Department of Defense
Legacy Resource Management Program

PROJECT NUMBER 09-425

Habitat Use at Multiple Scales by Pinyon-Juniper Birds on Department of Defense Lands: Landscape Scale

Kristine Johnson, Lynn Wickersham, Teri Neville, John Wickersham, Jacqueline Smith, Matthew Baumann, and Carol Finley
Natural Heritage New Mexico Publication 11-GTR-360

5 January 2011

Habitat Use at Multiple Scales by Pinyon-Juniper Birds on Department of Defense Lands: Landscape Scale

Project Year 1

Kristine Johnson, Lynn Wickersham, Teri Neville, John Wickersham,
Jacqueline Smith, Matthew Baumann, and Carol Finley
Natural Heritage New Mexico Publication 11-GTR-360
5 January 2011

Contents

List of Figures

Acknowledgments

Many thanks to Gregg Dunn, Rachel Grey, Michael Hilchey, Pete Skartvedt, Cristin Salaz, Raymond VanBuskirk, James Wickersham, Cassandra Wilson, and Cole Wolf for their excellent work in the field. Trish Griffin provided logistical support, Gray Vireo location data, and access to WSMR field sites. Steve Latimer provided access and support for Gray Vireo field work at CTTA. Steve Cox provided guidance on potential Pinyon Jay study sites at KAFB and attaching transmitters and assisted with banding Gray Vireos at the MAPS (Monitoring Avian Productivity and Survivorship) station he operates at KAFB. Doug Burkett provided Gray Vireo location data and field support at WSMR. Suzanne Field alerted us to the presence of the SOR group and collected data on banded birds at SOR. We thank our pinyon seed supplier "Pinyon Penny" Frazier for constantly supplying high-quality *P. edulis* seed and for her unflagging commitment to Pinyon Pine Woodlands and their birds. We appreciate the excellent support provided by Jane Mallory and Pedro Morales of the DoD Legacy Program. This study was supported by DoD Legacy contract number W912DY-09-2-0023.

Abstract

Pinyon-juniper woodlands cover approximately 40 million hectares of the western US. They represent the dominant woody vegetation and contain the most biodiverse terrestrial habitats on at least six Department of Defense (DoD) installations. Throughout their range, pinyon-juniper habitats are threatened by drought, insects, disease, and fire, all of which can be exacerbated by climate change, and several pinyon-juniper animal species have been classified as Species-at-Risk (SAR). This project investigates habitat use at multiple scales (landscape, territory/colony, and nest) by two pinyon-juniper SAR, Gray Vireo and Pinyon Jay, at three DoD installations in New Mexico. This study of habitat use by two at-risk species that differ in seasonal movements, social structure, and foraging habits, viewed at multiple scales and several installations, will provide a broad perspective on the management of pinyon-juniper woodlands. This report covers the first year of the project, in which we focused on landscape-scale habitat use.

The GIS landscape-scale habitat model for Gray Vireos at New Mexico Army National Guard Camel Tracks Training Area covers approximately 797 ha of potential habitat ranging in elevation from 1935-2110 m. The juniper upland vegetative type occurs at slightly higher elevation (mean = 2027 m) than the lowland counterpart (mean = 2001 m) and is characterized as Juniper Woodland and Savanna on Volcanic Hills. The juniper lowland type is classified as Juniper Savanna on Lava Plains. Greater than 75% of Gray Vireo detections (n=129) and nests (n=20) in this study occurred within the Juniper Woodland and Savanna on Volcanic Hills vegetation type.

The GIS landscape-scale model for Gray Vireos at Kirtland Air Force Base (KAFB) covers approximately 9275 ha, ranging in elevation from approximately 1742 to 2449 m. The Gray Vireo study area is located almost entirely within the Juniper Woodland and Savanna vegetation type, with only the most southeastern and eastern portions occurring partially within the Pinyon-Juniper Woodland and Pinyon Pine Woodland vegetation types. The Juniper Woodland and Savanna type comprises approximately 4441 ha and ranges in elevation from 1742 to 2319 m. In this study, 100% of Gray Vireo detections and nests were within the Juniper Woodland and Savanna vegetation type. Most vireo territories at KAFB occurred in juniper woodland habitat, with only a few territories in the southwestern portion of the study area located in juniper savanna habitat, generally between 1750 and 1800 m in elevation.

The landscape-scale habitat model for Pinyon Jays at KAFB covers 9275.6 ha of potential habitat, ranging in elevation from approximately 1780 m to 2420 m. The majority of Pinyon Jay observations at KAFB were from Juniper Woodland and Savanna (n=91) and Pinyon-Juniper Woodland (n=22), with only eight in Pinyon Pine Woodland and two in previously-burned woodland, now Grassland. Pinyon Jay breeding and nonbreeding ranges at KAFB contain similar proportions of higher-elevation Pinyon Pine Woodland, and the smaller Grassland and Shrubland units are similarly-represented. The breeding home range, however, contains 66.9% Juniper Woodland and Savanna, compared to 55.7% in the nonbreeding home range. Pinyon-Juniper Woodland is higher in the nonbreeding area (27.3%) than in the breeding area (20.4%).

The landscape model for Pinyon Jays in the Oscura Mountains at White Sands Missile Range (WSMR) covers 21,188 ha of potential habitat, ranging in elevation from approximately 1800 m to 2430 m. Pinyon Pine Woodland, Pinyon-Juniper Woodland, and Juniper Woodland and Savanna are included in the landscape habitat model for Pinyon Jays at WSMR. The breeding season home range of the WSMR flock contains a slightly higher percentage of Pinyon Pine Woodland (63.7% vs. 59.2 %) than the nonbreeding season range. Conversely, the nonbreeding season home range model contains slightly more Pinyon-Juniper Woodland (10.6 % vs. 5%). Other vegetation types are comparable between seasons. However, the actual differences in habitat use between seasons could be much larger than indicated here, due to the incompleteness of our spatial data for wintering Pinyon Jays at WSMR.

We discuss proximity of both species to military activities and infrastructure and make recommendations for landscape scale management of pinyon-juniper habitats for both species.

Introduction

Pinyon-Juniper Habitats and Wildlife

Pinyon-juniper (*Pinus edulis*, *P. monophylla*, *P. cembroides*, *Juniperus* spp.) woodlands cover approximately 40 million hectares of the western US (Romme et al. 2009). They represent the dominant woody vegetation and contain the most biodiverse terrestrial habitats on at least six DoD installations (Figure 1). Pinyon-juniper habitats throughout their range, including on military installations, are currently threatened by drought, insects, disease, and fire, all of which can be exacerbated by climate change. Since 2001, dramatic, rapid, large-scale mortality of pinyon pine trees has occurred in the southwestern US due to drought-related insect and disease outbreaks (Allen-Reid et al. 2005, Breshears et al. 2005). In addition to natural impacts, some private, state, and federal land managers are implementing pinyon-juniper management programs that include thinning, mechanical clearing, herbicides, and fire (Bureau of Land Management, BLM, 2009). Outside DoD lands, development and livestock management also contribute to degradation of pinyon-juniper woodlands. Unlike private lands, which are subject to development, management for livestock, and fuelwood exploitation, woodlands on military installations have been managed relatively sustainably.

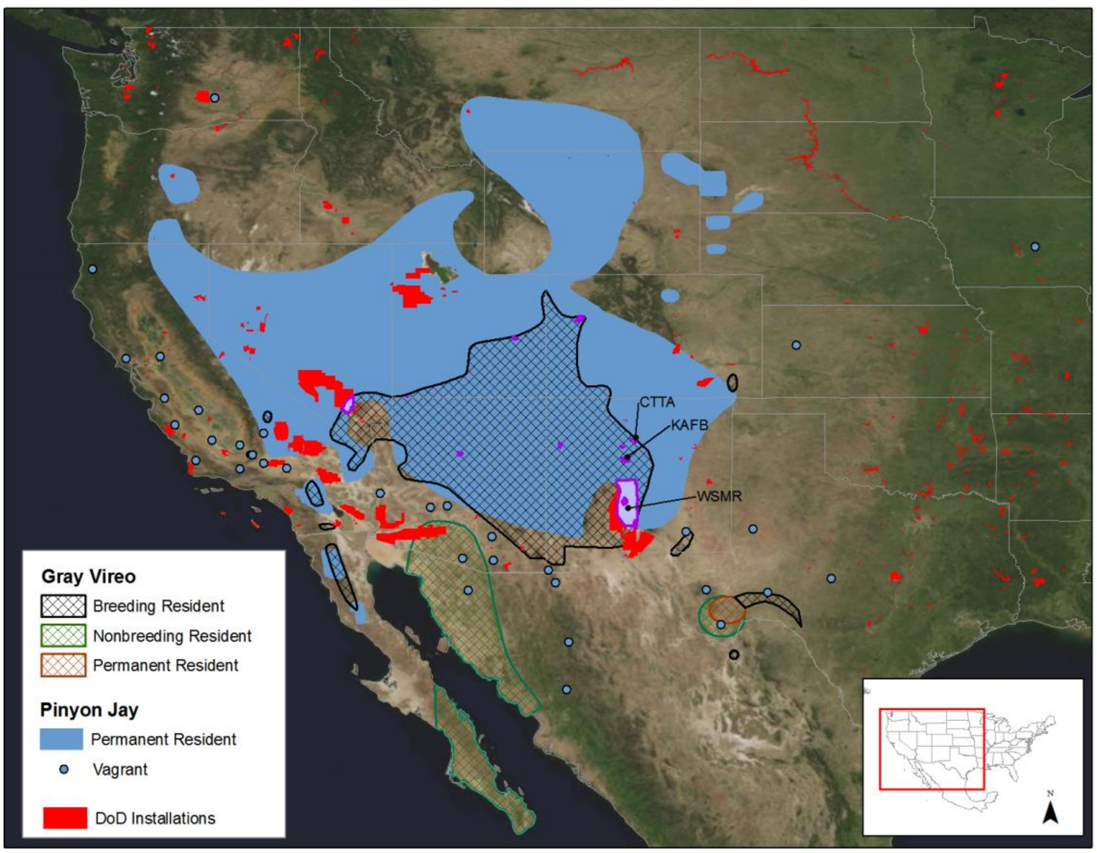

Figure 1. Gray Vireo and Pinyon Jay distribution throughout North America showing DoD installations.

Although fire has been found to play a role in structuring pinyon-juniper woodlands on New Mexico installations (Muldavin et al. 2003) and across the region (Baker and Shinneman 2004), fire is only one factor affecting the processes and patterns of this complex ecosystem. In addition, recent research indicates that fire has not historically been an important factor in structuring some types of pinyon-juniper woodlands (Romme et al. 2009). Birds, particularly Pinyon Jays (*Gymnorhinus cyanocephalus*), drought, and insect pests also play critical roles in the establishment and demise of these woodlands (Romme et al. 2009). Pinyon Jays serve as short- and long-distance seed dispersers for pinyon pines, and the pines in turn provide mast crops of pinyon seeds that ensure Pinyon Jay population viability (Ligon 1978, Marzluff and Balda 1992). Adapted for carrying and caching millions of seeds in a few weeks, Pinyon Jays are the only seed disperser capable of re-planting an entire woodland decimated by fire, chaining, or insect pests. It has been suggested that an evolved keystone mutualism between the tree and the bird ensures their mutual, long-term sustainability (Ligon 1978, Lanner 1996).

The impacts of insects on pinyon-juniper ecosystems have become poignantly evident in recent years, with the drought-induced expansion of pinyon bark beetle (*Ips confusus*) impacts across the western United States. In 2002-2003, regional-scale die-off of *P. edulis* occurred across the Southwest. At one site, >90% of pinyon trees died. The mortality was detectable in a remotely-sensed index of greenness, the Normalized Difference Vegetation Index, over 12,000 km^2 (Breshears et al. 2005). In addition, wildfire and management for livestock grazing have recently removed significant areas of pinyon-juniper woodland in New Mexico and the Southwest (BLM 2009). Global climate change is expected to bring increased temperatures and frequent drought, which will only exacerbate insect and wildfire impacts. The range of pinyon-juniper habitat is predicted to significantly contract in southern New Mexico, Utah, and Arizona under climate change (Thompson et al. 1998, Cole et al. 2007) and expand in northern New Mexico and Colorado (Cole et al. 2007).

The insecure status of several native pinyon-juniper wildlife species provides further evidence that these habitats are threatened. The Gray Vireo (*Vireo vicinio*r) is a DoD Species at Risk (SAR), listed as threatened by the state of New Mexico, a US Forest Service Sensitive Species (Region 3), and a New Mexico Partners in Flight (NM PIF) Level 1 Species of Concern. The Pinyon Jay is a SAR and a NM PIF Level 1 Species of Concern (NMPIF 2007). Both species are on the North American Partners in Flight Watch List (Rich et al. 2004). Both are identified as Species of Greatest Conservation Need (SGCN) by the states of Colorado and New Mexico, and the Gray Vireo is a SGCN in Utah (Sutter et al. 2005, Colorado Division of Wildlife 2006, New Mexico Department of Game and Fish 2006).

Other pinyon-juniper bird and mammal species that occur on DoD lands are also at risk; for example, Oscura Mountains Colorado chipmunk (*Neotamias quadrivittatus oscuraensis*), Black-throated Gray Warbler (*Dendroica nigrescens*), and Juniper Titmouse (*Baelophus ridgwayi*). All are SGCN in New Mexico, the latter two in Colorado, and the warbler in Utah (Sutter et al. 2005, Colorado Division of Wildlife 2006, New Mexico Department of Game and Fish 2006).

In contrast to the Pinyon Jay, which is resident, omnivorous, and highly social (flocking in winter and nesting colonially and cooperatively), the Gray Vireo is migratory, insectivorous, and territorial. The jay nests largely in pinyon-dominated vegetation types. The vireo nests primarily in juniper and has not evolved the mutualism shared by Pinyon Jays and pinyon pines. In spite of the differences in their natural histories, both are species of concern. This, in addition to the other pinyon-juniper species that are at risk, suggests that impacts to pinyon-juniper habitats are far-reaching.

Gray Vireo

Gray Vireos are short-distance migrants that breed in the southwestern US and northwestern Mexico. Throughout their range, Gray Vireos prefer pinyon-juniper, scrubland, or chaparral habitats in arid, mountainous terrain or high plains (Barlow et al. 1999). In New Mexico, they are primarily associated with juniper woodlands and savannas of the foothills and mesas, usually with a well-developed grassy understory, and in some areas, a pinyon or oak component (New Mexico Department of Game and Fish 2005). Diet includes a variety of large arthropods, including grasshoppers, cicadas, and caterpillars. In the winter, they may also eat fruit (Barlow et al. 1999). Distribution of the Gray Vireo in New Mexico is patchy, and the majority of occupied habitats contain fewer than 10 territories (DeLong and Williams 2006). Reported density estimates have been as low as 0.005 and as high as 0.069 birds/ha throughout the species' range (Weathers 1983, Colorado BLM 1995, Giroir 2001, DeLong and Williams 2006, Hutton et al. 2006, Schlossberg 2006, Wickersham and Wickersham 2007). Breeding territory size has not been well-documented; however, a few studies have reported territories ranging from 2–10 ha (Barlow et al. 1999, J. Wickersham and L. Wickersham unpublished), and singing males have been reported every 300 m in Texas and Arizona (Wauer 1983 in Barlow et al. 1999, Barlow 1978, respectively). Gray Vireos are commonly parasitized by Brown-headed Cowbirds (*Molothrus ater*), but the impact on vireo population viability is not well understood.

Pinyon Jay

Pinyon Jays are year-round residents in pinyon-juniper habitats across the southwestern US. They also occur in Idaho, Montana, Wyoming, and central Oregon, where they inhabit woodlands and scrublands containing ponderosa pine (*Pinus ponderosa*), juniper, and chaparral vegetation (Balda 2002). They nest colonially and breed cooperatively on traditional nesting grounds. Pinyon jays are omnivorous, taking pine seeds, acorns, juniper berries, arthropods, and small vertebrates, but they especially depend on the seeds of pinyon pines. With their ability to carry up to 50 pinyon seeds at a time, Pinyon Jays are the main long-distance seed disperser for pinyon trees. In return for seed dispersal services, the trees provide mast crops of abundant, highly nutritional seeds. Cached seeds sustain Pinyon Jays over winter, support successful nesting, and strongly influence jay population viability (Marzluff and Balda 1992). Pinyon Jays form large winter flocks that historically have numbered up to several hundred birds and range widely in search of pinyon seeds and other foods. Due to its unique keystone mutualism with pinyon trees (Ligon 1971, 1974, 1978), the Pinyon Jay is arguably the most important avian indicator of pinyon woodland productivity. The pinyon pine's most important seed disperser is considered to be at risk because populations range-wide have been declining significantly for over 40 years (Sauer et al. 2007).

The Project

The predominance of pinyon-juniper woodlands on military installations in the Southwest, along with the current threats to these habitats and their wildlife, underscore the need for information on proper management of pinyon-juniper. The management history of pinyon-juniper woodlands on military lands makes them excellent laboratories for the study of the habitat needs of pinyon-juniper wildlife and the compatibility of at-risk species with military activities.

For this project, we are investigating pinyon-juniper habitat use by two avian SAR, Pinyon Jay and Gray Vireo. We are collecting data on habitat use at multiple scales (landscape, territory, and nest) at three installations: White Sands Missile Range (WSMR), Kirtland Air Force Base (KAFB), and Camel Tracks Training Area (CTTA) (Figure 2). CTTA has ~1200 ha of juniper woodland/savanna, and WSMR and KAFB have ~54,100 ha and ~7497 ha of pinyon-juniper habitats, respectively. This study of habitat use by two at-risk species that differ in seasonal movements, social structure, and foraging habits, viewed at multiple scales and several installations, will provide a broad perspective on the proper management of pinyon-juniper woodlands. This report covers the first year of the project, in which we focused on landscape-scale habitat use by Pinyon Jays and Gray Vireos. The second-year report will address habitat use at the colony/territory and nest scales.

