTS-ZETTNER

Figure 4.8.4-4. Photo of site #2 from the rapid grassland assessment indicates a good mix of functional groups including grasses, forbs, subshrubs, and shrubs.

TOMYE FOLTS-ZETTNER

Figure 4.8.4-5. Photo of site #2 from the rapid grassland assessment indicates good recovery of the C4 grasses after the 2011 fire.

would also likely imply our assessment is a bit conservative. That is, conditions may have appeared even better had they been assessed under more typical rainfall period.

Another uncertainty is that part of the site is changing in response to disturbance. A fire burned 100 acres in 2011, and it seems grasses are recovering, however, it will likely take decades before we fully understand the degree to which these areas might recover to their pre-disturbed state.

4.8.5. Sources of Expertise

During the course of this assessment, we consulted with the following individuals who provided subject matter expertise as well as an on-site rapid assessment.

Dr. Timothy Seastedt is a Professor at University of Colorado, Boulder, Department of Ecology and Evolutionary Biology. He also has an extensive background of research and publications related to the ecology of grasslands.

Cheryl McIntyre is a Physical Scientist (Pathways Intern) with the Chihuahuan Desert Network and a PhD student at the University of Arizona studying biological soil crusts.

Table 4.8.4-3. Summary of the grassland indicators and measures and their contributions to the overall assessment of grassland condition.

Indicator	Measure	Condition	Condition Rationale
Soil/Site Stability and Hydrologic Function	3 measures	Good	Soil/Site Stability was consistent with natural conditions. Soil cover and soil crust were rated in good condition, some erosion was evident and soil surface stability was rated moderate, but overall soil/site stability is in good condition.
Biotic Integrity	5 measures	Good	All measures of biotic integrity showed consistency with the range of variability that would be expected for those sites. Cover was generally dominated by perennial C4 grasses; there was a high level of species diversity; a good mixture of grasses, forbs, subshrubs, and shrubs; and disturbed areas (due to fire) are recovering well. There was little evidence of exotic species, though it is prudent to continue to assess this in light of shifts in climate or disturbance events. Biological integrity is assessed to be high, and in good condition.

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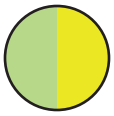
4.9. Exotic Plants

Indicators/Measures

- Potential to Alter Native Plant Communities (1 measure)
- Prevalence of Exotic Plant (2 measures)

Condition – Trend - Confidence



Good to Moderate – Insufficient Data - Medium

4.9.1. Background and Importance

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of Earth's biota. Approximately 4-19% of species introduced into the United States may become invasive (USFWS 2012).

Invasive species have been directly linked to displacing several native species of plants (Pimentel et al. 1999) (Figure 4.9.1-1). Approximately 42% of threatened and endangered species are at risk primarily because of alien-invasive species (Pimentel et al. 2005). Changes in ecosystem structure and alteration of nutrient cycles and soil chemistry negatively impact agriculture (Pimentel 2009), limit water availability (USFWS 2012), and alter normal successional trajectory of a system (Ehrenfeld 2003, Emery 2012).

The spread of invasive species is one of the most environmentally serious global changes, causing economic and environmental damage in the United States and worldwide (UCSUSA 2008). Consequently, the dynamic relationships among plants, animals, soil, and water that have become established over many thousands of years are at risk of being destroyed in a relatively brief period.

For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the "unimpaired [resources] for the enjoyment of future generations" management goal. National parks, like other land management agencies, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo

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Figure 4.9.1-1. Johnson grass (*Sorghum halepense*) spreads aggressively and can form dense stands, creating concerning ecological impact.

containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes). Nonnative plants claim an estimated 4,600 acres per day on federal lands alone in the Western United States, quadrupling their range from 1985-1995, invading approximately 17 million acres (BLM 2011), significantly altering local flora. Invasive plants are dominant on approximately 5% of the lands managed by the NPS (NPS 2009).

In Great Smoky Mountains National Park, over ¼ of the plants (27%) are non-native species. On the big island of Hawaii, 35% of the plants are non-native (Pimentel et al. 2005). At Fort Davis NHS, the fort grounds have been disturbed for over 125 years. As a result of its long history of use, the land may be more susceptible to exotic plant establishments and persistence.

4.9.2. Data and Methods

In assessing current condition and trend for exotic plants at the NHS, we used two indicators. The first indicator, which has one measure, evaluates the overall impact an exotic plant has on the native plant communities throughout the NHS. This indicator utilizes known natural history characteristics of exotic plant species to characterize and rank their relative impact on natural ecosystems using Hiebert and Stubbendieck's (1993) Handbook for Ranking Exotic Plants for Management and Control.

The second indicator, with two measures, was used to assess the prevalence of the exotic plant species throughout the NHS. Data for the prevalence indicator and measures were collected by Chihuahuan Desert Inventory and Monitoring Network (CHDN) staff through their exotic plants annual monitoring program, post-fire monitoring, and through a one-time park-wide rapid assessment.

<u>CHDN Annual Exotic Plants Monitoring</u>

The CHDN's systematic monitoring program gathers information about the occurrence of exotic plants in select park areas that can be spatially represented and used for data analysis (Folts-Zettner et al. 2013). The protocol involves annual monitoring of high priority vectors (e.g., roads and trails) that have been identified based on their potential risk for invasion by exotic plants. The overall approach is based on a generalized linear model, where 50-meter blocks on both sides of the vector are surveyed from a transect running along (e.g., trails) or adjacent to (e.g., along the mow strip of roads) the vector (Figure 4.9.2-1). Four distance classes per block are assessed to provide information that may indicate that a given species has invaded interior habitats or whether it remained localized near the likely source of invasion (Folts-Zettner et al. 2013).

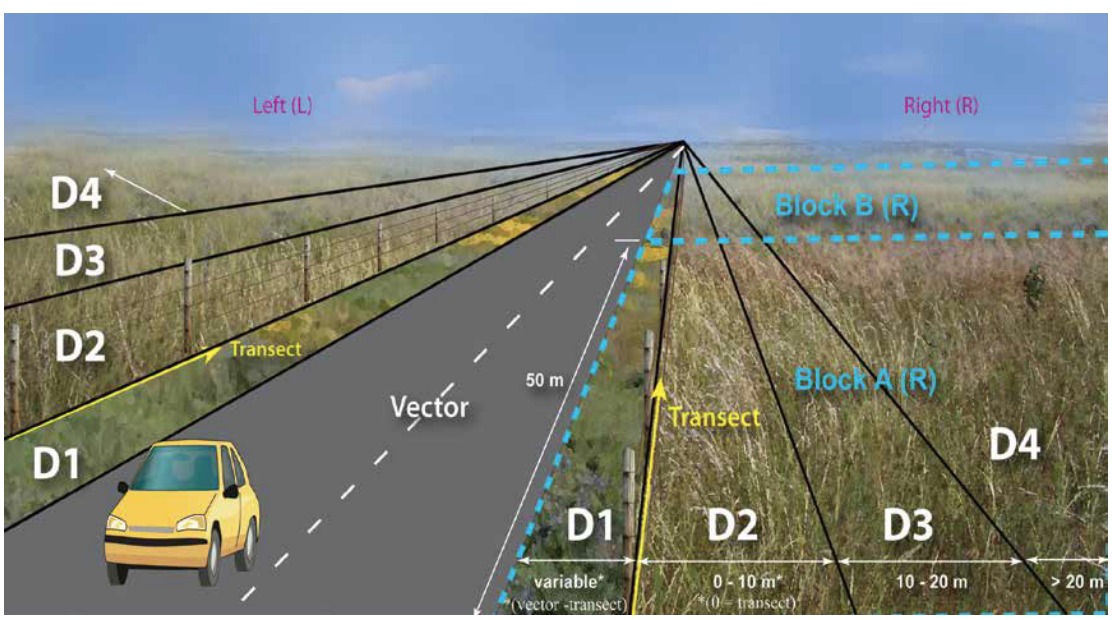


Figure 4.9.2-1. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., roads and trails).

Sampling within these high priority vectors is conducted during the spring and fall of each year.

It is important to emphasize that CHDN's sampling approach does not provide a complete survey of exotic plants throughout the park. Instead, it provides a repeated snapshot for a limited area with high potential for new invasions.

We utilized CHDN's annual monitoring data collected between 2011 - 2013 to report the current condition of the NHS' exotic plants (McIntyre and Studd 2013, CHDN 2013a). In addition to the high priority vector areas, 30 short (50-m) transects were surveyed within the area burned by the 2011 Rock House Fire and are included in this assessment.

CHDN (2013b) Rapid Assessment (one time only)

In addition to the annual CHDN monitoring, a one-time rapid assessment of exotic plant occurrence was conducted by CHDN staff in 2013 to collect information about the presence of exotic species in other areas of the Historic Site for the purposes of this condition assessment (CHDN 2013b). Data for these supplemental points were recorded in a similar fashion, but not the same exact way: circular plot of smaller area without distance classes vs linear block with distance classes as in the standard monitoring described Folts-Zettner et al. (2013), although these plots will not be included in CHDN's permanent rotating panels.

It's important to note that prior to the field crew's arrival, park staff had recently mowed much of the area around the site, which may have led to some bias in the data collected.

CHDN's (2011-2013) annual monitoring locations along vectors, burned area blocks, and parkwide plots for the 2013 time rapid assessment are shown in Figure 4.9.2-2.

Indicators/Measures

Potential to Alter Native Plant Communities (significance of exotic plant impact)

The first indicator, potential to alter native plant communities, was derived from the Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993). The handbook's approach provides park managers with scientific information that includes the full array of significant factors that predispose an exotic plant to alter native ecosystems. The approach is comprised of a series of questions for which answers are assigned points based

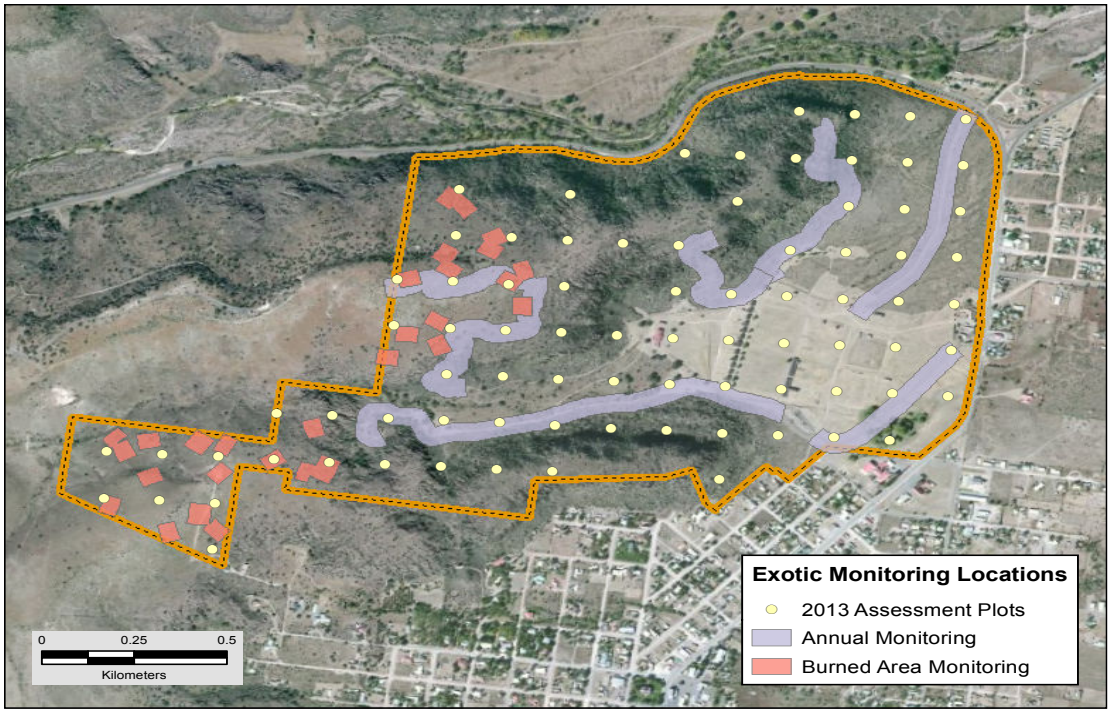


Figure 4.9.2-2. Locations of high-priority blocks (annual monitoring) sampled twice per year during 2011-2013, burned area, and one-time rapid assessment plots sampled in 2013 only.

upon the degree of impact. An overall score reveals the significance of impact.

For the purposes of this assessment, Hiebert and Stubbendieck's (1993) significance of exotic plant impact ranking system was modified to capture only its innate ability to become a pest. The innate ability for a species to become a pest quantifies the characteristics, such as ability to reproduce vegetatively, the number of seeds per plant, and the plant's competitive ability, that preadapt it to become a problem.

The numerical ranking for this measure ranged between 0 - 50 possible points, with 50 representing the highest possibility of impacting and altering the native plant communities throughout the NHS. We assigned the numerical rankings to the following categories:

- 40 - 50 = Highest Concern
- 35 - 39 = High Concern
- 30 - 34 = Medium Concern
- 0 - 29 = Low Concern

The significance of exotic plant impact rankings for each exotic species found during CHDN's annual (2011-2013), burned area, and 2013 rapid assessment monitoring are reported in Table 4.9.2-1.

Table 4.9.2-1. Significance of exotic plant impact ranking for species detected in CHDN 2011-2013 monitoring (McIntyre and Studd 2013, CHDN 2013a) and the CHDN (2013b) rapid assessment, using a subset of Hiebert and Stubbendieck's (1993) Handbook for Ranking Exotic Plants for Management and Control.

Species	Common Name	Ranking
Alternanthera pungens	khaki weed	High
Amaranthus blitoides	mat amaranth	Low
Amaranthus retroflexus	redroot amaranth	Low
*Bothriochloa ischaemum**	King Ranch bluestem	Highest
Bromus catharticus	rescue grass	Low
Chenopodium album	lambsquarters	Low
Convolvulus arvensis	field bindweed	Highest
Cynodon dactylon	Bermudagrass	Low**
Dactylis glomerata	orchardgrass	Low
Eragrostis barrelieri	Mediterranean lovegrass	Highest
Eragrostis cilianensis	stinkgrass	Low
Erodium cicutarium	redstem stork's bill	High
Euphorbia davidii	David's spurge	High
Euphorbia dentata	toothed spurge	High
Marrubium vulgare	common horehound	Medium
Portulaca oleracea	little hogweed	Medium
*Salsola kali **	Russian thistle	High
Salsola tragus	prickly Russian thistle	Medium
Setaria pumila	yellow bristlegrass	Medium
Sisymbrium irio	London rocket	Medium
*Sorghum halepense **	Johnsongrass	Highest
Stellaria media	common chickweed	Medium
Taraxacum officinale	common dandelion	Medium
Tribulus terrestris	puncturevine	Medium
Ulmus pumila	Siberian elm	Medium

Species highlighted are considered to be of highest or high concern based upon the significance of exotic plant impact ranking measure (Hiebert and Stubbendieck 1993).

* Identified among the top 15 priority species for early detection and monitoring in the CHDN (NMSU 2009). **1 point from moderate ranking.

Indicators/Measures
Prevalence of Exotic Plant (2 measures)

The prevalence of exotic plants includes two measures: extent and density (Table 4.9.2-2). These measures describe how often and how much an exotic plant species was observed during the annual and the 2013 rapid assessment monitoring.

Indicators/Measures
Extent of Exotic Plant

The extent is the percentage of the surveyed blocks or plots that contained a given exotic species and reports the frequency that blocks and plots contained the plant. This measure only indicates whether the plant was found in the surveyed areas, and does not include its density (e.g., number of plants found). Extent is reported for all species identified during the CHDN 2011-2013 monitoring in Table 4.9.2-3 and in Table 4.9.2-4 during the 2013 rapid assessment.

Indicators/Measures
Density of Exotic Plant

The density measure is the number of exotic plants per unit of area (block or plot). During CHDN's annual (2011-2013), burned area monitoring, and 2013 rapid assessment monitoring, the occurrence of each observed exotic species was assigned to one of five density classes, representing a range from not observed to a small number of individual plants to a continuous matrix within the block or plot for that species.

These density classes defined in Folts-Zettner et al. 2013 are as follows:

- 0 = Not observed
- 1 = 1-5 plants present
- 2 = Scattered in patches
- 3 = Scattered fairly evenly
- 4 = Forming a matrix.

Density is reported for all species identified during the CHDN 2011-2013 monitoring in Table 4.9.2-5 and for all exotic species identified during CHDN's 2013 rapid assessment in Table 4.9.2-6. Maps showing the densities of the plants in the distance class closest to the actual vector (Distance Class 1

Table 4.9.2-2. Definitions of the two measures used for the prevalence of exotic plants indicator.

Measure	Description
Extent	*Answers how often.* A measure of the percent of surveyed monitoring locations (blocks or plots) that contained a given exotic species.
Density	*Answers how much.* The number of exotic plants per unit of area (block or plot).

Table 4.9.2-3. Number and percentage of exotic plant species detected in CHDN 2011-2013 monitoring blocks (N=272), including blocks in the area burned by the Rock House fire at Fort Davis NHS.

Scientific Name	No. Plots	% (N=62)
Tribulus terrestris	140	50.9%
Portulaca oleracea	101	36.7%
Chenopodium album	91	33.1%
Salsola kali	71	25.8%
Sorghum halepense	46	16.7%
Convolvulus arvensis	40	14.5%
Cynodon dactylon	29	10.5%
Eragrostis cilianensis	27	9.8%
Marrubium vulgare	24	8.7%
Bothriochloa ischaemum	20	7.3%
Euphorbia dentata	9	3.3%
Amaranthus blitoides	7	2.5%
Euphorbia davidii	7	2.5%
Salsola tragus	6	2.2%
Erodium cicutarium	5	1.8%
Eragrostis barrelieri	4	1.5%
Taraxacum officinale	4	1.5%
Bromus catharticus	3	1.1%
Ulmus pumila	2	0.7%
Alternanthera pungens	1	0.4%
Amaranthus retroflexus	1	0.4%
Dactylis glomerata	1	0.4%
Setaria pumila	1	0.4%
Sisymbrium irio	1	0.4%
Stellaria media	1	0.4%

Species highlighted are considered to be of highest or high concern based upon the significance of exotic plant impact ranking measure (Hiebert and Stubbendieck 1993).

Table 4.9.2-4. Number and percentage of exotic plant species detected in CHDN 2013b rapid assessment plots (N=62) at Fort Davis NHS.

Scientific Name	No. Plots	% (N=62)
Salsola kali	25	40.32%
Tribulus terrestris	6	9.68%
Portulaca oleracea	2	3.23%
Sorghum halepense	2	3.23%
Bothriochloa ischaemum	1	1.61%
Eragrostis barrelieri	1	1.61%
Eragrostis cilianensis	1	1.61%
Taraxacum officinale	1	1.61%

Species highlighted are considered to be of highest or high concern based upon the significance of exotic plant impact ranking measure (Hiebert and Stubbendieck 1993).

only) are located in Appendix E. Note that not all species were found in Distance Class 1.

4.9.3. Reference Conditions

Whenever an exotic plant is present that has the biological characteristics to alter native plant communities, there is cause for concern. However, early detection of these species provides managers with the necessary information to apply a rapid response management strategy before the exotic plant becomes established. If a rapid response is not implemented, the exotic plant may become established and potentially degrade the integrity of the native plant communities.

Our good, moderate, and significant concern reference conditions are based upon both an exotic plant's ability to alter native plant communities as well as its prevalence (i.e., extent and density) throughout the Historic Site. A summary of the reference conditions is shown in Table 4.9.3-1.

A good reference condition is the capability for primary communities (e.g., shrublands and grasslands) to be maintained. By this, we mean that the ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type. A good reference condition is for exotic species with low to medium impact ranking scores and low prevalence.

A moderate condition is assigned to exotic plant species that have been ranked as high or highest concern but prevalence remains low or when a plant has been assigned a medium impact ranking score and is found in medium to high prevalence.

A condition of significant concern is assigned when an exotic plant is ranked as high or highest for its ability to alter native plant communities and is found at medium to high prevalence levels.

Further consideration of condition is warranted on a case by case basis when a plant has a low impact ranking score but is exhibiting medium or high prevalence, which is shown as variable in Table 4.9.3-1.

4.9.4. Condition and Trend

A total of 25 exotic plant species were found within the NHS during 2011-2013 surveys; NPSpecies includes an additional nine exotic species at Fort Davis NHS that have not been detected during CHDN's monitoring (Reiser et al. 2012).

<u>Significance of Exotic Plant Impact Ranking Summary</u>

Four species (16%) had the highest impact ranking scores, five species (20%) were ranked as high, nine species (36%) were ranked as moderate, and the remaining seven species (28%) had low impact ranking scores for potential to alter native plant communities throughout the NHS (refer to Table 4.9.2-1 for specific species).

All of the nine species ranked as high or highest for their potential to alter native plant communities were found during CHDN's 2011 - 2013 annual monitoring of roads, trails, and burned areas. Four were found during CHDN's 2013 park-wide assessment.

<u>Extent of Exotic Plants</u>

<u>CHDN Annual Exotic Plants Monitoring</u>

A total of 25 exotic plants were detected during monitoring, with one species, puncturevine (*Tribulus terrestris)* found in over half the blocks (50.9%). Three of the four species of highest concern, Johnsongrass (*Sorghum halepense)*, field bindweed (*Convolvulus*

Table 4.9.2-5. Density of exotic plants in CHDN 2011-2013 vector blocks along roads and trails and in the burned area at Fort Davis NHS, with the density class information in percentage of total occurrences recorded for each species for density classes 1-4.

Species	Number of Occurrences[1] in Density Classes 1-4	Density Classes			
		Class 1 (%) 1-5 individuals	Class 2 (%) Scattered patchy	Class 3 (%) Scattered even	Class 4 (%) Matrix
Tribulus terrestris	721	56.9	40.5	2.6	
Portulaca oleracea	592	56.8	41.7	1.5	
Chenopodium album	507	44	53.1	2.9	
Sorghum halepense	268	19.4	77.2	3.4	
Cynodon dactylon	191	6.3	56	37.7	
Bothriochloa ischaemum	156	12.8	57.7	29.5	
Convolvulus arvensis	126	75.4	24.6		
Eragrostis cilianensis	100	69	31		
Marrubium vulgare	98	60.2	35.7	4.1	
Salsola kali	60	56.7	43.3		
Euphorbia dentata	44	65.9	34.1		
Amaranthus blitoides	31	51.6	48.4		
Euphorbia davidii	24	100			
Salsola tragus	23	78.3	21.7		
Taraxacum officinale	22	27.3	72.7		
Erodium cicutarium	14	14.3	85.7		
Bromus catharticus	12	83.3	16.7		
Dactylis glomerata	4	100			
Eragrostis barrelieri	4	100			
Amaranthus retroflexus	3		100		
Alternanthera pungens	2	100			
Setaria pumila	2	100			
Sisymbrium irio	2	100			
Stellaria media	2	100			
Ulmus pumila	2	100			

[1]The number of occurrences includes those in all distance classes from the vector.

Species highlighted are considered to be of highest or high concern based upon the significance of exotic plant impact ranking measure (Hiebert and Stubbendieck 1993).

arvensis), and King Ranch bluestem (*Bothriochloa ischaemum)*, were particularly widespread throughout the blocks. Russian thistle (*Salsola kali)*, which was ranked as high concern for its ecological impact, was found in 25.8% of the blocks, respectively.

Three species including puncturevine, little hogweed (*Portulaca oleracea)*, and lambsquarters *(Chenopodium album)* had the widest extents and were found in 50.9%, 36.7%, and 33.1% of the blocks. Both puncturevine and little hogweed were equally dispersed along trails as well as in natural areas away from trails. Lambsquarters was found primarily along trails.

Extent of Exotic Plants

CHDN 2013b Rapid Assessment

A total of eight exotic plant species were detected during the CHDN (2013b) rapid assessment, with Russian thistle found in 40.3% of the rapid assessment plots, by far the most widespread exotic plant detected.

Table 4.9.2-6. Density of exotic plants in CHDN (2013b) rapid assessment plots at Fort Davis NHS, with the density class information in percentage of total occurrences recorded for each species for density classes 1-4.

Species	Number of Occurrences in Density Classes 1-4	Class 1 (%) 1-5 individuals	Class 2 (%) Scattered patchy	Class 3 (%) Scattered even	Class 4 (%) Matrix
Salsola kali	25	52	48		
Tribulus terrestris	6	16.7	83.3		
Portulaca oleracea	2	100			
Sorghum halepense	2	50	50		
Bothriochloa ischaemum	1		100		
Eragrostis barrelieri	1		100		
Eragrostis cilianensis	1		100		
Taraxacum officinale	1		100		

Species highlighted are considered to be of highest or high concern based upon the significance of exotic plant impact ranking measure (Hiebert and Stubbendieck 1993).

The remainder of exotic plants found during the 2013 rapid assessment did not have wide extents. Almost all species (7 of 8) were found in less than 10% of the plots, including six species that were found in only 1-2 of the park-wide plots.

Density of Exotic Plants

CHDN Annual Exotic Plants Monitoring

Exotic plant species were most often found in density class 1 (1-5 individuals) during the 2011-2013 CHDN surveys. The densities of the three species, puncturevine, little hogweed, and lamsquarters, that had the largest extents, were also the ones growing in higher densities. However, Bermudagrass (*Cynodon dactylon)*, King Ranch bluestem, Johnsongrass, and common horehound (*Marrubium vulgare)* were observed forming scattered to even densities (density class 3) as well. No species formed a matrix at any of the locations monitored.

Table 4.9.3-1. Descriptions for determining condition based on exotic plant potential to alter native plant communities impact ranking and degree of prevalence.

Prevalence of Exotic Plant	Potential to Alter Native Plant Communities Impact Ranking			
	Low	Medium	High	Highest
Low	Good Condition	Good Condition	Moderate Condition	Moderate Condition
Medium	Variable[1]	Moderate Condition	Significant Concern	Significant Concern
High	Variable[1]	Moderate Condition	Significant Concern	Significant Concern

[1]If a plant's prevalence is increasing, even though it has a low impact ranking, it may warrant further consideration of its ability to alter native plant communities.

Density of Exotic Plants
CHDN 2013b Rapid Assessment
Eight exotic plant species were mostly detected in scattered-patchy densities (density class 2) during CHDN's 2013 rapid assessment. Russian thistle and puncturevine had the highest number of occurrences within the 1-5 individuals and scattered patchy density classes throughout the 62 surveyed plots.

Combining the Significance of Impact Rankings and Prevalence Indicators
When we combined the significance of impact ranking scores with the prevalence measures, four species were considered to be of highest concern and eight species were considered to be of moderate concern. The rationale for identifying these species of concern is summarized in Table 4.9.4-1.

Species of Highest Concern Based on High - Highest Impact Rankings and Medium to High Prevalence
Based on combining the potential to alter native plant communities rankings and exotic plant prevalence (extent and density measures), the four species of highest concern are King Ranch bluestem, field bindweed, Russian thistle, and Johnsongrass.

King ranch bluestem was present in 7.3% of the blocks annually monitored and also present in 1.6% of the rapid assessment plots. This species was found in moderate or higher densities in many areas, establishing scattered to even stands. It can dominate grassland communities and reduce insect, landbird, and mammal diversity. It is also difficult to control (Institute for the Study of Invasive Species 2014).

Field bindweed is listed in the state of Texas as a noxious plant (USDA NRCS 2014) and has a vigorous root and rhizome system that makes it persistent and very difficult to control once established. The seeds can stay dormant in the soil for long periods of time (up to 60 years), and it is very drought tolerant, so can thrive when other plants cannot. It was found in 14.5% of the blocks but not found in any of the rapid assessment plots, implying that it is likely restricted to the vector corridors and may be responding well to mechanical practices (e.g., mowing). The majority (75%) of field bindweed plants were found growing in a lower density class of 1-5 individuals.

Russian thistle is a difficult plant to control and contain due to its tumbling habit of seed dispersal. It was found in the highest number of park-wide rapid assessment plots (40.3%) and in 25.8% of CHDN's annual and burned area blocks, representing a wide extent and implying that it is spreading throughout the Historic Site. It was found growing almost equally in density classes 1 and 2.

Johnsongrass was found in 16.7% of the annual monitoring blocks and in 3.23% of the rapid assessment plots. It is also beginning to form denser stands (3.4% in class 3-scattered to even patches). This species is highly invasive and can outcompete native grasses. It reproduces both by seed and from rhizomatous roots and grows well in disturbed sites (Institute for the Study of Invasive Species 2014). Johnsongrass is also very difficult to eradicate, making the infestations throughout the Historic Site of even greater concern.

The four plants discussed above have the ability to alter native vegetation communities based upon their prolific seed production and excellent competitive abilities, coupled with their higher prevalence during the 2011-2013 annual monitoring and the 2013 rapid assessment. In addition, three of the four plants (King Ranch bluestem, Russian thistle, and Johnsongrass) are identified among the top 15 priority species for early detection and monitoring in the CHDN due to their ability to alter native plant communities as well as their difficulty to control (NMSU 2009).

Species of Moderate Concern Based on High Impact Rankings and Low Prevalence
Five species, khaki weed (*Alternanthera pungens),* Mediterranean lovegrass (*Eragrostis barrelieri),* redstem stork's bill (*Erodium cicutarium),* David's spurge (*Euphorbia davidii)*, and toothed spurge (*E. dentata*) were considered to be of moderate concern due to

Table 4.9.4-1. Exotic species found within Fort Davis National Historic Site that are considered to have the most impact to native habitats throughout the park based on combined indicators and measures.

Scientific Name	Common Name	Noxious[1]	Rationale for Rating[2]
Highest Concern			
Bothriochloa ischaemum	King Ranch bluestem		This is one of the top 15 priority species for early detection and monitoring in the CHDN (NMSU 2009) and is ranked as one of the highest exotic plants for its innate ability to alter native vegetation communities. It was also found in over 7% of the CHDN blocks annually surveyed. It was the second to highest plant forming the highest densities in 29.5% of the class 3-scattered even density class.
Convolvulus arvensis	Field bindweed	AK, AZ, AR, CA, CO, HI, ID, IA, KS, MI, MN, MO, MT, NM, ND,OR, SD, TX, UT, WA, WI, WY	Listed in Texas, as well as many other states, as a noxious plant, bindweed is tenacious once established and difficult to manage. It is found in 14.5% of CHDN's annual monitoring blocks and occurred in density classes of 1-5 individuals and scattered patchy. It also ranked as one of the highest for its innate ability to alter native plant communities.
Salsola kali	Russian thistle	AR, HI	This is one of the top 15 priority species for early detection and monitoring in the CHDN (NMSU 2009) and is ranked as high for its innate ability to alter native vegetation communities. This plant was found in almost 26% of the annual monitoring blocks and in over 40% of the rapid assessment plots, forming densities of 1-5 individuals and scattered patchy throughout the Historic Site.
Sorghum halepense	Johnsongrass	AR, CA, CO, DE, ID, IL, IN, KS, KY, MD, MS, MO, NV, OH, OR, PA, SD, UT, WA, WV	This is one of the top 15 priority species identified for early detection and monitoring in the CHDN (NMSU 2009) and is ranked as one of the highest exotic plants for its innate ability to alter native vegetation communities. It was also found in almost 17% of the CHDN blocks annually surveyed and in over 3% of the park-wide rapid assessment plots. It was found in three density classes, with class 2-scattered patchy-accounting for over 77% of the density.
Moderate Concern (High Impact/Low Prevalence)			
Alternanthera pungens	Khaki weed		This plant ranked as high for its innate ability to impact a native plant community, but was of low prevalence for both extent and density measures.
Eragrostis barrelieri	Mediterranean lovegrass		This plant ranked highest for its innate ability to impact a native plant community, but was of low prevalence for both extent and density measures.
Erodium cicutarium	Redstem stork's bill	CO	This plant ranked as high for its innate ability to impact a native plant community, but was of low prevalence for extent but in moderate condition for its density.
Euphorbia davidii	David's spurge		This plant ranked as high for its innate ability to impact a native plant community, but was of low prevalence for both extent and density measures.
Euphorbia dentata	Toothed spurge		This plant ranked as high for its innate ability to impact a native plant community, but was of low prevalence for both extent and density measures.
Moderate Concern (Moderate Impact/High Prevalence)			
Marrubium vulgare	Common horehound		This plant ranked as moderate for its innate ability to impact a native plant community, but was quite prevalent and forming scattered to even densities at some locations.
Portulaca oleracea	Little hogweed	AZ	This plant ranked as moderate for its innate ability to impact a native plant community, but was the second highest plant in extent and was found forming scattered to even densities at some locations.
Tribulus terrestris	Puncturevine	AZ, CA, CO, ID, IA, NV, NC, OR, WA	This plant ranked as moderate for its innate ability to impact a native plant community, but was the most common exotic plant in extent and forming scattered to even densities at some locations.

[1] States in which the plant is listed as noxious (USDA NRCS 2014).