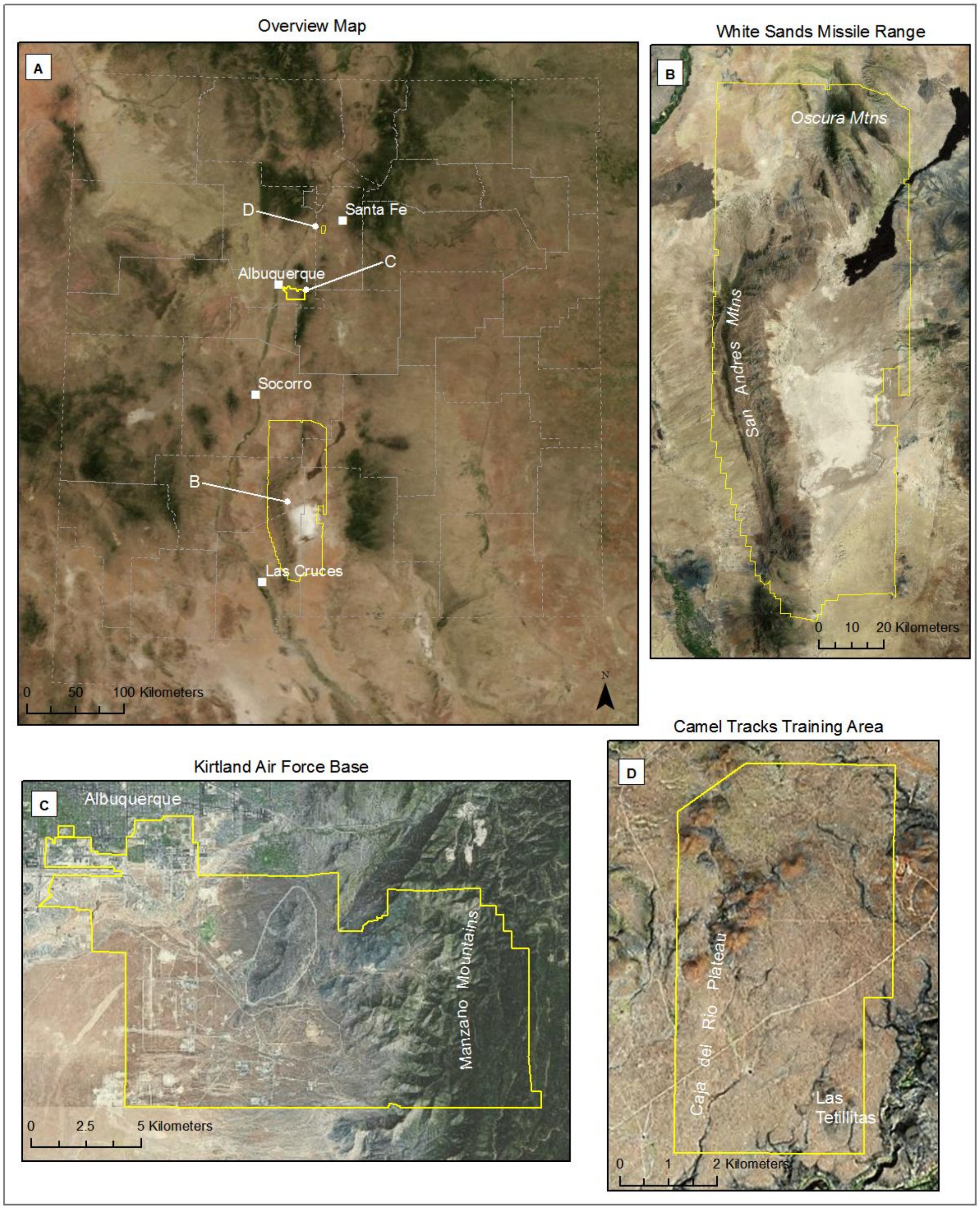

Figure 2. Study area maps for the three DoD installations in New Mexico: a) overview map of all installations, b) White Sands Missile Range, c) Kirtland Air Force Base, and d) Camel Tracks Training Area.

Study Areas

Camel Tracks Training Area (CTTA)

CTTA is a ~3345 ha area owned by Bureau of Land Management (BLM) and used by the U.S. Army National Guard for military training. It is located approximately 22.5 km southwest of Santa Fe, NM and is bounded on the north and west by Santa Fe National Forest. Our study area included only the northwestern portion of CTTA, where most of the suitable Gray Vireo habitat occurs and a breeding population has been monitored by Natural Heritage New Mexico since 2001 (Figure 2d). Topography in the study area is relatively flat to rolling terrain ranging in elevation from approximately 1950 to 2100 m. The only access to the study area is via unimproved two-track roads. Vehicle traffic is minimal during the Gray Vireo breeding season due to a seasonal closure to military training activities. CTTA has approximately 1200 ha of juniper woodland habitat. Habitat in the study area is primarily one-seed juniper (*Juniperus monosperma*) woodland, with ≤5% pinyon pine. Understory vegetation is dominated by native grasses, tree cholla (*Cylindropuntia imbricata*), yucca (*Yucca* spp.) and prickly pear cactus (*Opuntia phaecantha*). Shrub density is relatively low, but some of the most common species include antelope bitterbrush (*Purshia tridentata*), Sonoran scrub oak (*Quercus turbinella*), and wolfberry (*Lycium* spp.).

Situated mid-way between the Sangre de Cristo Mountains to the east and the Jemez Mountains to the west, CTTA maintains a relatively low average annual precipitation of 21 cm with nearly 40% of total precipitation occurring during the summer monsoons (Figure 3, Western Regional Climate Center 2010). Average monthly temperature ranges from -7.5º C in January to relatively mild summer highs averaging 30º C (Figure 3, Western Regional Climate Center 2010).

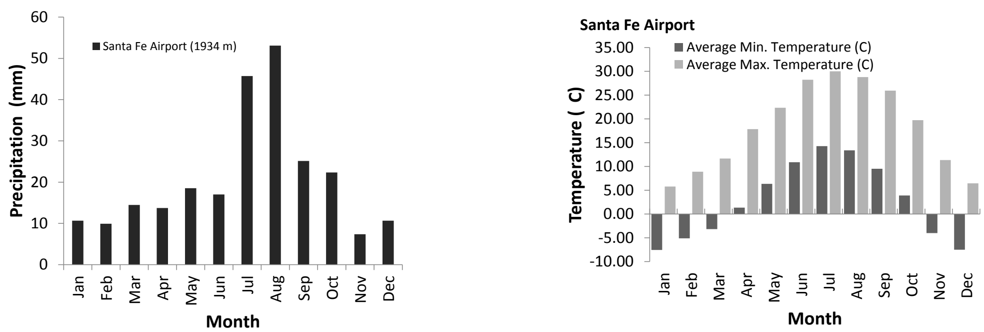

Figure 3. Average monthly precipitation and temperature for CTTA at the Santa Fe Airport.

Kirtland Air Force Base (KAFB)

KAFB, 20,359 ha in area, is located at the southeast corner of Albuquerque, NM. Pinyon-juniper habitats at KAFB occur primarily on the western slopes and bajadas of the Manzanita Mountains, a north-south chain that connects the relatively higher Sandia Mountains to the north (elevation 3255 m) and Manzano Mountains (elevation 2802 m) to the south. KAFB has about 2697 ha of juniper and pinyon-juniper habitats ranging in elevation from 1888 to 2427 m. These habitats are situated between lower-elevation desert shrubland and grassland and higher-elevation ponderosa pine woodland.

Climate at KAFB is characterized by low precipitation and wide temperature extremes. Precipitation comes primarily during the summer months in the form of heavy, short-duration thunderstorms (Figure 4). Annual precipitation varies from 20.3 cm in arid valleys and mesas to 76.2 cm in the Sandia Mountains (Kirtland Air Force Base 2007). At the Albuquerque Airport weather station, the average monthly temperature ranges from 6.2-21^0 C (Western Regional Climate Center 2010, Figure 4).

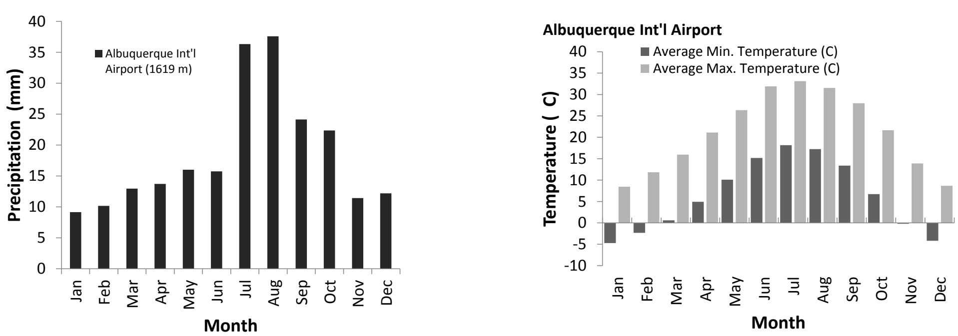

Figure 4. Average monthly precipitation and temperature for KAFB at Albuquerque International Airport.

Our Gray Vireo study area includes a portion of the known Gray Vireo breeding habitat on KAFB located east of the Withdrawal Area boundary in the foothills of the Manzanita Mountains (Figure 5). It includes areas north and south of Arroyo del Coyote and the adjacent Coyote Springs Road and includes Madera, Lurance and Sol se Mete Canyons. Historically occupied Gray Vireo habitat occurs primarily on toe slopes, although some territories also extend into side canyons or relatively flat terrain at the base of the foothills. Elevation ranges from approximately 1676-2137 m. Habitat is juniper woodland and savanna, with approximately 90% juniper and 10% pinyon. Understory vegetation is dominated by native grasses, tree cholla, yucca, and prickly pear. While shrub density is relatively low, some common species include fourwing saltbush (*Atriplex canescens*), mule fat (*Baccharis salicifolia*), Sonoran scrub oak, wolfberry, and big sagebrush (*Artemisia tridentata*).

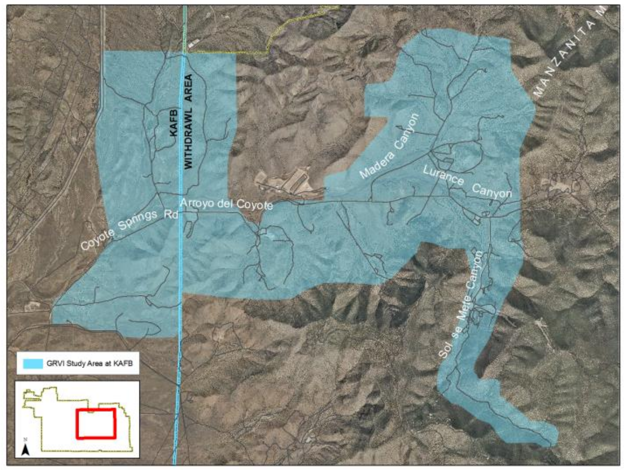

Figure 5. Gray Vireo study area at KAFB.

Our Pinyon Jay study area at KAFB partially overlaps the Gray Vireo study area in lower-elevation juniper woodland habitat but extends through higher-elevation mixed pinyon-juniper woodlands and into pinyon-dominated woodland with varying ages of pinyon, including many large trees (Figure 6). Our study focused on two disjoint areas, the northern area along Coyote Springs Road, and the southern area in steep, isolated terrain near the southern installation boundary. Shooting and ground-based military training occur in the northern area. The area between these two focal areas was included in the study area, but birds were rarely detected there.

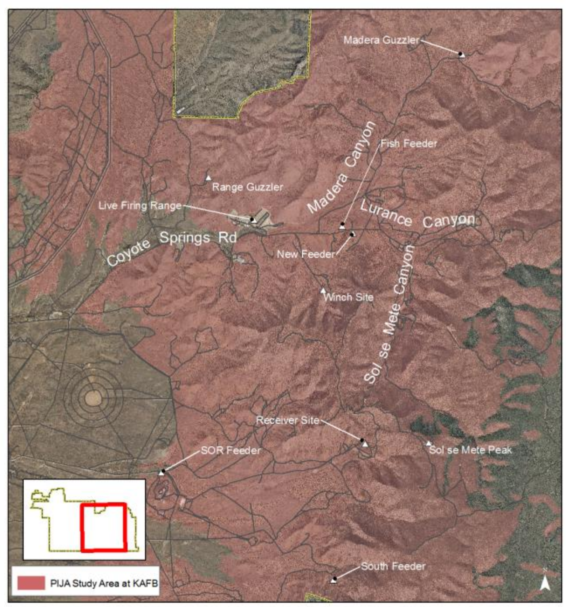

Figure 6. Pinyon Jay study area at KAFB.

White Sands Missile Range (WSMR)

WSMR, approximately 885,910 ha in area, excluding buffer extension areas, is located in south-central New Mexico. The installation includes three major mountain ranges, the Oscura Mountains (maximum elevation 2431 m at North Oscura Peak, NOP) in the north, the San Andres Mountains (maximum elevation 2733 m at Salinas Peak) in the south, and a portion of the Organ Mountains in the southwest corner of the missile range. The San Andres Mountains are a large, west-tilted fault block with precipitous, east-facing escarpments and long, gentle slopes to the west. The Oscuras are also fault-block mountains but are tilted downward toward the east, with escarpments facing west. WSMR has about 54,100 ha of juniper, pinyon, and pinyon-juniper woodlands and savannas within the mountain ranges (Muldavin et al 2000 a, b).

The climate in the mountains of WSMR is semi-arid, with annual precipitation averaging between 31-35 cm. Salinas Peak (SAL) averages greater precipitation than North Oscura Peak (Figure 7). The majority of precipitation comes during the summer in the form of short-duration, intense thunderstorms (Muldavin et al. 2000b) throughout July and August (WSMR Climate Stations 2009). Average temperatures range from -3.8 º C in January at NOP to 29.9 º C at Salinas Peak in July.

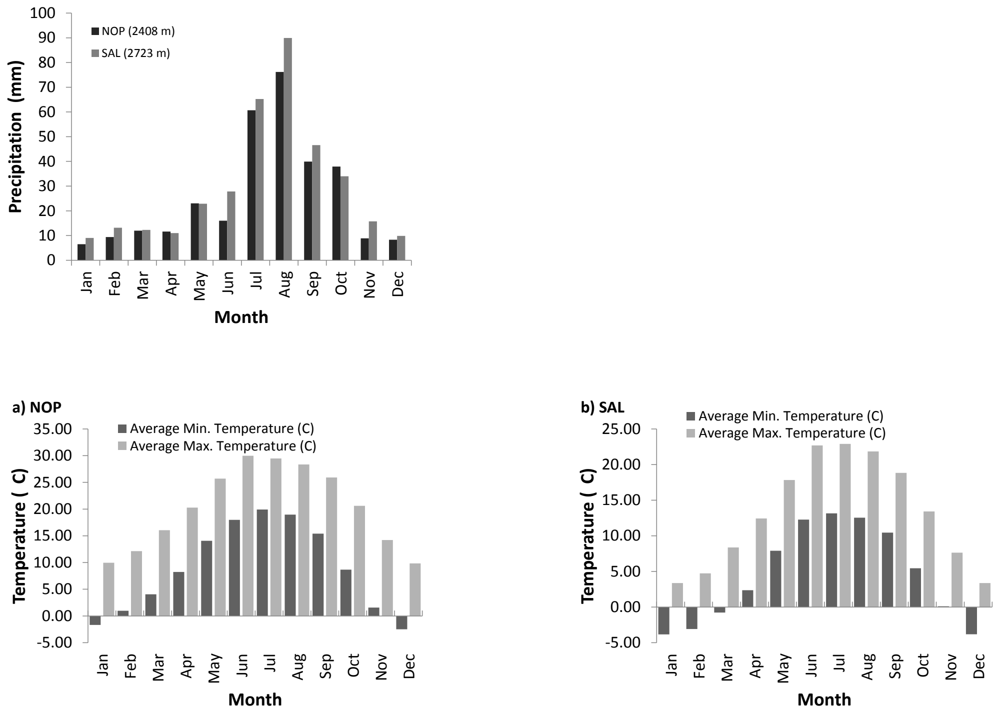

Figure 7. Average monthly precipitation and temperature at NOP and SAL for WSMR.

Our Pinyon Jay study area at WSMR ranges from the highest elevations of the Oscura Mountains at NOP into mid-elevation, one-seed juniper woodland and savanna vegetation (Figure 8). The eastern slopes of the Oscuras support some of the largest stands of contiguous, minimally disturbed woodlands in the Southwest, approximately 13,750 ha (Muldavin et al. 2003). The east-dipping slopes are cut by several small canyons that create moderate landscape heterogeneity. At lower elevations, the woodlands are dominated by junipers with scattered pinyons, while at higher elevations pinyons dominate and form heterogeneous, multi-tiered canopies with various mixtures of shrubs and grasses in the understory. Cooler north-facing slopes tend to be dominated by pinyon-wavyleaf (*Quercus undulata*) and Gambel oak (*Q. gambelii*) communities, and drier south-facing slopes are dominated by scattered grasses, wavyleaf oaks, and yuccas (*Yucca* spp.). Pinyon pine stands have complex, multi-age class sub-structures that could be a result of animal seed caching and seed rain coupled with climate-driven recruitment following fires. Pinyon patches vary in age from 0-60 y, 60-100 y, and >100 y (Muldavin et al. 2003). This multi-aged structure may be an attribute of corvid-initiated pine forests (Lanner 1996). Military training does not typically occur at this site, but vehicle traffic is associated with research facilities located at NOP.

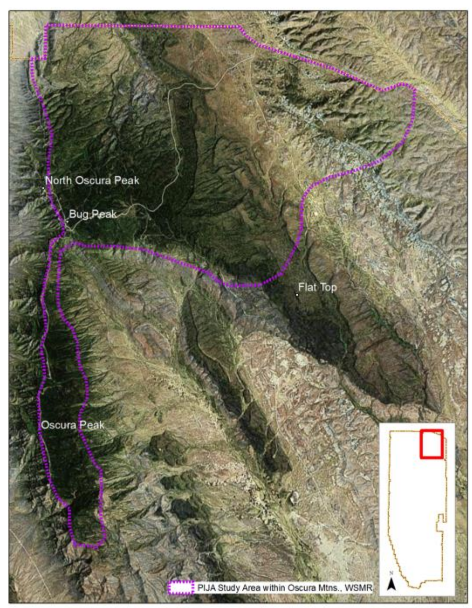

Figure 8. Pinyon Jay study area within the Oscura Mtns., WSMR.

Methods

Gray Vireos

We conducted field work for landscape-level habitat use at KAFB and CTTA in 2009 and 2010. We added WSMR as a study site in 2010, because a base-wide survey conducted in 2009 identified approximately 196 Gray Vireo territories (Burkett et al. 2009). The Year 1 report, however, includes only landscape-level habitat use for Gray Vireos at KAFB and CTTA. The landscape-level results for WSMR will be presented in the Year 2 report.

KAFB and CTTA

During each year, we initiated Gray Vireo occupancy surveys in May, generally following the playback method developed by DeLong and Williams (2006). We focused our survey efforts within traditional Gray Vireo territories identified at each installation in prior years (Arbetan and Muldavin 2006, Arbetan 2009, Wickersham and Wickersham 2009). We conducted surveys between sunrise and noon when birds sing most. We walked transects through traditional territories, stopping and using playback surveys about every 200–300 m. Each stop began with a 1 min listening period. If no vireos were detected during the listening period, we broadcast Gray Vireo songs for approximately 20–30 s using MP3 players with external speakers. The broadcast period was followed by another 1 min listening period. We continued this cycle of playbacks and listening, rotating the direction of the playback to ensure songs were broadcast 360^0 from each survey point. Where Gray Vireos were detected, we marked their locations in the field using GPS units. We mapped each Gray Vireo detection using ArcGIS. We completed one set of occupancy surveys at KAFB and CTTA by the end of May of each year.

After initial occupancy surveys in 2009 and 2010, we conducted target mist netting and color banding at KAFB and CTTA to assist in identifying individual Gray Vireos and delineating territories. All Gray Vireo color banding activities, including the capturing, handling and marking of Gray Vireos, were conducted under USGS Federal Bird Marking and Salvage Permit #23488 and New Mexico Department of Game and Fish Scientific Collection Permit #3362, issued to Lynn Wickersham.

We attempted to color band as many adult Gray Vireos as possible at KAFB and CTTA between late May and late July, generally during the morning hours but sometimes into early afternoon if vireos were still actively singing. We revisited territories occupied by unbanded Gray Vireos and listened for singing birds. When vireos were detected, we attempted to capture the birds using mist nets. We erected one or two 12 x 2.6 m mist nets (30 mm mesh) immediately adjacent to a juniper tree near the vireo's center of activity and secured a portable audio speaker to a tree branch directly behind the mist net. A ~15 m cable was attached to the speaker and extended to a nearby tree, where we could sit and view the mist net inconspicuously. At the viewing spot, we attached the speaker cable to an MP3 player containing Gray Vireo songs and scolding calls as well as Western Screech-Owl (*Megascops kennicottii*) vocalizations. After set up, we allowed for an approximate 5 min resting period to allow birds to return to their activities. After the resting period, we broadcast Gray Vireo songs during 20–30 s intervals to lure them into the mist net. If we were unsuccessful at capturing a vireo after 5 min, we allowed for another 5 min resting period before broadcasting more songs or calls. If Gray Vireos approached but avoided the mist net, we used scolding calls, pishing, or Western Screech-Owl vocalizations to lure birds into the net. If we were unsuccessful after three to four cycles of broadcasting, we discontinued our efforts.

We immediately removed captured vireos from the mist net and temporarily placed them in a holding bag for processing. During processing, each bird was examined for injury and to determine stress level. We sexed each vireo to determine an appropriate color band combination from a list of available combinations. Males were always marked with at least one dark blue color band, while female combinations always included at least one hot pink band. Most of the vireos we captured were probably males because of their highly territorial responses to the playbacks; however, because female Gray Vireos may also sing on the breeding grounds, we sexed each bird using either the presence of a cloacal protuberance to identify a male or a brood patch for a female. Male Gray Vireos may also develop partial brood patches during the breeding season, making sexing more difficult but, males would also have a swollen cloaca and females would not. If sex could not be determined, neither a dark blue nor hot pink band was used. After sexing, we marked each bird with a unique color band combination consisting of three plastic colored leg bands and one USGS numbered aluminum band (Figure 9). We checked each bird for fat, measured wing chord and tail length, and weighed each bird using a 30 g pesola scale. After processing, vireos were released on site.

Figure 9. Banded Gray Vireo.

During the color banding period, we revisited all occupied Gray Vireo territories and gathered GPS locations for inclusion in the landscape level GIS habitat model. We marked the locations of adult vireos in the field using Garmin GPS units whenever possible and mapped them in ArcGIS. We created estimated territory boundaries based on the point locations and our field observations. These estimated territory boundaries were revised as we acquired more location data. After fieldwork was complete, we used Hawth's Analysis Tools for ARCGIS (Beyer 2004) to create Minimum Convex Polygons (MCP) for each Gray Vireo territory for which we recorded at least three GPS locations. We calculated the area of each MCP using ArcGIS. MCPs were used as a reference for the GIS habitat model and to create baseline data on Gray Vireo territory size and movements.

Nest searching, monitoring, and associated vegetative sampling were conducted at KAFB and CTTA in 2009 and 2010 and at WSMR in 2010. These data will be analyzed and presented in the Year 2 report, which will focus on habitat use at the territory scale.

Pinyon Jays

KAFB

From March through December 2009, we surveyed for Pinyon Jays in suitable pinyon-juniper habitats at KAFB. Initially we visited areas where Pinyon Jays had been reported by KAFB biologists, MAPS (Monitoring Avian Productivity and Survivorship) station operators, and Sandia Laboratory biologist Steve Cox. Once we had located several areas frequented by groups of jays, we focused our surveys on those sites. From one to five times weekly (except for the weeks of 26 April and 6 May, when we did not survey), we visited areas frequented by the birds and collected GPS points wherever we found jays. Some detections were in areas we could not access. For example, we could not enter the Live Firing Range, and we could not reach locations high on hills before the birds left the area. In those cases we placed location points on a mapping GPS unit.

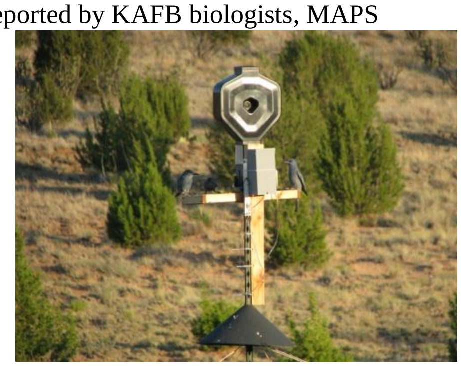

Figure 10. Coyote Springs Road Pinyon Jay feeder, KAFB.

On 16 June 2009 we erected an automatic koi feeder from Super Feeder (http://www.super-feeder.com/) at a wildlife guzzler where Pinyon Jays had been observed. After several weeks jays were not visiting the feeder regularly, and on 1 July we moved it to a site next to Coyote Springs Road (Figure 10). We set up a livestock watering tub near the feeder. On 9 June, we set up a standard (non-automatic) feeder near the MAPS station in the south part of the base. All feeders were kept supplied with *P. edulis* seeds and water was kept in the tubs constantly, except when deer emptied them overnight or the water evaporated on weekends. Water was supplied at both feeders.

Figure 11. Pinyon Jay walk-in trap (right foreground) at Coyote Springs Road, KAFB.

After Pinyon Jays were regularly visiting, we trapped them near the Coyote Springs Road koi feeder on 12 and 31 August 2009. We used a 107 x 61 x 20 cm welded wire walk-in trap designed after a standard pigeon trap (Figure 11). The trap was baited with *P. edulis* seeds. Each captured bird was banded with a USGS numbered aluminum band and a unique combination of three plastic color bands. We recorded the following data on each captured bird: age, sex, weight, culmen length, bill height, tarsus, and wing chord. We attached 2.5 g, tail-mounted, whip antenna radio transmitters (Holohil Systems Ltd.) to three of the birds captured on 12 August. We tied each transmitter to the base of the two central rectrices with sturdy thread, and then glued the body of the transmitter to the top of the same two rectrices (Figure 12). All birds were released unharmed after processing. Pinyon Jays were captured and banded under USGS Federal Marking and Salvage Permit #22158 and New Mexico Department of Game and Fish Scientific Permit #1795.

Figure 12. Transmitter affixed to Pinyon Jay.

After transmitters had been attached to the birds, we used a TRX 1000S receiver from Wildlife Materials to listen for transmitter birds one to four times each week from mid-August through November and once each on two weeks in December. Each time we received a signal, we recorded our location when we heard the signal and took a compass bearing of the strongest signal. We then attempted to take a second GPS point and directional bearing from a different location, to triangulate on the bird's specific location. The success of obtaining a second bearing depended on the jays' movements. GPS coordinates for all sightings of jays and all signal bearings were recorded in an Excel spreadsheet. Using GIS, we mapped the location where we were standing when we received a signal from each bird. We then mapped the vector indicating the direction we heard the strongest radio signal. Where the vectors crossed on the map, we added a point to signify the approximate location of the bird. Each point was associated in the GIS with the following data for the observation: date, time elapsed between observations, weather, transmitter frequency, and general location. We combined all GPS coordinates of Pinyon Jay locations into a GIS layer. This included points derived from visual detection, audio detection of Pinyon Jays, and radio telemetry. We used only telemetry locations resulting from bearings taken 25 or fewer minutes apart, a total of eleven. We divided GPS point locations into breeding (1 March through 31 July), nonbreeding (1 August to 28 February), and year-round (all points combined).

WSMR

We visited North Oscura Peak (NOP) and vicinity at WSMR approximately once weekly from 24 March through 29 October 2009. On each trip we watched the traditional colony site at NOP to determine where Pinyon Jays were nesting. When we saw birds going in and out of an area repeatedly during March-May, we searched for nests in the area. We took GPS coordinates of any nests we found.

Figure 13. Pinyon Jay feeder at NOP, WSMR.

On 10 April we set up a solar-powered, battery-operated automatic feeder (Sweeney Enterprises, Boerne, TX, Figure 13) within the traditional nesting colony area at NOP. The feeder was set to deliver about two cups of pinyon seed twice a day, early morning and late afternoon. We took down the feeder after we finished trapping in June. On 24 June, 30 June, 1 July, 21 July, and 17 August 2009, we trapped jays in a modified Australian crow trap set near the feeder and baited with pinyon seed. We processed captured birds as at KAFB, above.

We attached radio transmitters to five of the captured birds, as described above at KAFB: two adults, two second-year birds, and one older hatch-year bird. We tracked birds with a TRX-1000 receiver from Wildlife Materials International, Inc. We attempted to locate the birds with radios each time we visited the study site from the time we banded them until the last transmitter batteries failed or birds left the area. We located the last transmitter, one that had fallen off the bird and was transmitting, on 29 October. We mapped locations as at KAFB, above.

KAFB and WSMR

Because Pinyon Jays are highly social, we mapped and analyzed locations for the flock rather than for any single individual. Telemetry points were used to find an individual, but that individual was almost invariably with other jays. To determine home ranges, we first created MCPs for each season using Hawth's Analysis Tools for ArcGIS (Beyer 2004). The resulting MCPs showed the minimum area used by the flock in either the breeding or nonbreeding season. Because the MCPs lack detail on probability of detection/use, we followed with a fixed kernel density analysis.

For the kernel analysis we used the Hawth's Tool, Fixed Kernel Density Estimator (KDE). Kernel analysis is a nonparametric statistical method for estimating probability densities from a set of points. When used to analyze home range data, kernel density methods describe the probability of finding an animal in any one place. The KDE calculates a fixed kernel density estimate and produces contour lines representing the boundary of the area that contains a specified percent of the volume of a probability density distribution. A 95% volume contour, for example, typically contains 95% of the points used to generate the kernel density estimate. Kernel parameters were set as follows: scaling factor- 1000000, kernel- bivariate normal, single parameter smoothing factor (h)- 1000, raster cell size- 100, and percent volume contours- 50, 90, and 95.

Habitat Modeling

An unpublished vegetation map at CTTA (P. Arbetan, unpublished data) was available to use as a guide to identify juniper woodland and savanna-dominated landscapes. In addition, we used 2009 one-meter natural color aerial photography acquired in July 2009 (NAIP 2009). Because the spatial resolution of the aerial photos was higher than was previously available for the existing map, we used the aerial photography to delineate a separate set of map units to encompass the area occupied by Gray Vireos in this and previous studies (DeBruin 1995, DeBruin 1996, Arbetan et al. 2002, Arbetan and Muldavin 2003, Arbetan and Muldavin 2004a, Arbetan and Muldavin 2004b, Chauvin and Arbetan 2005, Arbetan and Muldavin 2006, Arbetan 2007). Color, texture, and size of landscape elements were used to delineate the map units. When Gray Vireo observations and nest locations were added to the GIS overlay, it became evident that geology and vegetative cover together play an important role at CTTA. We therefore incorporated surface geology and landform into the CTTA landscape-level model.

Because an accurate vegetation map did not exist for KAFB, we created our own vegetation layers for the landscape-level habitat modeling. The Mid-Region Council of Governments provided six-inch-resolution, natural color ortho-imagery of Bernalillo County. The imagery, flown in March and April 2008, covered all pinyon-juniper habitats of interest at KAFB. Using GIS, we delineated polygons on the imagery that contained similar habitat types in juniper woodland and savanna, pinyon-juniper woodland, and pinyon pine woodland surrounding areas with Gray Vireo territories and Pinyon Jay colonies. We then visited a subset of these polygons and collected the following data at each polygon: date, GPS coordinates, aspect of the described slope, percent cover class of the nine dominant species, canopy cover, and relative cover of pinyon and juniper. We used these data to drive the delineation of map units for a classification of landscape-level vegetation in Pinyon Jay home ranges and Gray Vireo territories. At a scale range of 1:3,000-6:000, we applied aerial photo interpretive techniques of visual landscape elements including color, texture, and size, with overlays of elevation contours and field data descriptions to refine the previously mapped areas. We delineated all landscapes where the birds were observed using data collected under this contract, as well as previously collected datasets (Black 1994, Mehlhop and DeBruin 1995, Frei 2007).

Exact boundaries along the continuum of juniper savanna to pinyon-juniper woodland landscape are difficult to delineate. Dick-Peddie (in Aldon et al. 1993) defined woodlands as having trees whose canopies do not overlap. He distinguished juniper savanna as scattered stands with densities less than 130 trees/acre. Using these definitions as a basis, we differentiated the juniper to pinyon-juniper woodland boundary and classified as pinyon-juniper areas where pinyon accounts for greater than 25% of the cover; this is typically identified by greater density of trees. In New Mexico, Pinyon- pinyon-juniper woodlands are considered a high priority for further classification review (Grossman et al. 1998).

A vegetation classification and map were available for WSMR (Muldavin et al. 2000 a,b). To model landscape-level habitat use by Pinyon Jays at WSMR, we used the existing vegetation map and associated plot data, in combination with the same aerial photography used for CTTA (NAIP 2009). The aerial photography allowed us to photo interpret the landscape elements at a finer spatial scale. In addition to the Muldavin et al. (2000 a, b) map, we used overlays of elevation contours and bird observations collected for this project, as well as previously collected datasets (Johnson and Smith 2006, Johnson and Smith 2007).

Results

Map Units for Landscape-scale Models

Vegetation Map Units

Vegetation structure and composition drive the broad landscape-scale map units in the landscape-scale models. The majority of these vegetation units are at the Alliance Level according to the National Vegetation Classification (Grossman et al. 1998). For example, the Pinyon Pine Alliance is distributed throughout mountain ranges of New Mexico, southern Colorado, eastern Arizona, and Utah and includes plant associations where pinyon pine is the dominant but can be co-dominant with juniper, having a variety of sub-canopy shrubs and grasses. Our target species are woodland, versus grassland, birds, found infrequently in shrublands and grasslands. Thus, we use more general categories of shrubland and grassland where these types dominate.

Ponderosa Pine Woodland

Ponderosa Pine Woodland occurs within the study area along the KAFB eastern boundary within the Manzano Mountains. Elevations range from 1985 to 2439 m and cover approximately 1894 ha (20.4%) of the mapped area. This woodland ranges from nearly closed canopies with understory trees including *Juniperus* spp. and pinyon pine to very open stands associated with grasses. This unit is not currently included in any landscape models for either bird species.

Pinyon Pine Woodland

Pinyon Pine Woodland occurs on both KAFB and WSMR, covering approximately 1083 ha (11.6%) and 5622 ha (26.5%) of the mapped areas, respectively. These woodlands are dominated by pinyon pine but co-occur with juniper in nearly closed canopies. The cover of pinyon pine relative to juniper exceeds 50% in this unit. At KAFB these woodlands typically occur on steep slopes and continue to the mountain summits between Pinyon-Juniper Woodlands below and Ponderosa Pine Woodlands above. The understory is relatively sparsely vegetated with scattered mountain mahogany (*Cercocarpus montanus*), scrub oak, and grama grasses. At WSMR, this woodland dominates NOP and continues along the crest of the Oscura Mountains to the south. These older, closed-to-open pinyon stands have well-developed, diverse understories of shrubs and grasses that include wavyleaf oak, mountain mahogany, banana yucca (*Yucca baccata*), and Gambel's oak. Grasses include Scribner's needlegrass (*Achnatherum scribneri*), muhly (*Muhlenbergia* spp.), and grama grasses. A discussion of plant associations of the Pinyon Pine Alliance at WSMR can be found in Muldavin et al. (2000).