[2] The rationale for rating is a combination of the results for the two indicators and the three measures.

their high impact ranking scores even though they were found in low prevalence.

Their ability to alter native plant communities is similar to the species listed as the highest concern but these species were found in lower extents and densities throughout the Historic Site, which is a primary goal of CHDN's monitoring program: Early Detection and Rapid Response. The low occurrences of these five species, based on early detection, provides an opportunity for effective control. This is where the cost benefits of implementing a rapid response (control) program far outweigh the costs associated with treating established stands of exotic plants over time.

Species of Moderate Concern Based on Medium Impact Rankings and Higher Prevalence

Three species, common horehound, little hogweed, and puncturevine were identified as being of moderate concern due to their medium impact to native plant communities rankings and their high prevalence in at least extent and/or density measures.

Puncturevine and little hogweed were the top two most prevalent exotic plants found during annual monitoring, and they were the second and third top exotics found during the park-wide rapid assessment, although in lower proportions than the high priority vector blocks. These species ranked as having a moderate ability to alter a native plant community and could pose greater problems as they become more established.

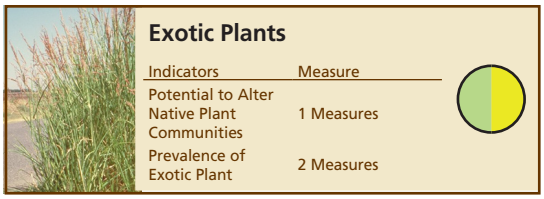
Puncturevine was found in 50.9% of the annual monitoring blocks along roads and trails and in the burned area and in almost 10% of the rapid assessment plots and found in density classes 1-3. It's a plant that easily spreads along pathways and requires regular maintenance to prevent its rapid spread. It already appears to be rapidly spreading and was found in 19/29 (65%) Rockhouse Fire distance class 1 plots.

Little hogweed was found in 36.7% of the annual monitoring blocks and in 3.2% of the rapid assessment plots. This plant also appears to be rapidly spreading throughout the Rockhouse Fire plots. This species has both a tap root and fibrous secondary roots and can readily grow in compacted soils. It also thrives under drought conditions.

Common horehound is a perennial herb that invades arid grasslands/scrub areas. Most impacts are related to grazing animals and pastureland, so once horehound is established, it is important to discourage or prevent its spread to other areas. While it is found relatively sparsely in terms of its extent (only 8.7% of monitored blocks and not detected during the rapid assessment), it is found in higher densities (4% of detections forming scattered to even patches).

Flagged Species of Concern

While ranked as low for its significance of impact, Bermudagrass (*Cynodon dactylon*) was found in over 10% of the annual monitoring blocks and is forming denser populations (almost 38% in density class 3) suggesting it may begin to rapidly spread.



Overall Condition and Trend

For assessing the condition of exotic plants, we used two indicators and three measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we think represents an exotic plant's potential for altering the Historic Site's native plant communities. A summary of exotic plant condition is summarized in Table 4.9.4-2.

Overall, we consider the condition of exotic plants at Fort Davis NHS to be good to moderate with an unknown trend.

Level of Confidence/Key Uncertainties

The exotic plants monitoring program occurs during spring and fall when cool- and warm-season plants are still identifiable and rosettes are present for fall blooming plants. This strategic timing ensures the highest degree of

Table 4.9.4-2. Indicator, measures, and their contributions to the overall exotic plants condition rationale.

Indicator of Condition	Measure	Condition	Rationale for Condition
Potential to Alter Native Plant Communities	Significance of Exotic Plant Impact	Moderate to Significant Concern	This measure is based on the premise that species with the largest negative impacts on native plant ecosystems generally cause the most severe problems. Four species (16% of total) ranked highest and five (20%) ranked high for significance of impact. This represents 36% of all exotics plants found throughout the NHS. Only 28% of the plants were considered to be of low impact and 35% were moderate. Given the relatively high percentage for the highest and high impact rankings, we consider this measure to be of moderate to significant concern.
Prevalence of Exotic Plant	Extent of Exotic	Good	Seven exotic species were found in greater than 10% of the annual sampling blocks between 2011-2013, three of which are considered to be of highest concern for impact. Only one species, *Salsola kali*, was found in greater than 10% of the rapid assessment plots but is one of the species of high concern of impact as well. With the exception of *Salsola kali*, it appears that the extent of exotic plants is restricted to the high priority vectors vs. interior. We consider this measure to be in good condition.
	Density of Exotic	Good	Most exotic species were found growing in low densities throughout the Historic Site, and none of them were found forming populations within the highest density class (matrix). There are two species of highest concern forming scattered to even density patches, but overall this measure is considered to be in good condition at the NHS.

detection. In addition, with vectors surveyed twice per year, CHDN staff feel confident that they will identify new plants before they become established even if the plant is introduced right after the survey has been completed, warranting a medium confidence level.

A key uncertainty is knowing how a given exotic plant species will respond to localized conditions. What may be considered a non-threatening plant in one region may become a nuisance in a different region. As stated above, semi-annual monitoring of exotic plants helps to quickly identify changes, which is necessary for early detection and rapid responses.

4.9.5. Sources of Expertise

Surveys for exotic plants at Fort Davis NHS were conducted by the CHDN exotic plants monitoring team who are well trained in species identification and methods. Our confidence is high regarding the reliability of their surveys.

This section was reviewed by Cheryl McIntyre (Physical Scientist), Julie Christian (Ecologist), and Melissa Powell (Biologist/ Assistant Data Manager) at the National Park Service Chihuahuan Desert Inventory and Monitoring Network. Jonathin Horsley is a biological technician for both the Chihuahuan Desert Network and the Southern Plains Network. He is the crew leader for their exotic plant monitoring crews.

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4.10. Breeding Landbirds

Indicators/Measures

- Species Occurrence (3 measures)

Condition - Trend - Confidence

Good - Insufficient Data - High

4.10.1. Background and Importance

The National Park Service's mission is to manage park resources "unimpaired for future generations." Protecting and managing some of our nation's most significant natural resources requires basic knowledge of the condition of ecosystems and species that occur in national parks. Landbirds are a conspicuous component of many ecosystems (Figure 4.10.1-1) and have high body temperatures, rapid metabolisms, and occupy high trophic levels. As such, changes in landbird populations may be indicators of changes in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000; Bryce et al. 2002). Relative to other vertebrates, landbirds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000; Buckland et al. 2001).

Changes in landbird population and community parameters can be an important element of a comprehensive, long-term monitoring program, such as that being implemented for the CHDN parks. Birds select habitat based on the presence of behavioral cues triggered by the environment (Hutto 1985; Alcock 2005). In some environments, however, especially those that vary unpredictably, habitat may not be saturated and changes in resources may not always be tracked by changes in animal populations (Wiens 1985). In these situations, relating changes in bird populations to environmental features can be complex, especially when confounded by time lags that are characteristic of site-tenacious bird species. Additional complications occur if birds respond more sensitively to environmental change than we can detect, and when cyclical environmental changes result in erratic changes in population size that are ultimately inconsequential. However, the utility of monitoring landbirds is strengthened by concurrent monitoring of a broad suite of environmental parameters (Dale and Beyeler 2001) that may assist with elucidating changes in the bird community to other environmental factors. Such a broad-based approach is now being undertaken by the CHDN program (NPS, CHDN 2010) and other monitoring approaches (e.g., Ringold et al. 1996; Stevens and Gold 2003; Barrows et al. 2005).

Perhaps the most compelling reason to monitor landbird communities in CHDN parks is that birds themselves are inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife is acknowledged in the agency's Organic Act: "to conserve . . . the wildlife therein . . . unimpaired for the enjoyment of future generations." Bird watching, in particular, is a popular, longstanding recreational pastime in the United States and forms the basis of a large and sustainable industry (Sekercioglu 2002).

4.10.2. Data and Methods

In 2010, Rocky Mountain Bird Observatory (RMBO) began systematic surveys of birds at Fort Davis NHS as part of the CHDN

Figure 4.10.1-1. Bewick's Wren (*Thryomanes bewickii*), a species known to breed at Fort Davis NHS.

Monitoring program. Although these data will enable quantitative evaluation of trends in birds in the future (e.g., in occupancy), it is premature to use them in such a context at the present with only four years of data. Rather, for this assessment, we focus on species occurrence (presence/absence), focusing on what species are, or are not, observed at the Historic Site. The most recent data we have for occurrence of birds at the Historic Site are the RMBO surveys. With the use of additional data sources, we evaluated species occurrence in three contexts: (1) a temporal context (i.e., changes over time), (2) a spatial context (i.e., comparison with surrounding region), and (3) a conservation context (i.e., the occurrence and status of species of conservation concern). We describe each of these below, followed by descriptions of the data sources used to support the comparisons.

In addition to the comparisons made for the condition assessment, we also present a list of species that are known to breed at the Historic Site or that may potentially breed at the park. The list is based on specific local records and recent survey data and was provided by a local bird expert (Bryan 2014a). The list makes use of ornithological investigations that have occurred in the area, including at the adjacent Davis Mountains State Park.

Indicators/Measures

Species Occurrence

Temporal Context – Changes over Time

To evaluate birds in a temporal context, we compared the occurrence of species detected during 2010-2013 RMBO surveys at Fort Davis NHS (described below) to a 2004-2006 inventory of birds at Fort Davis NHS (2005-2006 data only for breeding birds) (Meyer and Griffin (2011; described below). This analysis compares information from 2005-2006 to 2010-2013- a time span of only five to eight years.

Our analysis is not intended as a rigorous or quantitative comparison; rather, it is intended as a crude qualitative indicator of major changes over time. To do this in the most meaningful way, we needed the sources to be comparable. For example, the recent RMBO surveys were conducted during the breeding season; thus it is not reasonable to compare these results with sampling results at the Historic Site during other seasons. The 2005-2006 Meyer and Griffin (2011) inventory was also conducted during the breeding season (in June). The RMBO surveys were conducted in April, May, or June (somewhat different months in different years). We focused our comparisons on those species for which Fort Davis NHS is within their breeding range. We initially made this determination based on the Birds of North America (BNA) species accounts (Cornell Lab of Ornithology 2013), but later refined the determination based on reviews by local ornithologists with extensive experience at the park and surrounding areas.

We further refined our comparisons to species for which reasonably suitable breeding habitat exists at the Historic Site (since comparisons are based on the breeding season). We similarly assigned each species to one of three breeding habitat classes based on the BNA accounts, which was later revised using local knowledge (Table 4.10.2-1).

Spatial Context – Comparisons with Surrounding Region

We also evaluated species occurrence in a spatial context. Again, this is intended only as a qualitative measure rather than a rigorous quantitate estimate. For this assessment, we compared the recent RMBO surveys at the Historic Site to Breeding Bird Surveys (BBS) that are near the Historic Site (described below) and conducted in habitats similar to those within the Historic Site; the BBSs serve as a general spatial reference for species occurrence within the region. As with the temporal comparison, we focused our comparisons on those species for which the Historic Site is within their breeding range. We used the BBSs because, like the RMBO surveys, they are conducted within the breeding season. It should be noted, however, that both the BBSs and the RMBO surveys may record species that do not breed at the sampling location. The RMBO surveys are conducted during a timeframe to maximize the number of breeding landbirds. However,

Table 4.10.2-1. Breeding habitat classes assigned to each species that has been reported to occur at Fort Davis NHS and is within or near its reported breeding range.

Breeding Habitat Class	Class Description
Exists	This class was assigned when the habitat at the Historic Site is characteristic of habitats where a given species might be expected to breed.
Possibly Exists	This class was assigned when it was unlikely that the habitat at the Historic Site would support consistent or widespread breeding, but does not preclude some breeding in limited numbers.
Limited to None	This class was assigned when it is unlikely that the habitat at Fort Davis NHS would support breeding by that species. This does not imply that the species would not occur at the Historic Site in limited numbers or during other seasons, but rather that it would be unlikely to breed there.

breeding status is not determined for all bird observations, so the surveys may include species that do not breed in the park. We addressed such situations on a case by case basis.

Conservation Context – The Occurrence and Status of Species of Conservation Concern

Our intent for this context was to determine which species that have been recorded at Fort Davis NHS are considered species of concern at either national or regional scales, to assess the current status (occurrence) of those species at the Historic Site, and to evaluate the potential for the Historic Site to play a role in the conservation of those species. For the latter, we assigned each species of conservation concern to a class representing the potential for the Historic Site to play a role in its conservation, at least during the breeding season (Table 4.10.2-2). This was based primarily on whether or not the Historic Site was within the breeding range of the species and the availability of breeding habitat at the Historic Site.

To develop a candidate list for species of conservation concern, we used the lists developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations, such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of confusion, and perhaps frustration, for managers that need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, several of which are presented below, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (NABCI 2013). Bird Conservation Regions are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (Figure 4.10.2-1). Fort Davis NHS lies within the Chihuahuan Desert Unit (BCR-35) (Figure 4.10.2-2).

Conservation Organizations Listing Species of Conservation Concern

Below we identify some of the organizations/efforts that list species of conservation concern; these are the listings we used for the condition assessment. Appendix F presents additional details on each of the organizations/efforts.

Table 4.10.2-2. Classes assigned to species of concern regarding the potential for Fort Davis NHS to play a role in their conservation.

Potential for Conservation	Conservation Class Description
High	These are species for which the Historic Site is within their breeding range. They are also species for which we considered the Historic Site to have good breeding habitat. We assigned species to this class if we believed, based on the evidence, that the potential for breeding was good, regardless of whether they currently occur at the Historic Site in substantial numbers.
Moderate	These are the species for which the Historic Site is within their breeding range, and for which there is some habitat at the Historic Site that might support occurrence or even some breeding in limited numbers.
Low to None	These are the species that are either outside of their breeding range and/or for which the habitat at the Historic Site is unlikely to support breeding. This does not preclude limited occurrences of the species, but the potential for the Historic Site to play any significant role in the conservation of that species is very limited.

- U.S. Fish & Wildlife Service: Under the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) lists species as threatened, endangered, or candidates for listing.
- State of Texas: In 1973, the Texas Parks and Wildlife Department (TPWD) was authorized to develop a list of endangered and threatened animal species in the state. Legal protection of endangered and threatened animals is provided by laws and regulations contained in Chapters 67 and 68 of the Texas Parks and Wildlife Code and Sections 65.171-65.176 of Title 31 of the Texas Administrative Code (TPWD 2013a).
- USFWS: This agency also developed lists of birds of conservation concern according to: the Nation, USFWS Region, and BCR.
- The National Audubon Society (NAS) and American Bird Conservancy (ABC): These groups combined efforts to produce a "Watch List," based on, but not identical to, the Partners in Flight approach to species assessment (see below). The 2007 WatchList has two primary levels of concern: a "Red WatchList," which identifies what these organizations consider as species of highest national concern; and a "Yellow WatchList," which is made up of species that are somewhat less critical.
- Partners in Flight (PIF): This is a cooperative effort among federal, state, and local government agencies, as well as private organizations. PIF has adopted BCRs as the geographic scale for updated regional bird conservation assessments. At the scale of the individual BCRs, there are species of Continental Importance (Continental Concern [CC] and Continental Stewardship [CS]) and Regional Importance (Regional Concern [RC] and Regional Stewardship [RS]).
- Texas Species of Greatest Conservation Need: The State of Texas also designated species that, "due to limited distributions and/or declining populations, face the

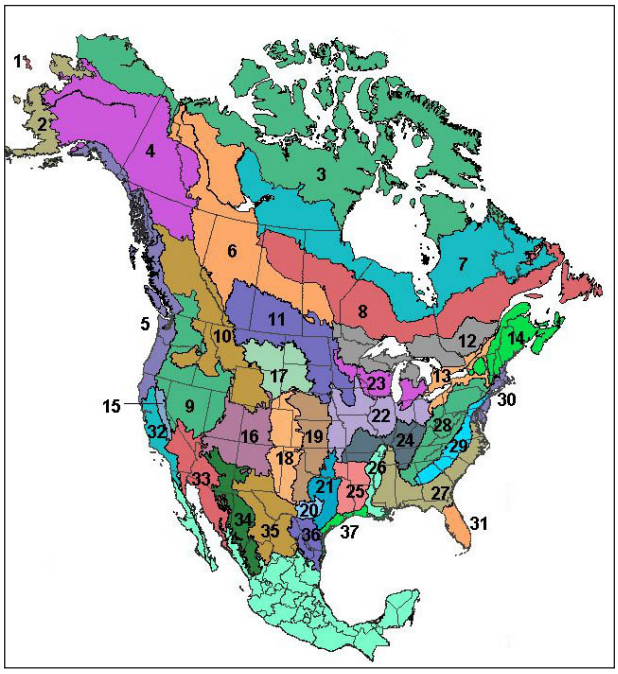

Figure 4.10.2-1. Bird Conservation Regions in North America.

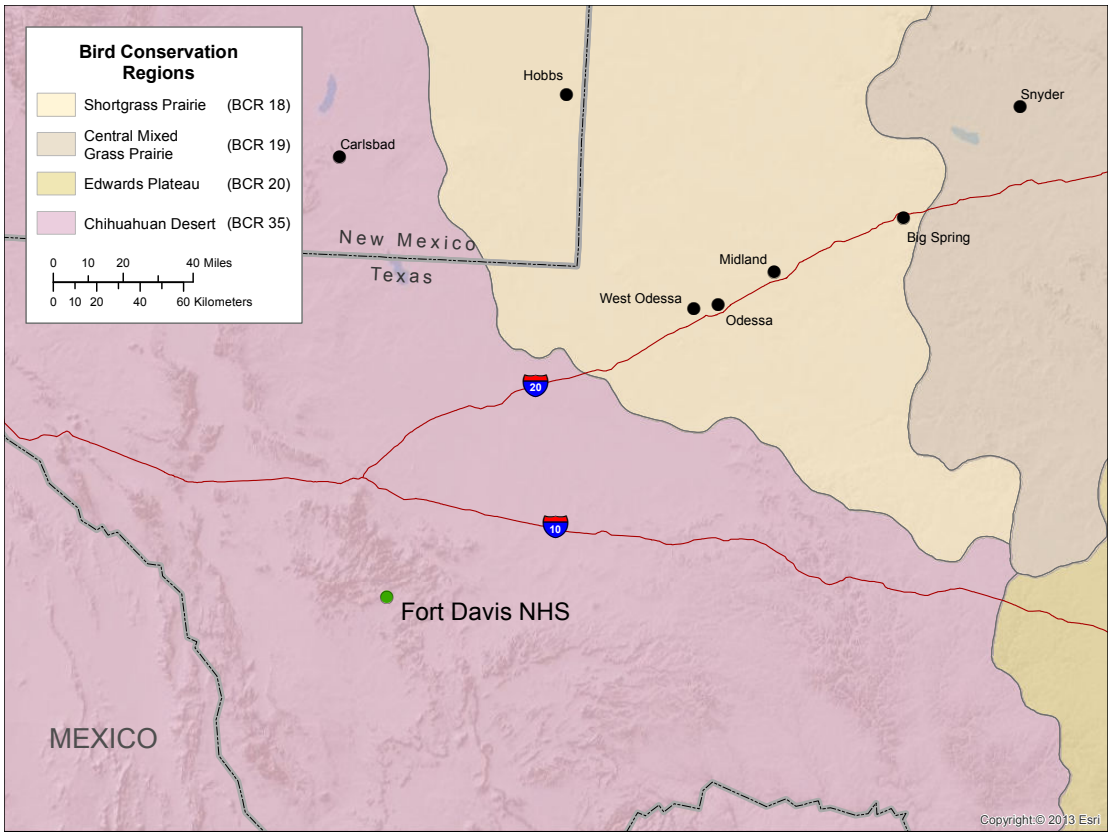

Figure 4.10.2-2. Bird Conservation Regions in the vicinity of Fort Davis NHS.

threat of extirpation or extinction but lack legal protection" (TPWD 2013b). The lists were developed for the TPWD's Texas Conservation Action Plan. Species are rated or ranked using a system developed by NatureServe.

Primary Data Sources

Data used as part of this assessment include: breeding bird surveys conducted by RMBO at Fort Davis NHS in 2010-2013; an inventory of breeding (and migratory) birds in several CHDN parks in 2004 (migratory seasons only) and 2005-2006 (Meyer and Griffin 2011); and data from the BBSs. As mentioned previously, we also used and present the list of known and potentially breeding species at the Historic Site provided by a local ornithologist (Bryan 2014a). Although this list is an important part of this chapter, it was not used directly for the condition comparisons since it was based on cumulative information over a number of years and included species that potentially breed at the park in addition to those that have been confirmed breeding at the park. Rather, it provided specific information on species range and occurrence to support the comparisons.

Some additional sources of information on the birds at Fort Davis NHS and/or vicinity are discussed in the Secondary Data Sources section.

RMBO Surveys at the Historic Site in 2010-2013

RMBO used point-transect surveys (Buckland et al. 2001) during the breeding season to estimate and monitor landbird population parameters. A total of up to 52 points were sampled in grassland habitat each year in 2010-2013 (Figure 4.10.2-3) (e.g., White and Valentine-Darby 2013 for 2012). Points in the grid were placed 250 meters apart (there were 26 points in the grid which were sampled twice). All birds detected at a given point were recorded. Observers spent six minutes at each point along the transect or grid and used a rangefinder to estimate the linear distance to each bird or group detected. This protocol of spending six minutes per site is consistent with other efforts being conducted by RMBO. After counts were completed, observers used a handheld GPS (Global Positioning System) unit to locate successive survey points. While walking between points, observers noted only the species that were not recorded during the

count period; sometimes these represented species that had not been reported previously for the Historic Site. It should be noted that although surveys are conducted during the breeding season, some species recorded may not be breeding in the park. Field technicians note evidence of breeding when such evidence is observed; however, birds with no such evidence may or may not be breeding in the park.

2005-2006 Breeding Season Inventories at Fort Davis NHS (Meyer and Griffin 2011)

The 2005-2006 data on birds during the breeding season came from a larger study entitled *Seasonal Inventory of Birds in Low Elevation Riparian Habitats at Chihuahuan Desert Network Parks, 2007 Final Report* (i.e., Meyer and Griffin 2011). At Fort Davis NHS, sampling was conducted in Hospital Canyon, using a point count and an area search, and a mesquite grassland adjacent to the point count transect (using an area search). The survey points for the point count transect were located at intervals of at least 200 meters along the transect. The point count surveys were started no earlier than 15 minutes before sunrise and finished by 11:30 am. In both the 2005 and 2006 breeding seasons, surveys were conducted between June 5th and June 15th (Meyer and Griffin 2011).

BBS Routes

Breeding Bird Surveys are conducted on over 4,100 survey routes located across the continental U.S. and Canada (http://www.pwrc.usgs.gov/BBS/). Each year during the height of the avian breeding season, participants skilled in avian identification sample birds along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about five hours to complete. We used four BBS routes in the vicinity of Fort Davis NHS for our assessment (Figure 4.10.2-4); three are in Jeff Davis County (83189, 83331, and 83392) and one is in Brewster County (83088). We used data from BBS routes for the spatial comparison of species occurrence. Note that we attempted to select routes with similar habitat as that which

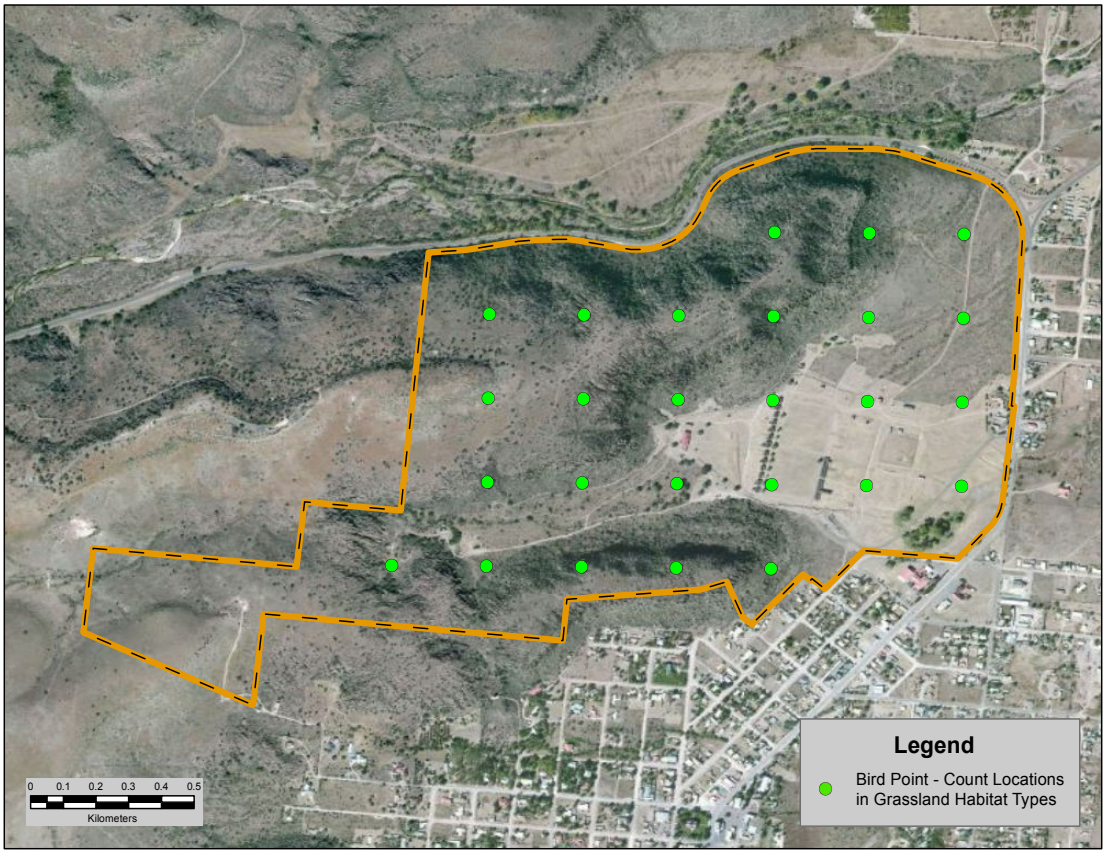

Figure 4.10.2-3. Survey points sampled by the Rocky Mountain Bird Observatory at Fort Davis NHS in 2010-2013.

Figure 4.10.2-4. Breeding Bird Survey routes in the vicinity of Fort Davis NHS used for the spatial/regional breeding landbird species comparison.

occurs at the Historic Site; however, some of the routes probably contain some habitat types that do not occur at the park. Such discrepancies are dealt with in the Condition and Trend section (4.10.4) by examining the habitat needs of specific species. One of the expert reviewers of the chapter suggested using only two routes (83392 and 83088). In section 4.10.4, we discuss how this change in route usage would have affected our results.

Breeding and Potentially Breeding Species at Fort Davis NHS

A comprehensive list of species known to breed or that have the potential to breed at the Historic Site was provided by Kelly Bryan, a local bird expert and reviewer of this chapter (Section 4.10). The complete list (Bryan 2014a) appears in the Condition and Trend section.

Secondary Data Sources

Additional information on the birds at Fort Davis NHS was provided by a second reviewer of the chapter, Joshua Burns. Mr. Burns conducted 134 surveys of lowland areas of the Historic Site between 2005 and 2013. These areas included Hospital Canyon, the area along the San Antonio-El Paso road to the old Pump House, and the regularly mowed area. The trips included 27 visits during the breeding season. Data are available on the total number of birds of each species observed during various periods of time, such as monthly, seasonally, and during the breeding season (Burns 2014). A summary of his data is provided in Appendix G. Of the 84 species on the Appendix G list, the majority are on the breeding or potentially breeding birds list for the park (Bryan 2014a), while the remainng species are on the non-breeding list for the park (Bryan 2014b; see below).

The data discussed above from Mr. Burns, as well as data from other birders in the vicinity of the Historic Site, is available on the eBird website (http://ebird.org/content/ebird/about/). The website was launched in 2002 by the National Audubon Society and Cornell Lab of Ornithology to "maximize the utility and accessibility of the vast numbers of bird observations made each year by recreational and professional bird watchers" (National Audubon Society and Cornell Lab of Ornithology 2014). The website provides data for basic information on bird abundance and distribution at multiple temporal and spatial scales.

Reviewer Mr. Bryan also provided a list of species that may occur at the Historic Site but are not known to breed there. This list, which contains about 160 species, is based on specific local records and recent survey data (Bryan 2014b). The list is contained in Appendix H.

4.10.3. Reference Conditions

Temporal Reference Condition for Species Occurrence

The 2004-2006 *Seasonal Inventory of Birds in Low Elevation Riparian Habitats at Chihuahuan Desert Network Parks* is the first study that specifically focused on avian communities at the Historic Site, although comprehensive species lists had been developed for the Davis Mountain and Trans-Pecos regions (Meyer and Griffin 2011). Also, as previously mentioned, local ornithologists have conducted their own bird observations at the Historic Site, and one of them combined his observations from the park and data from Davis Mountains State Park to create a list of known and potentially breeding birds at the Historic Site; this list contains 81 species at this time (Bryan 2014a). Meyer and Griffin (2011) observed a total of 44 species during their June sampling in 2005 and 2006. Thirty-seven additional species that were not observed during the breeding season in 2005-2006 were observed during fall and spring migratory seasons in 2004-2006.

We compared the species list from the 2005-2006 breeding seasons (from Meyer and Griffin 2011) to the species list from 2010-2013 RMBO surveys to see if there were any differences. Specifically, we looked at species that were not observed during 2010-2013 RMBO surveys that had been documented in 2005-2006. In our list, we noted any species that were outside of their breeding range at the park (using local expert input). Although this is a crude measure and only spans a relatively short time differential, it does potentially provide some insights as to major shifts that might have occurred at the Historic Site. Table 4.10.3-1 summarizes the qualitative condition classes we assigned for the temporal and spatial indicators.

Spatial Reference Condition for Species Occurrence

In a spatial context, we compared the species observed during recent RMBO surveys (2010-2013) at Fort Davis NHS to those recorded during BBSs in the general vicinity of the Historic Site (the most applicable [habitat-wise] nearby routes). Both surveys were conducted during the breeding season. Again, we used the list of known and potentially breeding species at the park (and other input) from local experts to inform our comparison.

Reference Condition for Species of Concern

This aspect of the assessment is somewhat different than the other two in that the focus is on the avian species for which the Historic Site can play a role in their conservation. From the list of species detected at the Historic Site during recent RMBO surveys (and the 2005-2006 breeding season surveys), we identified the species that occurred on one or more of the lists of species of conservation concern. Those considered as having the greatest potential for conservation at the Historic Site are those within their breeding range and for which breeding habitat exists at the Historic Site.

4.10.4. Condition and Trend

There have been a total of 96 bird species recorded at Fort Davis NHS during relatively recent surveys (Appendix I)-- 79 were recorded during the 2010-2013 RMBO breeding season surveys and/or the 2005-2006 breeding season inventories; the other 17 species were observed only during the 2004-2006 fall or spring migratory seasons. As discussed in greater detail below, some of the species recorded by RMBO or Meyer and Griffin (2011) during the breeding season may not actually breed in the park.

In reviewing this chapter of the draft report, one local avian expert provided a list of bird species that are known to breed at the Historic Site or that may potentially breed at the site (Bryan 2014a). The list is based on ornithological investigations in the area, including those occurring in the adjacent Davis Mountains State Park. This list of

Table 4.10.3-1. Reference conditions used to assess the current condition of landbird species occurrence in temporal and spatial contexts.

Occurrence Indicator	Significant Concern	Moderate Concern	Good
Temporal Context	We considered condition to be of significant concern if several species of birds that are within their breeding range and have existing habitat at the Historic Site were detected in the 2005-2006 breeding season inventories but not in recent RMBO surveys, particularly if those species had previously been considered common at the Historic Site.	We considered condition to be of moderate concern if a few bird species that were detected during the 2005-2006 breeding season inventories that are within their breeding range and have breeding habitat at the Historic Site were not detected during recent RMBO surveys.	We considered condition to be good if all, or nearly all, birds that were detected during the 2005-2006 breeding season inventories that are within their breeding range and have breeding habitat at the Historic Site were detected during recent RMBO surveys.
Spatial Context	We considered condition to be of significant concern if several species of birds that are within their breeding range and have breeding habitat at the Historic Site were detected during regional surveys but not during recent RMBO surveys, particularly if those species had previously been considered common at the Historic Site.	We considered condition to be of moderate concern if a few bird species that were detected during regional surveys and that are within their breeding range and have breeding habitat at the Historic Site were not detected during recent RMBO surveys.	We considered condition to be good if all, or nearly all, birds that were detected during regional surveys and that are within their breeding range and have breeding habitat at the Historic Site were detected during recent RMBO surveys.

81 species is presented in Table 4.10.4-1. Although this list was not used directly to assess condition (because some of the species on it have not been recorded breeding in the park itself, and the list does not come from a single survey effort), it is a valuable resource for the park. The information provided in the list was used to support our assessment of condition.