Pinyon-Juniper Woodland

The definition of the Pinyon-Juniper Woodland is debated, with some classifying a few scattered pinyons within a juniper-dominated landscape as pinyon-juniper (Esteban Muldavin pers. comm.). In contrast, we define this map unit as having between approximately 25% and 50% relative cover of pinyon. When relative cover was ≥50% we assigned the unit to Pinyon Pine Woodland. At KAFB, Pinyon-Juniper Woodlands occur on slopes in transition between juniper dominated landscapes below and pinyon pine dominated slopes above. Understory species composition is similar to the Pinyon Pine Woodland, with transitions toward more open canopies. These woodlands cover approximately 1615 ha (15.4%) of the mapped area within KAFB. At WSMR, the Pinyon-Juniper Woodland covers 2245 ha (10.6%) of the mapped area and occurs in a narrow band on east- to northeast-facing slopes at the lower elevation margins of the Pinyon Pine Woodlands of NOP and on slopes within the less mesic, lower-elevation ranges near

Pink Peak along the eastern boundary. Species composition within the understory is similar and as diverse as the Pinyon Pine Woodland but has more open canopies.

Juniper Woodland and Savanna

Juniper Woodland and Savanna occurs at all three installations. At CTTA, we split this map unit into two separate units based on landscape position and surface geology (see below). Oneseed junipers occur with open to very open tree canopies having a diverse understory of shrubs and grasses. Pinyon can be scattered throughout this landscape but typically comprises less than 10% cover relative to juniper. Within KAFB, this unit covers 4441 ha (47.8%) of the mapped area and has the broadest elevation range of the mapped units, covering distal foothills to steep slopes reaching 2319 m in elevation. Shrubs can dominate the inter-canopy spaces, with either fourwing saltbush or mountain mahogany well represented. Mountain mahogany tends to establish on rocky slopes, replaced by fourwing saltbush near drainages and on alluvial surfaces with deeper soil horizons. Tree cholla appears throughout this map unit, often at densities greater than the other shrubs. Grama grasses are found throughout this unit and can be more abundant than shrubs. Tobosagrass or New Mexico needlegrass can be locally abundant but rarely dominates the inter-canopy spaces. Within WSMR, this map unit covers approximately 11,348 ha (53.5%) of the mapped area and supports a diverse understory of shrubs and grasses. However, grasses rather than shrubs are more representative within the inter-canopy spaces and include blue grama, black grama, hairy grama, sideoats grama, and curlyleaf muhly.

Juniper Woodland and Savanna on Volcanic Hills

At CTTA only, oneseed juniper with an understory of grasses dominates relatively steep conical volcanic hills of Pliocene age. Hills range in elevation from 1960 to 2100 m, comprising approximately 373 ha (46.7%) of the mapped area. Juniper is most often associated with grasses such as sideoats grama, black grama, blue grama and needle and thread grass (*Hesperostipa comata*).

Juniper Savanna on Lava Plains

Also at CTTA, oneseed juniper with an understory of grasses dominates eolian and alluvium plains derived from basalt. The Juniper Savanna on Lava Plains unit is characterized by low slopes and incised drainages, exposing the basalt, with open to very open juniper savannas. Grasses dominate the understory and are the same species as on the volcanic hills; however, tree cholla, broom snakeweed (*Gutierrezia sarothrae*) and rubber rabbitbrush (*Ericameria nauseosa*) can be locally dominant within this unit, which covers approximately 424 ha (53.2%) of the mapped area.

Shrubland

The Shrubland mapping unit is used on KAFB and WSMR to indicate relatively large areas dominated by shrubs other than juniper. Within KAFB, these shrublands are on dry, relatively steep south-facing slopes near the northern boundary. They are characterized by very scattered oneseed juniper that occupies some of the drainages, but otherwise relatively sparse grasses with shrubs dominate. Shrubs include mountain mahogany, sacahuista (*Nolina microcarpa*), tree cholla, *Yucca* spp., scrub oak, and *Opuntia* spp. On KAFB this mapping unit covers approximately 155 ha (1.7%) of the mapped area. Within WSMR the shrubland category delineates broad drainages within the Oscura Mountains that are dominated by fourwing saltbush and scattered juniper covering approximately 1208 ha (5.7%) of the mapped area.

Grassland

The Grassland mapping unit is used on KAFB and WSMR to indicate relatively large areas dominated by grassland but without the woody vegetation characteristic of the woodland and savanna units. Within KAFB, some of the larger grasslands are old burns, a transitional state that is a departure from woodlands. These grasslands are typically dominated by either blue (*Bouteloua gracilis*) or black grama (*B. eriopoda*); however, sideoats grama (*B. curtipendula*) may dominate on some of the more rocky slopes. Tobosagrass (*Pleuraphis mutica*) or New Mexico needlegrass (*Achnatherum perplexum*) can be locally dominant. Montane grasslands occur within openings of the Ponderosa Pine Woodland. This mapping unit covers approximately 87 ha at KAFB, almost 1% of the mapped area. At WSMR, the grasslands typically occur within broad, open valleys of Pinyon Pine Woodland dominated by blue grama-western wheatgrass (*Pascopyrum smithii*) or at the base of low, dry hills where blue grama is associated with sub-shrubs such as winterfat (*Krascheninnikovia lantana*). Tobosagrass and alkali sacaton (*Sporobolus airoides*) may be locally dominant. On WSMR, the Grassland unit covers 522 ha, approximately 2.5 % of the mapped area.

Other

At WSMR we delineated some of the larger areas of disturbance along roads and within some of the developed areas. This mapping unit covers approximate 243 ha, a little more than 1% of the mapped area on WSMR.

Gray Vireos CTTA

Banding

We captured and banded five male Gray Vireos in 2009 (Appendix A1). In 2010, however, none of the color banded males from the previous year were observed in the study area. We therefore assumed that they did not survive during migration or over winter. In 2010, we captured and banded one new male Gray Vireo (Appendix A1).

Territories

We identified 11 occupied Gray Vireo territories at CTTA in 2009 and 14 territories in 2010 (Figure 14). In 2010, there were also six vireo detections that we were unable to assign to a territory. Three of these detections occurred in mid-May, when birds may have still been establishing their territories, while the

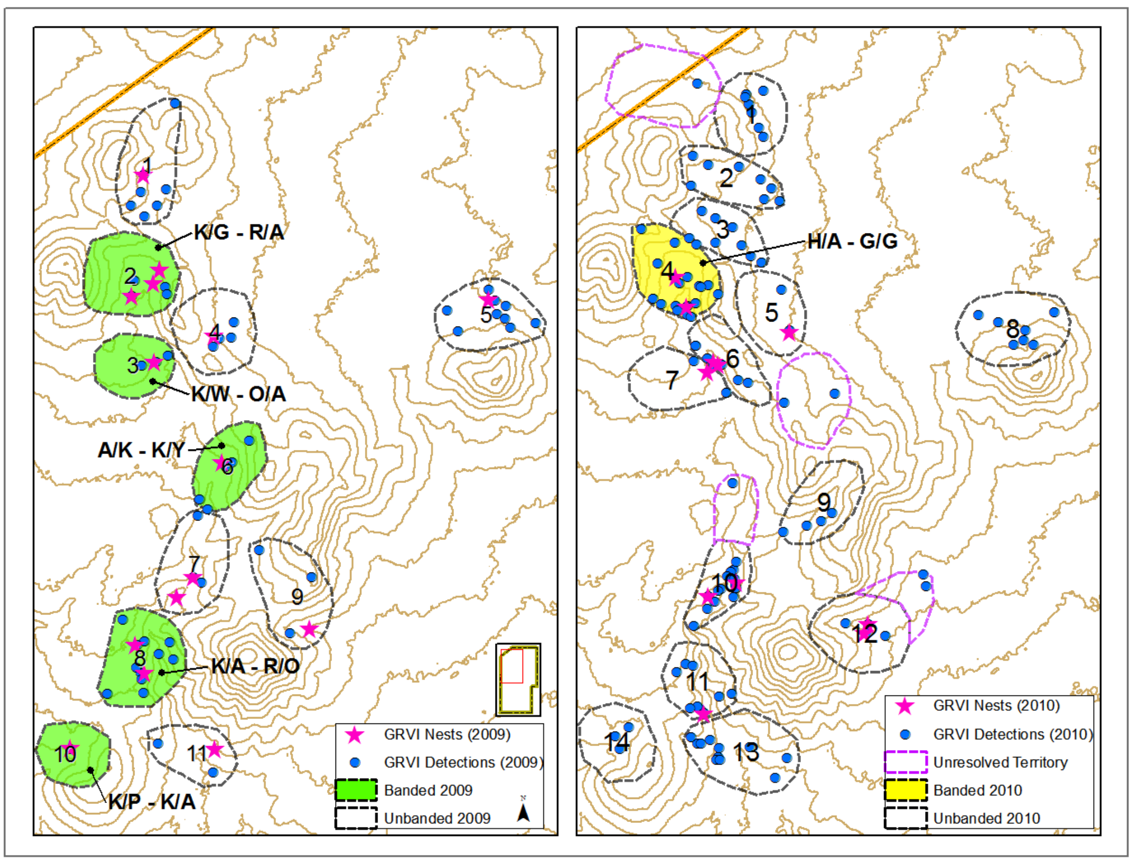

Figure 14. Gray Vireo territories at CTTA, 2009-2010. Letters indicate color band combinations. Dashed lines indicate approximate territory boundaries.

remaining three occurred in June, at which point Gray Vireos should be on territories. At most, we may have had as many as 17 territories in 2010, but we lacked sufficient data to delineate more than 14 with certainty. Territory size based on the MCP analysis ranged from <0.1−12.4 ha, with a mean of 2.8 ha (n=24, Appendix A2).

GIS Habitat Model

The GIS habitat model for CTTA covers approximately 797 ha of potential habitat ranging in elevation from approximately 1935 to 2110 m. Two general vegetation types occur within this model, juniper upland and juniper lowland (Figure 15). The juniper upland vegetative type occurs at slightly higher elevation (mean = 2027 m) than the lowland counterpart (mean = 2001 m) and is characterized as Juniper Woodland and Savanna on Volcanic Hills. The juniper lowland is classified as Juniper Savanna Lava Plains. Over 75% of Gray Vireo detections (n=129) and nests (n=20) occurred within the juniper upland vegetation type, with only 35 detections and 5 nests located within juniper lowlands. Most of the territories at CTTA occurred at elevations higher than 2000 m, with the highest individual vireo detection at approximately 2070 m.

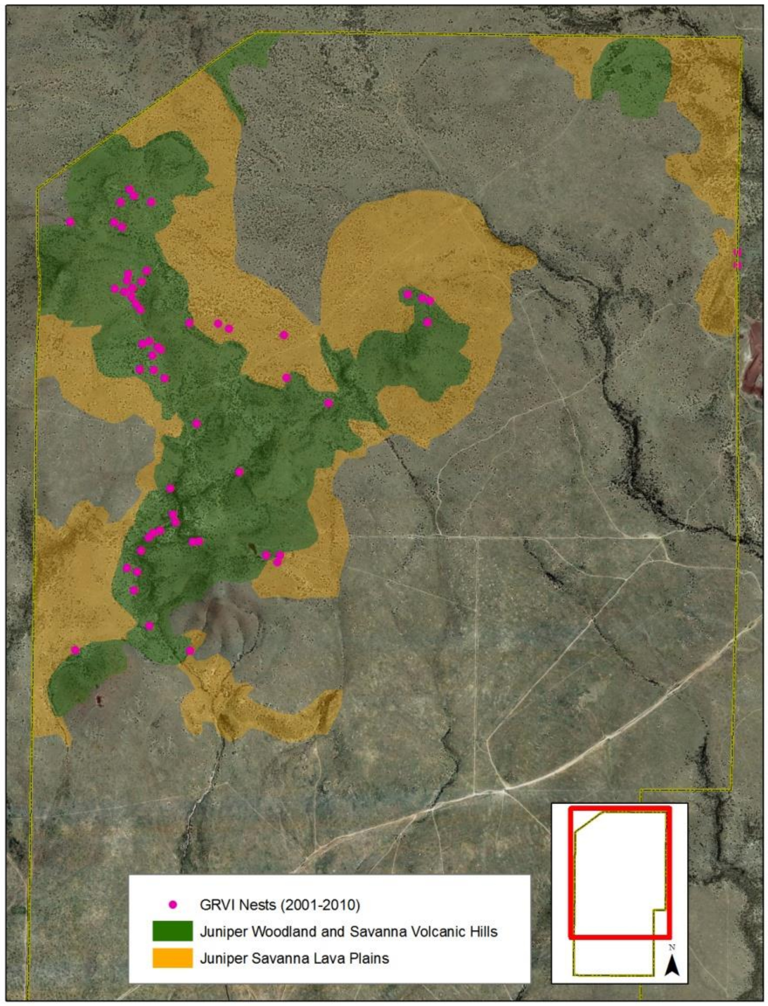

Figure 15. Gray Vireo landscape-level habitat model, CTTA.

Distance to Military Infrastructure and Activities

Although the CTTA study area is used as training grounds for the New Mexico Army National Guard, no military infrastructure and no major roads occur within it. The study area is dissected by numerous unimproved, two-track roads that receive little vehicle traffic except for military training activities. The entire area is closed to military training from 15 May through 15 July annually, to protect the state threatened Gray Vireo during its peak breeding period. Therefore, the proximity of breeding habitat to military activities may not be as biologically relevant at CTTA as at KAFB and WSMR. Historically, only a few observations of Gray Vireos have occurred within the Training Area Management Units (TAMUs) on CTTA (Arbetan and Muldavin 2005, 2006). In the Year 2 report, we will present territory and nest scale data on distance to military infrastructure and activities.

Gray Vireos KAFB

Banding

Gray Vireo color banding has been conducted at KAFB since 2008. In 2008, Animas Biological Studies (ABS) color banded nine males and one female. In 2009, seven (78%) color-banded males from the previous year returned to the study area (Appendix A3), and all seven returned to the same territories they defended in 2008. One male, however, was forced out of its 2008 territory and subsequently established a new territory approximately 1,000 m from its old territory. We captured and banded six new male Gray Vireos and three females in the study area in 2009, while Steve Cox captured and banded two additional males, two females, and two vireos of unknown sex at his MAPS station (Appendix A3). By the end of the 2009 breeding season, there were 17 males, 5 females, and 2 birds of unknown sex color banded in the study area.

In 2010, 10 (59%) color banded males and 2 (40%) females from the previous year returned to the study area, along with one color banded male and one female banded in 2008 but not seen in 2009 (Appendix A3). Ten of the returning males occupied the same general territories as in previous years. In 2010, we were only successful at capturing and banding three new males and one new female (Appendix A3). Steve Cox captured and banded two new males, two females, and two hatch year birds of unknown sex at his MAPS Station, while we also captured and banded one new female at the MAPS Station approximately 5 km south of the study area (Table 3). Thus, by the end of the 2010 breeding season, there were 15 males, five females, and two birds of unknown sex color banded in the study area.

Territories

We identified 27 occupied Gray Vireo territories in 2009 and 30 in 2010 (Figure 16). Two of the territories identified in 2010 were located between approximately 550 and 750 m north of the study area boundary in Madera Canyon. Thus, the number of territories within the original study area at KAFB increased only by one from 2009 to 2010. MCP territory size ranged from <0.1−12.4 ha, with a mean of 3.2 ha (n=52, Appendix A4).

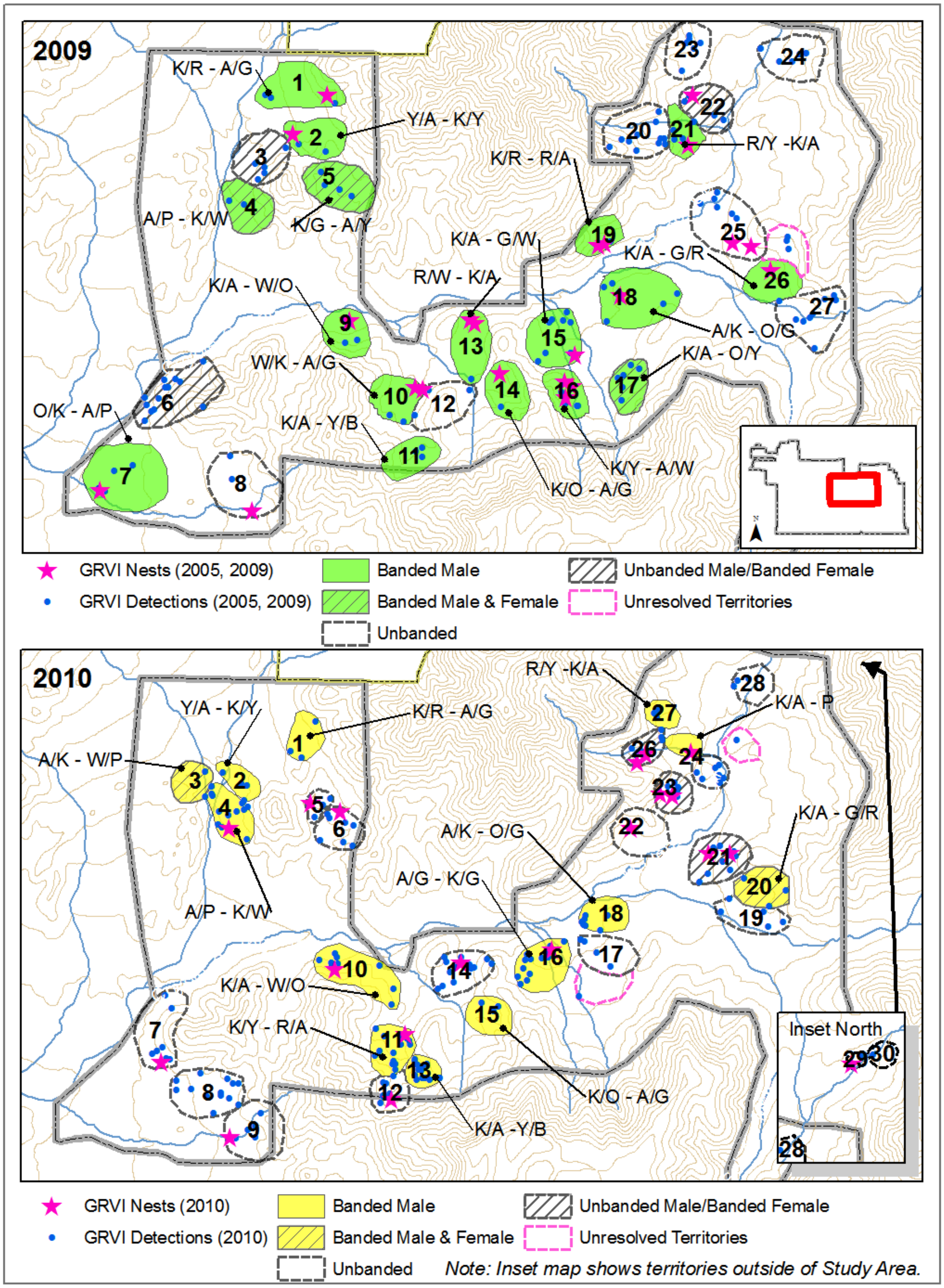

Figure 16. Gray Vireo territories, KAFB, 2009-2010. Dashed lines indicate approximate territory boundaries.

GIS Habitat Model

The GIS habitat model for KAFB covers approximately 9275 ha of habitats ranging in elevation from approximately 1742 to 2449 m. The main general vegetation types within this map are Ponderosa Pine Woodland, Pinyon Woodland, Pinyon-Juniper Woodland, Juniper Woodland and Savannah, Shrubland, and Grassland (Figure 17). Our Gray Vireo study area is located almost entirely within the Juniper Woodland and Savannah vegetation type, with only the most southeastern and eastern portions occurring partially within the Pinyon-Juniper Woodland and Pinyon Woodland vegetation types. The Juniper Woodland and Savannah type in this model comprises approximately 4441 ha and ranges in elevation from 1742 to 2319 m. In this study, 100% of Gray Vireo detections and nests have occurred within the Juniper Woodland and Savannah vegetation type. Vireo territories at KAFB occurred in Juniper Woodland and Savannah habitat, on toe slopes or rolling terrain ranging in elevation from approximately 1800−1950 m. A few territories in the southwestern portion of the study area were located in this habitat between 1750 and 1800 m, and several in the south central and northeastern portion of the study area included areas higher than 2000 m, with the highest vireo detection at approximately 2030 m.

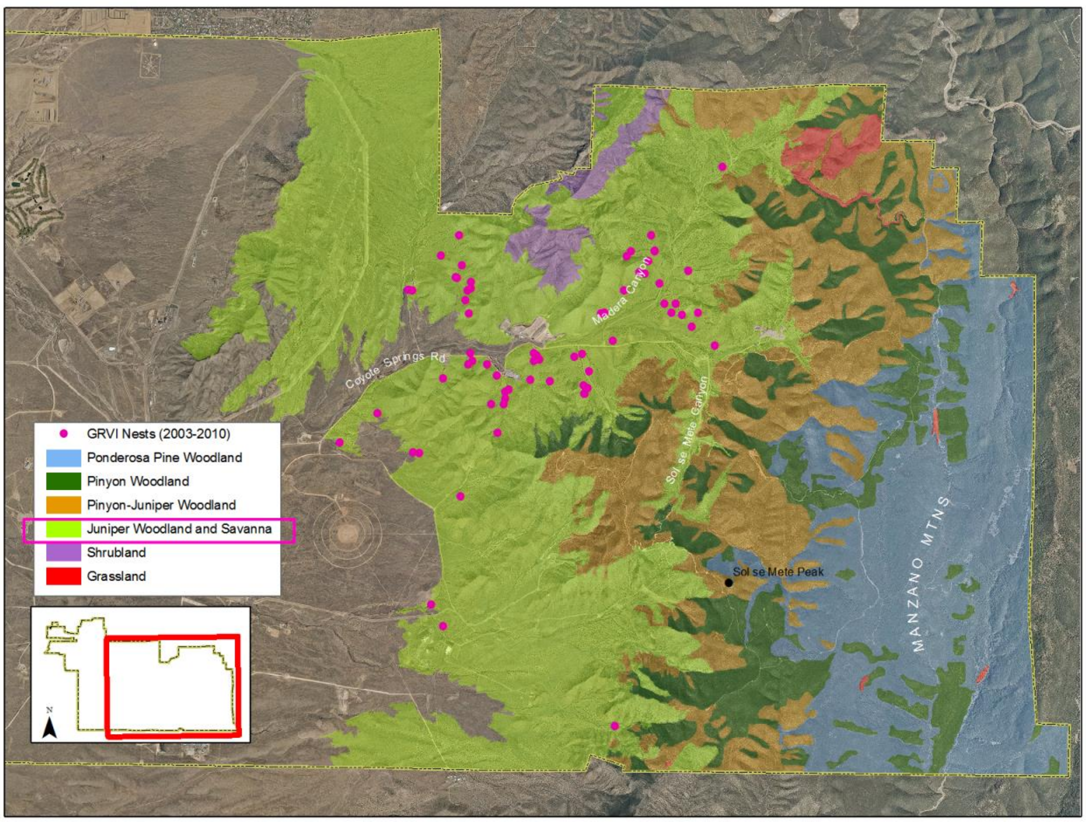

Figure 17. Gray Vireo landscape-level habitat map, KAFB. Vegetation type within the pink box was used by Gray Vireos at KAFB.

Distance to Military Infrastructure and Activities

The Gray Vireo study area on KAFB is intersected by Coyote Springs and Madera Canyon Roads, which service numerous military buildings and the Live Firing Range. Approximately 40% of territories at KAFB were within 100 m of Coyote Springs or Madera Canyon Roads; and, in some cases, territories spanned these roads (Figure 16). We also identified numerous territories at KAFB that occurred within 200 m of buildings (9−12 and 27 in 2009, and 10, 14, and 19 in 2010). Although our study area does not include the Live Firing Range, noise from training activities at that site could be heard within the territories to the southeast, south, and southwest. This included a distance range from approximately 200−800 m, and possibly farther. ABS conducted a base-wide Gray Vireo survey in May and June of 2010 and identified two territorial vireos, approximately 200 m and 350 m away from the footprint of the Live Firing Range (L. Wickersham and J. Wickersham unpublished data). In the Year 2 report, we will present territory and nest scale data relating to the distance to military infrastructure and activities.

Pinyon Jays KAFB

Banding/Transmitters

We captured and banded seven Pinyon Jays on 12 August 2009 and 11 more on 31 August 2009. Ten of these were after-hatch-year birds and eight were hatch-year birds. The presence of hatch-year birds indicates that the jays at KAFB nested successfully in 2009. We attached transmitters to three birds, all after-hatch-year birds.

One transmitter was detectable only until 23 October. This was well within the expected battery life of the transmitter, which suggests that the bird left the area. A second transmitter stopped moving on 11 November, which suggests that the bird died or the transmitter fell off. We were unable to triangulate on this transmitter, and we failed to find it. We continued to receive moving signals from the third transmitter until 28 December, when the battery presumably died. The third transmitter provided several flock locations through the fall and into the winter.

Flock Size

We have 54 records of Pinyon Jays at KAFB where we noted flock size, excluding observations at the feeder. For these 54, the mean number of birds was 18.2 (range 1-135). Most observations were of groups of birds. Only nine observations were of a single bird. Over half (29) of the observations were of groups of six or more individuals. For these larger groups, the mean group size was 31.7. On seven occasions we counted or estimated 50 or more birds in a flock. These observations occurred in June (n=4), July (n=2), and October (n=1). These data suggest that the flock in the north area has up to 135 members but that the flock typically breaks up into smaller groups for nesting, foraging, caching, etc.

We found three separate breeding groups of Pinyon Jays at KAFB, which we call the North, South, and SOR Colonies. The North Colony was found in juniper-dominated woodland at low elevation (1859-1945 m). The South Colony was in higher-elevation pinyon-dominated woodland (2117-2144 m). A third group, the SOR Colony (Starfire Optical Range, named by the site of the feeder), nested east of the Receiver Site, but we were unable to access this site. We believe the birds in this group nested in pinyon-dominated habitat. These breeding groups were small relative to the sizes of the large flocks we observed in the nonbreeding season. We found nine active nests and four inactive nests (which could have been from previous years) at the North Colony, which suggests that no more than 13 pairs nested there in 2010. We found nine nests in the South Colony. We could have missed a few nests in the south, but the South Colony was probably no larger than the North Colony. If the SOR group was similarly-sized, all three groups together with their fledglings could have numbered around 100 birds. This suggests that a large winter flock at KAFB splits into at least three smaller breeding groups.

Home Ranges

From the transmitters, we obtained 23 useful overlapping bearings that resulted in 11 point locations in the GIS. Ground surveys yielded 112 additional point locations. The kernel density map depicts the 50, 90, and 95% kernel density polygons for all Pinyon Jays detected in 2009 and nest sites from 2010 (Figure 18). This map provides a reasonably good prediction of where Pinyon Jays could be found at KAFB between March and December 2009 and March through June 2010.

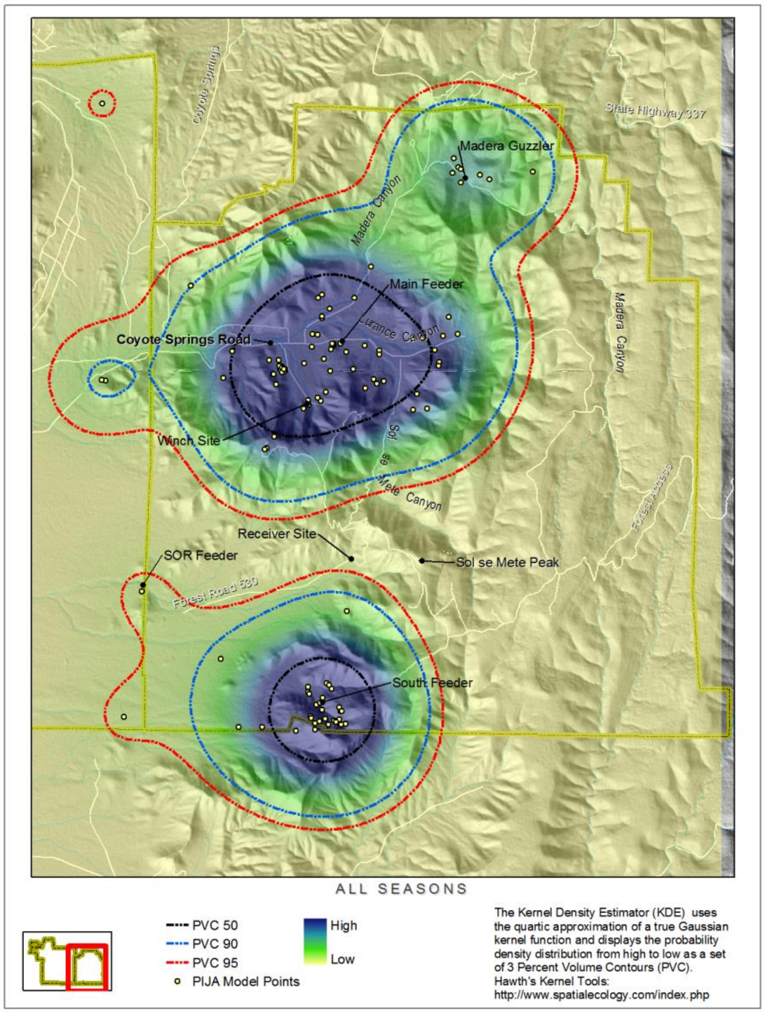

Figure 18. Kernel Density Estimator (KDE) for Pinyon Jays, all seasons, KAFB.

Breeding

The breeding season home range of the North Colony birds centered around the slopes of the Winch Site and Sol Se Mete Canyon, extending north to a caching area in Juniper Woodland and Savanna habitat inside the Live Firing Range. Another, smaller center of activity occurred on a hill to the northeast of the Burn Site near the Madera Guzzler (Figure 19). Birds were detected in the north area on 2-10 d each month from 22 March through 28 December 2009 and nested at the Winch Site in March and April 2010.

The South Colony was present near the south KAFB boundary in steep terrain of pinyon-dominated vegetation from May through late August 2009 and nested in the area from late March into May 2010. We did not hear or see jays in the south area in June or July 2010 when we were in the area on several occasions collecting nest plot data, but a large flock re-appeared in the area on 20 August 2010 so was likely in the area all summer.

In February 2010, we learned of a third group of Pinyon Jays, the SOR Colony, that was frequenting a feeder between the summer ranges of the North and South Colonies. Based on the appearance of fledglings at the feeder starting 22 April 2010, we believe this group nested on the east side of the Receiver Site, an area of frequent testing and limited access (Figure 19).

The 95% breeding season kernel for both breeding areas covers 4305.3 ha. The 95% breeding kernel for the north area was 2638.3 ha in area which includes the single observation in the northwest, and the 95% breeding season kernel for the south area was 1666.9 ha (Figure 19). We do not have enough location data to estimate the breeding season area of the SOR Flock. The breeding season MCP including both north and south areas covers 4509.4 ha (Figure 20) and does not distinguish a north-south area, as does the more statistically rigorous kernel density estimator.

Nonbreeding

Jays left the south area by the beginning of August 2009 and were gone by 20 May 2010, but they returned on 20 August 2010. Although at least one radio was transmitting through 28 December 2009, we never detected a radio signal or found the flock in the south area after August in 2009. The nonbreeding MCP covers 2554.1 ha (Figure 20), and the nonbreeding 95% kernel model covers 3951.9 ha (Figure 19).

Combined Breeding and Nonbreeding

The MCP polygon including breeding and nonbreeding areas north and south and everything in between covers 5027.4 ha (Figure 20). The 95% kernel model for both north and south breeding areas and both seasons covers 5741.7 ha and shows the persistent area of activity during both the breeding and nonbreeding seasons in red (Figure 21). The most spatially extensive use occurs in the north, with distinct breeding season centers of activity.

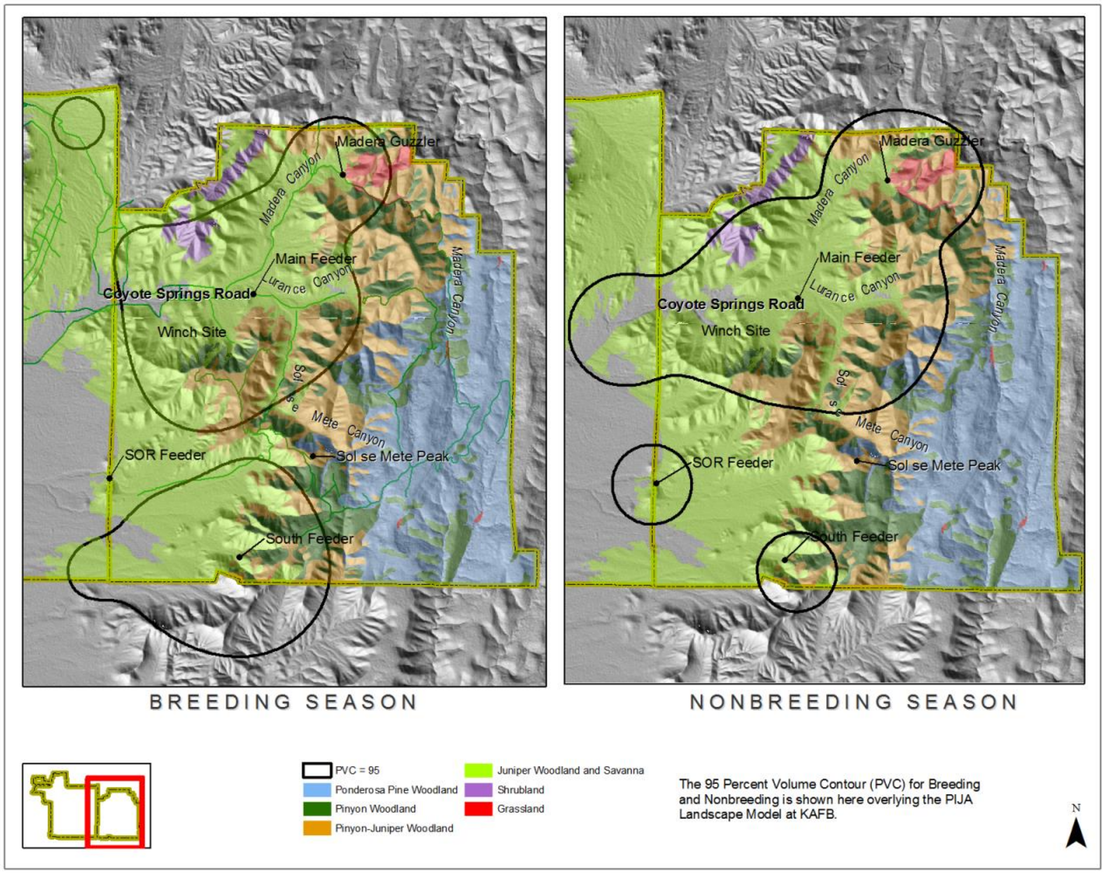

Figure 19. Pinyon Jay breeding and nonbreeding season KDE, KAFB.