Species Comparisons using 2005-2006 Breeding Season Inventories (Temporal Context)

A total of 44 species of birds were observed at Fort Davis NHS during the 2005-2006 breeding season inventories by Meyer and Griffin (2011) (Appendix I). Of these 44 bird species, only six were not observed on recent (2010-2013) RMBO surveys (Table 4.10.4-2). Four of these species have the potential to breed in the park, but only one (Greater Roadrunner) is known to do so. The sixth species is reported to breed at higher elevations than occur in the park. Based on this comparison, we have no particular concerns for species occurrence at this time. Only one species that is known to breed in the park (from those reported by Meyer and Griffin [2011])has not yet been detected during four years of RMBO surveys. As more annual surveys are conducted, it is likely that additional species known to exist in the park will be recorded.

A different set of species (33) was detected in the 2010-2013 surveys but not in the 2005-2006 breeding season inventories (e.g., Black-chinned Sparrow, Black-tailed Gnatcatcher, Common Raven, Great Horned Owl, House Sparrow, and Montezuma Quail; see Appendix I).

Species Comparisons to Surrounding Region (Spatial Context)

During BBSs in 2009-2012 in the vicinity of Fort Davis NHS (on the four routes specified), 83 species were counted. Fifty-seven of the 83 species were observed during 2010-2013 RMBO surveys at the Historic Site, but the other 26 species were not observed in any of the years from 2010-2013 (Table 4.10.4-3). Eight of the 26 species were observed during either the 2005-2006 breeding season surveys or the 2004-2006 migratory season surveys of Meyer and Griffin (2011).

Of the 26 species, 13 fall into the "Limited to None" breeding habitat class. Of the 13 species, most are winter residents or migrants only in the park. Of the remaining

Table 4.10.4-1 Species known to breed or that have the potential to breed at Fort Davis NHS based on specific local records and recent survey data (Source: Bryan 2014a). [Note that the original list from Bryan presents species in taxonomic order, rather than alphabetically as shown here].

Common Name	Range Status	Breeding Habitat Class
Acorn Woodpecker	Year-round	Exists
American Kestrel	Year-round	Possibly Exists; has nested nearby
American Robin	Year-round	Limited to None; rare, but nests in Fort Davis; sporadic as a migrant and winter resident
Ash-throated Flycatcher	Summer resident	Exists
Barn Owl	Year-round	Possibly Exists; nests nearby
Barn Swallow	Summer resident	Exists; abundant
Bell's Vireo	Summer resident	Possibly Exists; nests along Limpia Creek
Bewick's Wren	Year-round	Exists
Black Phoebe	Year-round	Possibly Exists; declining due to the ongoing drought and the drying up of Limpia Creek; formerly nested in caves formed by the "pinnacles" adjacent to the creek
Black-chinned Sparrow	Year-round	Exists, but uncommon
Black-chinned Hummingbird	Summer resident	Exists
Black-crested Titmouse	Year-round	Exists
Black-headed Grosbeak	Summer resident	Exists
Black-tailed Gnatcatcher	Year-round	Possibly Exists; very uncommon at the Historic Site; prefers open desert scrub
Black-throated Sparrow	Year-round	Exists; uncommon; prefers open desert scrub
Blue Grosbeak	Summer resident	Exists
Bronzed Cowbird	Summer resident	Possibly Exists; nests annually in Fort Davis
Brown-headed Cowbird	Summer resident	Exists
Bushtit	Year-round	Exists; noticeable decline in population (possibly due to drought)
Cactus Wren	Year- round	Exists
Canyon Towhee	Year-round	Exists; abundant
Canyon Wren	Year-round	Exists; typically only 2-3 pairs found at the Historic Site
Cassin's Sparrow	Year-round	Exists; nests in the mesquite-grasslands along the highway; a few birds winter in Hospital Canyon
Cassin's Kingbird	Summer resident	Exists; abundant
Cave Swallow [1]	Summer resident	Limited [1]
Chimney Swift	Summer resident	Limited to None; has nested in Fort Davis
Chipping Sparrow	Year-round	Possibly Exists; a few birds nest in the foothills; abundant in the mountains; abundant migrant and winter resident at the Historic Site
Cliff Swallow	Summer resident	Possibly Exists; nests on several building in Fort Davis, far more common than Cave Swallow
Common Black-Hawk	Summer resident	Exists (nests in the Limpia Creek riparian zone and utilizes the "pinnacles" area of the Historic Site for feeding and resting)
Common Nighthawk	Summer resident	Exists
Common Poorwill	Year-round	Exists
Common Raven	Year-round	Exists (the only nesting raven around Fort Davis)
Cooper's Hawk	Year-round	Possibly Exists; nests nearby
Curve-billed Thrasher	Year-round	Exists
Eastern Meadowlark	Year-round	Exists; the only nesting meadowlark in the area
Elf Owl	Summer resident	Possibly Exists; nests annually in Davis Mountains State Park

Table 4.10.4-1 continued Species known to breed or that have the potential to breed at Fort Davis NHS based on specific local records and recent survey data (Source: Bryan 2014a). [Note that the original list from Bryan presents species in taxonomic order, rather than alphabetically as shown here].

Eurasian Collared- Dove	Year-round	Exists
European Starling	Year-round	Possibly Exists; nests in Fort Davis
Gray Hawk	Summer resident	Exists (nests in the Limpia Creek riparian zone and utilizes the "pinnacles" area of the Historic Site for feeding and resting)
Great Horned Owl	Year-round	Exists
Greater Roadrunner	Year-round	Exists
Great-tailed Grackle	Summer resident	Limited to None; a few pairs are starting to nest near the U.S. Post Office; uncommon as a migrant, very rare in winter
Horned Lark	Resident	Limited to None; nests within 20 miles of the Historic Site only in open plateau grasslands
House Finch	Year-round	Exists
House Sparrow	Year-round	Exists
Inca Dove	Year-round	Possibly Exists; declining status in Fort Davis
Indigo Bunting	Summer resident	Limited to None; small nesting population along Limpia Creek
Killdeer	Year-round	Possibly Exists; nests nearby
Ladder-backed Woodpecker	Year-round	Exists
Lark Sparrow	Summer resident	Exists; abundant
Lesser Goldfinch	Year-round	Exists
Loggerhead Shrike	Year-round	Exists
Montezuma Quail	Year-round	Exists; more common in the foothills and mountains, avoids plateau grasslands; population fluctuates with climate
Mourning Dove	Year-round	Exists
Northern Cardinal	Year-round	Exists
Northern Mockingbird	Year-round	Exists
Orchard Oriole	Summer resident	Exists
Painted Bunting	Summer resident	Possibly Exists; small population of nesting birds along Limpia Creek and in Fort Davis
Phainopepla	Year-round	Exists; nesting population may be different than the winter population
Pyrrhuloxia	Year-round	Possibly Exists; far more common in winter than in summer
Red-tailed Hawk	Year-round	Exists
Rock Pigeon	Year-round	Possibly Exists; common in Fort Davis
Rock Wren	Year-round	Possibly Exists (altitudinal migrant, far more common in winter than in summer when rare at the Historic Site)
Rufous-crowned Sparrow	Year- round	Exists
Say's Phoebe	Year-round	Exists
Scaled Quail	Year-round	Possibly Exists; more common in the surrounding plateau grasslands
Scott' s Oriole	Summer resident	Exists
Summer Tanager	Summer resident	Exists
Turkey Vulture	Summer resident	Exists; nests in caves under the "pinnacles"
Verdin	Year-round	Exists; uncommon
Vermilion Flycatcher	Summer resident	Possibly Exits; nests nearby
Warbling Vireo	Summer resident	Extirpated; nested in cottonwoods along Limpia Creek in the 1970s, now only above 6,500 ft
Western Kingbird	Summer resident	Possibly Exists; nest nearby
Western Screech-Owl	Year-round	Exists
Western Scrub-Jay	Year-round	Exists
Western Wood-Pewee	Summer resident	Limited to None; has nested at Davis Mountains State Park

Table 4.10.4-1 continued Species known to breed or that have the potential to breed at Fort Davis NHS based on specific local records and recent survey data (Source: Bryan 2014a). [Note that the original list from Bryan presents species in taxonomic order, rather than alphabetically as shown here].

White-breasted Nuthatch	Year-round	Possibly Exists; nests in the foothills of the mountains when resources are abundant
White-winged Dove	Year-round	Exists
Wild Turkey	Year-round	Possibly Exists; nests nearby
Yellow-billed Cuckoo	Summer resident	Possibly Exists; nests in Fort Davis annually
Yellow-breasted Chat	Summer resident	Possibly Exists; nests nearby

[1] Has been noted (by reviewer J. Burns) nesting under eaves of park buildings.

Table 4.10.4-2 Species reported in 2005-2006 by Meyer and Griffin (2011) at Fort Davis NHS that were not observed during the 2010-2013 RMBO surveys. Information on range status and/or occurrence at the Historic Site provided by Kelly Bryan. Species that are not known to breed at the park are shown in green (considered migrant species).

Common Name	Range Status / Occurrence at the Historic Site
American Kestrel	Local breeder; has nested in the Catholic church bell tower; feeding territory when nesting includes the Historic Site
Bronzed Cowbird	Uncommon summer resident; breeds in town and potentially at the Historic Site
Greater Roadrunner	Uncommon resident; breeds at the Historic Site
Indigo Bunting	Local breeder; small breeding population found in the 1990s along Limpia Creed adjacent to the Historic Site; could breed in Hospital Canyon; current status needs to be checked
Violet-green Swallow	Migrant only at the Historic Site; breeds at elevations above 7,000 ft.
Western Kingbird	Breeds in town and possibly at the Historic Site; every summer a few pairs nest among the abundant nesting Cassin's Kingbirds

13 species, all are within their breeding range at the park and are year-round or summer residents. However, eight of the species are in the "Possibly Exists" category (with most of the eight known to breed near the park). Only five of the species fall into the "Exists" category, with breeding habitat at the park (Common Nighthawk, Common Poorwill, Greater Roadrunner, Loggerhead Shrike, and Orchard Oriole). As there have only been four years of RMBO sampling to date, it is very possible that these species may be detected in future breeding season surveys by RMBO at the park. Also note that while an attempt was made to select BBS routes that would have habitats comparable to those within the Historic Site, it is possible there were some differences. In this regard, one of the reviewers of the chapter suggested using only two of the routes (83392 and 83088). If we had not used the two other routes (83189 and 83331, whose use had been recommended by others at the onset of work on the chapter), 10 species would not appear in Table 4.10.4-3. Seven of these 10 species are said to be migrants only at the Historic Site or otherwise fall into the Limited to None habitat class (Hepatic Tanager, Hermit Thrush, Red-winged Blackbird, Violet-green Swallow, Western Bluebird, Western Meadowlark, and White-throated Swift), two of them are in the Possibly Exists habitat class (American Kestrel and Wild Turkey), and one is in the Exists class (Common Poorwill). We believe that it was reasonable to include the two routes for the comparison, because we can use the information available on breeding range and habitat to address whether they might be expected to occur at the park.

In summary, after comparison of species found in the surrounding region to those reported from recent RMBO surveys at Fort Davis NHS, we do not believe that a concern for bird species occurrence is justified at this time. However, as five species not detected by RMBO to date fall into the Exists breeding habitat class at the Historic Site, we consider the condition for this indicator to be good or, possibly, moderate.

Species of Conservation Concern

There are 25 species that have been recorded at Fort Davis NHS during 2010-2013 RMBO surveys that are listed as species of conservation concern on one or more of the lists described in Section 4.10.2. Additionally, there is one species (American Kestrel) that was detected in the 2005-2006 breeding season inventory that is also considered a species of conservation concern, which we include here.

- USFWS / Listed Species: There are no bird species listed by the USFWS as endangered or threatened (or candidates) that have been recorded during monitoring at the Historic Site in 2010-2013 or 2005-2006 (USFWS 2013) (Table 4.10.4-4).
- State of Texas / Listed Species: There are no bird species that have been recorded during monitoring at the Historic Site that are listed as endangered or threatened by the State of Texas.
- USFWS / Birds of Conservation Concern: There are four species that have been detected at the Historic Site during 2010-2013 monitoring that have been identified by the USFWS as having the greatest conservation need at a National, Regional, or BCR geographic scale (U.S. Fish and Wildlife Service 2008).
- NAS / ABC: There are four species detected during 2010-2013 sampling that have been listed on the NAS/ABC 2007 WatchList. Three of the species are on the Yellow List, two due to population declines and one because it is rare (Montezuma Quail), and one species (Black-chinned Sparrow) is on the Red List.
- PIF: Twenty-one of the 26 birds in Table 4.10.4-4 are listed by PIF in one or more of its categories (i.e., CC, RC, CS, RS).
- Texas Species of Greatest Conservation Need: Eight of the species in Table 4.10.4-4 are on the list of Species of Greatest Conservation Need for the Chihuahuan Desert (TPWD 2012). This includes American Kestrel, which was observed during the breeding season in 2005-2006 only.

Summary of Species Listed as Birds of Conservation Concern (Conservation Context)

For this summary, we emphasize species for which Fort Davis NHS has the greatest potential to positively impact their conservation during the breeding season, based on their breeding habitat and range. We do not mean to imply that other seasons are not important for the conservation of birds, they are. Rather, we have limited this assessment to the breeding season because that is the primary season for which we have current monitoring data. We also recognize that there is some level of uncertainty and subjectivity in our assessment, although we believe that this has been minimized by incorporating information on species occurrence and use of the Historic Site and surrounding area from two expert reviewers.

Of the 26 species listed by one or more organization as being of conservation concern (Table 4.10.4-4, including American Kestrel), we believe that 15 have sufficient habitat at the Historic Site to be considered as having high conservation potential (Table 4.10.4-5). These are the species that are within their breeding range and sufficient habitat exists at the Historic Site to support breeding. It should be noted that some of these fifteen species are considered of conservation concern on regional lists only (e.g., Canyon Wren, Eastern Meadowlark), while others appear on continent-wide lists (e.g., Cactus Wren, Verdin).

All species of conservation concern that are within their breeding range and have "existing" breeding habitat at the Historic Site have been observed during recent RMBO surveys (in 2010, 2011, 2012, and/or 2013). Some of these species have been observed in relatively high numbers during surveys. We consider the condition for species of conservation concern to be good.

Table 4.10.4-3 Bird species detected on four Breeding Bird Survey (BBS) routes in 2009-2012 near Fort Davis NHS that have the potential to be observed at the Historic Site, but were not detected at the Historic Site during the 2010-2013 RMBO point-count surveys (26 species). Information on Range Status and Breeding Habitat Class provided/reviewed by Kelly Bryan. Green highlights indicate migratory species not expected to breed at the Historic Site.

Common Name	Range Status	Breeding Habitat Class: Exists, Possibly Exists, Limited to None
American Kestrel [1, 2]	Year-round	Possibly Exists; has nested nearby
Barn Owl	Year-round	Possibly Exists; nests nearby
Bell's Vireo	Summer resident	Possibly Exists; nests along Limpia Creek
Bullock's Oriole	Migrant only at Historic Site	Limited to None; nests in extensive mesquite grasslands found elsewhere (north to Balmorhea and west to the Valentine area)
Burrowing Owl	Year-round (very rare in winter)	Limited to None; nests within 20 miles of Historic Site in open grasslands
Common Nighthawk	Summer resident	Exists
Common Poorwill	Year-round	Exists
Greater Roadrunner [1, 2]	Year-round	Exists
Hepatic Tanager	Rare migrant only at Historic Site; breeds only above 5,500 ft.	Limited to None
Hermit Thrush [1]	Winter resident and migrant	Limited to None; uncommon nesting species within 20 miles of Historic Site above 6,500 ft.
Horned Lark	Year-round	Limited to None; nests within 20 miles of Historic Site only in open plateau grasslands
Killdeer [1]	Year-round	Possibly Exists; nests nearby
Loggerhead Shrike [1]	Year-round	Exists
Orchard Oriole [1]	Summer resident	Exists
Painted Bunting	Summer resident	Possibly Exists; small population of nesting birds along Limpia Creek and in Fort Davis
Purple Martin	Outside Normal Breeding Range	Limited to None
Red-winged Blackbird	Year-round	Limited to None
Scissor-tailed Flycatcher	Extirpated from area; shifted 40 miles east to Marathon and north to Balmorhea	Limited to None
Swainson's Hawk	Summer resident	Limited to None; may be a common migrant overhead; nests within 20 miles of Historic Site in open plateau grasslands
Violet-green Swallow [2]	Migrant	Limited to None; uncommon migrant in foothills; common nesting species within 20 miles of Historic Site above 6,500 ft.
Western Bluebird	Winter resident	Limited to None; common nesting species within 20 miles of Historic Site above 5,500 ft.
Western Kingbird [1, 2]	Summer resident	Possibly Exists; nests nearby
Western Meadowlark	Winter resident	Limited to None; does not breed around Fort Davis
White-throated Swift	Year-round (migrant and winter status sporadic)	Limited to None; breeds only above 7,000 ft.
Wild Turkey	Year-round	Possibly Exists; nests nearby
Yellow-breasted Chat	Summer resident	Possibly Exists; nests nearby

1 = Species recorded during 2004-2006 Migratory Season Surveys of Meyer and Griffin (2011).
2 = Species recorded during 2005-2006 Breeding Season Surveys of Meyer and Griffin (2011).

Table 4.10.4-4. Summary of species detected during 2010-2013 RMBO surveys at Fort Davis NHS (or 2005-2006 breeding season surveys only, with superscript of "3") of conservation concern, as listed by government agencies and non-governmental organizations.

Common Name	Listed Species		Species of Conservation Concern Lists								TX SGCN	Comments
	Federal	State	US Fish & Wildlife Service			NAS/ ABC [1]	Partners in Flight National Conservation Strategy [2]					
	USFWS	TPWD	National	Region 2	BCR 35	2007 Watch List	BCR 35 (2012 List) CC	RC	CS	RS	Chihuahuan Desert	
American Kestrel [3]											•	[3] Detected 2005-2006 only
Black-chinned Sparrow			•	•	•	•	•		•	•		
Black-tailed Gnatcatcher									•	•		[4] Rare as potential nester due to lack of nesting habitat
Black-throated Sparrow									•			
Brewer's Sparrow			•			•						[4] Migrant & winter resident
Cactus Wren									•			
Canyon Towhee									•			
Canyon Wren										•		
Cassin's Sparrow					•			•	•	•	•	[4] Numerous breeder in area
Cave Swallow										•		
Chihuahuan Raven										•		[4] Migrant only
Curve-billed Thrasher									•			
Eastern Meadowlark								•			•	
Gray Flycatcher									•			[4] Migrant only
Green Tailed-towhee									•			[4] Migrant & winter resident
Lark Sparrow											•	
Montezuma Quail						•					•	
Phainopepla									•			
Pyrrhuloxia									•	•		
Rufous-crowned Sparrow											•	
Scaled Quail						•			•	•	•	
Scott's Oriole									•	•		
Summer Tanager								•			•	
Verdin									•			
Virginia's Warbler			•		•		•					[4] Migrant only
Western Scrub-jay									•			

[1] NAS/ABC - 2007 Watchlist: • = Red List; • = Declining or Rare
[2] PIF NCS Categories: CC = Continental Concern; RC = Regional Concern; CS = Continental Stewardship; RS = Regional Stewardship.
[3] Species observed in 2005-2006 inventory (Meyer and Griffin 2011) only
[4] Comments from reviewers; Green shading denotes non-breeding species at park per K. Bryan.

Overall Condition

For assessing the condition of landbirds, we used one indicator (with three contexts or measures) that assessed landbird species occurrence. This indicator is summarized in Table 4.10.4-6. Although our assessment is based on only four years of recent monitoring data (2010-2013), as well as two years of earlier data (2005-2006), we found no justification to warrant concern for landbird occurrence at Fort Davis NHS at this time. We consider the overall condition of breeding landbirds at the Historic Site to be good. Our assessment utilized input from local experts (including a species list of breeding and potentially-breeding landbirds) as supporting information. Unfortunately, we do not have sufficient data to justify a trend in the condition, although ongoing monitoring should provide such an estimate for future assessments.

Level of Confidence/Key Uncertainties

The key uncertainties related to this assessment are the lack of long-term annual monitoring data. There was also some subjectivity with respect to assigning individual species to breeding habitat and conservation classes. Although we are currently collecting additional data that will provide for a quantitatively rigorous analysis in the future, at the present time we relied primarily on qualitative indicators to assess the condition of landbirds. We had only four years of recent RMBO data and two years of older (only slightly older) data to use for our temporal comparison, and a similar amount of data for our spatial comparison of species occurrence. We were fortunate, however, in having information on species occurrence at the Historic Site and surrounding area and breeding habitat classes from two local expert reviewers. See below for information on these reviewers.

4.10.5. Sources of Expertise

The Breeding Landbirds section (particularly tables 4.10.4-2 through 4.10.4-5) was reviewed by two local experts. Kelly Bryan, a retired Texas Parks and Wildlife Department manager, is presently conducting a field project on the status and distribution of the hummingbirds of west Texas. In addition to reviewing the chapter and providing input on the tables mentioned, Mr. Bryan provided the information that appears in Table 4.10.4-1 and Appendix H. Joshua Burns is a retired architect and a birder since 1974. He has participated in Christmas Bird Counts, Breeding Bird Surveys, and other projects in Texas, Utah, Arizona. In addition to providing comments on the tables and our use of the BBSs, he provided a spreadsheet containing breeding season, seasonal, and monthly data on birds from his 134 birding trips to the park. We presented some of his data in Appendix G.

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Table 4.10.4-5. Species detected at Fort Davis NHS during 2010-2013 RMBO surveys (and 2005-2006 breeding season surveys by Meyer and Griffin 2011) that have also been identified as species of concern on one or more watch list. Species are organized by whether they have high, moderate, or low potential for the Historic Site to contribute to their conservation. Information on Range Status and Breeding Habitat Class provided by/reviewed by local bird expert Kelly Bryan. Green highlights indicate migratory species not expected to breed at the Historic Site.

Common Name	Detected During		Range Status	Breeding Habitat Class	On Regional (R) or Continental/ Nationwide (C) Lists [1]
	2010-2013 Surveys (RMBO)	2005-2006 Breeding Season Sampling (Meyer & Griffin 2011)			
High Potential					
Black-chinned Sparrow	•		Year-round	Exists	C, R
Black-throated Sparrow	•	•	Year-round	Exists	C [2]
Cactus Wren	•	•	Year-round	Exists	C [2]
Canyon Towhee	•	•	Year-round	Exists	C [2]
Canyon Wren	•	•	Year-round	Exists	R
Cassin's Sparrow	•	•	Year-round	Exists	C, R
Curve-billed Thrasher	•		Year-round	Exists	C
Eastern Meadowlark	•		Year-round	Exists	R
Lark Sparrow	•	•	Summer resident	Exists	R
Montezuma Quail	•		Year-round	Exists	C, R
Phainopepla	•	•	Year-round	Exists	C
Rufous-crowned Sparrow	•	•	Year-round	Exists	R
Scott's Oriole	•	•	Summer resident	Exists	C, R
Summer Tanager	•	•	Summer resident	Exists	R
Verdin	•	•	Year-round	Exists	C
Moderate Potential					
American Kestrel		•	Year-round	Possibly Exists	-----
Black-tailed Gnatcatcher	•		Year-round	Possibly Exists	-----
Pyrrhuloxia	•		Year-round	Possibly Exists	-----
Scaled Quail	•		Year-round	Possibly Exists	-----
Western Scrub-jay	•	•	Year-round	Possibly Exists	-----
Low to No Potential					
Brewer's Sparrow	•		Wintering only	------	-----
Cave Swallow	•		Summer resident	Limited [3]	-----
Chihuahuan Raven	•		Migrant at Historic Site	------	----
Gray Flycatcher	•		Rare migrant only; breeds above 6,000 ft.	-----	-----
Green-tailed Towhee	•		Winter resident and migrant; breeds only above 7,000 ft.	-----	----
Virginia's Warbler	•		Migrant only; breeds above 6,500 ft.	-----	-----

[1] For High Potential species, C or R indicates whether species is on a Regional and/or Continental-wide list.

[2] Reviewer (Kelly Bryan) commented that the species is not of concern in the region; these species, and all with a "C" only, are found only on Continental lists (see note above also).

[3] Reviewer (Joshua Burns) reported that birds (no numbers indicated) are nesting under eaves of buildings at the park.

Table 4.10.4-6. Summary of the breeding landbirds indicator/measures and their contributions to the overall landbirds condition.

Indicator	Measures	Condition	Condition Rationale
Species Occurrence	Temporal Context	Good	Eighty-six percent of 44 species observed in the 2005-2006 breeding season bird inventories were observed in 2010-2013 RMBO bird surveys at the Historic Site. Of the six species not observed in recent surveys, only one is known to breed in the park (and falls into the "exists" habitat class). Additionally, 33 species were observed in the 2010-2013 RMBO surveys that were not observed in 2005-2006. In a temporal context, the condition of breeding landbirds at the Historic Site is good. Data are available for a relatively small number of years, so no trend information is available at this time.
	Spatial Context	Good or possibly Moderate	In a comparison of Breeding Bird Surveys (BBSs) in the general vicinity of the Historic Site to RMBO surveys within the Historic Site, there were 26 species that were not observed at the Historic Site during any of the years from 2010-2013. Thirteen of the 26 species fall into the "Limited to None" breeding habitat class, with most being winter residents or migrants only in the park. Of the 13 remaining species, all are within their breeding range and are year-round or summer residents. However, eight of the species are in the "Possibly Exists" category (with most of the eight known to breed near the park). Only five of the species fall into the "Exists" category, with breeding habitat at the park. It is very possible that these species may be detected in future breeding season surveys by RMBO at the park. Based on the comparison, the condition of breeding landbirds is good or possibly moderate. Because data are available for a relatively small number of years, no trend information is available at this time.
	Conservation Context	Good	There are 25 species that have been observed during 2010-2013 surveys (and one species observed in 2005-2006 only) that are listed by one or more organization as being of conservation concern. We believe that 15 of these species have high conservation potential at the Historic Site. These are species that are within their breeding range and sufficient habitat exists at the Historic Site to support breeding. It should be noted that some of the species are considered of conservation concern on regional lists only (e.g., Canyon Wren, Eastern Meadowlark), while others appear on continent-wide lists (e.g., Cactus Wren, Verdin). Many of the species were recorded in all four years of RMBO surveys. We consider the condition of species of conservation concern at the Historic Site to be good. We do not have sufficient data to justify a trend in the condition at this time.

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Upland vegetation and soil rapid assessment site for Fort Davis NHS' NRCA.

Chapter 5: Discussion of NRCA Findings and Considerations for Park Planning

5.1. Introduction

The primary purpose of the Natural Resource Condition Assessment (NRCA) Chapter 5 is to provide a "big picture" - broader application of resource condition findings (Albright 2010). We will fulfill this purpose by:

- creating a framework that connects the natural resource findings to Fort Davis National Historic Site's purpose, and significance statements
- delivering completed *State of the Park* natural resource condition summary tables and resource briefs for each of the topics assessed; and
- providing resource narratives for each assessed topic indicating data gaps and highlighting potential management and project considerations that were developed with park staff, if applicable.

These Chapter 5 reporting pieces are *value added* products that can be used by park managers for a variety of resource planning and comprehensive park management purposes (Jeff Albright, NRCA Program Coordinator, pers. comm. August 23, 2013). Additionally, efficiencies are gained by providing these "ready to use products" because they deliver information to park staff that directly meet other reporting requirements, such as those for the *State of the Park* report, or by providing information that can be easily modified as needed (re: resource management discussions) to be used for technical assistance requests or PMIS proposals as background information and problem statements, for other funding proposals, priority setting, or for interpretive purposes.

5.2. Connecting Natural Resource Condition Assessment Findings to Park Purpose and Significance

Managing the natural resources at Fort Davis NHS is inextricably tied to its historic purpose and significance. It is most often within this interdisciplinary perspective that managers consider potential actions and alternatives when addressing resource issues or needs. As such, we have created a table (Table 5.2-1) where natural resource topic relevance is

Table 5.2-1. Summary of natural resource topic relevance (denoted by black dots) as it relates to Fort Davis National Historic Site's purpose, significance, and fundamental resources and values as identified in NPS (2002).

Natural Resource Condition Assessment Topics	Viewshed	Night Sky	Soundscape	Air Quality	Geology	Groundwater	Dry Wash and Cottonwoods	Upland Vegetation	Exotic Plants	Landbirds
I. Park Purpose										
Perpetuate and conserve the cultural and natural resources of Fort Davis NHS	●	●	●	●	●	●	●	●	●	●
Educate the public about the influence of Fort Davis on the development and settlement of the Southwest and about the impact of military operations on American Indians			●							
II. Park Significance										
Fort Davis is one of the best remaining examples in the Southwest of a typical post–Civil War frontier fort because of the extent of the surviving structures and ruins.	●							●	●	●
Fort Davis provides an excellent opportunity for understanding and appreciating the important role played by African Americans in the West and specifically in the frontier army, because Black troops served at the post from 1867 to 1885.										
Fort Davis provided essential troops and supplies to the Victorio Campaign, which ended meaningful resistance of Apache bands in the Trans-Pecos.			●							
The historic integrity and character of the military post have not been significantly altered since its establishment. Much of the landscape immediately adjacent to the post has experienced little visible change.	●	●	●			●	●	●	●	
Fort Davis was strategically located to defend the Trans-Pecos portion of the San Antonio–El Paso Road and the Chihuahua Trail. This encompassed controlling activities on the southern portions of the Great Comanche War Trail and Mescalero Apache War Trails.	●		●		●			●	●	●

Literature Cited: National Park Service 2002

presented within a framework of the Historic Site's purpose and significance statements (NPS 2002). This provides a "snapshot" look at how each natural resource condition ties into the Historic Site's primary reasons for establishment.

All of the natural resource topics shown in Table 5.2-1 relate to Fort Davis NHS' purpose statement of "perpetuate and conserve the cultural and natural resources of Fort Davis NHS" (NPS 2002). These resources comprise not only the current Historic Site setting but were also integral to the site during the Fort's establishment and active period. The viewshed and soundscape are both important to interpreting life within the military fort, with bugle calls and dress retreat parades depicting the way-of-life at this remote location. The historic views, along with the geologic formations provided safety and defense against the rising tensions with Apache bands in the Trans-Pecos.

Fort Davis was established near Limpia Creek, providing a welcome and rare resource - water, especially in this arid environment. The area's surrounding geologic formations and trees provided a variety of building materials for constructing the Fort's structures, which are actively preserved and restored by Historic Site staff. All of these natural resources supported life in a rural and harsh landscape. The resources provided the backdrop from which Fort Davis came into existence and is still preserved for visitor enjoyment to this day.

The resource condition highlights for each resource topic, if applicable, will be presented in the *State of the Park* resource brief (section 5.3). Condition findings relative to potential resource issues/data gaps, opportunities and management considerations will be presented in the resource narratives section 5.4.

5.3. *State of the Park* Reporting

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2012).

The key purposes of each *State of the Park* report are to:

- Provide to visitors and the American public a snapshot of the status and trend

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Local materials such as groundwater and soils are used in the adobe brick making for historic structure restoration.

in the condition of a park's priority resources and values.

- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.
- Highlight park stewardship activities and accomplishments to maintain or improve the state of the park.
- Identify key issues and challenges facing the park to help inform park management planning.

The format for relevant *State of the Park* content in sections 5.4-5.14 will integrate resource condition findings into the required format for the Historic Site's *State of the Park* report, such that relevant pieces can easily be used for such reports. This includes an overall natural resource summary table showing the resource topic condition and rationale for overall condition ratings (Note: A summary of the Status and Trend symbols for condition ratings can be found in Chapter 3, Table 3.2.3-1). We then present each natural resource topic individually, including all indicators and/or measures by which resource topics were assessed. Finally, a resource brief summarizing the condition rationale, will follow the condition table and include any significant condition highlights and potential management considerations and opportunities.

Table 5.3-1 *State of the Park* Natural Resource Summary Table

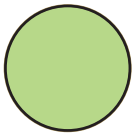
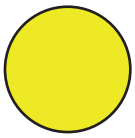
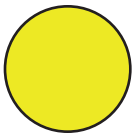
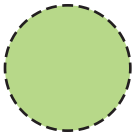
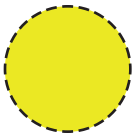
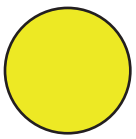
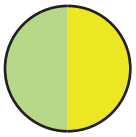
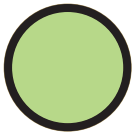
Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Natural Resources		
Viewshed		The viewshed at Fort Davis NHS is largely shielded by the canyon walls and vegetation toward town. As visitors climb in elevation for views from Sleeping Lion or the overlook, non-contributing features become more conspicuous. Overall, the viewshed condition is good and unchanging.
Night Sky		Quantitative modeling of sky brightness (all-sky anthropogenic light ratio) and a qualitative assessment of sky quality (the Bortle Dark Sky Scale) were used to assess the condition of the night sky. The overall condition of the Historic Site's night sky is good, based on the more reliable ALR modeling results.
Soundscape		We used two indicators, audibility and sound level, with a total of three measures, to assess the condition of the soundscape at the Historic Site. We found the current condition of the soundscape to be moderate - significant concern for percent time audible, moderate for on-site monitoring sound level, and good to moderate for the modeled sound level impact (Mennitt et al. 2013). Overall, we consider the soundscape to be in moderate condition, and do not have sufficient data to justify a trend.
Air Quality		Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen and total sulfur. All indicators and measures warranted moderate concern. No trends for ozone or wet deposition indicators could be determined due to lack of nearby monitoring stations. From 2000-2009, the visibility trend improved on the haziest days, while visibility on the clearest days showed no trend.
Geology		A geologic resource evaluation scoping summary was completed in 2008. No geologic concerns were identified, so condition is considered good until further assessment can be conducted.