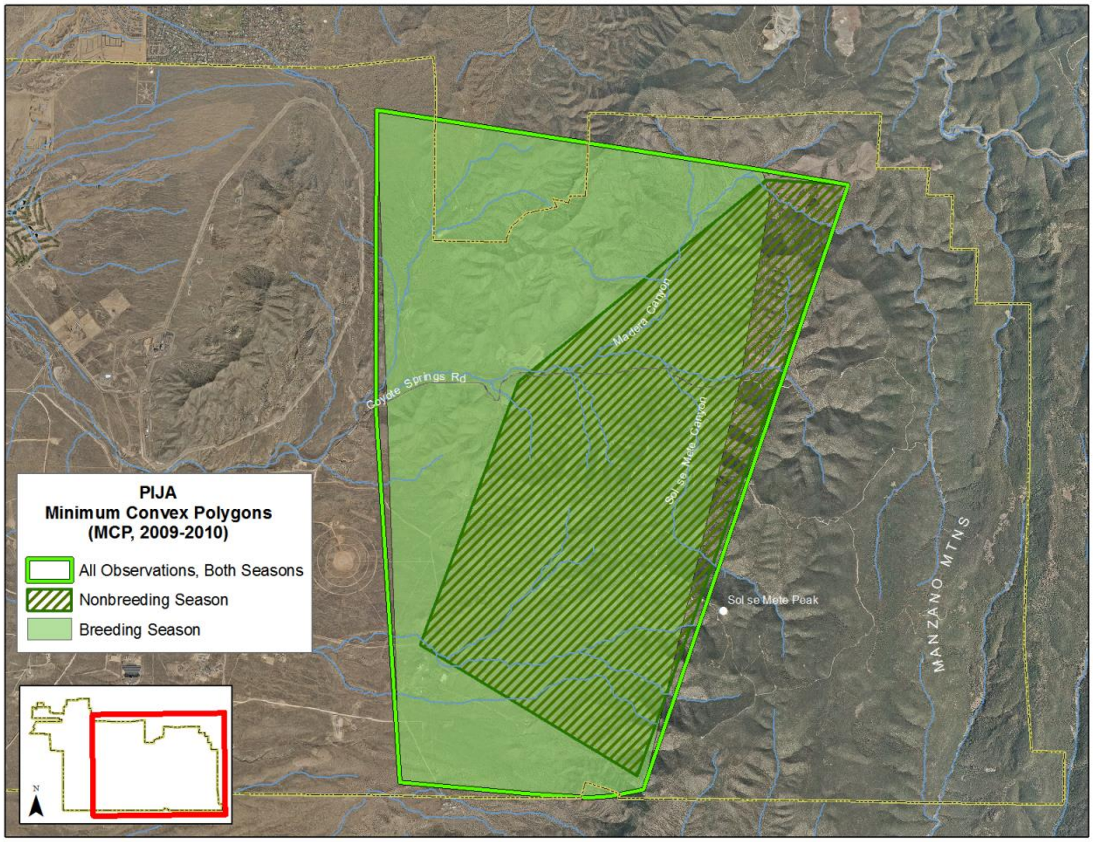

Figure 20. Pinyon Jay minimum convex polygons for all seasons, KAFB.

Caching Areas

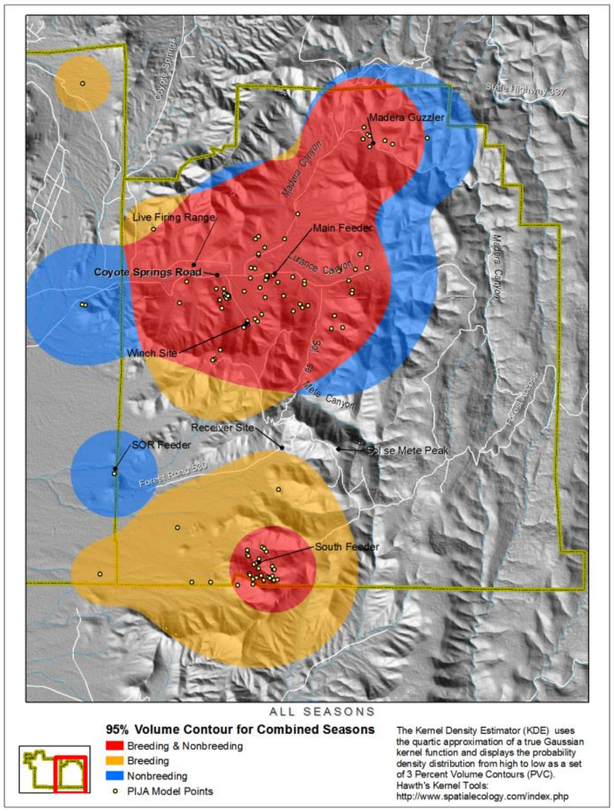

Figure 21. Kernels showing areas of maximum use by Pinyon Jay, KAFB.

Only two activity polygons were clearly in caching areas. One, at the top of a hill near the Madera Canyon guzzler, was in a burned area. We observed birds in this area in early spring of 2009 apparently retrieving caches. These birds may have been retrieving seeds collected from the nearby woodland and cached in late 2008. We found several pinyon seedlings near the top of this hill, which was relatively free of trees and shrubs. The presence of seedlings on top of a hill suggests that avian seed dispersers cached there in previous years.

The main caching area, used in both breeding and nonbreeding seasons, was a mostly south-facing 18 ha gentle hillslope within the Live Firing Range (Figure 21). The lower hillslope is moderately sparse, dominated by grasses and shrubs with very scattered juniper. Higher slopes and hillslope drainages have more shrubs and juniper, transitioning to gently sloping juniper scrub mix in open woodland and juniper with fourwing saltbush in drainages. We frequently observed jays walking on the ground in this area, apparently caching and/or retrieving caches. Birds probably cached seeds from the feeder there, but they might have also had caches there from the cone crop in the fall of 2008. We observed jays in this area on nine occasions, between August and December 2009. We noted that in January and February when deep snow was present on north-facing slopes, the caching area was free of snow. Soon after we put up the feeder in February 2010 jays began frequenting this caching area again.

GIS Habitat Model

The GIS habitat model for KAFB covers 9275.6 ha of potential habitat ranging in elevation from approximately 1780 m to 2420 m. The general vegetation types within this map are Ponderosa Pine Woodland, Pinyon Pine Woodland, Pinyon-Juniper Woodland, Juniper Woodland and Savanna, Shrubland, and Grassland (Figure 22). The latter five are included in the landscape model for Pinyon Jays at KAFB. Pinyon Jays occur rarely in the Ponderosa Pine Woodland to the east of the KAFB eastern boundary. However, we do not include ponderosa pine in this model, because when the model was created we had no data indicating that Pinyon Jays from the KAFB flock ranged higher into the ponderosa.

The majority of Pinyon Jay observations at KAFB are from Juniper Woodland and Savanna (n=91) and Pinyon-Juniper Woodland (n=22), with only eight in Pinyon Pine Woodland and two in previously burned woodland, now Grassland.

Beginning in the first week of March and continuing through April, Pinyon Jays nested at the North Colony in Juniper Woodland and Savanna habitat at an elevation of ~1868 m. The South Colony was active one or two weeks later, from late March through early May. South Colony nests were in Pinyon-Juniper Woodland (n=4), Pinyon Pine Woodland (n=4), and Juniper Woodland and Savanna (n=1) at elevations from 1951 to 2142 m. Thus, breeding habitat ranges from juniper-dominated to pinyon-dominated woodlands.

Pinyon Jay breeding and nonbreeding ranges at KAFB contained similar proportions of higher-elevation Pinyon Pine Woodland, and the smaller Grassland and Shrubland units were also similarly-represented. The breeding home range, however, contained 66.9% Juniper Woodland and Savanna, compared to 55.7% in the nonbreeding home range. The percentage of pinyon-juniper habitat was higher in the nonbreeding area (27.3%) than in the breeding area (20.4%).

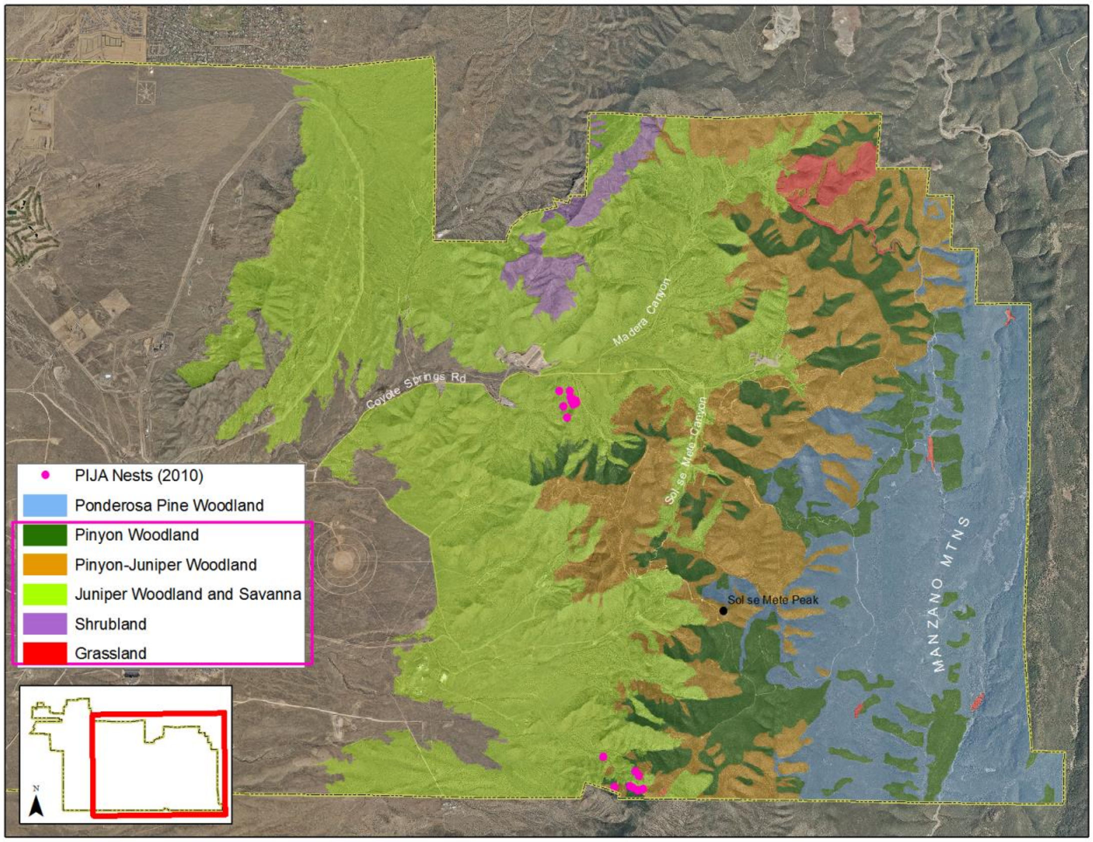

Figure 22. Pinyon Jay landscape habitat model, KAFB. Vegetation types within the pink box were used by Pinyon Jays at KAFB.

Distance to Military Infrastructure and Activities

The type of infrastructure differs near the two principal breeding colonies of the north and south. The North Colony lies within 380 m of Coyote Springs Road, a secondary east-west trending road and only 60 m to a less used tertiary road (Winch Site Road, FR 24e). The area is relatively flat with the infrastructure lying essentially at the same elevation as the nest sites. The principal impacts are vehicle travel noise and dust, as both roads are unpaved. Additionally, a firing range lies within 850 m of the North Colony and live firing can be easily heard at the nest sites. The South Colony lies in relative isolation from impacts approximately 130 m to the boundary of the installation bordering the Pueblo of Isleta. It is in a less-utilized area of the installation and is accessible by only two tertiary roads. One nest tree lies adjacent to the tertiary road, while the remaining breeding colony is upslope 160-180 m and 370-600 m from the nearest road.

Pinyon Jays WSMR

Banding

At WSMR in 2009, we trapped and banded 24 new Pinyon Jays and re-captured three banded birds from previous years. Including all birds captured for the first time in 2009, 15 were after-hatch-year birds and 12 were hatch-year birds. The number of hatch year birds captured indicates that the NOP flock fledged young in 2009, although relative numbers of hatch- year and after- hatch- year birds captured suggests that 2009 was not a highly successful breeding season. The year 2009 was apparently also a transition year for the location of the colony. We found no nests in the traditional colony site in 2010 and only three in 2009. It is likely that the birds were in the process of moving the colony site in 2009 but we did not find the new site until 2010. Some of the nests we found at the new colony site in 2010 were inactive and could have been constructed in 2009.

Flock Size

We recorded flock sizes on five occasions at WSMR on 30 June, 30 September, and 29 October 2009. Flocks ranged from 10 to over 100, with a mean flock size of 38.4. We observed the flock of 100+ on 30 September. This flock was larger than the group of jays that nested at NOP and was likely an aggregate of more than one breeding group, but we have not located a breeding colony outside of NOP at WSMR

Location Data

From the transmitters, we obtained 79 bearings in 2009 that resulted in 17 point locations in the GIS. Ground surveys in 2009 and 2010 yielded 38 additional point locations. We included 47 locations from 2005, 2007, and 2008 in the KDE analysis. All points from previous years fell within the 95% kernel boundaries. We used 102 point locations from all sources in the kernel analyses. The kernel density maps depict the 50, 90, and 95% kernel density polygons for all Pinyon Jays detected in 2005 and 2007-2010.

Home Ranges

The combined KDE model provides a reasonably good depiction of where Pinyon Jays could be found at or near NOP between 24 March and 29 October 2009. Jays left NOP the last week of September 2009. We saw a flock of over 100 birds northeast of NOP in the Garden Spring Canyon area on 30 September and heard transmitters in lower-elevation juniper habitat to the east of there. We detected a few birds in low-elevation juniper habitat on 29 October. The NOP flock has left NOP after the breeding season every year from 2005 to 2010, and we have never found the flock after October. We do not know where they winter.

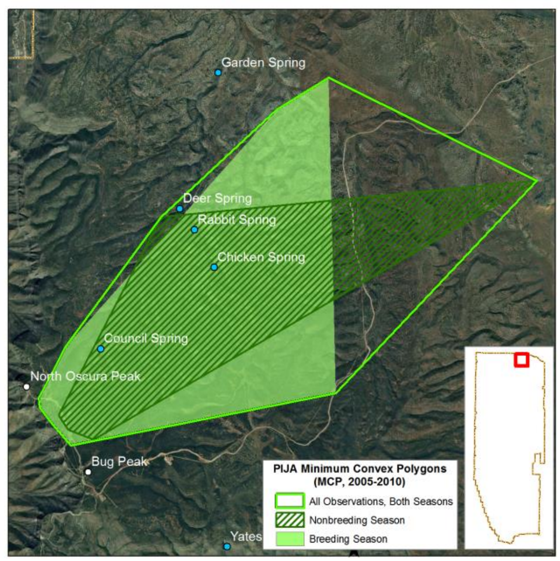

Figure 23. Pinyon Jay minimum convex polygons for all seasons, Oscura Mtns., WSMR.

Breeding

The NOP breeding season MCP covered 2161.8 ha (Figure 23), and the 95% KDE model for the breeding season at NOP covered 2550.9 ha (Figure 24).

Nonbreeding

The nonbreeding MCP covered 1635.9 ha (Figure 23), and the nonbreeding KDE model covered 2720.9 ha (Figure 24).

Combined Breeding and Nonbreeding

The combined breeding and nonbreeding MCP covered 3415.7 ha (Figure 23), and the combined 95% kernel covered 3486.8 ha, with the greatest amount of activity occurring in all seasons shown in red (Figure 25). Seasonal activities overlap 51% of the time, with the remaining breeding and nonbreeding areas fairly disjoint.

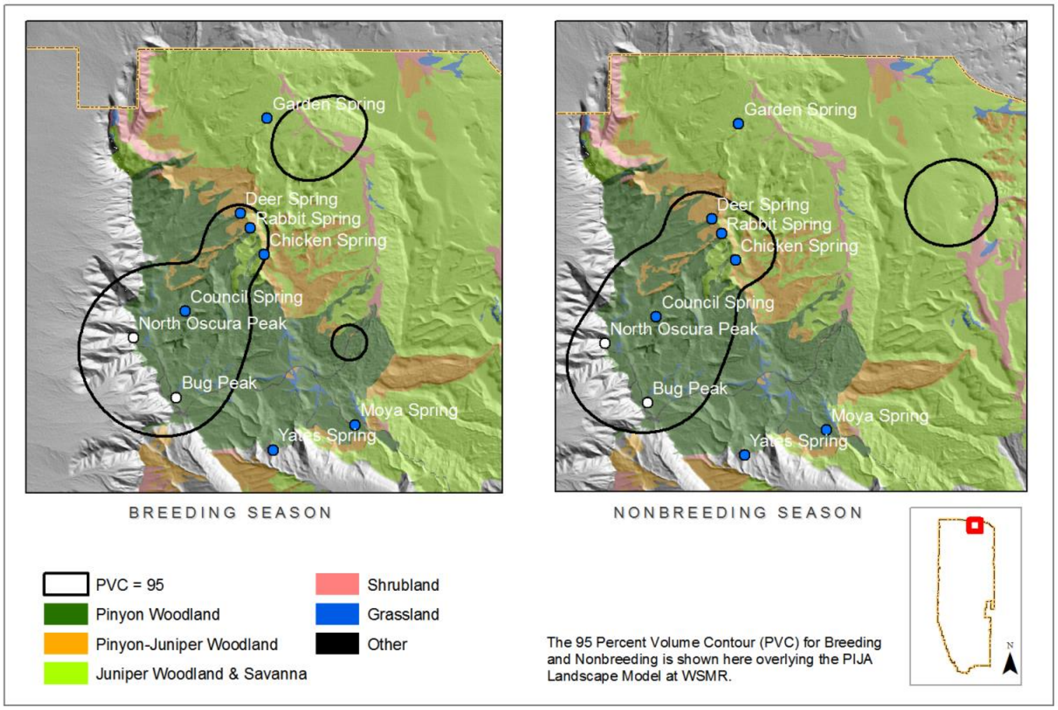

Figure 24. Pinyon Jay KDE model, Oscura Mtns., WSMR.