Table 5.3-1 State of the Park Natural Resource Summary Table (continued)

Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Groundwater		The Historic Site has three groundwater wells on their property, located within the Alluvium and Tertiary Volcanic aquifer. To date, no groundwater levels have been recorded in these wells so water levels from a proxy well, located directly across the street and within the same aquifer, and records from another well located in a different aquifer but likely hydrologically connected, were used to assess groundwater condition at the Historic Site. Based upon the apparent decline of water levels, especially since 1992, we consider the resource to be in moderate condition with an indeterminate trend.
Dry Wash and Cottonwood Grove		We used two indicators to assess the condition of dry wash and historic cottonwood grove. The dry wash channel formation and bank stability varies and was in better condition along the higher areas vs. the lower sections closer to the Fort grounds. The historic cottonwood grove does not have a varied age distribution of trees and does not naturally recruit. Overall, we consider the dry wash and historic cottonwoods to be in moderate condition. The trend for each resource is uncertain.
Upland Vegetation and Soils		Both biotic integrity and soil/site stability indicate good condition at Fort Davis NHS. Soil/Site Stability was consistent with natural conditions. Soil cover and soil crust were rated in good condition, some erosion was evident and soil surface stability was rated moderate, but overall soil/site stability is in good condition. All measures of biotic integrity showed consistency with the range of variability that would be expected for those sites. Cover was generally dominated by perennial C4 grasses; there was a high level of species diversity; a good mixture of grasses, forbs, subshrubs, and shrubs; and disturbed areas (due to fire) are recovering well. There was little evidence of exotic species, though it is prudent to continue to assess this in light of shifts in climate or disturbance events. Biological integrity is assessed to be high, and in good condition.
Exotic Plants		For assessing the condition of exotic plants, we used two indicators and three measures that included an exotic plant's potential for significance of impact to the native plant communities throughout the Historic Site as well as the plants prevalence. We consider the overall condition for exotic plants at Fort Davis NHS to be in a good to moderate condition with an unknown trend.
Breeding Landbirds		We used one indicator, species occurrence (presence/absence), in three separate contexts (or measures; temporal, spatial, and conservation), to assess the condition of breeding landbirds at the Historic Site. We found the overall current condition of breeding landbirds to be good. We do not have sufficient data to justify a trend in the condition at this time.

5.4. Viewshed Resource Brief and Narrative

5.4.1. Noteworthy Highlights

From a cultural and historical perspective, the views surrounding Fort Davis NHS are not just about the scenery, but rather an important way to better understand life in a frontier fort. Historians consider Fort Davis NHS to be one of the best remaining examples of a frontier military post in the American Southwest. Visitors can explore the restored and refurnished buildings to get a sense of what life was like, see the remains (ruins) of other buildings that made up the Fort, and experience the natural setting in a condition similar to the way it was at the time the Fort was occupied. In addition, hiking trails within the Historic Site connect with trails in adjacent Davis Mountains State Park, where visitors can get an aerial view of the Fort.

5.4.2. Condition Rationale

Based on this assessment, the viewshed condition at Fort Davis NHS is considered good. While some non-contributing features such as developments are conspicuous from higher vantage points, the natural and historic features are largely intact and from a ground-based view, non-contributing features are less conspicuous. Because the Historic Site is adjacent to the state park, much of the viewshed is likely to remain protected.

5.4.3. Management and Project Considerations and Narrative

The Historic Site's viewshed is significant to the integrity of the historic context of the Fort and has the potential to be altered in adverse way(s). The town of Fort Davis is a historic town that attracts visitors and has a locally active support group who work to preserve the character and integrity of the beautiful Davis Mountains setting. In 2012, the group worked to ensure that a new business

Table 5.4.2-1. Summary of overall viewshed condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Viewshed			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Scenic and Historic Integrity	Intactness of View		Views within the Historic Site to the north, west, and east are framed by the box canyon and maintain a high degree of integrity. The views are dominated by natural features of the canyon and historic features of the fort buildings (both restored and ruins) and parade grounds. Non-contributing features exist, but they do not dominate the view. The sense of place is largely retained.
	Conspicuousness of Noncontributing Features		Non-contributing features to the south and east are mostly shielded by vegetation. The view to the east of the parking lot and town buildings are fairly conspicuous. The town of Fort Davis existed during the time of the fort, but has certainly grown over time, and the light-colored buildings contrast more and are conspicuous. To the west, there is a road that winds up a hill to homes on the hillside, and those are also somewhat conspicuous. Views from ground level are mostly shielded from non-contributing features. Once the vantage point rises (as in Sleeping Lion and the Overlook), more terrain is visible, and the non-contributing features become more conspicuous.

blended within the surrounding environment to create a more visually pleasing look and feel and to maintain the historic feel of the town.

Potential future development proposals have the potential to significantly alter and negatively impact the Historic Site's viewshed. Examples include new communication towers, and alternative forms of energy development (e.g.,wind energy) that are being developed in the surrounding regions. In addition, the proximity of the Historic Site to homes in the town creates another potential for future visual intrusions.

Proactive strategies to preserve the Historic Site's viewshed may include promoting community partnerships/education about the landscape-scale resources (e.g., viewshed, night sky, soundscape). Information via brochures or meeting attendance can promote the benefits of working together to preserve the resources that make the town of Fort Davis and the Historic Site so unique. A toolkit has been developed "to aid parks in engaging in community conversations" titled, *A Call to Action #13: Stop Talking and Listen(C2A #13)* (NPS 2013). The toolkit is provided in the literature cited DVD for reference.

5.5. Night Sky Resource Brief and Narrative

5.5.1. Noteworthy Highlights

Natural dark skies are a valued resource for many reasons; they are an important factor for maintaining healthy biological systems and have an aesthetic appeal for recreational value. Night skies, and the objects that can be seen, also have strong cultural connections. For thousands of years, people have watched the night sky and told stories connected to the stars, planets, and constellations that they observe.

5.5.2. Condition Rationale

Night skies are part of the cultural landscape, and night sky interpretive programs at the park are an important component. Night sky viewing is protected by local ordinances surrounding McDonald Observatory; this helps keep the night sky in good condition at Fort Davis NHS.

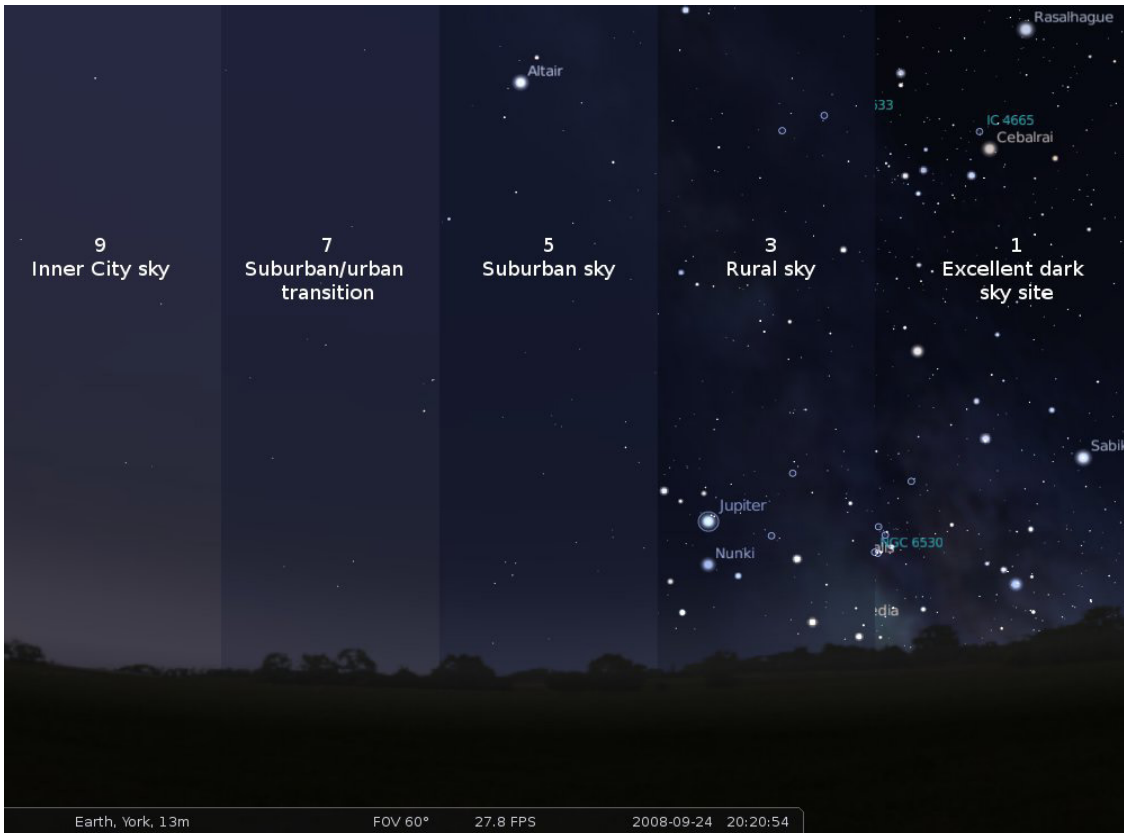
5.5.3. Management and Project Considerations and Narrative

The Texas Commission on Environmental Quality (TCEQ) has several air quality monitors located throughout the state to track trends on conditions that help to protect and preserve dark night skies. A monitoring site was located at the McDonald Observatory beginning in February 2003 through August 7, 2011 when it was shut down (TCEQ 2013). The station monitored for fine particulate matter (visibility), wind speed/direction, and temperature. A fully functional station is located at Big Bend National Park measuring all air quality parameters listed in this NRCA. Wet deposition and visibility stations are located at Guadalupe Mountains National Park as well.

Some management opportunities discussed during the on-site NRCA review meeting included building a stronger partnership with the McDonald Observatory to obtain program and night sky information. Also the Historic Site's Chief of Maintenance has been talking with McDonald Observatory staff about modifying the outdoor lighting to direct light down toward the ground and away from the sky to help preserve the darkness. However, a recent Fire Protection and Museum Security assessment for the Historic Site raised concerns regarding security and safety if adequate lighting does not exist on the premises (John Morlock, Fort Davis NHS Superintendent, pers. comm.).

Table 5.5.2-1. Summary of overall night sky condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Night Sky			
Indicators of Condition	Specific Measures	Condition Status/ Trend	Rationale
Sky Brightness	All-sky Anthropogenic Light Ratio		This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS; condition at Fort Davis NHS is good (0.08). No ground-based measurement has been collected, therefore, the confidence level in this assessment is medium.
Sky Quality	Bortle Dark-Sky Scale		Star gazing at Fort Davis NHS is very good for observing constellations, the Milky Way, and other celestial bodies. The qualitative assessment of good condition (Bortle class 2) reflects the high-quality night sky.



Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

5.6. Soundscape Resource Brief and Narrative

5.6.1. Condition Rationale

Soundscape condition was assessed using audibility and noise level. In general, the primary category of sounds heard at both sites during the day was traffic noise, comprising 91.9% and 71.5% of the daytime hours at the North Ridge Trail and Sleeping Lion Mtn. sites, respectively. Amplified music and recordings broadcast over the public address system were also audible but could not be separated from a general "voices" category, although the perecnt time audibility was infrequent enough to not warrant a change to the condition of this indicator. Based on the percent time audibility of noises recorded and because the General Management Plan Summary (NPS 2002) reports that bugle calls and recordings are used "to help cover up modern sounds from the parking area and adjacent highway," we consider the condition based on percent time audible to be of moderate - significant concern.

Measured sound levels were generally higher at the Sleeping Lion Mtn. site, which is closer to the Fort (and parking lot). At both sites, louder days correlated with higher wind conditions. Based on hourly data, louder sound levels occurred at night and early morning hours (and insect activity was present at night). The ambient sound level map from the modeling effort indicated that sound levels are highest (45 to <65 dBA) along the roads bordering the park (i.e., State Road 118, 17, and 17/118). The Historic Core is exposed to lower sound levels, so a visitor would not be exposed to the loudest areas for most of the time they are in the park. However, because there is a need to use recordings to help cover up the modern noises from the parking area and adjacent highway (NPS 2002), we consider the condition based on loudness to be moderate.

Modeled sound level impact was less than the recorded sound levels and predicted to be within the range of 4.6-4.9 dBA. This range is within a threshold for good to moderate condition when evaluating a park classified somewhere between a non-urban and urban park using NSNSD thresholds. When combining all indicators and measures, we consider the overall soundscape condition of Fort Davis NHS' soundscape to be moderate.

Appropriate sounds at Fort Davis NHS include the cultural sounds of the historic context, such as the small arms demonstration shown here, as well as the natural sounds of the Fort's setting.

Table 5.6.2-1. Summary of overall soundscape condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Soundscape			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Audibility	% Time Audible		The mean percent time audible (during the day) of all non-natural sounds was 91.9% and 71.5% of the time at N. Ridge Trail and Sleeping Lion Mtn., respectively, indicating that noises could be heard more than half of the 7am-7pm monitoring period. This warranted moderate - significant concern, especially given the prevalence of audible traffic noise at the North Ridge Trail, which is in the natural backdrop resource opportunity area as identified in the Historic Site's GMP (NPS 2002).
Sound Level	Amplitude (on-site monitoring)		The loudest sounds heard occurred at night (compared to day) at both sites. Measured sound levels were generally higher at Sleeping Lion Mtn. (closer to the Fort and parking lot and highway). Louder days correlated with higher wind conditions. Modeled sound levels showed that levels are highest (45 to <65 dBA) along the roads bordering the park (i.e., State Road 118, 17, and 17/118) (NPS 2013). The Historic Core is exposed to lower sound levels, so a visitor would not be exposed to the loudest areas for most of the time they are in the park. However, again, because there is a need to use dress retreat parade recordings to help cover up the modern noises from the parking area and adjacent highway (NPS 2002), we consider the condition to be moderate.
	Amplitude (Mennitt et al. (2013) modeled sound level impact)		The modeled impact sound level for the Historic Site ranged between 4.6-4.9 dBA. This range is within a threshold for good to moderate concern when evaluating a park classified somewhere between a non-urban and urban park using NSNSD thresholds.

5.6.2. Management and Project Considerations and Narrative

Historic Site staff identified potential areas of concern related to the soundscape, including increasing commercial truck and motorcycle traffic travelling along the highways that flank the site's boundary, cloud bursting explosions that create a sonic boom, and the potential of international trade increasing traffic volume due to a relatively close port of entry along the international border.

Soundscape Study

While an acoustical monitoring study was conducted for the Historic Site in 2010, it did not differentiate between cultural-related sounds and other anthropogenic noise. These cultural sounds are integral to the park's purpose, which is evidenced by the military Retreat Parade audio program. As such, Historic Site managers require a more detailed analysis of the noises recorded at both monitoring locations used in the NPS (2013) study in order to better understand soundscape conditions and to develop a management plan accordingly.

Additionally, staff are concerned about the impact upon visitor experience due to rising levels and frequency of traffic noise resulting from increasing international commerce traffic outside the park boundary. A seemingly increasing number of motorcycle tours visit the Historic Site and surrounding area as well. Consequently, of particular concern, are current noise levels from motorcycles and semi-trucks and potential mitigation techniques that may improve soundscape condition at the Historic Site.

Donna Shorrock, NRCA Coordinator for the National Park Service Intermountain Region, wrote two technical assistance requests for the Historic Site to:

- conduct a targeted acoustic assessment to identify any increased noise from traffic and to evaluate candidacy for quiet pavement, and
- provide additional analyses and new report to identify specific non-contributing vs desired (i.e., related to fort activities) sounds from baseline acoustical monitoring data collected in 2010.

The technical assistance requests are listed below.

FY 2014 Technical Assistance Request Form

Park: Fort Davis National Historic Site	**Region:** Intermountain
Fiscal Year: 2015	**Estimated Time:** NSNSD to determine based upon request
Program Area: Soundscapes/Acoustical Assistance	
Title: Additional analyses to identify specific noncontributing vs desired (i.e., related to fort activities) sounds from baseline acoustical monitoring report based on recordings taken in 2010	
Problem Statement: (A brief summary of the issue, including information pertaining to park management prescriptions/management objectives tied to the issue, known resources at risk, etc.)	
FODA's 2010 acoustical monitoring study did not differentiate between cultural-related noise and other noncontributing anthropogenic noise. As a cultural site, FODA managers require a more detailed analysis of the "other human" noise category at both monitoring locations in order to better understand current conditions and develop a management plan accordingly. These cultural sounds are integral to the park's purpose, which is evidenced by the daily military Retreat Parade audio program that is played daily at 11 am, 2pm, and 4pm for park visitors. It is stated in the park's General Management Plan (NPS 2002, p24) that this audio program is played "to help cover up the modern noises from the parking area and the adjacent highway." These more detailed analyses will help identify the times of day, the types of sounds, including cultural-related, the percent time audibility of sounds heard, and any distinction between the two monitoring locations (e.g., more natural sounds vs. noises heard).	
What are you asking the NRSS to do? (Tied to already scheduled construction project or GMP? Provide consultation, protocol development, scoping, report writing, position paper, product development, etc.) 1) re-analyze 2010 data files and provide information to the park for soundscape planning and impacts analysis (narrative report, graphs, charts, audio files, etc). Include weekdays and weekends- the Retreat Parade audio program is played three times per day at 11am, 2pm, and 4pm.- and include as many days as possible in the reanalysis, especially to serve as an additional baseline to the traffic noise assessment that is identified in a separate request. 2) help to identify appropriate indicators and standards for monitoring desired cultural sounds and managing park soundscapes	
Target Expertise: This project requires appropriate technical expertise to process and interpret existing data (such as audibility logs and/or collected sound files), so that cultural-related noise appropriate for an historic fort setting and undesired, modern noise can be parsed apart and reported separately.	
What alternatives does the park have to accomplish the work? The park lacks the technical expertise to perform the analyses. Without the requested assistance, the data will not be analyzed and will not be useful to park managers.	
Park has Superintendent Approval? Yes	**Travel Needs (No travel, Park will provide assistance, Request NRSS assistance, Unknown):** Travel funding assistance and available government housing is very likely.
Park has Travel Funding? Likely	**Requires Private Land Access?**

Expected Date of Completion?	**Multi-Year Project?**

Park Contacts:
John Morlock, 432-426-3224 x 221, john_morlock@nps.gov
John Heiner, 432- 426-3224 x 223, john_heiner@nps.gov

FY 2014 Technical Assistance Request Form

Park: Fort Davis National Historic Site	**Region:** Intermountain
Fiscal Year: 2015	**Estimated Time:** 80+ hours
Program Area: Soundscapes/Acoustical Assistance	
Title: Conduct Targeted Acoustic Assessment at FODA to Identify any Increased Noise from Traffic and to Evaluate Candidacy for Quiet Pavement	
Problem Statement: (A brief summary of the issue, including information pertaining to park management prescriptions/management objectives tied to the issue, known resources at risk, etc.)	
Two of the primary management objectives of Fort Davis NHS that were stated in the 1988 Resource Management Plan are: 1. To stabilize, preserve, and protect the historical resources and to perpetuate the natural-landscape qualities that contribute to their significance in the manner that is consistent with historic preservation 1aw and current National Park Service Management Policies. 2. To foster appreciation and understanding of the significance of Fort Davis, with emphasis upon the life and activities in a west Texas frontier military fort in the mid to late l9th century, by providing varied and balanced interpretive opportunities. The park is concerned about the impact upon visitor experience due to rising levels and frequency of traffic noise resulting from increasing international commerce traffic outside the park boundary due to increase in commerce traffic crossing at Presidio – Ojinaga Port of Entry. Additionally, a seemingly increasing number of motorcycle tours visit the historic site and surrounding area. Consequently, of particular concern are noise levels from motorcycles and semi-trucks.	
The park wants to measure the sound levels from the road at various locations in the site.	
Target Expertise: Someone experienced with developing soundscape standards & identifying and implementing methods for assessment of soundscape conditions.	
What are you asking the NRSS to do? Provide consultation for development of a soundscape assessment program to include: 1) identifying and implementing indicators of soundscape quality; 2) identifying and implementing methods for assessment of current and future soundscape conditions to ensure that quality standards are being met; 3) identifying processes to eliminate or mitigate sources of sound that are not appropriate to park purposes and management objectives. Focus will be on identifying traffic noise level and other relevant metrics. Assistance is also requested to evaluate the area surrounding FODA for quiet pavement or other noise mitigation measures. A monitoring effort near the road would serve as baseline documentation of the "before" condition prior to quiet pavement installation. Ideally, a second study could be conducted in order to measure the "after" condition. It's fair to argue that proximity to a national historic site in itself makes the surrounding roads candidates for quiet pavement (with road safety being the ultimate goal). 1. Develop a plan for conducting a targeted acoustic survey at the park. 2. Conduct the acoustic modelling or acoustic survey work, or alternatively, develop and manage a contractor to conduct the work. 3. Identify management and mitigation measures for noise pollution. 4. Compile this information in a technical report, formatted for the Natural Resource Technical Series, and available on IRMA (https://irma.nps.gov). Uncertain when to conduct monitoring, perhaps mid-spring.	

What alternatives does the park have to accomplish the work? Park staff can provide a general framework for a soundscape assessment program by providing park specific information concerning present and potential sources of noise pollution. But expertise relating to soundscape standards, indicators, noise modeling, and monitoring is lacking to develop a soundscape assessment program.	
Park has Superintendent Approval? Yes	**Travel Needs** Travel funding assistance and available government housing is very likely.
Park has Travel Funding? Likely	**Requires Private Land Access?**
Expected Date of Completion?	**Multi-Year Project?**

Park Contacts:
John Morlock, 432-426-3224 x 221, john_morlock@nps.gov
John Heiner, 432- 426-3224 x 223, john_heiner@nps.gov

5.7. Air Quality Resource Brief and Narrative

5.7.1. Condition Rationale

There are different facets to air quality monitoring including measuring ozone levels, visibility conditions, and wet deposition levels. Currently, all air quality indicators and measures are in moderate condition at the Historic Site. The Historic Site contains four ozone-sensitive plant species, all of which are bioindicators. No trends are reported for the ozone and wet deposition air quality indicators. From 2000-2009, the visibility trend improved on the haziest days, while visibility on the clearest days showed no trend. The Historic Site's air quality is largely influenced by activities and operations that occur outside its boundary, and the future of its air quality condition is ultimately dependent on local, regional, and national planning.

5.7.2. Management and Project Considerations and Narrative

The Historic Site's air quality condition is currently represented by interpolated values using data from surrounding monitoring sites. Both Big Bend and Guadalupe Mountains National Parks have monitoring stations for visibility and wet deposition and Big Bend NP also monitors ozone. The Historic Site staff advocate for continued monitoring at these locations to help inform local air quality conditions. Local monitoring of lichens may also provide data that informs air quality condition at the Historic Site.

Table 5.7.1-1. Summary of overall air quality condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Air Quality			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Visibility	Haze Index		For 2006–2010, estimated average visibility in the Historic Site was 6.2 deciviews above natural conditions, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. From 2000-2009, the visibility trend improved on the haziest days, while visibility on the clearest days showed no trend.
Ozone	Annual 4th-Highest 8-hour Concentration		The estimated ozone level for 2006–2010 at the Historic Site was 68.8 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. Four ozone-sensitive plants are found in the Historic Site, and all are bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitoring stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr		For 2006–2010, estimated wet nitrogen deposition was 1.7 kilograms per hectare per year, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitoring stations.
	Total S in kg/ha/yr		For 2006–2010, estimated wet sulfur deposition was 1.2 kilograms per hectare per year, therefore, the resource is in moderate condition based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitoring stations.

5.8. Geology Resource Brief and Narrative

5.8.1. Noteworthy Highlights

Fort Davis National Historic Site (NHS) is located in a box canyon near Limpia Creek on the eastern side of the Davis Mountains, the most extensive mountain range in Texas. From 1854 to 1891 when the Fort was occupied, most of the buildings at the Fort were adobe, however, the nearby cliffs of red volcanic tuff provided material for foundations, as well as stone for the officers' quarters. The source for building materials was the Tertiary volcanics that flank the flat, bajada-like terrain where the Fort's parade grounds and buildings rest.

Volcanic activity surrounding Fort Davis NHS ended 20 million years ago; however, most of rock types that will appear on the digital geologic map are volcanic: rhyolite, tuff, basalt, and sedimentary deposits between flows. Some units may be particularly interesting and enjoyable to interpret, for example, ignimbrites—rock formed by the widespread emplacement of ash flows and swiftly flowing nuées ardentes. In addition, the Davis Mountain volcanic field and Buckhorn Caldera express a violent geologic past and may be of interest to visitors (KellerLynn 2008).

These rocks create microhabitats that retain moisture and provide shade. This creates an environment that supports a variety of plants and other species that may otherwise be absent without these unique features.

5.8.2. Condition Rationale

Geologic resources serve as the foundation of ecosystems and yield important information needed for science-based decision making in National Park System units. Geology is a major determinant of topography, water and soil chemistry, fertility of soils, stability of hill slopes, and flow styles of surface water and groundwater. These factors, in turn, influence biology, including the distribution of habitats and the locations of threatened and endangered species. Geology also influences human settlement patterns and how people use natural resources—for farming, ranching, industry, construction, hunting, fishing, and recreation. Landforms, such as the box canyon where the fort is located, probably figured in the location of the Fort.

A geologic resource evaluation scoping report was completed in 2008. There are no geologic concerns identified, and the Historic Site is considered in good condition.

5.8.3. Management and Project Considerations and Narrative

Please refer to dry wash topic for discussion of rock formations relative to gully depth and capacity to carry floodwaters.

Table 5.8.2-1. Summary of overall geology condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Geology			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Geologic Integrity	None		The integrity of the geologic resources at Fort Davis NHS is intact, there are no geologic concerns, and a resource evaluation scoping report was completed for this site.

5.9. Groundwater Resource Brief and Narrative

5.9.1. Condition Rationale

For assessing the condition of the groundwater resource at the Historic Site, we chose one indicator (change in groundwater elevation). In general, it appears as if the groundwater level within the Alluvium and Tertiary Volcanic Aquifer near the Historic Site has been declining. It's worth mentioning that there have been no significant water level declines in wells measured by the Texas Water Development Board throughout the Volcanics Aquifer (George et al. 2011), which is where the second proxy well was located for the purposes of the condition assessment. If there is inter-aquifer connection between the Volcanics and Alluvium and Tertiary Volcanics aquifers, the declining level in the Alluvium and Tertiary Volcanics aquifer may be less of an overall concern. However, at this time, we consider the groundwater resource at the Historic Site to be of moderate condition, with an unknown trend due to lack of site-specific information. We also assigned a low confidence level since we do not know the cause of decline.

5.9.2. Management and Project Considerations and Narrative

Historic site staff identified the groundwater resource as their highest management priority. With prolonged drought conditions in an already arid environment and increased usage of groundwater, both within and outside park boundaries, more efficient and effective ways of managing the culturally significant cottonwood trees is desired. On-site groundwater level monitoring will provide the most accurate information to determine the groundwater condition at the Historic Site. Historic Site staff have already begun the process of purchasing and coordinating the implementation of groundwater monitoring devices with Jeff Bennett, Big Bend National Park Hydrologist, and with hydrologists from the NPS Water Resources Division. Larry Martin, with the NPS-Water Resources Division, is writing a groundwater monitoring plan for the Historic Site (L. Martin, NPS-Water Resources Division, pers.comm.).

Table 5.9.1-1. Summary of overall groundwater condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Groundwater			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Groundwater	Change in Groundwater Level		The groundwater level records for well #5225309, which is located in the same aquifer as two of the Historic Site's wells, indicate a rather variable fluctuation in water table elevation, with apparent decline (but indeterminate trend). Well #5225308, located in the Volcanics Aquifer, may be hydrologically connected to the park's wells and does not exhibit significant water level declines according to George et al. (2011). Overall, we consider the Historic Site's groundwater condition to be moderate

5.10. Dry Wash and Historic Cottonwoods Resource Brief and Narrative

5.10.1. Noteworthy Highlights

The historic cottonwood grove at the Historic Site contains trees that were planted by officers' wives during the active period of the Fort. The grove currently contains the first- and second-largest Rio Grande cottonwoods in the state.

5.10.2. Condition Rationale

Using the two measures of channel formation and slope stability we consider the dry wash (overall) to be in moderate condition. There are varying degrees of erosion/slope stability and channel formation, with the upper washes being in better condition than the lower washes. This is primarily due to vegetation cover, which provides bank stability, and the steeper slope affords more channel incision to occur. Also, the hand-dug channels/ditches are located on the alluvial fan, which doesn't typically have well confined channels.

A concern for the lower portion of the channel is the potential for the failing dam to break, which would rapidly release accumulated sediment, most likely overloading the current hand-dug ditch/wash diversion channels. We consider the dry wash areas to be in moderate condition.

Using one indicator of cottonwood grove health, we consider condition to be moderate. There is not a desirable age distribution of trees and no new, young trees are recruiting into the stand because conditions are not conducive for their natural establishment. NPS personnel supply supplemental water to maintain the trees. While there are trees younger than the oldest ones

Table 5.10.2-1. Summary of overall dry wash and historic cottonwood grove condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Dry Wash and Historic Cottonwood Grove			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Dry Wash	Channel Formation		Upper areas of the wash had good channel formation, including some sinuosity, which will help dissipate flow energy during rain events. Below Church Camp, the channel became less confined and began the formation of an alluvial fan, typical of a semi-arid environment. The alluvial soils in this section of the channel showed signs of erosion. There was minimal channel formation beyond the Fort. There is concern regarding the failing dam within the Historic Site and the potential to fill the channels with sediment, decreasing the ability to convey flood waters.
	Bank Stability		Expected species (bulb panicgrass and bristlegrass) were present in the bed and on the banks (Emory oak and net-leaf hackberry), providing stability within the upper washes. Lower areas of the wash were less vegetated and early successional forbs were more prevalent. At still lower portions of the wash (where the ditches are present), exotic grasses and forbs were present and in some areas vegetation was absent.
Cottonwood Grove Health	Age Structure		The historic cottonwood grove does not have a wide distribution of age classes. No new, young trees are naturally recruiting into the grove because conditions are not conducive for their natural establishment, Younger trees have been planted to maintain the historic setting but will require routine maintenance and resources to persist.

that are presently weakening and dying, the grove is not self-sustaining. Currently, visitors are not permitted within the immediate area due to the hazard of falling branches.

5.10.3. Management and Project Considerations and Narrative

In 2013, Historic Site staff began the process of incrementally notching the failing dam, with a goal of gradually releasing the sediment that has built up behind it. Barring any extreme rainfall events, a partial notch combined with the grass roots holding the sediment should ensure a slow release of sediment that will not harm the established vegetation and channels. Once the sediment load behind the dam is somewhat reduced, a second, deeper notch in the dam will be made to continue the incremental release process.

In addition, Historic Site staff removed sediment from one of the hand-dug ditches to proactively manage sediment accumulation within the channel. Some soil slumping, vegetation uprooting, and bank destabilization occurred as a result (Figure 5.10.3-1). Michael Martin, Hydrologist with NPS Water Resources Division, was consulted about this issue since he has been on-site and conducted a flood hazard assessment (Martin 1999) and evaluated the Historic Site's flood mitigation plan (Martin 2008). He suggested slightly reconfiguring the sides and laying the banks back at a 45° angle and periodically removing the slumping that occurs as part of routine maintenance(M. Martin, NPS-WRD Hydrologist, pers. comm.).


K. STRUTHERS

Figure 5.10.3-1 Sediment was removed from a dry wash channel to improve flood water conveyance capacity.

5.11. Upland Vegetation and Soils Resource Brief and Narrative

5.11.1. Noteworthy Highlights

Despite its relatively small size, Fort Davis NHS supports 22 different associations of plants. These plant associations are typical of the broadly defined desert grassland/shrub-steppe borderlands of New Mexico, Texas, and northern Mexico (Apacherian-Chihuahuan region) and the desert scrub groups of the Chihuahuan Desert. Many areas of the park exhibit characteristics of both regions, having rich and diverse perennial grass, shrub, and succulent cover. Topographic and edaphic variation drive the majority of these differences across these species' ranges with the colluvial slopes, ridges, and upper bajadas supporting scrub communities, and lower slopes and flatlands containing the semi-desert grasslands and steppe communities. Overall, the upland vegetation and soils are in good condition.

5.11.2. Condition Rationale

For assessing the condition of grasslands, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the condition of the Historic Site's grasslands, upland vegetation communities, and soils. Grassland condition can be assessed from many different angles, but we chose two main categories for this resource—biotic integrity and soil/site stability. Based on the indicators, data, and expert opinion, we consider the overall condition of the grasslands at Fort Davis NHS to be in good condition.

5.11.3. Management and Project Considerations and Narrative

The following management discussion is excerpted from the Historic Site's (FODA) Fire Management Plan (FMP) and Environmental Assessment (EA) (Ecosystem Management, Inc. March 2014, pp. 4-5).

"FODA is proposing a new FMP to address changes in the vegetation resulting from land use changes since the historic periods, fire suppression, and drought events and to address updates in the national fire policy terminology.

Historically, the landscape was more open with fewer shrubs due to intense human activities in the area, such as grazing of domestic livestock. The grazing reduced the density and continuity of herbaceous fuels important to fire frequency and spread. These grazing practices reduced grasslands and favored increased shrub density and introduction of non-native invasive species (Grover and Musick 1990, Haynie 2000). Change in land use from intense grazing and human activities (e.g., firewood gathering), then suppression of wildfires, followed by cessation of grazing and tree cutting has resulted in more dense woody vegetation than historic periods and shrub encroachment. Hazardous fuel loads have increased with increasing brush densities, ladder fuels, and accumulation of dead and down woody debris. The current fuel loads increase the potential for more intense wildfires and associated risk to visitors, employees, cultural and natural resources, NPS structures, and neighboring lands. The vegetation needs to be actively managed to reduce hazardous fuel loads and risk to life and property and to help perpetuate the vegetation conditions that developed during historic periods of cultural significance—frontier military posts active from 1854 to 1862 and 1867 to 1891—that NPS is mandated to interpret and protect.

Restoring vegetation communities in FODA would also help to restore some of the ecological integrity of fire-adapted vegetation communities and associated wildlife species. Periodic disturbances such as fire contribute to ecological diversity because moderate levels of disturbance provide opportunities for a larger number of species (Connell 1978). A new FMP would provide FODA with a means to continue to use prescribed fire and manual and mechanical vegetation treatments to manage hazardous fuel loads, protect sensitive sites, restore cultural landscapes,

and control invasive plant species. FODA is also considering limited herbicide application as a follow up vegetation management tool to help prevent the encroachment of invasive and/or exotic plant species and to eliminate already present exotic species. Limited herbicide treatments would consist of spot treatments of individual plants or groups of individual plants. The use of prescribed fire, manual and mechanical treatments, and limited herbicide as fire management tools would provide a means to continue protecting life, property and resources from unwanted wildland fire in a safe and efficient manner.

In summary the following objectives of this proposed action are:

- To protect human life and safely conduct all wildland fire management activities.
- To conduct vegetation management activities including prescribed fire and manual methods of fuel reduction as a means to reduce hazardous fuels and restore cultural landscapes and natural resource processes.
- To consider targeted herbicide application as a limited vegetation management tool.
- To provide effective rehabilitation of wildfire areas—that is rehabilitation of fire suppression impacts and Burned Area Emergency Rehab (BAER).
- To continue and increase interagency cooperation and coordination, and public outreach about FODA fire management and restoration activities.
- To update fire policy and terminology language and discussions.
- To continue active research and monitoring of fire program field actions, by supporting sound resource management and research science, and utilize adaptive management to improve the program."

Table 5.11.2-1. Summary of overall upland vegetation and soils condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Upland Vegetation and Soils			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Soil/Site Stability and Hydrologic Function	Soil Cover		Total cover of the sites is very high with little exposed bare soil (bare soil without vegetative cover averaged less than 10%). Litter and woody debris cover ranges from 6% to 25%. Gravel, rocks, and bedrock dominate and protect the soil surface.
	Biological Soil Crust		A variety of biological soil crusts were found, with mosses, lichens, and some cyanobacteria documented. The presence and extent of the crusts indicate good condition
	Soil Surface Stability		Overall, the soil aggregate stability of the sites is moderate; some signs of erosion were present, but soils are considered to be fairly stable. Field assessments noted the good condition and stability of the sites and soils.

Table 5.12.2-1 Continued: Summary of overall upland vegetation and soils condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Upland Vegetation and Soils			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Biotic Integrity	Landscape-scale Diversity		Species composition is consistent with expected species based on spatial patterns of soils and disturbance; vegetation communities reflect the natural range of variation.
	Local Species Composition		Species composition is consistent with expected species; field notes indicate the lack of exotics (all native species), high diversity, and vigorous growth.
	Response of Annual Species to Disturbance		The extent to which annual species persist in sites not recently disturbed, compared to undisturbed and recently disturbed sites. How an ecosystem responds to disturbance is an important measure of resilience and integrity.
	Relative Proportion of Functional Groups		The relative proportions of functional groups are consistent with what would be expected; there was a good diversity of grasses, forbs, subshrubs, and shrubs.
	Relative Proportion of C3 and C4 species		The relative proportions of C3 and C4 plants are consistent with what would be expected based on site characteristics; all sites had C4 grasses and C3 shrubs.

5.12. Exotic Plants Resource Brief and Narrative

5.12.1. Noteworthy Highlights

The upland and higher-elevation areas of the Historic Site are in good overall condition relative to exotic plants. The Historic Site staff has actively managed their King Ranch bluestem infestations. This approach of managing before plants set seed has been successful, and the number of species seen along the roadways throughout the Historic Site by Chihuahuan Desert Inventory and Monitoring Network (CHDN) staff is greatly reduced as a result of proactive management through early detections and rapid responses (J. Horsley, Exotic Plants Lead, pers. comm.).

5.12.2. Condition Rationale

Several factors contribute to an exotic plant's ability to threaten the integrity of a native ecosystem, including its current extent, density, and potential for ecological impact based upon its life history characteristics. Also, the location where an exotic is found has implications pertaining to its establishment and potential control measures. Most of the exotic plant infestations were found along the blocks along roads and trails and in the burned area monitoring sites versus during the one-time rapid assessment. The exceptions to this were *Tribulus terrestris* (puncturevine) and *Portulaca oleracea* (little hogweed) which were each present in the majority of the randomly-distributed Rockhouse Fire plots. Four species (*Bothriochloa ischaemum (*king ranch bluestem), *Convolvulus arvensis* (field bindweed), *Salsola kali* (Russian thistle), and *Sorghum halepense* (Johnsongrass) were considered to be of highest concern due to their significant ability to alter native plant communities and their prevalence throughout the Historic Site. An additional eight species were of moderate concern due to either high impact rankings and low prevalence or due to their moderate impact rankings and higher prevalence. Overall, the impact ranking measure for all exotic plants found throughout the Historic Site was considered to be of moderate to significant concern but the prevalence measures were in good condition, in large part, due to the efforts of a successful early detection and rapid response program. The condition of exotic plants at the Historic Site is good to moderate.

5.12.3. Management and Project Considerations and Narrative

Historic Site staff identified the need for an exotic plants management program to aide with the prioritization and integrated management of exotic plant species due to limited park resources. So far, the proactive management strategies employed by CHDN staff for early detection of new exotic plants and/or increasing populations and by Historic Site staff for rapid responses through implementing effective control techniques have been very successful.

Prioritizing species that have yet to become established but are considered to have a high degree of impact on native ecosystems, such as Redstem stork's bill or Mediterranean lovegrass, is a recommended management strategy in addition to implementing a mowing protocol that aims at preventing the spread of exotic plant seeds and propagules for species like field bindweed. The benefits of continuing to implement an early detection and rapid response management strategy to control exotic plants far outweigh the costs associated with delayed treatment responses.

To help with identifying effective types and timing of exotic plant treatments, we have included literature on the final NRCA disk for several of the exotic plant species found throughout the Historic Site. As part of our approach while researching information to complete Hiebert and Stubbendieck's (1993) significance of impact ranking questions, we collected several literature sources for many of the exotic plants at the park, containing information pertaining to effective

Table 5.12.2-1. Summary of overall exotic plants condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Exotic Plants			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Potential to Alter Native Plant Communities	Significance of Exotic Plant Impact		This measure is based on the premise that species with the largest negative impacts on native plant ecosystems generally cause the most severe problems. Four species (16% of total) ranked highest and five (20%) ranked high for significance of impact. This represents 36% of all exotics plants found throughout the NHS. Only 28% of the plants were considered to be of low impact and 35% were moderate. Given the relatively high percentage for the highest and high impact rankings, we consider this measure to be of moderate to significant concern.
Prevalence of Exotic Plant	Extent of Plant		Seven exotic species were found in greater than 10% of the high-priority blocks between 2011-2013, three of which are considered to be of highest concern for impact. Only one species, *Salsola kali*, was found in greater than 10% of the rapid assessment plots but is one of the species of high concern of impact as well. With the exception of *Salsola kali*, it appears that the extent of exotic plants is restricted to the blocks along roads and trails and in the burned areas vs. interior. We consider this measure to be in good condition.
	Density of Plant		Most exotic species were found growing in low densities throughout the Historic Site, and none of them were found forming populations within the highest density class (matrix). There are two species of highest concern forming scattered to even density patches, but overall this measure is considered to be in good condition at the NHS.

control techniques. This information may assist Historic Site staff in the future as they continue to manage these infestations.

5.13. Breeding Landbirds Resource Brief and Narrative

5.13.1. Noteworthy Highlights

Based on two sets of surveys (in 2004-2006 and 2010-2013), a total of 127 bird species have been reported to occur at the Historic Site, with 71 of the species observed during 2010-2013 Rocky Mountain Bird Observatory (RMBO) surveys. Some of these 127 species are winter residents or migrants only, and do not actually breed in the park. Based on this and other existing information, a local ornithologist compiled a list containing 81 species that breed or potentially breed in the Historic Site (Bryan 2014). Twenty-six species (including one species observed in 2005-2006 only) observed by RMBO are considered species of conservation concern by one or more organization. Fifteen of these 26 species have high conservation potential at the Historic Site, because they are within their normal breeding range and breeding habitat exists for them at the park. Many of the species were observed in all four years of RMBO surveys (2010-2013) at the park.

5.13.2. Condition Rationale

The condition of breeding landbirds at the Historic Site, assessed using one indicator, species occurrence (presence/absence), is good. We evaluated species occurrence using three measures/in three contexts (temporal, spatial, and conservation contexts), all of which were determined to be in good condition (although one was considered good to moderate). The temporal species occurrence comparison found that, of 44 bird species detected at the Historic Site in 2005-2006, 38 were detected in recent RMBO surveys; six were not detected in recent surveys. However, of the six species, only one is known to breed in the park and falls into the "Exists" habitat class. Also, 33 additional species were observed only on recent (2010-2013) RMBO surveys. The spatial comparison found that 26 species were observed during nearby Breeding Bird Surveys but not at the Historic Site during RMBO surveys. Thirteen of the 26 species, however, are in the "Limited to None" breeding habitat class, with most being winter residents or migrants only in the park. Of the other 13 species, all are within their breeding range and are year-round or summer residents. However, eight of the species are only in the "Possibly Exists" category. Five of the 13 species fall into the "Exists" category, with breeding habitat at the park. It is very possible that these five species may be detected in future breeding season surveys by RMBO at the park. Based on the comparison, the condition of breeding landbirds is good or, possibly, moderate. Twenty-five species that have been observed during 2010-2013 RMBO surveys (and one from 2005-2006 surveys) are listed by one or more organization as being of conservation concern. Of these, we consider 15 species to have high conservation potential at the Historic Site; these are species that are within their normal breeding range, and sufficient habitat exists at the park to support their breeding. Many of these species were observed during all four years of RMBO surveys. Overall, the condition of breeding landbirds at the Historic Site is good. Adequate information does not exist at this time to evaluate trends in the condition.

THOMAS E. MOXLEY

The Canyon wren (*Catherpes mexicanus*) has high conservation potential at the Historic Site.

Table 5.13.2-1. Summary of overall landbirds condition, indicators and measures, and rationale for assigning condition ratings at Fort Davis National Historic Site.

Breeding Landbirds			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species Occurrence	Temporal Context		Eighty-six percent of 44 species observed in 2005-2006 breeding season bird inventories were observed in 2010-2013 RMBO bird surveys at the Historic Site. Of the six species not observed in recent surveys, only one is known to breed in the park (and falls into the "exists" habitat class). Additionally, 33 species were observed in the 2010-2013 RMBO surveys that were not observed in 2005-2006. In a temporal context, the condition of breeding landbirds at the Historic Site is good. Data are available for a relatively small number of years, so no trend information is available at this time.
	Spatial Context		In a comparison of Breeding Bird Surveys (BBSs) in the general vicinity of the Historic Site to RMBO surveys within the Historic Site, there were 26 species that were not observed at the Historic Site in 2010-2013 RMBO surveys. Thirteen of the 26 species fall into the "Limited to None" breeding habitat class, with most being winter residents or migrants only in the park. Of the 13 remaining species, all are within their breeding range and are year-round or summer residents. However, eight of the species are in the "Possibly Exists" category (with most of the eight known to breed near the park). Only five of the species fall into the "Exists" category, with breeding habitat at the park. It is very possible that these species may be detected in future breeding season surveys by RMBO at the park. Based on the comparison, the condition of breeding landbirds is good or possibly moderate. Because data are available for a relatively small number of years, no trend information is available.
	Conservation Context		There are 25 species that have been observed during 2010-2013 surveys (and one species observed in 2005-2006 only) that are listed by one or more organization as being of conservation concern. We believe that 15 of these species have high conservation potential at the Historic Site. These are species that are within their normal breeding range and sufficient habitat exists at the Historic Site to support breeding. It should be noted that some of the species are considered of conservation concern on regional lists only (e.g., Canyon Wren, Chihuahuan Raven), while others appear on continent-wide lists (e.g., Cactus Wren, Verdin). Many of the species were recorded in all four years of RMBO surveys. We consider the condition of species of conservation concern at the Historic Site to be good. We do not have sufficient data to justify a trend.

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Appendix A: Team Members and Subject Matter Experts

Table A.1. Fort Davis National Historic Site NRCA Project Team Members

Fort Davis NHS NRCA Project Team
Jeff Albright, NPS Water Resources Division's Coordinator of the NRCA Series
Rob Bennetts, NPS Southern Plains Inventory and Monitoring Network Program Manager
Nina Chambers, Northern Rockies Conservation Cooperative, Writer/Editor
Tomye Folts-Zettner, NPS Southern Plains Inventory and Monitoring Network Biologist
Kirsten Gallo, NPS Chihuahuan Desert Inventory and Monitoring Network Program Manager (former); Cheryl McIntyre provided CHDN review
John Heiner, NPS Fort Davis NHS Chief Ranger
Bill Manhart, NPS Fort Davis NHS, Park Ranger
Cheryl McIntyre, NPS Chihuahuan Desert Inventory and Monitoring Network Physical Scientist
John Morlock, NPS Fort Davis NHS Superintendent
Donna Shorrock, NPS Intermountain Region Natural Resource Condition Assessment Regional Coordinator
Heidi Sosinski, NPS Southern Plains Inventory and Monitoring Network Data Manager
Kim Struthers, Utah State University, Writer/Editor
Patty Valentine-Darby, University of West Florida, Biologist and Writer/Editor

Table A.2. Fort Davis NHS NRCA Subject Matter Experts

Subject Matter Expert	Topic	Project Deliverables
Jeff Albright, National Park Service Water Resources Division, Natural Resource Condition Assessment Series Coordinator	All	Provided program level review
Donna Shorrock, National Park Service Intermountain Region Natural Resource Condition Assessment Regional Coordinator	All	Provided program level review
Mark Brunson, Professor & Department Head, Environment and Society; Utah State University	All	Provided full NRCA review
Heidi Sosinski, National Park Service Southern Plains Inventory and Monitoring Network Data Manager	Viewshed	Performed viewshed analyses
Chad Moore, National Park Service Night Sky Program Manager	Night Sky	Provided NPS guidance on night sky monitoring and reviewed of night sky section
Bill Wren, McDonald Observatory	Night Sky	Provided information on night sky monitoring and reviewed of night sky section
Emma Lynch, National Park Service Natural Sounds and Night Skies Division, Acoustical Resource Specialist	Soundscape	Provided review of soundscape section
Randy Stanley, National Park Service Natural Resources Division & Submerged Resources Center Intermountain Region, Physical Scientist / Acoustic Specialist	Soundscape	Provided review of soundscape section
Ellen Porter, National Park Service Air Resources Division	Air Quality	Provided review air quality section
Bruce Heise, National Park Service Geologic Resources Division Geologist	Geology	Provided review of geology section

Table A.2. **Fort Davis NHS *NRCA Subject Matter Experts (cont.)***

Subject Matter Expert	Topic	Project Deliverables
Tim Seastedt, University of Colorado, Department of Ecology and Evolutionary Biology Professor	Upland Vegetation and Soils	Provided expert assessment for upland vegetation during 2013 field visit
Mike Martin, National Park Service Water Resources Division, Hydrologist	Groundwater	Provided expert assessment and review of groundwater section
Tomye Folts-Zettner National Park Service Southern Plains Inventory and Monitoring Network Biologist/ Botanist	Upland Vegetation and Soils, and Dry Wash/ Cottonwoods	Provided expert opinion on upland vegetation/soils and dry wash/cottonwoods assessments during 2013 field visit
Cheryl McIntyre, National Park Service Chihuahuan Desert Inventory and Monitoring Network Physical Scientist	All	Provided CHDN review and provided expert opinion on uplands/soils and dry wash/cottonwoods assessments during 2013 field visit
Missy Powell, National Park Service Chihuahuan Desert Inventory and Monitoring Network Biologist/Assistant Data Manager	Exotic Plants	Provided exotic plants section review
Julie Christian, National Park Service Chihuahuan Desert Inventory and Monitoring Network Ecologist	Exotic Plants	Provided exotic plants section review
Jonathin Horsley, National Park Service Chihuahuan Desert I&M Network and Southern Plains I&M Network Exotic/Invasive Plant Monitoring Crew Leader	Exotic Plants	Provided exotic plants section review
Kelly B. Bryan, Hummingbird Bander, West Texas Avian Research	Landbirds	Provided breeding landbirds review and data
Josh Burns, Local Resident Breeding Bird Surveyor	Landbirds	Provided breeding landbirds review and data

Appendix B: Viewshed Analysis Steps

The process Heidi Sosinski used to complete the Fort Davis NHS' viewshed analyses is listed below.

Downloaded 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from The National Map Seamless Server (http://seamless.usgs.gov/). The x and y values for the NED are in arc seconds while the z data are in meters. Projected NED into NAD83 UTM 13 to get all data in meters.

Adjustments were made to the elevation grid to compensate for areas obcured due to large areas of tree cover. Tree groves were on-screen digitized from basemap aerial imagery provided by ESRI. A height value of 22 meters due to the cottonwood grove was assigned to each record of the attribute table. This value represents an average height of trees in the area. A height value of 0 was set to the remaining analysis area. Using the conversion tool in ArcGIS 10.1, the polygon shapfile was converted to raster format with the cell value set to the height attribute. The tree value raster was added to the NED using the Weighted Sum tool in Spatial Analyst Toolbox, with the weighted value of each input set to 1. The resulting raster was used in the following viewshed analysis.

Downloaded Fort Davis National Historic Site boundary, roads, and trails layers from NPS Integrated Resource Management Applications (IRMA) portal (https://irma.nps.gov).

Prepared Observation Point layers for Viewshed Analyses.

Created point layers for vantage points at the fort.

Used Edit > Create New Feature tool to create 3 observation points (Sleeping Lion, Overlook and Barracks). Saved file as obs_point.shp

Added field named "OFFSETA" (type = double) to shapefile and set value to 1.68 for both records in the attribute table. The value in the field "OFFSETA" represents an observer height of 1.68m (~5'6").

Ran Viewshed Analysis using ESRI Spatial Analyst Viewshed Tool.

Using the Viewshed Tool in ESRI's ArcGIS 10, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

- Input raster = 1/3 arc second NED modified to include area tree cover.
- Input point observer feature = obs_point.shp.

Appendix C: Bortle Dark-Sky Scale

Key for the Summer Sky— Latitudes 30° to 50° N

The Milky Way is not visible and sky glow extends above 35 degrees. Little to no dark adaptation is possible. Ground texture is easily seen, and artificial light dominates the landscape. Visible constellations are limited to the very brightest if any. The sky has a uniform washed out appearance.[1]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

Sky appears nearly completely washed out, and is luminous. Dark adaptation is not possible, ground is brightly illuminated and fewer than 200 stars are visible. Only the most major constellations are identifiable. For instance, the entire keystone of Hercules or the five stars of Delphinus are not completely visible.

this is accurate **Bortle Class 9** if darker—proceed below

Constellations are visible but may be missing key stars, sky background has a uniform washed out glow with light domes reaching 60 degrees above the horizon. Stars such as the tip of Sagitta or epsilon Lyrae are not visible. If clouds are present they are brilliantly lit.

this is accurate **Bortle Class 8** if darker—proceed below

Brighter constellations are easily seen in full, yet sky background has greyish or yellow background. Milky Way may be just barely seen near the zenith. The Scutum and Cygnus star clouds are not visible.If clouds are present they are brilliantly lit. Ground texture is still visible.

this is accurate **Bortle Class 7**

The Milky Way is visible but discontinuous, and lost to light domes near the horizon. Fine details and structure are not easily visible, if at all. Ground texture is still visible, and shadows are cast from light pollution. Light domes are clearly visible along the horizon and appear brighter than any portion of the visible Milky Way.[2]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

The Milky Way is just visible overhead, but is not continuous and is diminished to obvious skyglow. Cygnus ,Scutum, and Sagittarius star fields just visible. If clouds present they are illuminated and reflecting light. Ground texture is seen with difficulty.

this is accurate **Bortle Class 6** if darker—proceed below

Milky Way is faintly present, but may have occasional gaps and is lost to skyglow near the horizon. Great rift in Cygnus is just visible. Any clouds present are brighter than the background sky and reflect light back. Zodiacal light may be glimpsed, but is difficult to see amidst the light pollution. Ground texture is not visible but forms are easily seen.

this is accurate **Bortle Class 5** if darker—proceed below

Milky Way is evident from horizon to horizon, but fine details are lost. Clouds are just brighter than background sky, but appear dark at zenith. Light domes are much brighter than brightest part of Milky Way and extend to up to 15 degrees above the horizon. Zodiacal light is evident in west after sunset or in east before dawn. Deep sky objects such as the M13 globular cluster and Northern Coal Sac are visible.

this is accurate **Bortle Class 4**

The Milky Way has a defined outline with visible structure and detail. Very few light domes are visible just along the horizon and do not cast shadows. You may see color in the Zodical light when compared to bluish-white color of the Milky Way. Scattered clouds appear dark against the night sky except those clouds just above light domes.[3]

If this describes your nighttime environment, continue below

Milky Way appears complex with visible outline, however some light pollution is still evident along the horizon. Light domes only slightly brighter than brightest part of the Milky Way. Zodiacal light easily seen, but band and gegenschein difficult or absent. Many summer globular clusters and emission nebulae are visible with the naked eye despite distracting light domes along the horizon. Venus casts an obvious shadow.

this is accurate **Bortle Class 3** if darker—proceed below

Very few light domes are visible; with none extending above 5 degrees and fainter than the Milky Way. Airglow is often visible, and character in its brightness may be seen. Ground is mostly dark. The Zodiacal band (away from the Milky Way and at least 45 degrees above the horizon) and gegenschein are visible. The rift in the Cygnus star cloud is visible. The Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares. Jupiter and Milky Way cast barely visible shadows.

this is accurate **Bortle Class 2** if darker—proceed below

The Milky Way is intricate, marbled, and veined with Sagittarius region of the Milky Way casting obvious shadows. Milky Way appears 40 degrees wide in some parts with a convoluted outline. The horizon completely free of light domes, though some distant light domes may be visible from mountain tops. Transparency and seeing are excellent (among the best of the year) with very low airglow. Many objects such as M81 or the Helix nebula are visible with the naked eye. Zodical light is striking as a complete band. Any clouds are very difficult to see.

this is accurate **Bortle Class 1**

The Bortle Dark-Sky Scale is a qualitative scale developed by John Bortle and published in Sky & Telescope Magaine in 2001. It provides a useful complement to quantitative measures. The National Park Service is testing this dichotomous key for use by professional and citizen scientists. Some knowledge of the night sky and visual observational techniques are required to properly implement this assessment.

note 1) At least 5 minutes of dark adaptation is required to properly differentiate Class 7,8 & 9 skies.

note 2) At least 10 minutes of dark adaptation is required to properly differentiate Class 4, 5 & 6 skies.

note 3) 20 to 120 minutes of dark adaptation is required to properly differentiate Class 1, 2 & 3 skies.

Developed by Jeremy White, Dan Duriscoe, and Chad Moore of the NPS Natural Sounds & Night Skies Division, www.nature.nps.gov/night

August 2, 2012

Appendix D: Soundscape Models

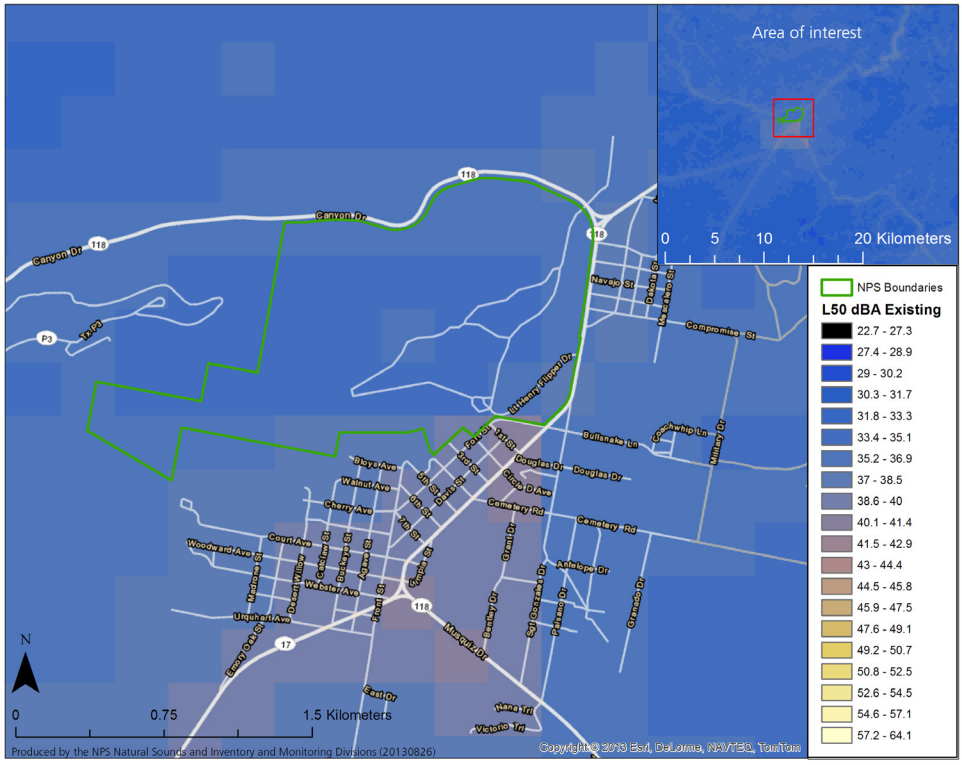

Figure D-1. Existing CONUS soundscape model zoomed to Fort Davis NHS..

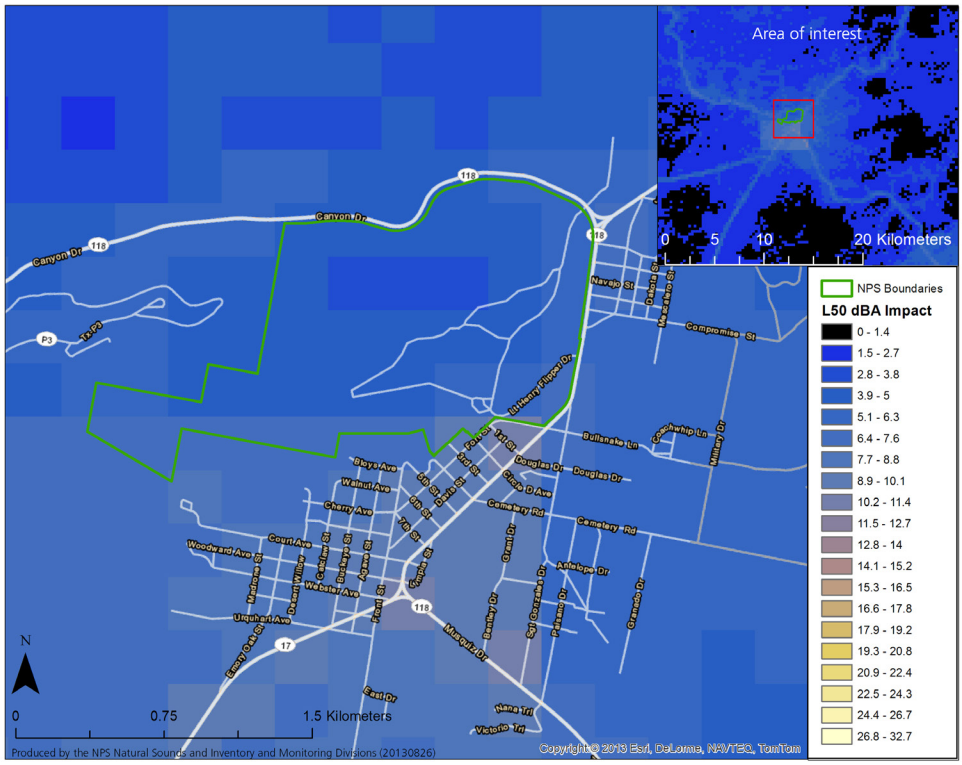

Figure D-2. Impact between existing and natural CONUS soundscape models zoomed to Fort Davis NHS..

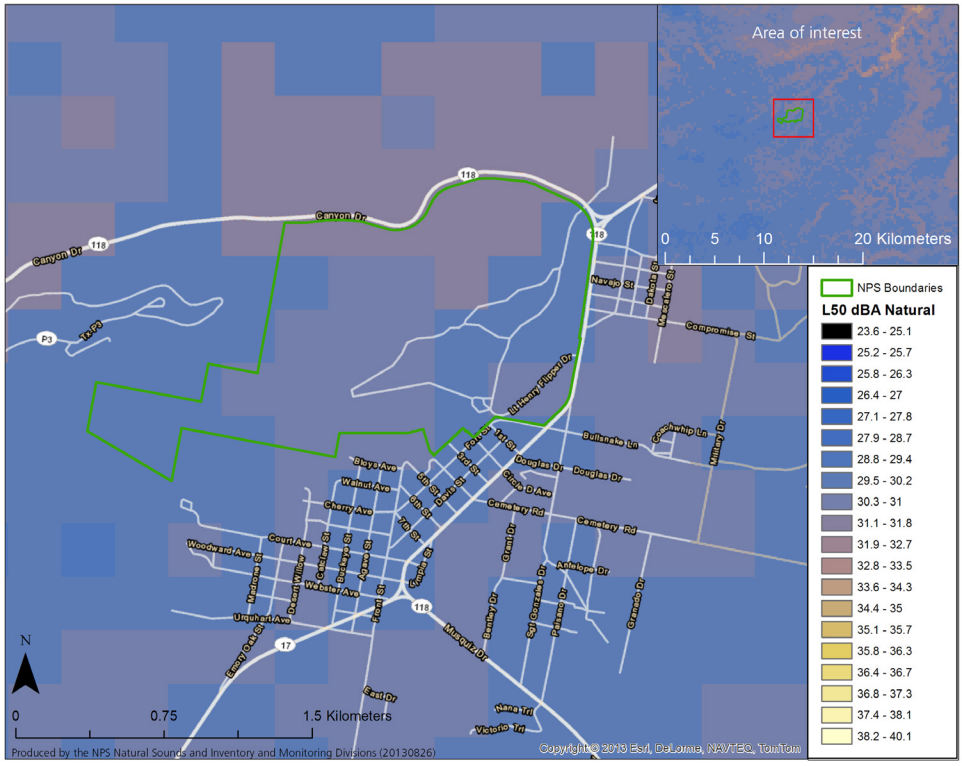

Figure D-3. Natural CONUS soundscape model zoomed to Fort Davis NHS..