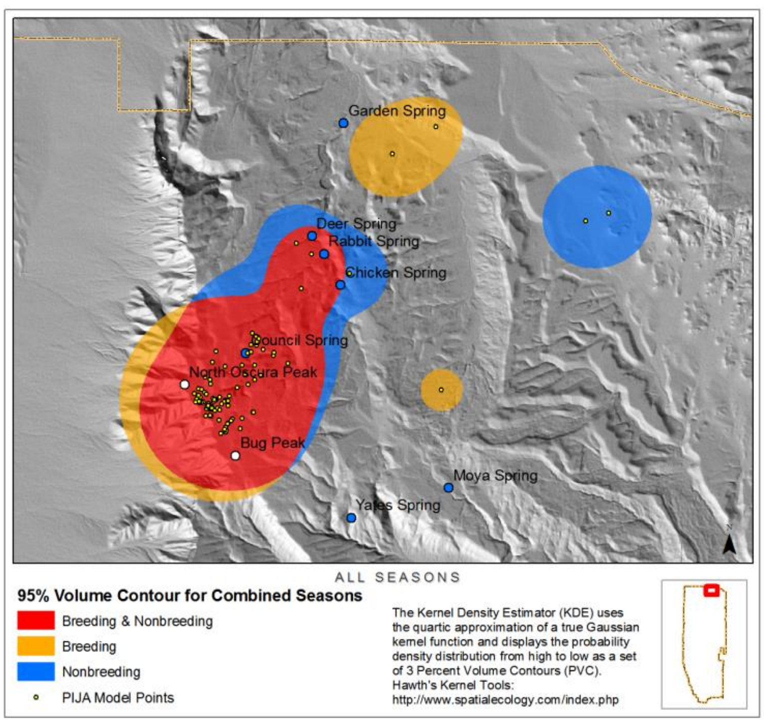

Figure 25. Pinyon Jay activity, all seasons, WSMR.

GIS Habitat Model

The landscape model for Pinyon Jays in the Oscura Mountains at WSMR covers 21,188 ha of potential habitat ranging in elevation from approximately 1800 to 2430 m. The general habitat types in this map are Pinyon Pine Woodland, Pinyon-Juniper Woodland, Juniper Woodland and Savanna, Shrubland, Grassland, and Other. Only Pinyon Pine Woodland, Pinyon-Juniper Woodland, and Juniper Woodland and Savanna are included in the landscape habitat model for Pinyon Jays at WSMR (Figure 26). We found fewer transitions from Pinyon Pine Woodland to Pinyon-Juniper Woodland than at KAFB. This may be due to abrupt changes in elevation, particularly along the western border, or changes in lithology. We delineated the boundaries based on field data, an existing vegetation map (Muldavin et al. 2000b), and visual aerial photo interpretation of the relative density of trees to distinguish between Pinyon-Juniper Woodland and Pinyon Pine Woodland.

Since 2005, Pinyon Jays at NOP have established a breeding colony in Pinyon Pine Woodland at elevations up to about 2400 m. This vegetation type at NOP contains some very old trees, some approaching 400 years of age (Muldavin et al. 2003), in what has been called “persistent woodlands” (Romme et al. 2009). The colony location has shifted within this habitat type among years, but at WSMR we have never found jays nesting in lower-elevation Juniper Woodland and Savanna or Pinyon-Juniper Woodland.

After fledglings are capable of strong flight, the flock moves widely, including to lower elevation Juniper Woodland and Savanna habitats. During these periods they pass over or through mid-elevation, mixed pinyon-juniper habitats.

The breeding season home range of the NOP flock contains a slightly higher percentage than the nonbreeding season home range of Pinyon Pine Woodland (63.7% vs. 59.2%). Conversely, the nonbreeding season home range model contains slightly more Pinyon-Juniper Woodland (10.6% vs. 5%). Other vegetation types are comparable between seasons (within 1% of each other). However, the actual differences in habitat use between seasons could be much larger than indicated here, due to the incompleteness of our spatial data for wintering Pinyon Jays at WSMR. Because the birds leave NOP during the winter and we have found them in Juniper Woodland and Savanna habitats in the fall, we suspect that they spend relatively more time in Juniper Woodland and Savanna and less time in Pinyon Pine Woodlands during the nonbreeding season.

Distance to Military Infrastructure and Activities

The breeding colony tracked since 2007 has centered nesting activities around NOP within Pinyon Pine Woodland on either side of a major north-south road (332), some falling within less than 15 m from the center of the unimproved road. Traffic along the road that runs through the colony site varies, depending on contractor presence at NOP facilities, but at busy times 10 or more vehicles may pass through the colony site per day. Several nests have been situated less than 100 m from regularly occupied buildings. Extremely loud sonic booms can be heard almost daily at NOP. The Red Rio bombing site is located approximately 12 km to the east of the NOP breeding colony, but sound from there does not typically carry to NOP.

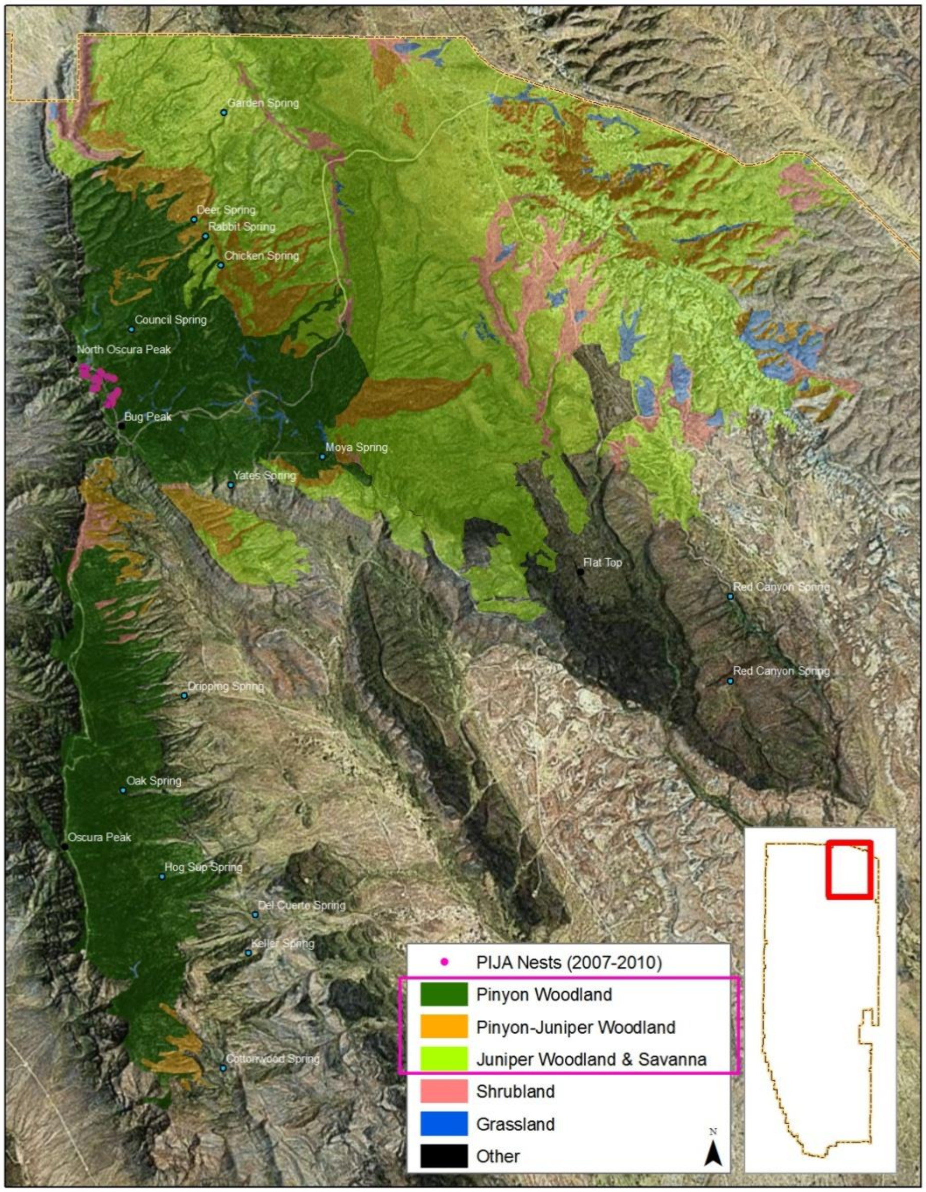

Figure 26. Pinyon Jay landscape-scale habitat model, Oscura Mountains, WSMR. Vegetation types within the pink box were used by Pinyon Jays at WSMR.

`

Discussion

Gray Vireos

Territories and Site Fidelity

Color banding Gray Vireos proved to be a useful technique to identify and track individual birds at both installations. Further, by following color-banded birds in the field, we were better able to identify and delineate adjacent territories, even where not all vireos were banded. Although no color banded vireos returned to CTTA in 2010, approximately the same territories that were occupied in 2009 were again occupied in 2010. The number of territories at CTTA increased by more than 25% from 2009 to 2010, and we also saw a slight increase in the number of territories at KAFB. The increase in territories in 2010 may be due to an extremely productive breeding year in 2009, resulting in an influx of second-year birds to both study areas. In 2009, spring precipitation was more than twice that from the previous year, which likely increased available food resources (Wickersham and Wickersham 2009). We will discuss Gray Vireo nesting success at CTTA and KAFB in detail in the year 2 report.

The MCP analysis yielded a large range of territory sizes for Gray Vireos at both installations. These results should be viewed with caution, as numerous MCPs were based on a relatively small sample of vireo locations, which would probably have caused us to underestimate territory sizes. By contrast, many of the larger MCPs used locations of color banded individuals, making those territory sizes more reliable. Therefore, our analysis probably does not overestimate the potential for some gray vireos to have large territories (>12 ha). In general, territory sizes for Gray Vireos in this study fall within the range reported in other studies. Territory size of Gray Vireos in the Sacramento and Organ Mountains in southern New Mexico ranged from 0.6−11.3 ha (n=37), and 1.6− 6.8 ha (n=14), respectively (Britt and Lundblad 2009). DeLong and Cox (2005) reported a mean territory size of 8 ha for Gray Vireos in central New Mexico. In the Chisos Mountains of Texas, Barlow et al. (1999) reported Gray Vireo territories ranging in size from 2−10 ha. Hutchings and Leukering estimated a territory at 7 ha for a Gray Vireo in western Colorado (Unpublished data cited in Barlow et al. 1999).

Our data indicate that site fidelity may be relatively high for Gray Vireos. At KAFB, we observed a high percentage of color banded males returning to the study area in 2009, with fewer returning in 2010. Still, color banded males that returned to the study area almost always re-occupied the same territory as the previous year. Further, one male-female pair color banded in 2008 paired again in the same territory in 2010. Barlow et al. (1999) also reported high site fidelity for Gray Vireos in west Texas, with 22 of 24 birds color banded over a four year period returning to their territories. Hutchings and Leukering reported one color banded vireo returning to the same territory in Colorado National Monument for three consecutive years (Unpublished data cited in Barlow et al. 1999).

Habitat Requirements and Management

On a landscape scale, Gray Vireo habitat requirements at CTTA and KAFB are fairly simple. As expected, vireos at KAFB occupied Juniper Woodland and Savanna habitat types and were not found in the Pinyon or Pinyon-Juniper Woodlands used by Pinyon Jays. At CTTA, potential habitat for vireos was Juniper Woodland and Savanna, with no significant pinyon component. Vireos appeared to prefer the slightly higher elevation, upland Juniper Woodland and Savanna Volcanic Hills compared to the lowland Juniper Savanna on Lava Plains habitat at CTTA. At KAFB, most territories occurred on slightly higher elevation toe slopes and hills, compared with the lower elevation savanna. Although the upper elevation limit for juniper habitat on KAFB was about 200 m higher than at CTTA, in general most of the territorial Gray Vireos at CTTA occupied habitat at slightly higher elevations (>2000 m) than at KAFB. In a recent study at similar elevation (1725−2228 m) in the San Juan Basin of northwestern New Mexico, Gray Vireos appeared to prefer habitat at elevations >1900 m (Wickersham and Wickersham 2007). Schlossberg (2006) also reported a relationship between elevation and Gray Vireo density in Arizona and Utah; however, in his study, density was lower at elevations greater than 1900 m, compared with habitat at lower elevations (1500−1900 m). Although habitat in Schlossberg's study was similar to Wickersham and Wickersham's (2007) study, elevation was lower in his study area (~1550−2100 m).

To manage habitat for Gray Vireos, maintaining healthy juniper-dominated habitats occurring on hills and toe slopes appears to be essential. It is important that land managers identify and differentiate between juniper-dominated habitats and Pinyon-Juniper Woodlands. At KAFB and likely elsewhere, juniper-dominated habitats overlap in elevation considerably with Pinyon-Juniper Woodlands (1742−2319 m and 1891−2368 m for juniper and pinyon-juniper, respectively). While management of Pinyon-Juniper Woodlands has been an important issue in recent years for federally owned lands in New Mexico, land managers must also manage for Juniper Woodlands and Savannas to ensure enough habitat is available to sustain populations of Gray Vireos in the state.

Probably the greatest threat to Gray Vireos is habitat loss or alteration due to land management activities, such as thinning, chaining, and clearing for exurban development, biofuel production, and oil-and-gas development (Walker and Doster 2009). Tree removal by way of fire, chaining, or thinning has been implemented on public lands to combat pinyon-juniper expansion into grasslands and shrublands. These expansions have been shown to be influenced by natural processes and changing climate and thus do not necessarily represent unnatural events (Romme et al. 2009). These management practices should be avoided at CTTA and KAFB. Additionally, removal of trees for the construction of military infrastructure where Gray Vireo populations are known to occur should also be avoided.

Juniper health may be compromised by mistletoe *(Phoradendron* spp.; Geils et al. 2002), insects (Itami and Craig 1989, Cain and Parker 1998), drought (Floyd et al. 2009), or other climatic conditions; however, the Juniper Woodlands and Savannas of CTTA and KAFB both appear to be in good health. Where mistletoe has infected stands of juniper, thinning and pruning may be effective treatments (Geils et al. 2002), while spraying of individual infected trees may protect juniper from insect outbreaks. Drought, coupled with increased temperatures, has increased insect mortality in pinyons; however, drought alone has been shown to cause large-scale juniper mortality (Floyd et al. 2009). With climate projections for the Southwest suggesting increases in temperatures and drought conditions, more research is needed to understand the potential for future adverse impacts to juniper habitats (Floyd et al. 2009).

Historically, fire regimes in most Pinyon-Juniper Woodlands have been infrequent and high intensity, wiping out large stands of trees. However, data are lacking on the history of low intensity fires and their role in maintaining low tree densities of juniper savannas (Romme et al. 2009). In the absence of more information on the role of fire in structuring juniper savannas, fire is not recommended as a management strategy for maintaining healthy juniper-dominated habitats.

Relationship to Military Activities

CTTA is closed to military activities between 15 May and 15 July annually. Therefore, Gray Vireos at this installation are not subject to the level of disturbance that potentially affect vireos during the peak breeding period at KAFB. Further, since only a few vireo detections have occurred within the TAMUs on CTTA, it is unlikely that military activities at CTTA have a significant effect on the population of Gray Vireos.

Disturbances at KAFB are primarily associated with human presence and noise. In general, human presence within Gray Vireo territories was limited to our field biologists; however, we did rarely encounter one to two military or civilian personnel walking for recreation within or adjacent to vireo territories. In this study, Gray Vireos appeared to tolerate human presence in their territories, but they typically displayed territorial and sometime aggressive behavior in response to playbacks and target mist netting. Sometimes, but not always, Gray Vireos exhibited scolding calls and aggressive postures to field biologists in close proximity to their nests. According to Barlow et al. (1999), Gray Vireos may abandon their nests during the building or egg-laying stage if disturbed by humans, although banding adults or nestlings does not usually disrupt their activities. We observed nest abandonment during both the building and egg-laying stage at both installations during 2009 and 2010, but other factors that we have not fully examined might have affected nest abandonment (e.g., parasitism by Brown-headed Cowbird). We will present nest success data in detail in the Year 2 report.

Noise disturbances in the study area are typically short-term and temporary, including noise generated by vehicles, heavy equipment, and the firing range. Occasionally, very loud, sonic boom type noises could also be heard within the study area, although their origin was unknown. Probably the most common noise disturbance in the study area is generated by vehicles. Vehicle traffic along Coyote Springs Road is variable but may approach approximately five vehicles per hour at times. The proximity of Gray Vireo territories to Coyote Springs Road, however, suggests that vireos are not avoiding habitats adjacent to lightly traveled roads. Noise from the firing range was considerably louder than vehicle traffic but again was relatively short-term. Although our study area did not include habitat directly adjacent to the firing range, a base-wide Gray Vireo survey conducted by ABS in May and June of 2010 identified two territorial vireos, approximately 200 m and 350 m away from the footprint of the firing range facility (LW unpublished data). Further, noise from the firing range could be heard well within many of the vireo territories to the southeast, south, and southwest of the facility. Therefore, the loud but short-term noise from the firing range apparently does not negatively affect territory selection by Gray Vireos.

We have collected data on the proximity of Gray Vireo nests to military infrastructure, but our data set is not complete enough to allow rigorous analysis of nest site selection and nesting success relative to military infrastructure and activities. We will present nesting data as related to military infrastructure and activities at both installations in the Year 2 report.