Mennitt et al. (in preparation) with the NPS NSNSD developed a geospatial sound model by mapping sound pressure levels on a continental U.S. scale. The model included biological, climatic, geophysical, and anthropogenic factors to assess expected sound pressure levels for natural and existing conditions. The model suggested that the area within and surrounding Fort Davis NHS had a natural L50 dBA average of 30.5 (D-3) and an existing L50 dBA average of 35.2 (D-1) (Emma Lynch, Acoustical Resource Specialist, NPS Natural Sounds and Night Skies Division, pers. comm.). The L50 represents the sound level reported that is exceeded 50 percent of the stated time period.

The impact of anthropogenic sound sources to the Historic Site's soundscape, which is the existing L50 dBA minus natural L50 dBA, was estimated to be an average of 4.8 dBA (D-2). According to Mennitt et al. (2013), "an impact of 3dB suggests that anthropogenic noise is noticeable at least 50% of the hour or more." This implies that based upon the model, the existing impact of anthropogenic noise to the Historic Site's soundscape warrants concern.

Coordination with NSNSD would help bring attention and focus to the importance and preservation of the Historic Site's soundscape. As NSNSD's predictive soundscape model continues to be developed and refined, it is intended to help Historic Site staff anticipate impacts by projecting future developments that have the potential to degrade a park's soundscape. Keeping in periodic contact with the NSNSD will allow managers to obtain the most recent information available to assist with park planning decisions and regional coordination.

Appendix E: Maps showing the 2011-2013 densities of the plants in the distance class closest to the actual vector (Distance Class 1 only). Note that not all species were found in Distance Class 1.

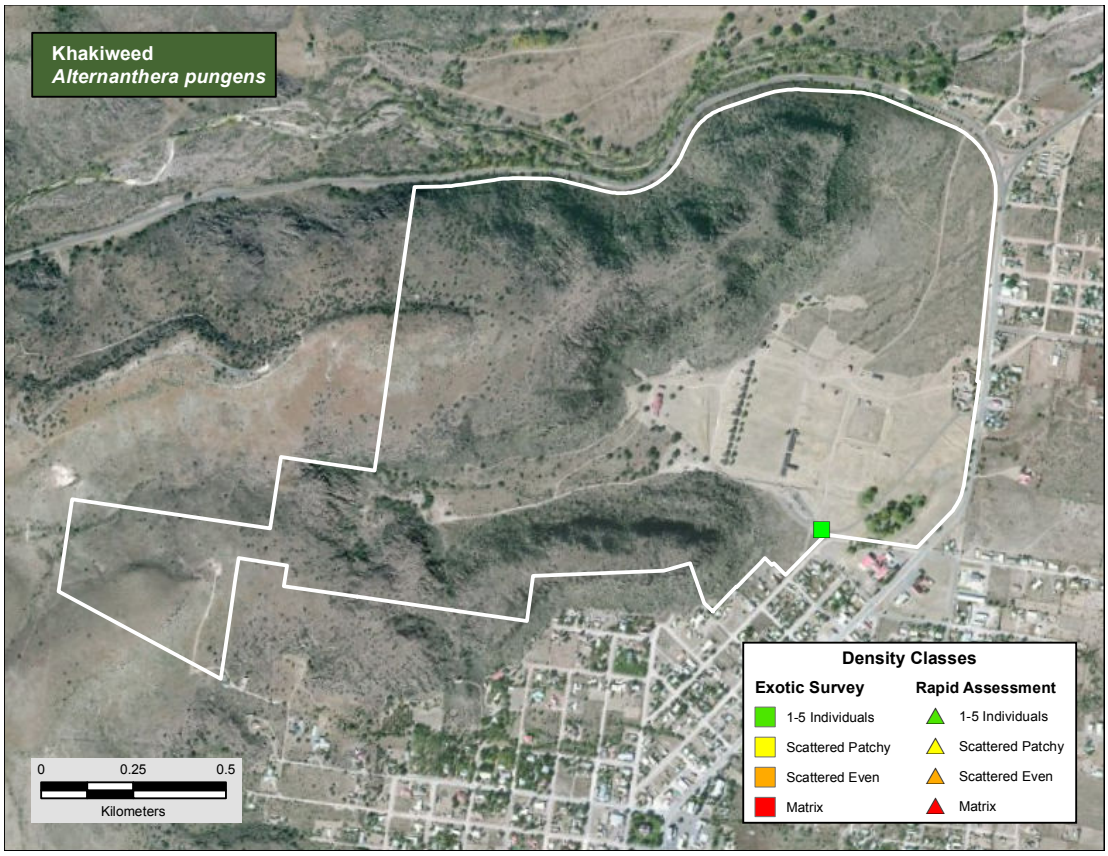

Figure E-1. Density of khakiweed (*Alternanthera pungens)* found in survey plots and during rapid assessment.

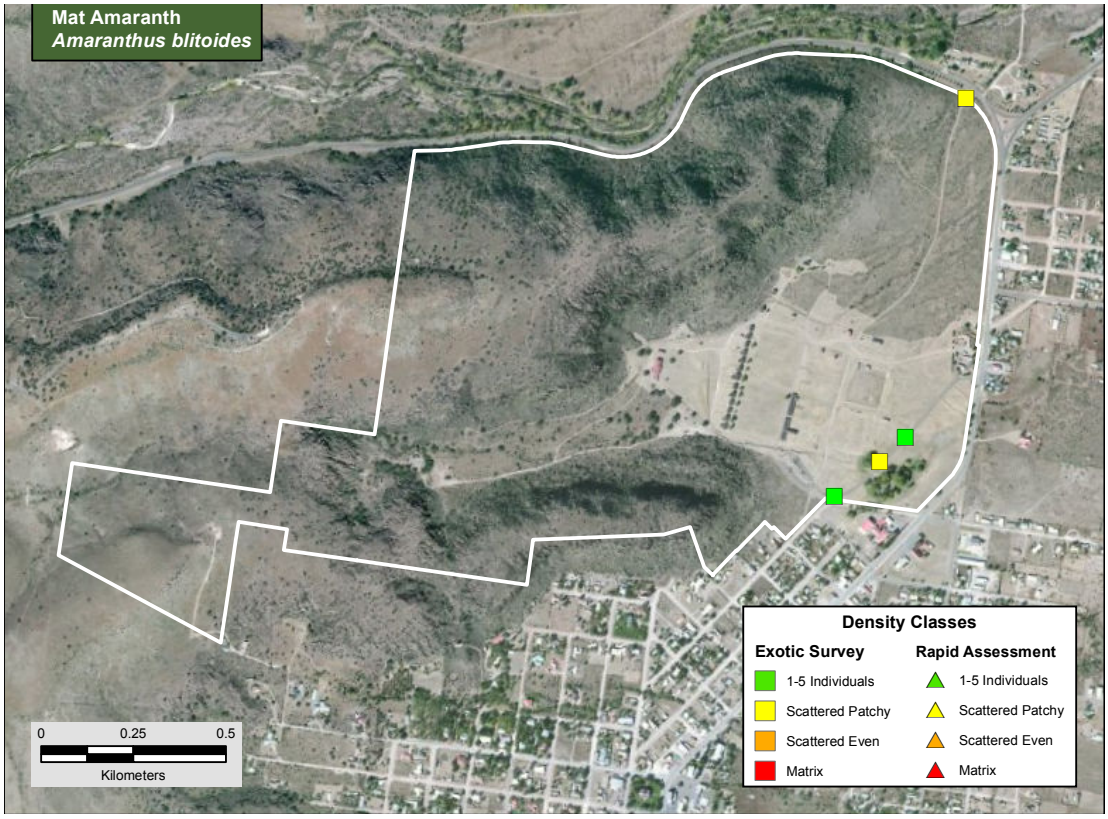

Figure E-2. Density of mat amaranth (*Amaranthus blitoides*) found in survey plots and during rapid assessment.

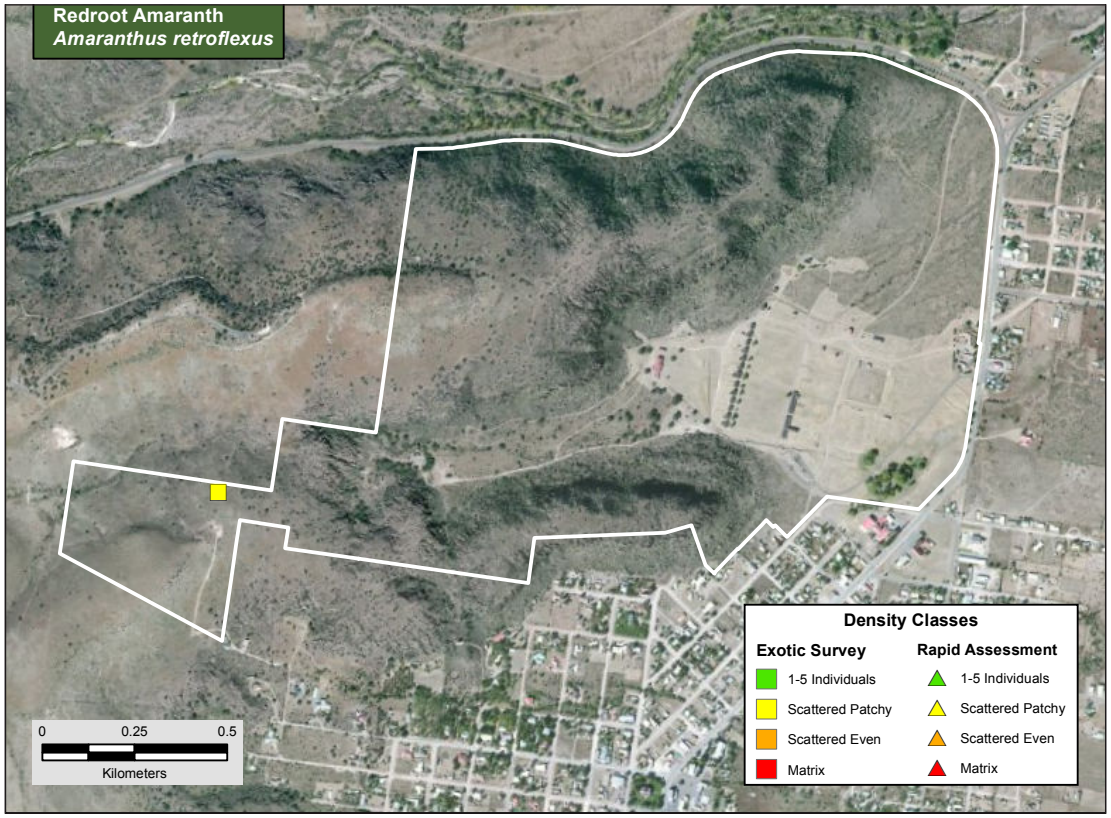

Figure E-3. Density of redroot amaranth (*Amaranthus retroflexus)* found in survey plots and during rapid assessment.

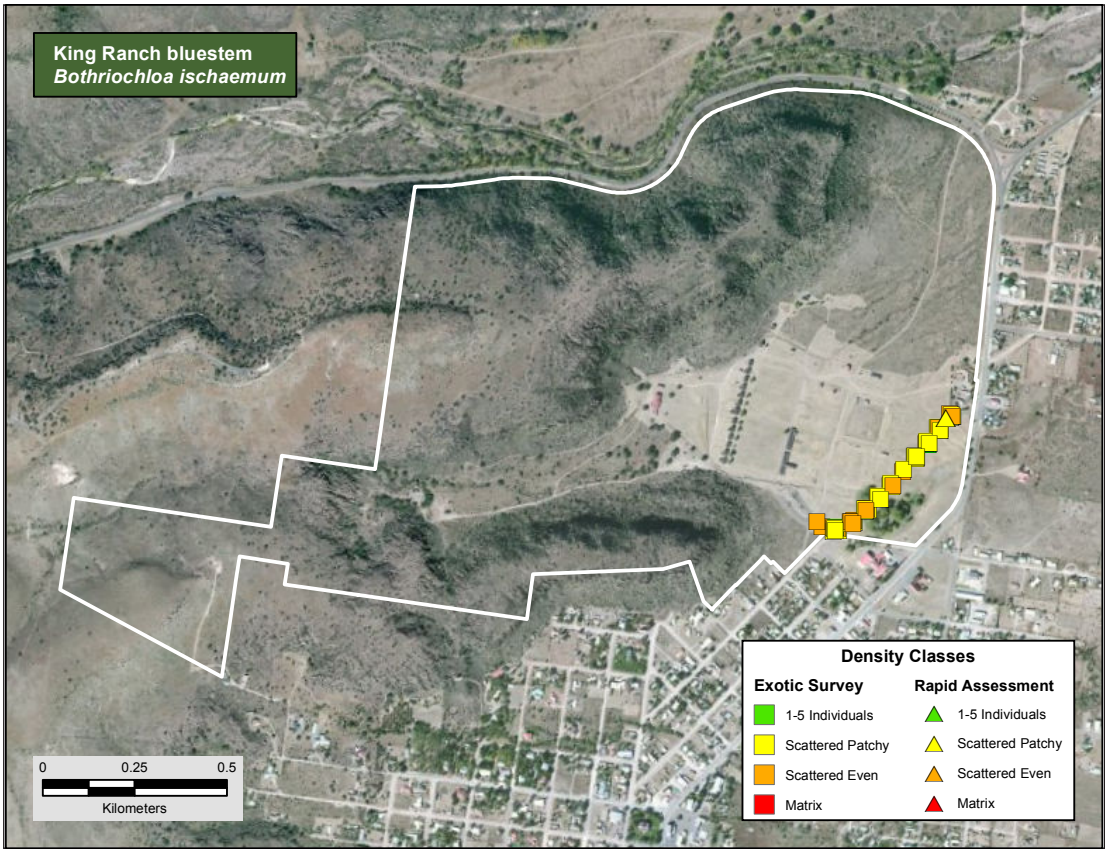

Figure E-4. Density of King ranch bluestem (*Bothriochloa ischaemum)* found in survey plots and during rapid assessment.

Plants were not found in distance class one.

Figure E-5. Density of rescue grass (*Bromus catharticus)* found in survey plots and during rapid assessment.

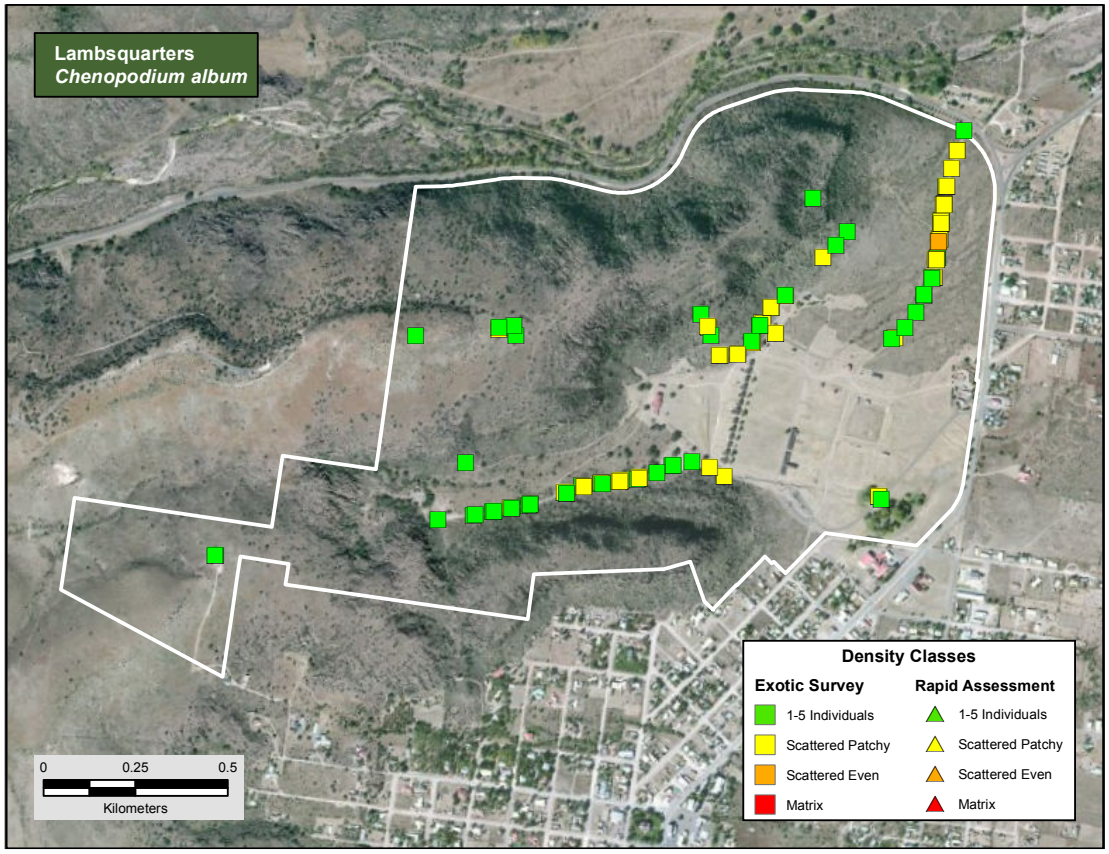

Figure E-6. Density of lambsquarters (*Chenopodium album*) found in survey plots and during rapid assessment.

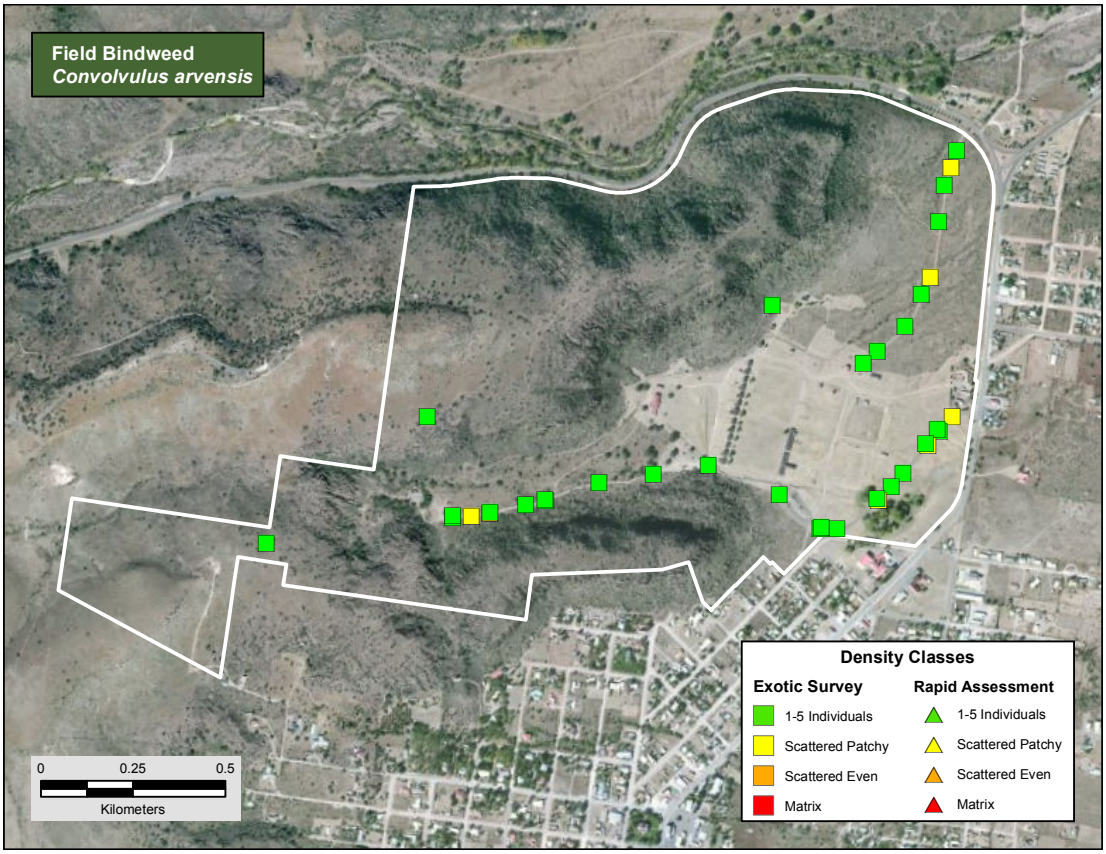

Figure E-7. Density of bindweed (*Convolvulus arvensis*) found in survey plots and during rapid assessment.

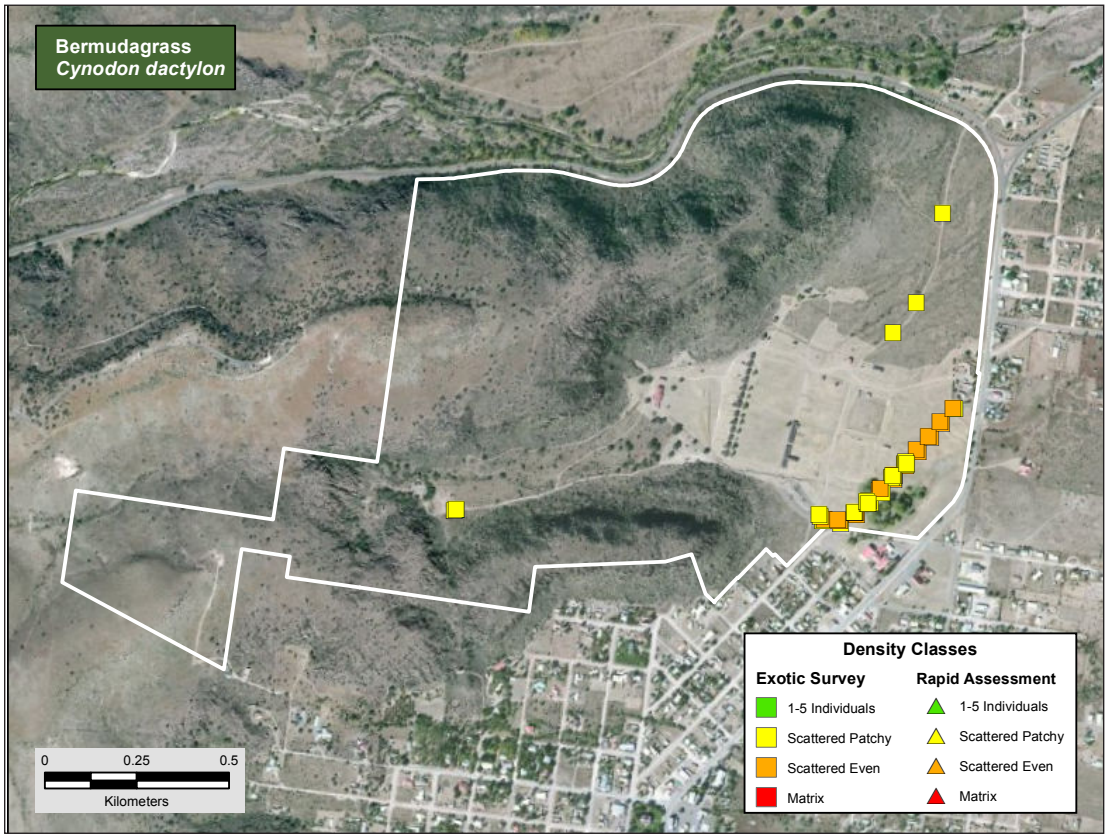

Figure E-8. Density of bermudagrass (*Cynodon dactylon*) found in survey plots and during rapid assessment.

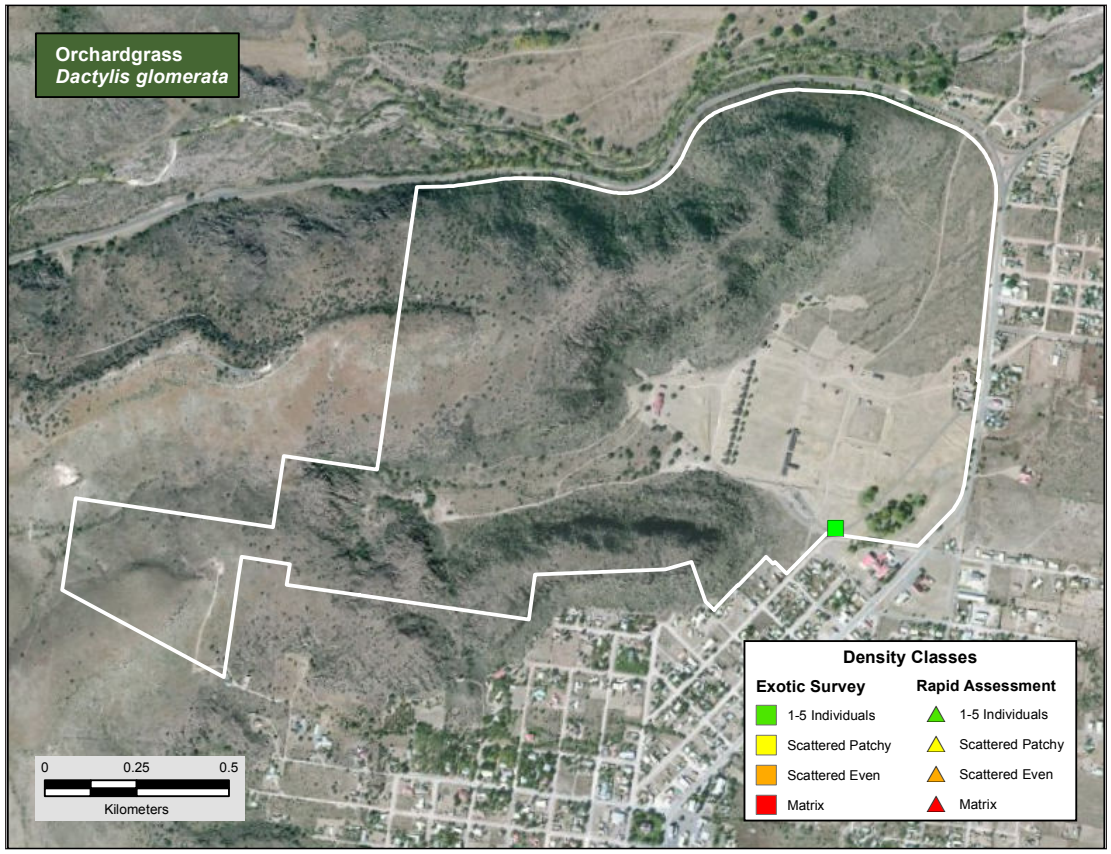

Figure E-9. Density of orchardgrass (*Dactylis glomerata*) found in survey plots and during rapid assessment.

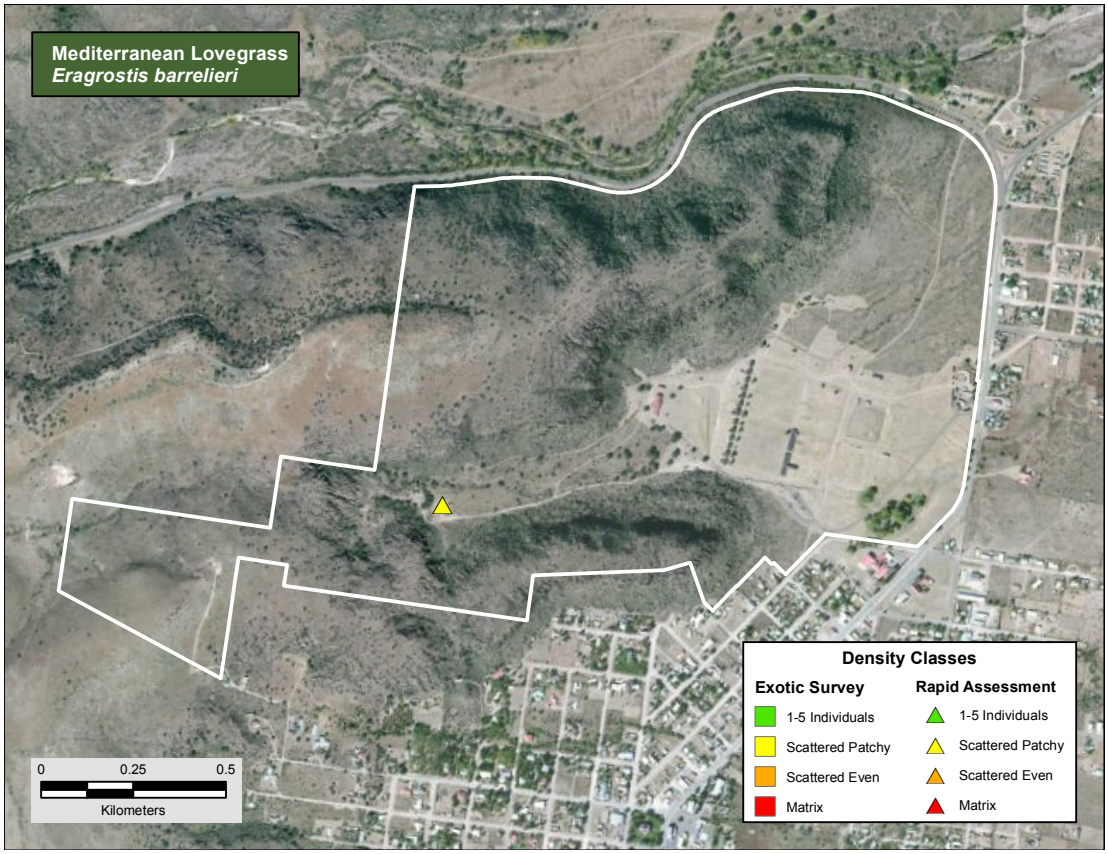

Figure E-10. Density of Mediterranean lovegrass (*Eragrostis barrelieri*) found in survey plots and during rapid assessment.

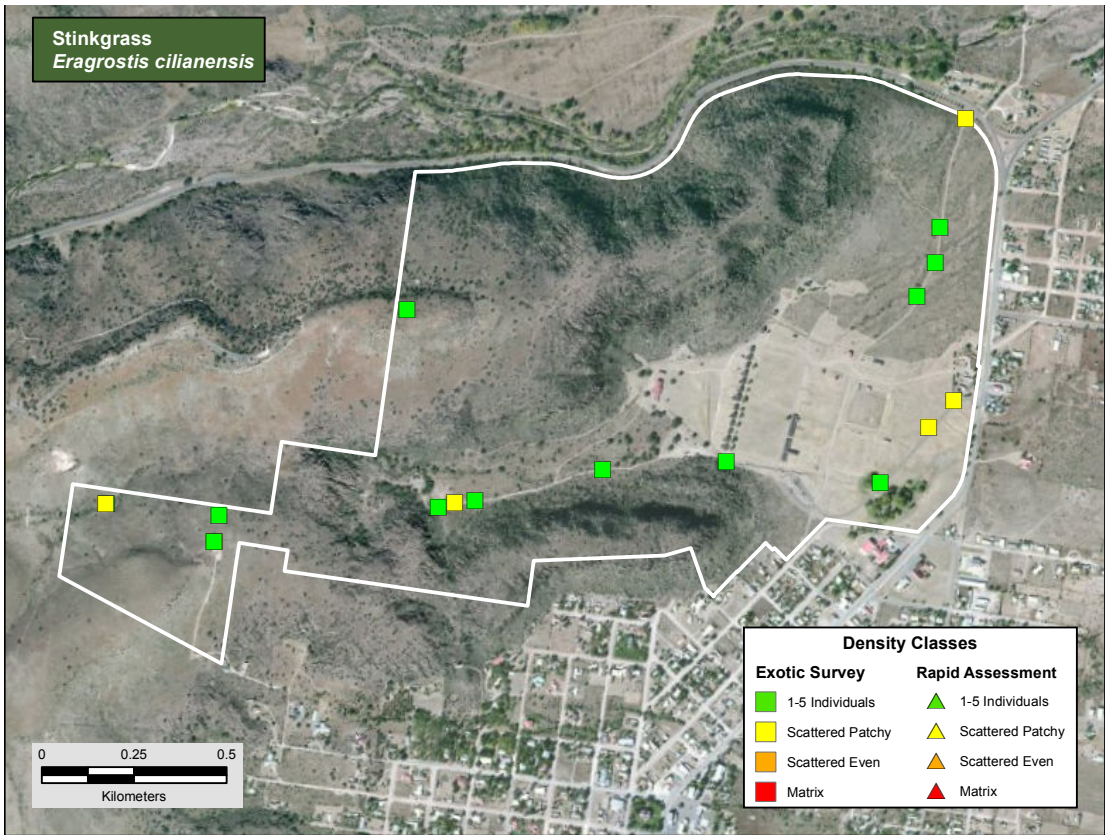

Figure E-11. Density of stinkgrass (*Eragrostis cilianensis*) found in survey plots and during rapid assessment.

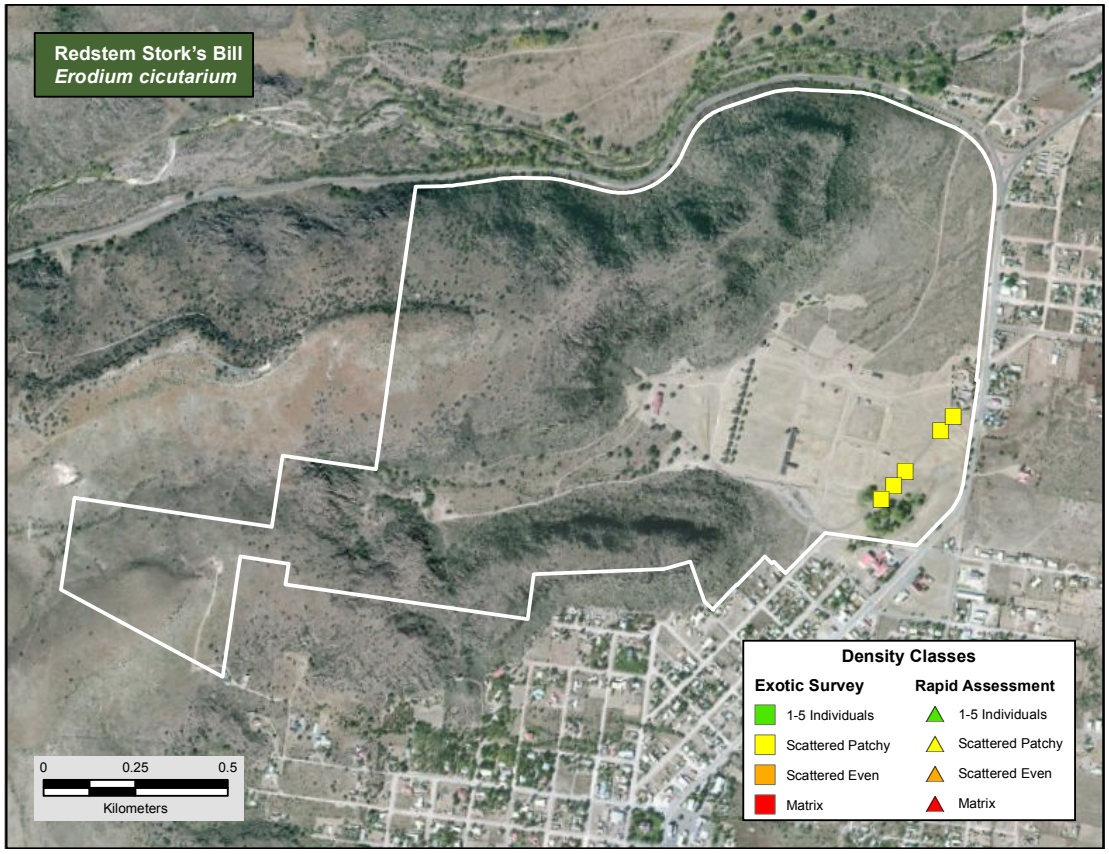

Figure E-12. Density of redstem stork's bill (*Erodium cicutarium*) found in survey plots and during rapid assessment.

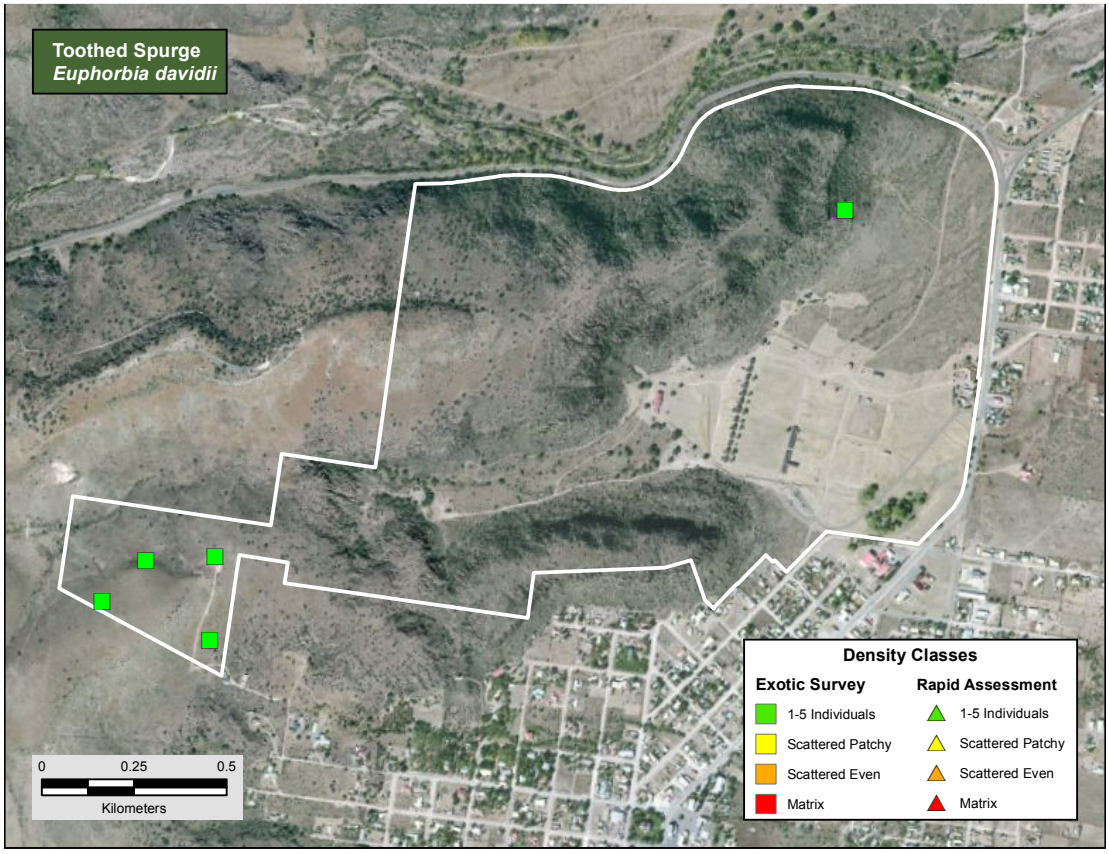

Figure E-13. Density of toothed spurge (*Euphorbia davidii)* found in survey plots and during rapid assessment.

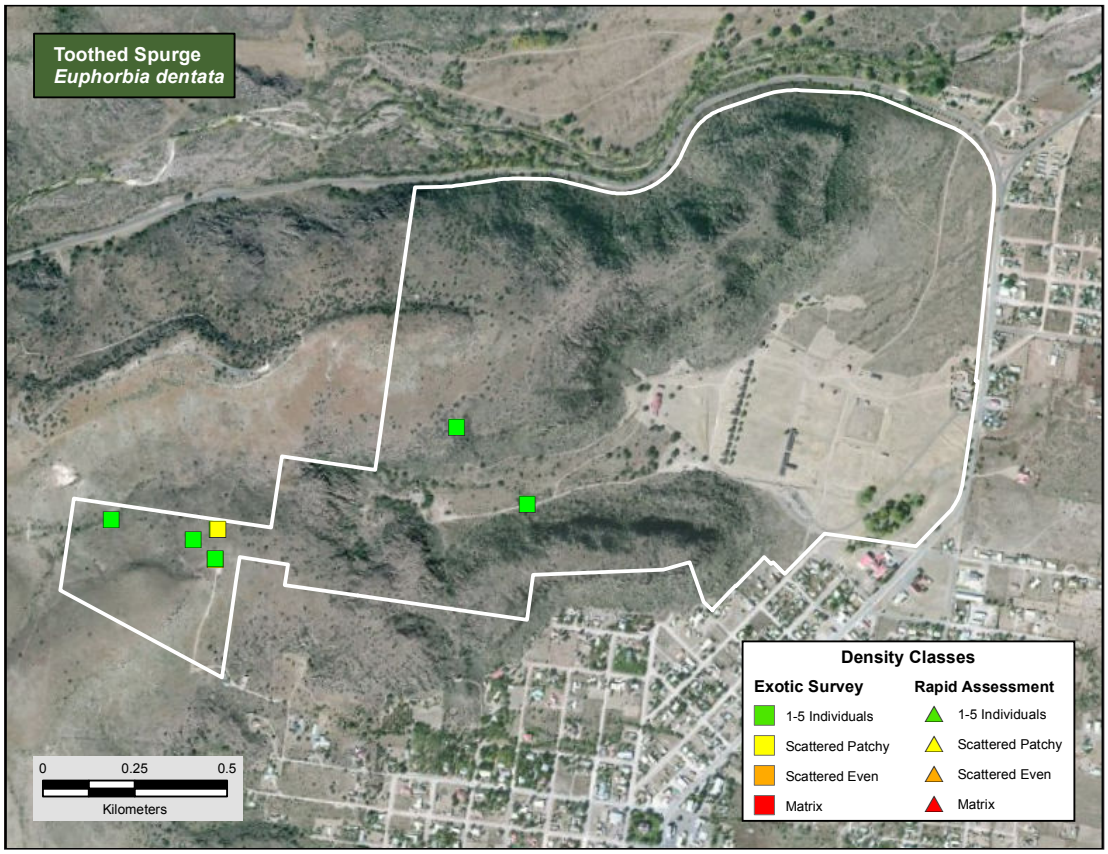

Figure E-14. Density of toothed spurge (*Euphorbia dentata*) found in survey plots and during rapid assessment.

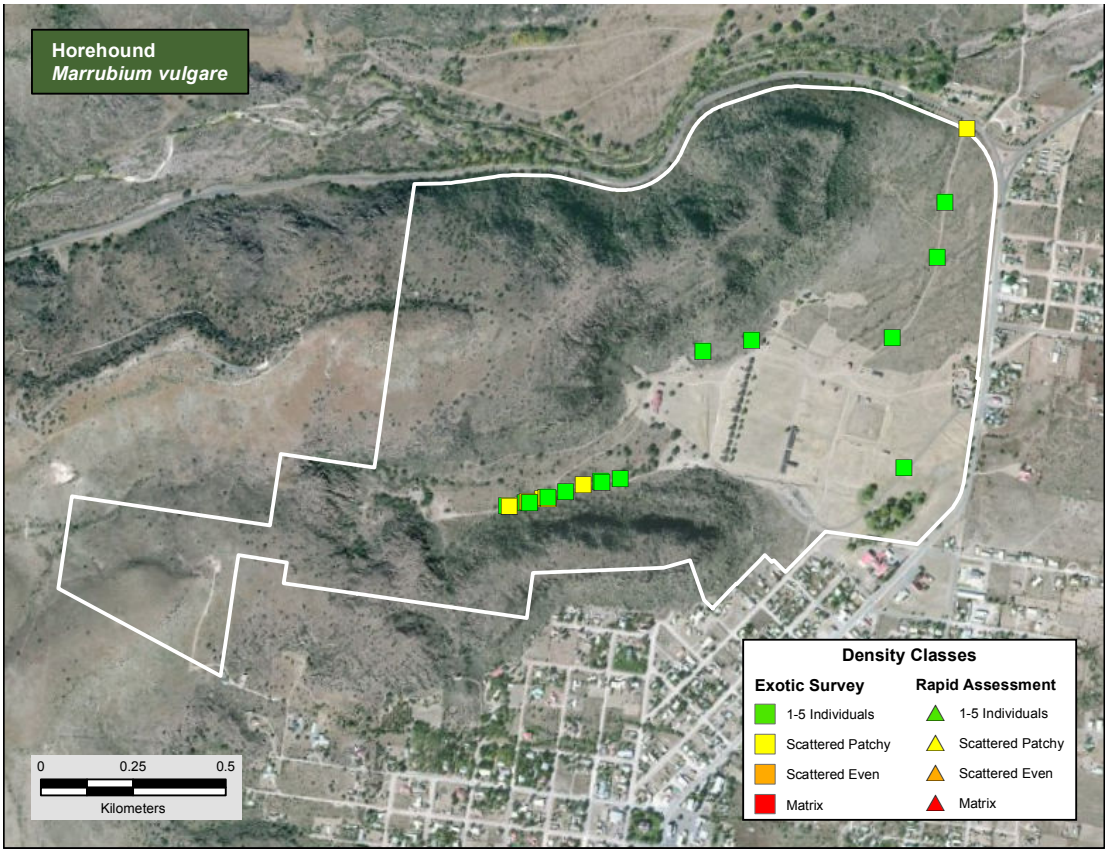

Figure E-15. Density of horehound (*Marrubium vulgare)* found in survey plots and during rapid assessment.

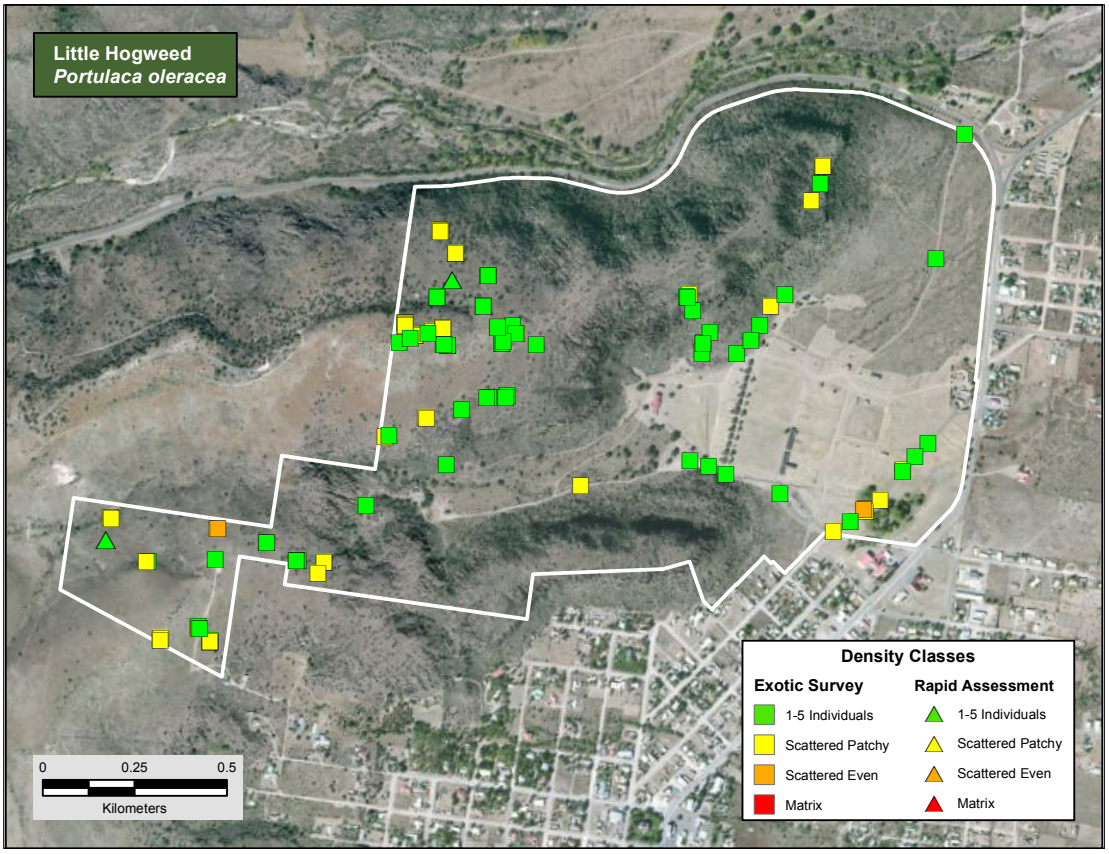

Figure E-16. Density of little hogweed (*Portulaca oleracea)* found in survey plots and during rapid assessment.

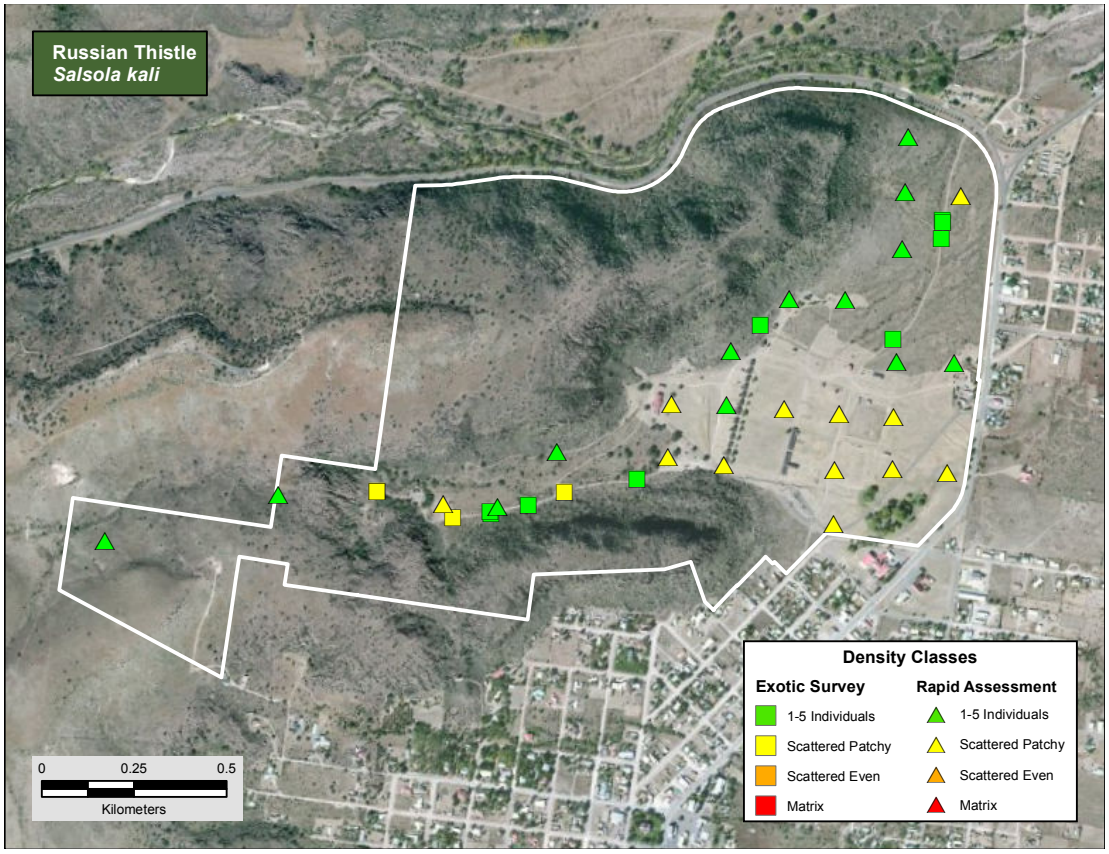

Figure E-17. Density of Russian thistle (*Salsola kali*) found in survey plots and during rapid assessment.

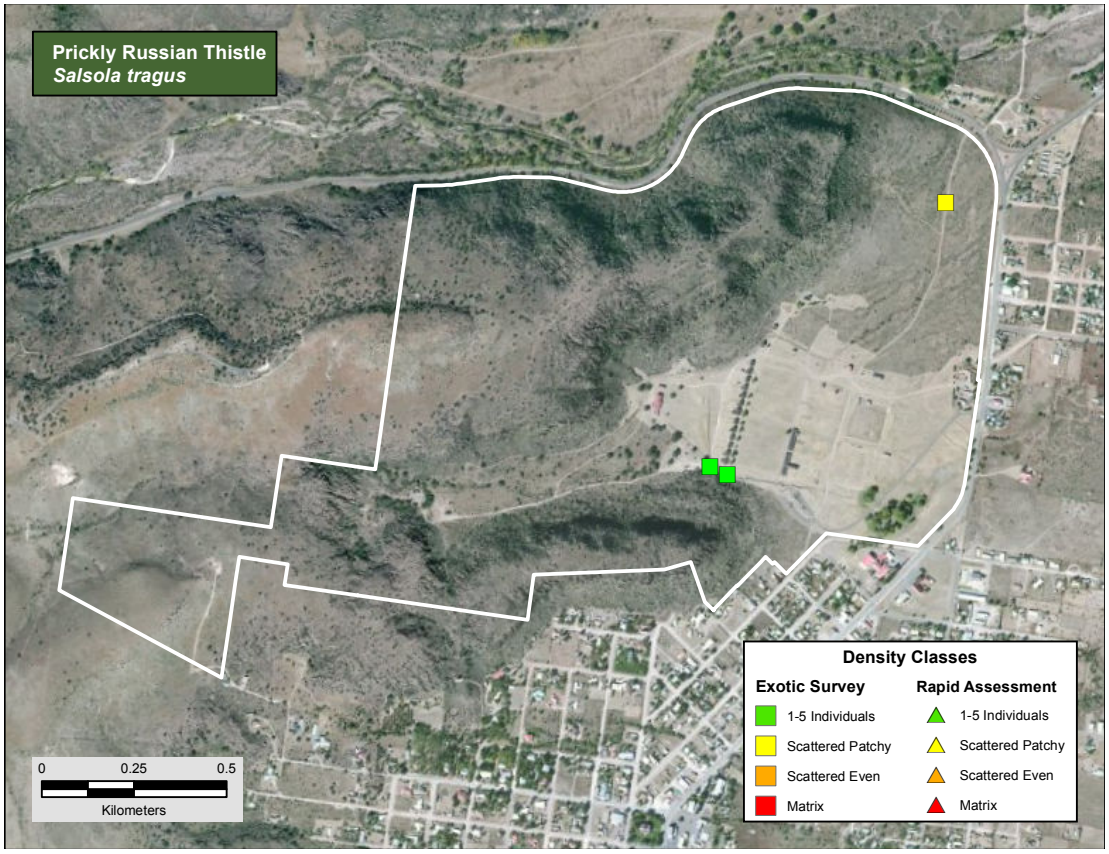

Figure E-18. Density of prickly Russian thistle (*Salsola tragus*) found in survey plots and during rapid assessment.

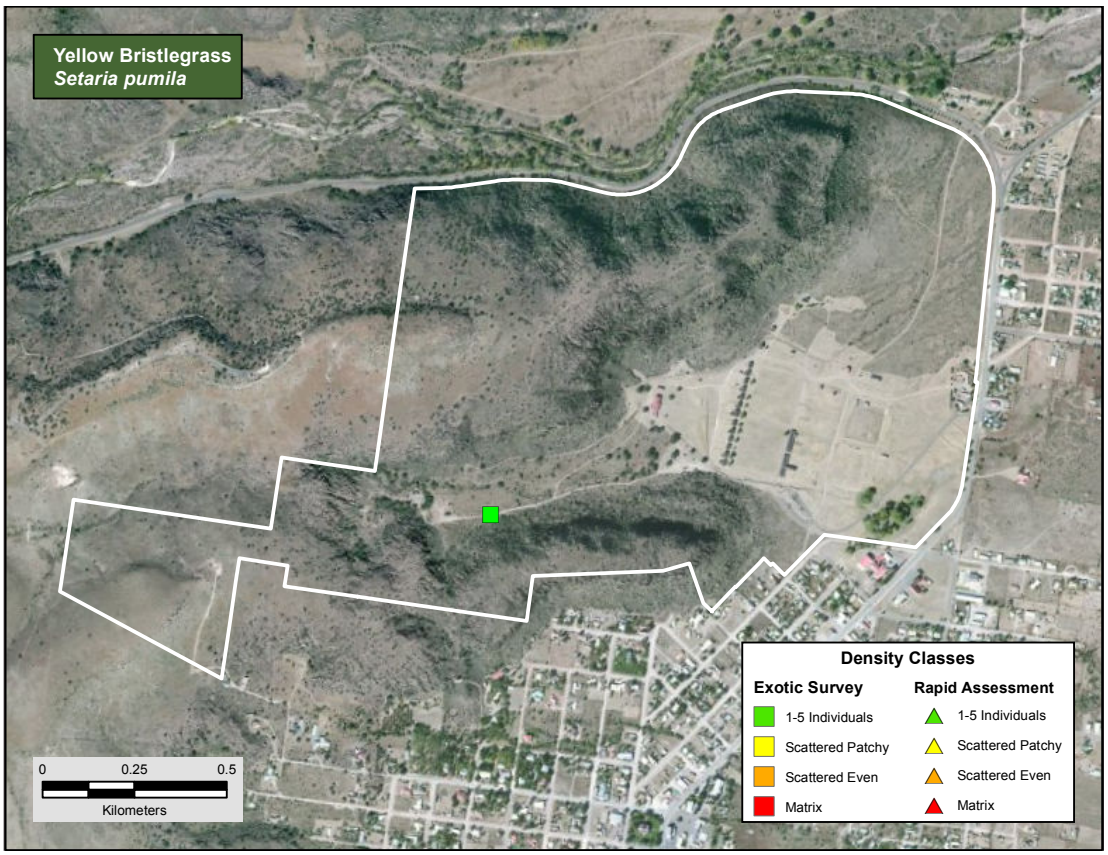

Figure E-19. Density of yellow bristlegrass (*Setaria pumila*) found in survey plots and during rapid assessment.

Plants were not found in distance class one.

Figure E-20. Density of London rocket (*Setaria pumila*) found in survey plots and during rapid assessment.

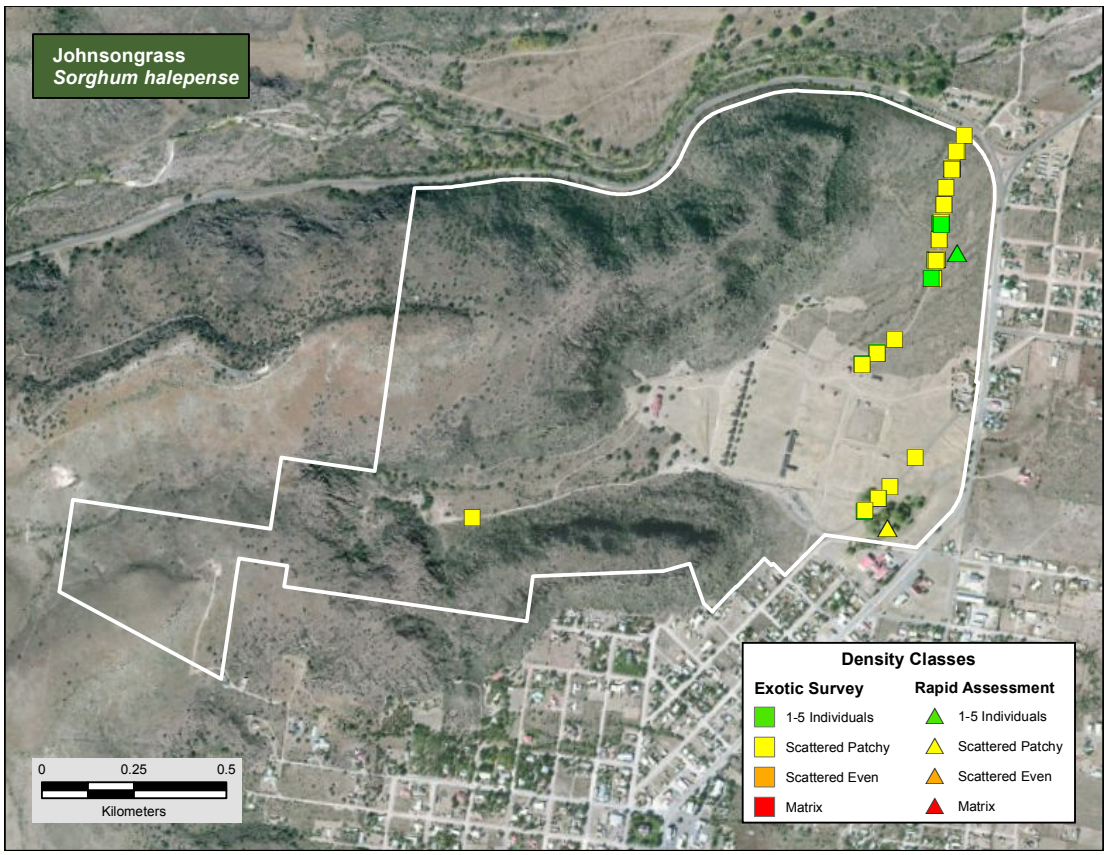

Figure E-21. Density of Johnsongrass (*Sorghum halepense*) found in survey plots and during rapid assessment.

Plants were not found in distance class one.

Figure E-22. Density of common chickweed (*Stellaria media*) found in survey plots and during rapid assessment.

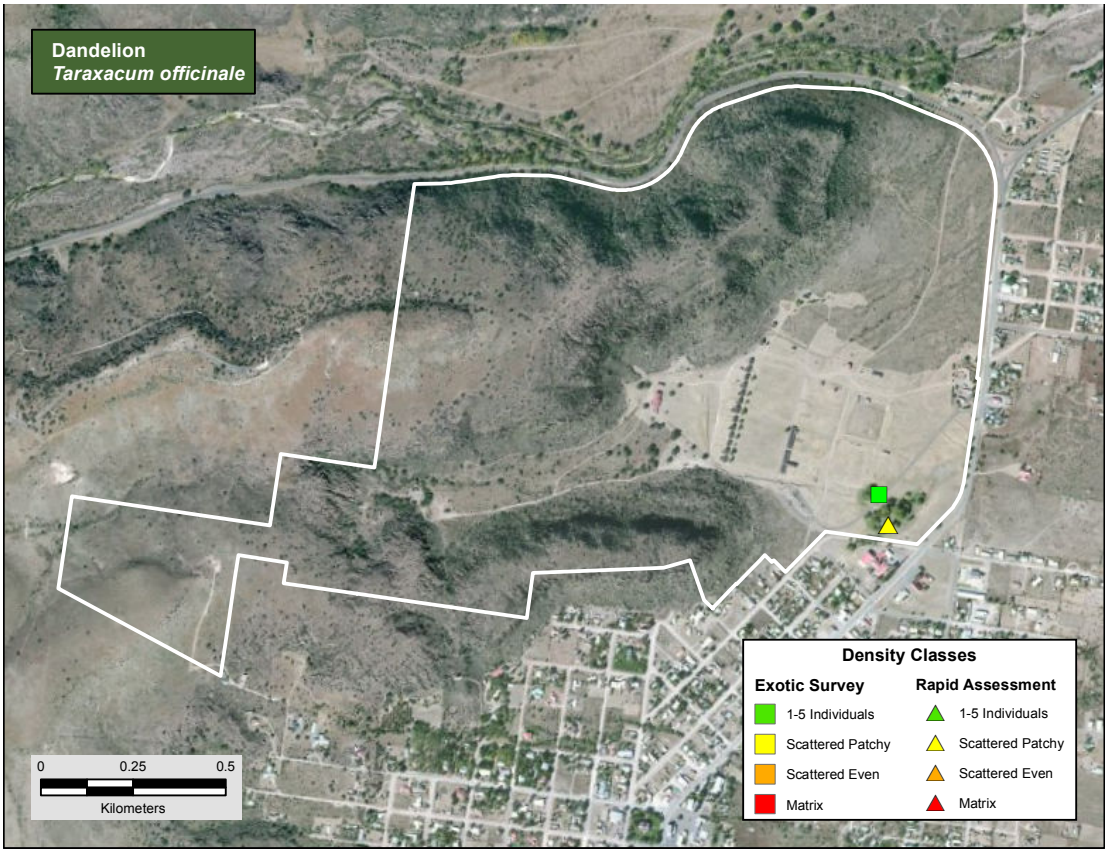

Figure E-23. Density of dandelion (*Taraxacum officinale*) found in survey plots and during rapid assessment.

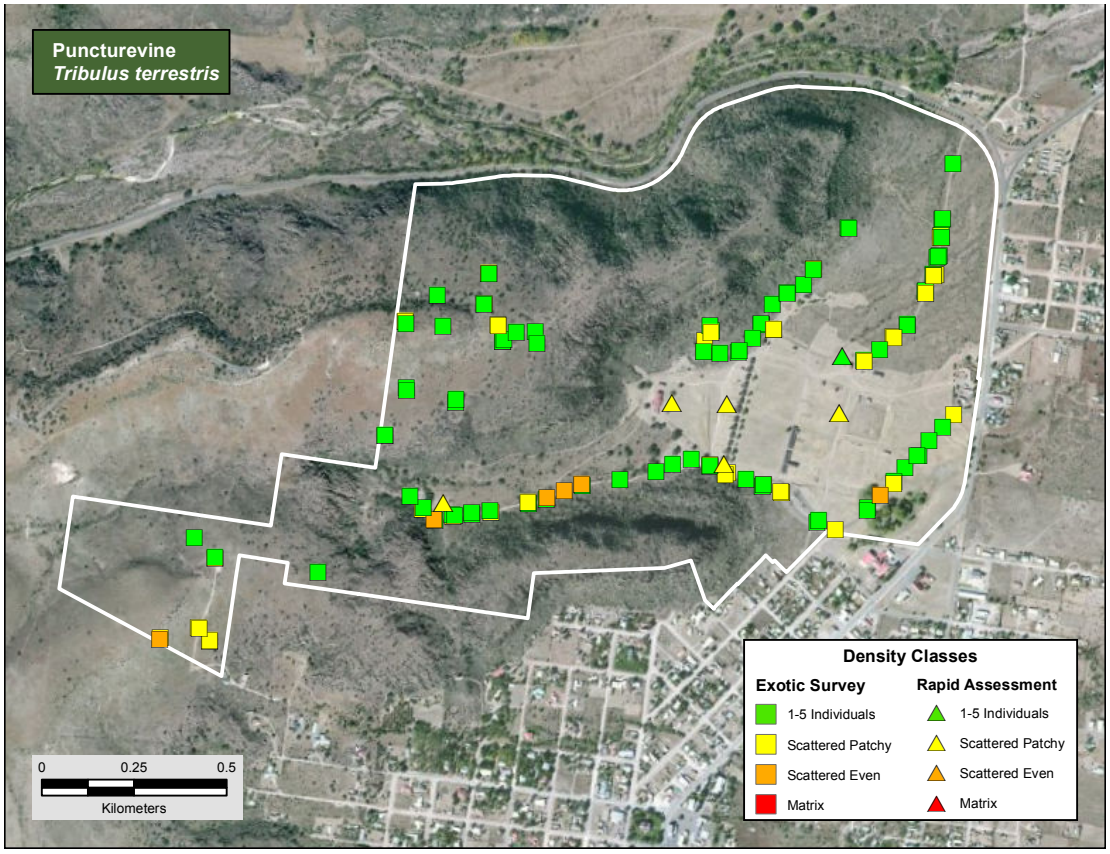

Figure E-24. Density of puncturevine (*Tribulus terrestris*) found in survey plots and during rapid assessment.

Plants were not found in distance class one.

Figure E-25. Density of Siberian elm (*Ulmus pumila*) found in survey plots and during rapid assessment.

Appendix F: Background on Bird Species of Conservation Concern Lists

This appendix provides background information on the organizations and efforts to determine species of birds that are in need of conservation. The information preseneted here supports Section 4.11.2, Data and Methods, of the breeding landbirds chapter. This appendix contains some of the same, but additional, information as that section of the report.

One component of the landbird condition assessment was to assess species occurrence in a conservation context. We compared the list of species that occur at Fort Davis National Historic Site (NHS) (i.e., those detected during Rocky Mountain Bird Observatory [RMBO] surveys at the NHS during 2010-2013) to lists of species of conservation concern developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of confusion and perhaps frustration for managers that need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 2013). Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues.

The purpose of delineating these BCRs was to:

- facilitate communication among the bird conservation initiatives;
- systematically and scientifically apportion the U.S. into conservation units;
- facilitate a regional approach to bird conservation;
- promote new, expanded, or restructured partnerships; and
- identify overlapping or conflicting conservation priorities.

Conservation Organizations Listing Species of Conservation Concern

Below we present a snapshot of some of the organizations that list species of conservation concern and briefly discuss the different purposes or goals of each organization.

F.14.1. U.S. Fish & Wildlife Service

The Endangered Species Act, passed in 1973, is intended to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the U.S. Fish and Wildlife Service (USFWS) and the Commerce Department's National Marine Fisheries Service (NMFS). USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of

NMFS are mainly marine wildlife, such as whales, and anadromous fish.

F.14.2. State of Texas

In 1973, the Texas Parks and Wildlife Department (TPWD) was authorized to develop a list of endangered and threatened animal species in the state. Legal protection of endangered and threatened animals is provided by laws and regulations contained in Chapters 67 and 68 of the Texas Parks and Wildlife Code and Sections 65.171-65.176 of Title 31 of the Texas Administrative Code (TPWD 2013a). The State also designated species that, "due to limited distributions and/or declining populations, face the threat of extirpation or extinction but lack legal protection" (TPWD 2013b). Lists of these species were developed for the TPWD's Texas Conservation Action Plan. Species are rated or ranked using a system developed by NatureServe.

F.14.3. USFWS Birds of Conservation Concern

The USFWS has responsibilities for wildlife, including birds, in addition to endangered and threatened species. The Fish and Wildlife Conservation Act, as amended in 1988, further mandates that the USFWS "identify species, subspecies, and populations of all migratory nongame birds (i.e., Birds of Conservation Concern) that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act" (USFWS 2008). The agency's 2008 effort, *Birds of Conservation Concern*, is one effort to fulfill the Act's requirements. The report includes both migratory and non-migratory bird species (beyond those federally-listed as threatened or endangered) that USFWS considers the highest conservtion priorities. Three geographic scales are included-- National, USFWS Regional, and the NABCI BCRs. The information used to compile the lists came primarily from the following three bird conservation plans: the Partners in Flight North American Landbird Conservation Plan, the U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. The scores used to assess the species are based on factors such as population trends, distribution, threats, and abundance.

F.14.4. National Audubon Society/ American Bird Conservancy

The National Audubon Society and American Bird Conservancy each formerly published their own lists of bird species of concern, but have recently combined efforts into a single "Watch List". This collaborative effort was based on a concern by these organizations that there were too many lists with similar purposes (Butcher et al. 2007). Their 2007 WatchList is based on, but not identical to, the Partners in Flight (PIF) approach to species assessment (see below).

The 2007 WatchList has two primary levels of concern: a "Red WatchList" and a "Yellow WatchList", although the latter is subdivided into two categories. The Red WatchList identifies what these organizations consider as species of highest national concern. This list overlaps considerably with the IUCNs "Red List" (not presented here), thus, can essentially be considered as a list of globally threatened birds that occur in the United States (Butcher et al. 2007). The Yellow WatchList is made up of species that are somewhat less critical, but serves as an early warning list of birds that have the potential of being elevated to the Red WatchList. Species on this list can be there either because their populations are declining or because they are considered rare.

F.14.5. Partners in Flight

Partners in Flight is a cooperative effort among federal, state, and local government agencies, as well as private organizations. One of its primary goals, relative to listing species of conservation concern, is to develop a scientifically based process for identifying and finding solutions to risks and threats to landbird populations. Their approach to identifying and assessing species of conservation concern is based on biological criteria to evaluate different components of vulnerability (Panjabi et al. 2005). Each species is evaluated for six components of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding,

and population trend. The specific process is presented in detail in the species assessment handbook (Panjabi et al. 2005).

Their assessments are conducted at multiple scales. At the broadest scale, the North American Landbird Conservation Plan (Rich et al. 2004) identifies what PIF considers "Continental Watch List Species" and "Continental Stewardship Species." Continental Watch List Species are those that are most vulnerable at the continental scale, due to a combination of small and declining populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2005). Continental Stewardship Species are defined as those species that have a disproportionately high percentage of their world population within a single Avifaunal Biome during either the breeding season or the non-migratory portion of the non-breeding season.

More recently, PIF has adopted BCRs, the common planning unit under the NABCI, as the geographic scale for updated regional bird conservation assessments. These assessments are available via an online database (http://www.rmbo.org/pif/pifdb.html) maintained by RMBO. At the scale of the individual BCRs, these same principles of concern (sensu Continental Watch List Species) or stewardship (sensu Continental Stewardship Species) are applied at the BCR scale. The intention of this approach is to emphasize conservation of species where it is most relevant, as well as the recognition that some species may be experiencing dramatic declines locally even if they are not of high concern nationally, etc. There are two categories (concern and stewardship) each for Continental and Regional levels. The details of the criteria for inclusion in each can be found in Panjabi et al. (2005), and a general summary is as follows:

Criteria for Species of Continental Importance

A. Continental Concern (CC)

- Species is listed on the Continental Watch List (Rich et al. 2004).
- Species occurs in significant numbers in the BCR.
- Future conditions are not enhanced by human activities.

B. Continental Stewardship (CS)

- Species is listed as Continental Stewardship Species (Rich et al. 2004).
- Relatively high density (compared to highest density regions) and/or a high proportion of the species occurs in the BCR.
- Future conditions are not enhanced by human activities.

Criteria for Species of Regional Importance

Regional scores are calculated for each species according to which season(s) they are present in the BCR. The formulae include a mix of global and regional scores pertinent to each season (see Panjabi et al. 2005 for details). The criteria for each category are:

A. Regional Concern (RC)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details).
- High regional threats or moderate regional threat combined with significant population decline.
- Occurs regularly in significant numbers in the BCR.

B. Regional Stewardship (RS)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details).
- High importance of the BCR to the species.
- Future conditions are not enhanced by human activities.

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Appendix G: Bird Observations in Fort Davis NHS from 2005-2013 by Joshua Burns

This appendix contains a summary of data collected by Joshua Burns (a reviewer of the Breeding Landbirds section) during 134 surveys he conducted of lowland areas of Fort Davis NHS (Hospital Canyon, the area along the San Antonio-El Paso road to the old Pump House, and the regularly mowed area) between 2005 and 2013 (Burns 2014). These trips included 27 visits during the breeding season (April-June). Data shown are the total number of birds of each species observed during each period. Although data are shown for periods including those outside of the breeding season, data are shown only for those species observed during the breeding season. The top ten most numerous species recorded during the April-June period are shown in bold. J. Burns also provided species totals by month and overall (all months and years combined), but these data are not shown here. Note that the original list was provided in taxonomic order.

Common Name	Winter (DJF) [1]	Spring (MAM) [1]	Summer (JJ) [1]	Early Fall (AS) [1]	Late Fall (ON) [1]	Breeding Season (AMJ) [1]
Acorn Woodpecker	2	6	2	4	7	8
American Goldfinch	0	6	0	0	0	6
American Kestrel	5	2	2	3	14	3
Ash-throated Flycatcher	1	33	33	7	1	44
Band-tailed Pigeon	0	1	0	0	2	1
Barn Swallow	**0**	**40**	**106**	**148**	**2**	**96**
Bell's Vireo	0	1	3	0	0	2
Bewick's Wren	23	79	39	10	40	67
Black-chinned Hummingbird	0	38	17	8	1	42
Black-crested Titmouse	13	42	19	17	48	15
Black-headed Grosbeak	0	1	5	6	0	5
Black-tailed Gnatcatcher	2	8	2	7	9	4
Black-throated Sparrow	**175**	**199**	**84**	**90**	**161**	**144**
Blue Grosbeak	0	18	24	53	0	37
Blue-gray Gnatcatcher	2	15	0	1	17	5
Brewer's Blackbird	27	31	0	0	40	31
Brewer's Sparrow	**29**	**95**	**0**	**14**	**94**	**90**
Broad-tailed Hummingbird	0	0	2	0	0	2
Bronzed Cowbird	0	0	3	0	0	3
Brown-headed Cowbird	0	15	20	0	0	26
Bushtit	0	12	13	11	40	4
Cactus Wren	66	107	66	67	64	81
Canyon Towhee	77	124	58	89	93	88
Canyon Wren	**30**	**125**	**60**	**85**	**39**	**104**
Cassin's Kingbird	**0**	**53**	**102**	**94**	**35**	**100**
Cassin's Sparrow	5	18	4	19	0	15
Cave Swallow	0	12	9	15	0	14
Chihuahuan Raven	0	10	0	0	0	6
Chipping Sparrow	**313**	**494**	**5**	**42**	**204**	**155**

1= Months are indicated in parentheses using their first initial (e.g., D for December).

Common Name	Winter (DJF) [1]	Spring (MAM) [1]	Summer (JJ) [1]	Early Fall (AS) [1]	Late Fall (ON) [1]	Breeding Season (AMJ) [1]
Clay-colored Sparrow	2	8	0	20	17	6
Cliff Swallow	0	43	21	29	0	47
Common Raven	54	38	7	16	80	16
Cordilleran Flycatcher	0	5	0	2	0	5
Eastern Meadowlark	10	19	0	0	161	2
Eurasian Collared-Dove	2	20	9	5	1	12
European Starling	31	14	1	4	7	12
Ferruginous Hawk	0	4	0	0	0	4
Grasshopper Sparrow	0	1	0	7	0	1
Gray Flycatcher	0	2	0	4	4	2
Gray Hawk	0	0	3	0	0	1
Green-tailed Towhee	7	15	0	1	6	13
House Finch	16	59	44	54	89	30
House Sparrow	19	16	10	58	24	20
Inca Dove	0	4	1	0	0	5
Ladder-backed Woodpecker	19	12	9	9	19	7
Lark Sparrow	**0**	**53**	**48**	**50**	**3**	**89**
Lesser Goldfinch	0	15	36	32	6	25
Lincoln's Sparrow	3	2	0	0	2	1
Loggerhead Shrike	5	1	0	1	4	1
Montezuma Quail	0	0	4	2	4	4
Mourning Dove	10	35	26	11	44	25
Northern Cardinal	16	51	32	24	15	43
Northern Flicker	17	9	0	0	36	8
Northern Mockingbird	34	55	58	16	45	79
Phainopepla	15	36	61	19	10	61
Pine Siskin	1	50	0	0	0	50
Pyrrhuloxia	65	63	2	7	73	30
Red-tailed Hawk	14	22	10	3	10	16
Rock Wren	**59**	**119**	**67**	**101**	**205**	**99**
Ruby-crowned Kinglet	32	15	0	2	27	3
Rufous-crowned Sparrow	16	34	15	7	16	24
Savannah Sparrow	0	8	0	2	6	7
Say's Phoebe	19	46	40	47	30	57
Scaled Quail	18	7	6	3	35	6
Scott's Oriole	0	2	1	5	0	2
Spotted Towhee	21	19	3	0	5	6
Summer Tanager	0	1	13	5	0	1
Turkey Vulture	**0**	**533**	**118**	**181**	**56**	**201**
Verdin	5	23	6	4	12	11
Vermilion Flycatcher	0	2	1	0	0	2
Vesper Sparrow	1	24	0	9	44	14
Warbling Vireo	0	6	0	0	0	6

1= Months are indicated in parentheses using their first initial (e.g., D for December).

Common Name	Winter (DJF) [1]	Spring (MAM) [1]	Summer (JJ) [1]	Early Fall (AS) [1]	Late Fall (ON) [1]	Breeding Season (AMJ) [1]
Western Bluebird	75	49	0	1	0	3
Western Kingbird	0	9	16	6	4	10
Western Scrub-Jay	14	3	1	20	10	1
Western Tanager	0	4	6	11	0	6
Western Wood-Pewee	2	4	1	2	2	1
White-crowned Sparrow	2	4	0	0	1	2
White-winged Dove	**89**	**129**	**53**	**40**	**48**	**95**
Wilson's Warbler	0	6	0	0	0	6
Yellow Warbler	0	2	0	0	0	2
Yellow-billed Cuckoo	0	0	5	0	0	1
Yellow-breasted Chat	0	2	0	0	0	2
Yellow-rumped Warbler	1	18	0	0	6	12

1= Months are indicated in parentheses using their first initial (e.g., D for December).

Appendix H: Non-breeding Landbirds

This appendix lists bird species that may occur at Fort Davis NHS but do not breed there. The table is based on specific local records and recent survey data and was provided by Kelly Bryan (an expert reviewer of the Breeding Landbirds section of the NRCA; Bryan 2014b). Note that the original list from Bryan ordered the species taxonomically rather than alphabetically as shown here.

Common Name	Range Status	Comments [1]
Allen's Hummingbird	Migrant	Occasional in fall; rare in winter
American Goldfinch	Winter resident	Occasional
American Pipit	Winter resident	Uncommon
American Redstart	Migrant	Occasional; more than 10 local records
Anna's Hummingbird	Winter resident	Uncommon in late fall; occasional in winter; one nesting record within 10 miles of FODA
Bald Eagle	Winter resident	Occasional to rare
Band-tailed Pigeon	Migrant	Can be common in spring when mulberry trees have fruit; nests within 20 miles of FDNHS above 7,000 ft.
Belted Kingfisher	Migrant	Occasional
Black-and-white Warbler	Migrant	Occasional; more than 10 local records
Black-billed Cuckoo	Migrant	Accidental; one record at DMSP
Blackburnian Warbler	Migrant	Accidental; fewer than 5 local records
Black-throated Blue Warbler	Migrant	Accidental; fewer than 5 local records
Black-throated Gray Warbler	Migrant	Rare migrant in the foothills
Blue Jay	Winter resident	Uncommon in Fort Davis during the invasions years of 1966, 1970, 1976, 1977, 1981, and 1983
Blue-gray Gnatcatcher	Migrant	Uncommon; nests within 50 miles of FODA (but not in the Davis Mts.)
Blue-headed Vireo	Migrant	Accidental; fewer than 5 local records
Blue-winged Warbler	Migrant	One record; photographed at FODA
Brewer's Blackbird	Winter resident	Abundant; rare nesting species within 20 miles of FODA at McDonald Observatory
Brewer's Sparrow	Winter resident	Uncommon
Broad-billed Hummingbird	Summer resident	Numerous records in Fort Davis; at least 2 nesting records in the Davis Mountains
Broad-tailed Hummingbird	Summer resident	Uncommon migrant in Fort Davis; common nesting species above 5,500 ft.
Broad-winged Hawk	Migrant	Accidental; fewer than 5 local records
Brown Creeper	Migrant	Occasional
Brown Thrasher	Winter resident	Rare
Bullock's Oriole	Migrant	Occasional; nests within 100 miles of FODA
Burrowing Owl	Year-round	Very rare in winter; nests within 20 miles of FODA in open grasslands
Calliope Hummingbird	Migrant	Uncommon fall migrant
Canada Warbler	Migrant	Accidental; 5 local records
Cape May Warbler	Migrant	Accidental; 1documented record from DMSP
Carolina Wren	Resident	Accidental; has been found along Limpia Creek (1 specimen record)
Cassin's Finch	Winter resident	Sporadic; absent most years

Common Name	Range Status	Comments [1]
Cassin's Vireo	Migrant	Occasional
Cedar Waxwing	Winter resident	Uncommon to abundant at times
Chestnut-collared Longspur	Winter resident	Rare; abundant at times in open grasslands
Chestnut-sided Warbler	Migrant	Accidental; 1 local record
Chihuahuan Raven	Migrant	Uncommon to common at times
Chimney Swift	Summer resident	Accidental; has nested in Fort Davis
Clark's Nutcracker	Winter resident	Uncommon in Fort Davis during the invasion winter of 1972-73
Clay-colored Sparrow	Migrant	Common to occasional; rare in winter
Common Grackle	Winter resident	Rare
Common Ground-Dove	Year-round	Occasional; only one area nesting record in 1975
Common Yellowthroat	Migrant	Occasional; nests within 50 miles of FODA
Cordilleran Flycatcher	Migrant	Rare migrant in the foothills; uncommon nesting species within 20 miles of FODA above 6,500 ft.
Crissal Thrasher	Migrant	Rare; one record at DMSP
Dark-eyed Junco	Winter resident	Common to abundant at times; nests within 100 miles of FODA at Guadalupe Mountains National Park
Dickcissel	Migrant	Occasional
Dusky Flycatcher	Migrant	Common in spring, uncommon in fall; uncommon nesting species within 20 miles of FODA above 7,500 ft.
Dusky-capped Flycatcher	Migrant	One record in Fort Davis; rare nesting species at scattered locations within 20 miles of FODA above 6,500 ft.
Eastern Kingbird	Migrant	Accidental; 7 local records
Eastern Phoebe	Winter resident	Occasional
Eastern Bluebird	Winter resident	Uncommon
Evening Grosbeak	Winter resident	Sporadic; common during invasion years
Ferruginous Hawk	Winter resident	Winter population here in severe decline
Field Sparrow	Winter resident	Occasional
Flammulated Owl	Migrant	Photographed in spring at FODA; uncommon nesting species within 20 miles of FODA above 6,500 ft.
Fox Sparrow	Winter resident	Rare
Golden Eagle	Year-round	More common in winter than in summer; nests within 20 miles of FODA at isolated locations
Golden-crowned Kinglet	Migrant	Rare in the foothills; common in the mountains at times
Golden-crowned Sparrow	Winter resident	Accidental; one record from DMSP
Grace's Warbler	Migrant	Accidental in the foothills; 1record at DMSP; common nesting species within 20 miles of FODA above 6,000 ft.
Grasshopper Sparrow	Winter resident	Sporadic; nests within 20 miles of FODA in open plateau grasslands at the onset of monsoon rains in July & August
Gray Catbird	Migrant	Rare
Gray Flycatcher	Migrant	Occasional migrant in the foothills; common nesting species within 20 miles of FODA above 6,000 ft.
Gray Vireo	Migrant	Rare; nests within 50 miles of FODA, but not in the Davis Mountains
Great Crested Flycatcher	Migrant	Accidental; fewer than 5 local records
Green-tailed Towhee	Migrant	Common in spring; uncommon in fall and winter; uncommon nesting species within 20 miles of FODA above 7,000 ft.
Hammond's Flycatcher	Migrant	Rare migrant in the foothills
Hepatic Tanager	Migrant	Rare in the foothills; common nesting species within 20 miles of FODA above 5,500 ft.

Common Name	Range Status	Comments [1]
Hermit Thrush	Winter resident	Common migrant and winter resident; uncommon nesting species within 20 miles of FODA above 6,500 ft.
Hermit Warbler	Migrant	Accidental in the foothills; 2 records from DMSP; occasional in the mountains
Hooded Oriole	Migrant	Rare; nests within 100 miles of FODA
Hooded Warbler	Migrant	Accidental; fewer than 5 local records
House Wren	Winter resident	Uncommon migrant; rare in winter; common nesting species within 20 miles of FODA above 6,500 ft.
Juniper Titmouse	Winter resident	Documented in Fort Davis during the winter of 2000-2001
Kentucky Warbler	Migrant	Accidental; 4 local records
Lark Bunting	Migrant	Occasional to abundant at times
Lazuli Bunting	Migrant	Occasional
Least Flycatcher	Migrant	Occasional in spring; uncommon in fall
Lesser Nighthawk	Migrant	Rare around Fort Davis; common in lower desert settings
Lewis' Wood peeker	Winter resident	Rare; several local records
Lincoln's Sparrow	Winter resident	Common
Long-eared Owl	Migrant	Rare; 2 area nesting records
Louisiana Waterthrush	Migrant	Accidental; 1 record from DMSP
Lucifer Hummingbird	Summer resident	Numerous area records; breeding suspected but not yet documented
MacGillivray's Warbler	Migrant	Common in spring; uncommon in fall; rare nesting species within 20 miles of FODA above 7,000 ft.
Magnificent Hummingbird	Summer resident	One record at DMSP; uncommon nesting species above 6,000 ft.
Marsh Wren	Migrant	Rare; nests within 50 miles of FODA
Merlin	Winter resident	Occasional to rare
Mississippi Kite	Migrant	Rare
Mountain Bluebird	Winter resident	Sporadic in winter; one nesting record for the Davis Mtns.
Mourning Warbler	Migrant	Accidental; 1 record from DMSP
Nashville Warbler	Migrant	Common in spring; uncommon in fall
Northern Flicker	Winter resident	Common in migration and winter; uncommon nesting species within 20 miles of FODA above 5,500 ft.
Northern Harrier	Winter resident	Uncommon
Northern Parula	Migrant	Accidental; 5 local records
Northern Rough-winged Swallow	Migrant	Occasional
Northern Waterthrush	Migrant	Occasional; more than 10 local records
Northern Saw-whet Owl	Winter resident	Accidental; specimen record from DMSP
Olive-sided Flycatcher	Migrant	Uncommon
Orange-crowned Warbler	Winter resident	Common migrant, rare in winter; nests within 20 miles of FODA above 6,500 ft.
Osprey	Migrant	Occasional to rare
Ovenbird	Migrant	Accidental; 5 local records (photographed in Fort Davis)
Peregrine Falcon	Migrant	Seen rarely during migration; 1-2 nesting eyries within 20 miles of FODA
Pine Siskin	Winter resident	Uncommon in fall, abundant in spring; rare nesting species within 20 miles of FODA above 6,000 ft.
Pinyon Jay	Winter resident	Uncommon to abundant during the invasion years of 1966, 1969, 1971, 1972,1977, 1978, 1979, mid-1980s and 2000/2001

Common Name	Range Status	Comments [1]
Plumbeous Vireo	Migrant	Uncommon migrant; common nesting species within 20 miles of FODA above 5,500 ft.
Prairie Falcon	Year-round	More common in winter than summer; 3-5 nesting eyries within 20 miles of FODA
Prothonotary Warbler	Migrant	Accidental; 5 local records
Purple Finch	Winter resident	Accidental; 1 local record
Pygmy Nuthatch	Resident	One record in Fort Davis, January 1978; rare and local nesting species within 20 miles of FODA above 7,000 ft.
Red Crossbill	Winter resident	Sporadic; occasionally nests within 20 miles of FDNHS above 5,500 ft.
Red-breasted Nuthatch	Winter resident	Uncommon migrant; rare in winter
Red-eyed Vireo	Migrant	Accidental; 2 records from DMSP
Red-naped Sapsucker	Winter resident	Common in fall; uncommon in winter
Red-shouldered Hawk	Winter resident	Accidental; fewer than 5 local records
Rose-breasted Grosbeak	Migrant	Rare
Ruby-crowned Kinglet	Winter resident	Common to abundant
Ruby-throated Hummingbird	Migrant	Rare in spring; at times common in fall; 2 winter records
Rufous Hummingbird	Migrant	Abundant fall migrant; uncommon in winter
Sage Thrasher	Migrant	Sporadic as a migrant, uncommon at times; occasional in winter
Savannah Sparrow	Winter resident	Uncommon
Scarlet Tanager	Migrant	Accidental; 2 local records
Scissor-tailed Flycatcher	Migrant	Rare
Sharp-shinned Hawk	Winter resident	Common migrant and winter resident; rare nesting species within 20 miles of FODA above 6,500 ft
Song Sparrow	Winter resident	Occasional
Spotted Towhee	Winter resident	Common migrant, uncommon in winter; abundant nesting species within 20 miles of FODA above 6,000 ft.
Steller's Jay	Winter resident	Common in Fort Davis during the invasion year of 1973; common nesting species above 6,500 ft.
Swainson's Hawk	Summer resident	At times a common migrant overhead; nests within 20 miles of FODA in open plateau grasslands
Swainson's Thrush	Migrant	Occasional in spring, rare in fall
Swallow-tailed Kite	Migrant	A single bird observed daily over Fort Davis from 25 August to 4 September, 1966; roosted in the large cottonwoods at FODA
Swamp Sparrow	Winter resident	Occasional
Tennessee Warbler	Migrant	Accidental; 1 record at DMSP
Townsend's Solitaire	Winter resident	Sporadic as a migrant and winter resident; common at times
Towsend's Warbler	Migrant	Rare in spring, uncommon in fall; common at higher elevations in pine-oak
Tree Swallow	Migrant	Occasional
Tropical Parula	Migrant	Accidental; one nesting attempt at the adjacent DMSP
Varied Bunting	Summer resident	Occasional; nests within 20 miles of FODA near the Boy Scout Ranch
Varied Thrush	Winter resident	Accidental; 4 area records
Vesper Sparrow	Winter resident	Uncommon
Violet-crowned Hummingbird	Migrant	Accidental in Fort Davis; 5 documented local records, 3 in winter
Violet-green Swallow	Migrant	Uncommon migrant in the foothills; common nesting species within 20 miles of FODA above 6,500 ft.

Common Name	Range Status	Comments [1]
Virginia's Warbler	Migrant	Rare in the foothills; nests within 20 miles of FODA above 6,500 ft.
Western Bluebird	Winter resident	Uncommon to abundant in winter in the foothills; common nesting species within 20 miles of FODA above 5,500 ft.
Western Meadowlark	Winter resident	Common at times in Fort Davis; singing birds leave in May (no nesting records)
Western Tanager	Migrant	Common; uncommon nesting species within 20 miles of FODA above 6,000 ft.
White-crowned Sparrow	Winter resident	Common
White-throated Sparrow	Winter resident	Occasional
White-throated Swift	Year-round	Occasionally observed overhead in the foothills; nests only above 7,000 ft
Williamson's Sapsucker	Winter resident	Rare migrant in the foothills; uncommon in winter at higher elevations
Willow Flycatcher	Migrant	Uncommon in spring and fall
Wilson's Warbler	Migrant	Common to abundant
Winter Wren	Winter resident	Rare
Wood Thrush	Migrant	Accidental; 2 records from DMSP
Worm-eating Warbler	Migrant	Accidental; 1 bird photographed in Fort Davis, 1 specimen, 3 other local records
Yellow Warbler	Migrant	Uncommon
Yellow-bellied Flycatcher	Migrant	Accidental; one record at DMSP
Yellow-bellied Sapsucker	Winter resident	Occasional in fall; rare in winter
Yellow-headed Blackbird	Migrant	Uncommon
Yellow-rumped Warbler	Winter resident	Common migrant, uncommon in winter; uncommon nesting species within 20 miles of FODA above 6,500 ft.
Yellow-throated Vireo	Migrant	Rare; more than 5 local records
Yellow-throated Warbler	Migrant	Rare; more than 5 local records
Zone-tailed Hawk	Summer resident	Individuals seen often over Fort Davis; nests within 20 miles of FODA at various locations in the mountains

[1] FODA = Fort Davis NHS; DMSP = Davis Mountains State Park

Appendix I: Birds Recorded at Fort Davis NHS by RMBO (2010-2013) and Meyer and Griffin (2011 [2004-2006])

Below is the list of species recorded at Fort Davis NHS during: 1) annual Rocky Mountain Bird Observatory (RMBO) point count surveys in 2010-2013, and 2) breeding season and migratory season surveys by Meyer and Griffin (2011) in 2004-2006.

Common Name	2010-2013 RMBO Surveys	Meyer and Griffin (2011): 2005-2006 Sampling- Breeding Season only	Meyer and Griffin (2011): 2004-2006 Sampling- Migratory Seasons only[1]
Acorn Woodpecker	X	X	X
American Kestrel		X	X
Ash-throated Flycatcher	X	X	X
Barn Swallow	X	X	X
Bewick's Wren	X	X	X
Black-chinned Hummingbird	X	X	X
Black-chinned Sparrow	X		X
Black-crested Titmouse	X	X	X
Black-headed Grosbeak	X	X	X
Black-tailed Gnatcatcher	X		
Black-throated Sparrow	X	X	X
Blue Grosbeak	X	X	X
Blue-gray Gnatcatcher	X		
Brewer's Blackbird	X		X
Brewer's Sparrow	X		X
Broad-tailed Hummingbird	X		X
Bronzed Cowbird		X	
Brown-headed Cowbird	X	X	X
Bushtit	X	X	X
Cactus Wren	X	X	X
Canyon Towhee	X	X	X
Canyon Wren	X	X	X
Cassin's Kingbird	X	X	X
Cassin's Sparrow	X	X	X
Cave Swallow	X		
Chihuahuan Raven	X		
Chipping Sparrow	X		X
Clay-colored Sparrow			X
Cliff Swallow	X	X	X
Common Black-hawk			X
Common Raven	X		X
Cooper's Hawk	X	X	X

1= Fall and/or Spring Seasons.

Common Name	2010-2013 RMBO Surveys	Meyer and Griffin (2011): 2005-2006 Sampling- Breeding Season only	Meyer and Griffin (2011): 2004-2006 Sampling- Migratory Seasons only[1]
Curve-billed Thrasher	X		X
Dusky Flycatcher			X
Eastern Meadowlark	X		X
Eurasian Collared-Dove	X	X	X
European Starling	X		X
Gray Flycatcher	X		X
Gray Hawk			X
Great Horned Owl	X		
Greater Roadrunner		X	X
Great-tailed Grackle	X		
Green-tailed Towhee	X		X
Hermit Thrush			X
House Finch	X	X	X
House Sparrow	X		
House Wren			X
Indigo Bunting		X	
Killdeer			X
Ladder-backed Woodpecker	X	X	X
Lark Sparrow	X	X	X
Lesser Goldfinch	X	X	X
Lesser Nighthawk	X		
Lincoln's Sparrow			X
Loggerhead Shrike			X
MacGillivray's Warbler	X		
Montezuma Quail	X		X
Mourning Dove	X	X	X
Northern Cardinal	X	X	X
Northern Flicker	X		X
Northern Mockingbird	X	X	X
Orange-crowned Warbler			X
Orchard Oriole			X
Phainopepla	X	X	X
Pine Siskin			X
Plumbeous Vireo	X		
Pyrrhuloxia	X		X
Red-breasted Nuthatch			X
Red-tailed Hawk	X	X	X
Rock Wren	X	X	X
Ruby-crowned Kinglet			X
Rufous Hummingbird			X
Rufous-crowned Sparrow	X	X	X
Savannah Sparrow	X		

1= Fall and/or Spring Seasons.

Common Name	2010-2013 RMBO Surveys	Meyer and Griffin (2011): 2005-2006 Sampling- Breeding Season only	Meyer and Griffin (2011): 2004-2006 Sampling- Migratory Seasons only[1]
Say's Phoebe	X	X	X
Scaled Quail	X		
Scott's Oriole	X	X	X
Spotted Towhee	X		
Summer Tanager	X	X	X
Townsend's Warbler			X
Turkey Vulture	X	X	X
Verdin	X	X	X
Vermilion Flycatcher	X		X
Vesper Sparrow	X		X
Violet-green Swallow		X	
Virginia's Warbler	X		
Western Kingbird		X	X
Western Scrub-Jay	X	X	X
Western Tanager	X		X
Western Wood-Pewee	X	X	X
White-breasted Nuthatch	X		
White-crowned Sparrow	X		X
White-winged Dove	X	X	X
Wilson's Warbler	X		X
Yellow-rumped Warbler	X		X
Zone-tailed Hawk			X

1= Fall and/or Spring Seasons.

NPS 418/127449, December 2014

National Park Service
U.S. Department of the Interior

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