Pinyon Jays

Home Ranges

Pinyon Jay flock home ranges reported in the literature vary widely: 1600 ha (Balda 2002), 2300 ha (Marzluff and Balda 1992), 2890 ha (Ligon 1971), and 6400 ha (Balda 2002). The KAFB breeding, nonbreeding, and year-round 95% kernel models fall within these ranges, but the combined MCP for KAFB is larger than all except an estimated home range of one flock that Balda (2002) reported as having a home range of 8 x 8 km. At WSMR, breeding and nonbreeding season ranges are also comparable to these reported ranges, but we have likely under-estimated the area of the nonbreeding range for the NOP flock (see below).

We have studied Pinyon Jays at NOP since 2005, with varying degrees of effort, depending on funding. We know both more and less about the NOP flock than about the KAFB flock. The NOP flock has returned to the area every year from 2005-2010. We have banded hatch-year birds in each of these years except 2008, and we found active nests in 2005, 2007, 2009, and 2010. However, the landscape model for WSMR is less complete for the nonbreeding season than for KAFB, because the NOP flock typically leaves NOP in September or October each year, and we have no location data for WSMR jays from November through February. We assume the flock wanders widely over a much larger area than the summer range, and our fall location data suggest that this range includes more lower-elevation, juniper-dominated habitat than the summer range. However, because they leave the area each winter, we have not identified the boundaries of the area they use in the winter months. Our model is based on location data from March through October.

Radio telemetry enabled us to collect a substantial number of point locations for the Pinyon Jays at WSMR and KAFB over four months, including points we would not have collected without the radios. However, on several occasions at KAFB, especially in winter, we were unable to locate any jays, even when we knew transmitters were functional. Our inability to find jays at these times could be due to the birds' mobility, their large home ranges, or the limitations of telemetry equipment in rough terrain. The home range we modeled for KAFB therefore may also be conservative, particularly in winter when the species is known to wander widely (Marzluff and Balda 1992).

Our home range models may also under-represent the higher-elevation vegetation types, particularly Pinyon Pine Woodland, because even with telemetry, it is difficult to cover the higher-elevation habitats where roads are sparse. It is also important to note that the kernel models were created in years with no pinyon mast crop. In a mast year, Pinyon Jays would be expected to be harvesting seeds in pinyon-dominated woodland until most seeds were harvested, which could take months in the case of a large crop. This would result in the inclusion of more Pinyon Pine Woodland in the nonbreeding home ranges. Nonetheless, the main caching area in the north at KAFB was in Juniper Woodland and Savanna, which would also be visited frequently during a mast year, and might partially balance additional time spent in Pinyon Pine Woodland.

Breeding

Pinyon Jays in this study nested in two general habitat types, Juniper Woodland and Savanna (KAFB) and Pinyon Pine Woodland (KAFB and WSMR). Although the South Colony at KAFB and the NOP Colony at WSMR both nested in habitat classified as Pinyon Pine Woodland, we detected differences in the age and stand structure of the two colony sites. At NOP, some stands contain very large trees approaching 400 years of age (Muldavin et al. 2003). The Pinyon Pine Woodland at KAFB, in contrast, contains mainly intermediate-sized trees and, at least where the jays nested, we did not see any of the huge, very old trees present at NOP. Percent slopes at KAFB were apparently steeper (20-65) in the Pinyon Pine Woodlands than those at WSMR (0-27), but these analyses will be the subject of our second report.

Another KAFB colony nested in relatively flat juniper woodland, in habitat that appeared similar to that favored by Gray Vireos. We found a Pinyon Jay nest 120 m from the nearest Gray Vireo nest. Although in close proximity with scattered junipers, the Gray Vireo nest was adjacent to a meandering dry wash in contrast to the landscape position of the Pinyon Jay nest. Although we believe breeders from the two KAFB colonies are likely members of the same wintering flock, the North Colony nested about two weeks earlier than the South Colony birds. Seven of the nine North Colony nests that we were able to monitor failed after late winter weather occurred in the area, and we believe that most of them were abandoned. Early-nesting birds can potentially produce young that will be older and better able to survive when winter comes, but by nesting in March, early-nesters are gambling with poor weather and limited food, and the risk of failure is therefore higher (Marzluff and Balda 1992). These risks can be ameliorated in years following a pinyon crop, when cached seeds provide reliable food (Ligon 1978, Marzluff and Balda 1992).

Caching

We have located two caching areas, both within the north area of the breeding home range. Both have sparse vegetation, which is consistent with other descriptions of Pinyon Jay caching sites (Ligon 1978, Marzluff and Balda 1992, Balda 2002). The main site is located on south-facing slopes. This area was free of snow in January and February, when north-facing slopes and tree-covered areas were covered in snow up to a meter deep. Caching in open, south-facing areas allows the jays to find caches when deep snow is present elsewhere in the study area. Marzluff and Balda (1992) also report that caching sites are often snow-free in winter.

Nonbreeding

When we visited the KAFB north area in December, January, and February, the birds were often nowhere to be seen. Out of seven visits to the study area during these months, we detected jays only twice. Although the difficulty in finding the birds in winter might suggest that they leave the area entirely, we believe the KAFB flock remains in the area. A large flock appeared at the feeder within six days of the feeder being set up in February, which indicates that they were not far from this activity center of their home range.

Habitat Requirements and Management

Perhaps the most striking feature of Pinyon Jay habitat use at the landscape scale is the size of a flock's home range. We consider the year-round home range sizes reported here to be minimum estimates, because we were often unable to locate flocks within these ranges, even with transmitters shown to be detectable over distances of 5 km or more. In addition, Pinyon Jay flocks are known to wander far outside their core home ranges in search of winter food (Ligon 1978, Balda 2002).

The second notable result of the landscape-level model is the variety of elevations and vegetation types where colonies were established. Within the landscapes modeled at KAFB and WSMR, we found Pinyon Jay flocks ranging over elevations from 1803 to 2420 m and in vegetation types from Juniper Woodland and Savanna to persistent, old-growth Pinyon Pine Woodland, and mixed woodlands in between. Although separated by a little over a degree of latitude (~135 km), the nesting colonies lie in a nearly direct north-south line between 106º 21´ - 22´ at WSMR and 106º 25´- 26´ at KAFB, approximately 7 km east. The difference in minimum and maximum elevation of these sites within our prescribed Pinyon Jay habitat is also similar, differing by less than 80 m at the lowest elevation to 20 m at the highest elevation.

Hence, the proper scale of habitat management for a single flock of Pinyon Jays is the large landscape, including pinyon, juniper, and Pinyon-Juniper Woodland types. A single flock can easily range over areas as large as half of an entire small mountain range such as the Oscuras. It is important to provide lower-elevation Juniper Woodland and Savanna for wintering, caching, and early spring breeding. Pinyon Pine Woodland is crucial for Pinyon Jays, not only because it is heavily used for nesting, but more importantly because it is the source of the pinyon seeds that strongly influence Pinyon Jay population viability. Because the production of pinyon mast crops is highly variable over years and to a lesser extent over landscapes (Ligon 1978, Forcella 1981, Zlotin and Parmenter 2008), Pinyon Jays need very large landscapes, into the thousands of hectares, of Pinyon Pine Woodland and/or Pinyon-Juniper Woodland. Most years are not mast years for *P. edulis* (Forcella 1981). In lean years when pinyon seeds are not available for caching, Pinyon Jays may move hundreds or even thousands of kilometers in search of pinyon seeds or other winter foods

(Balda 2002). Clearly, only managers with jurisdiction over the very largest stands of pinyon and juniper can practically manage for Pinyon Jays at a scale necessary to positively impact their populations; thus DoD lands could be crucial to the future of this at-risk species.

In considering how to manage habitat for Pinyon Jays, the first rule of thumb is that clearing of juniper and pinyon trees should be avoided when possible. Pinyon-dominated habitats, especially those with many mature, un-crowded pinyon trees, are areas of greatest seed production (Johnson and Smith 2006, 2007). Pinyon seeds provide food not only for Pinyon Jays but also for other wildlife, including sensitive species such as the Oscura Mountains chipmunk and Juniper Titmouse, and these woodlands, especially their large, mast-producing trees, should be retained. Research at NOP suggests that seed production is relatively lower in areas where trees are most dense (Johnson and Smith 2006, 2007). To foster health of the most productive trees, some selective thinning may be useful. However, research is needed on the usefulness of thinning in maintaining the productivity and health of pinyon-dominated woodlands, and thinning should only be initiated after careful consideration of current science and in the context of a pilot research program.

Persistent woodlands have always experienced infrequent fires, and in fact surface fires historically had a very limited role in structuring stands in most pinyon and juniper woodlands (Romme et al. 2009). In many pinyon and juniper woodlands, stand dynamics are driven more by climate, insects, and disease than by fire (Romme et al. 2009). Thus, fire is not recommended as a generally appropriate management tool in these woodlands. It should be added that Pinyon Jays play a crucial and likely under-appreciated role in establishing pinyon woodlands and determining stand structure (Lanner 1996).

Relationship to Military Activities

Our nest success data are not currently complete enough to allow analysis of nesting success relative to military infrastructure and activities. However, Pinyon Jays showed no apparent aversion to nesting near roads, buildings, or occasional loud noises. We have observed Pinyon Jays nesting within 10 m of roads and within 50 m of buildings. At times, several vehicles per hour pass along Coyote Springs Road at KAFB and along the NOP road (332) at WSMR. In addition, the north colony at KAFB is 850 m from the Live Firing Range, and loud gunfire can be heard from the colony site. At WSMR, extremely loud sonic booms occur almost daily over the NOP colony, and aircraft noise is common at both sites. The south KAFB colony is more isolated, and vehicle noise and explosions are not typically heard there. All of these noises occur occasionally and are not constant. Hence, our suggestion that Pinyon Jays tolerate noise disturbance does not mean that they can tolerate constant noise, which could be much more disruptive than occasional, very short-duration noises.

The jays alarm call at humans walking within their colonies, near active nests, near fledglings, or near foraging and caching flocks. We recommend that off-road traffic and on-foot training activities be planned to avoid nesting areas, especially between March and August, but potentially in any month in the year following a pinyon mast crop when Pinyon Jays might be nesting. Caching areas should be avoided year-round, and in mast years, areas with abundant cone crops should be avoided from August through the following May.

Landscape-scale Management of Pinyon-Juniper Habitats for Pinyon-Juniper Species at Risk

Pinyon-juniper is a major vegetation type in western North America, including on numerous DoD installations. Effective management of these vegetation types has been hindered by lack of understanding of 1. variation in vegetation structure and ecological process within this ecosystem, 2. historical disturbance regimes, and 3. drivers of change in these systems over the last 150 years (Romme et al. 2009). Planning for the management of pinyon and juniper habitats should therefore begin with definition, delineation, and understanding of pinyon-juniper vegetation types. Land managers have not typically distinguished between the various pinyon and juniper habitat types and have applied practices such as fire in habitats designated as “pinyon-juniper” (Bureau of Land Management 2009) that could include varying species composition and differing fire histories.

Romme et al. (2009) define three very different sub-types within the greater pinyon-juniper ecosystem. Persistent woodlands are found where soil, climate, and disturbance conditions favor pinyon, juniper, or a mix of both. These correspond to our Pinyon Pine Woodlands and Pinyon-Juniper Woodlands. Pinyon-juniper savannas occur where conditions are favorable for both trees and grasses (our Juniper Woodland and Savannah). Wooded shrublands occur where conditions support shrubs, but trees can increase during moist climate conditions and decrease during drought and disturbance.

Spreading, low-intensity surface fires likely had a very limited role historically in structuring stands in many pinyon and juniper woodlands. Most fires in pinyon and juniper woodlands have been high-severity fires that killed all the trees and top-killed most shrubs and herbs, largely because fuel structure is not typically conducive to low-intensity, spreading fire (Romme et al. 2009). Fire has always been infrequent in persistent woodlands. There is evidence for high-intensity fires in wooded shrublands and some evidence to suggest that historically fires were infrequent there. Many pinyon and juniper woodlands show no evidence of past widespread fire over many hundreds or even thousands of years (Romme et al. 2009), and thus fire is probably not an appropriate management tool in these vegetation types under most circumstances. Although it is logical that low-severity fires may have maintained low tree densities in pinyon-juniper savannas before Euro-American settlement, information is lacking on fire history in these types (Romme et al. 2009). In the absence of information on the historical influence of fire in pinyon-juniper savanna habitats, fire is not currently a recommended management tool in these habitats either.

It is widely assumed that recent infill and expansion in many existing pinyon and juniper habitats over the past 150 years are unnatural processes resulting from human land use practices, including fire exclusion. In this view, “restoration” requires fire, chaining, or thinning in these woodlands. However, both infill and expansion likely have been influenced by natural, long-term range expansion and changing climate (Romme et al. 2009). Thus, management policies aimed at thinning or reducing the extent of these habitats are not generally based on scientific evidence, and they should be avoided for pinyon-juniper habitats at DoD installations in the Southwest. Large-scale clearing of Juniper Woodland and Savannas would have strong negative impacts on both Pinyon Jays and Gray Vireos, and large-scale clearing of Pinyon Pine Woodlands would be devastating to Pinyon Jays and other species, such as Juniper Titmouse and Oscura Mountains chipmunk, that rely on pinyon seeds.

In this study, both Gray Vireos and Pinyon Jays nested within earshot of loud firing noise and near roads. These types of military activities do not appear to greatly impact either species, as long as they are intermittent and occur at a distance of a few hundred meters. However, CTTA is closed to military activities during the Gray Vireo nesting season, and Gray Vireo nesting areas at KAFB are currently not heavily used for military activities. A change in military activities at either installation could reveal as-yet-undetected impacts to vireo reproduction. In our Year 2 report we will present nesting data as related to military infrastructure and activities.

Unlike Gray Vireos, which spend only the nesting season at CTTA and KAFB, Pinyon Jays are year-round residents. Thus, their wintering habitat needs must also be considered. Large winter flocks of Pinyon Jays move constantly through their very large home ranges in search of food. In poor food years, they may wander hundreds of kilometers outside their home ranges. The presence of food within the home range helps a flock to survive the winter and avoid the stress and danger of long-distance movements. Hence, management for Pinyon Jay wintering habitat should include providing large, un-fragmented expanses of pinyon and juniper habitats, to increase the possibility that a flock will find some cone-producing pinyon trees. Older, cone-producing trees should be protected and the woodlands they inhabit conserved. In mast years, human activities should be strictly limited in areas of cone-production and in open, south-facing caching habitats. In Years 2 and 3 of this study we are gathering data to identify traditional caching and nesting areas that should be protected during mast years.

Pinyon Jay populations likely benefit from a good mast crop more than anything, but unfortunately, masting is likely to become less frequent and widespread with climate change, while pinyon insects and disease are expected to increase (Breshears et al. 2005). Thus, any management or military activities that would reduce the area of pinyon and juniper habitats on installations could impact Pinyon Jays, Gray

Vireos, and other pinyon-juniper animal species. In the future, if climate change affects the health and productivity of these habitats, more direct management actions, such as thinning or insect control may be warranted. However, understanding of how to increase health and productivity of pinyon and juniper habitats is currently insufficient to allow specific recommendations for direct management actions.

Literature Cited

Aldon, E.F., D.W. Shaw, tech. coords. 1993. Managing piñon-juniper ecosystems for sustainability and social needs; proceedings of the symposium 1993 April 26-30; Santa Fe, New Mexico. Gen. Tech. Rep. RM-236. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 169 pp.

Allen-Reid, D., J. Anhold, D. Cluck, T. Eager, R. Mask, J. McMillan, S. Munson, T. Rogers, D. Ryerson, E. Smith, B. Steed, and R. Thier. 2005. Piñon pine mortality event in the Southwest: an update for 2005. US Forest Service. Accessed at: http://fhm.fs.fed.us/posters/posters05/pinon_pine.pdf

Arbetan, P. 2009. Field observations at Camel Tracks Training Site for the Gray Vireo. Natural Heritage New Mexico Publ. No. 09-GTRdb-343. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM.

Arbetan, P. 2007. Database of compilation of Gray vireo nest and territory locations for 2004-2007 at Camel Tracks Training Site, New Mexico Army National Guard.

Arbetan, P. and E. Muldavin. 2006. Report of gray vireo monitoring surveys at the New Mexico Army National Guard Camel Tracks Training Area. Natural Heritage New Mexico Publ. No. 06-GTR-293. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 21 pp.

Arbetan, P. and E. Muldavin. 2004a. Report of gray vireo surveys and monitoring at the New Mexico Army National Guard Camel Tracks Training Area. Natural Heritage New Mexico Publ. No. 04-GTR-277. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 26 pp.

Arbetan, P. and E. Muldavin. 2004b. Report of Bird Surveys at the New Mexico Army National Guard Camel Tracks Training Area for 2003. Natural Heritage New Mexico Publ. No. 02-GTR-260, Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 17 pp.

Arbetan, P. and E. Muldavin. 2003. Report of bird surveys at New Mexico Army National Guard Training Areas, Camel Tracks, Roswell Weekend, Happy Valley. Natural Heritage New Mexico Publ. No. 03-GTR-259. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 15 pp.

Arbetan, P., K. Johnson, and E. Muldavin. 2002. Report of faunal surveys for the Gray Vireo and Black-tailed and Gunnison's Prairie Dogs at the New Mexico Army National Guard Camel Tracks Training Site. Natural Heritage New Mexico Publ. No. 02-GTR-231. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 27 pp.

Baker, W. L. and D. J. Shinneman. 2004. Fire and restoration of piñon–juniper woodlands in the western United States: a review. Forest Ecology and Management 189:1–21.

Balda, R. P. 2002. Pinyon Jay (*Gymnorhinus cyanocephalus*). *In* The Birds of North America, No. 605 (A. Poole and F Gill, eds.). The Birds of North America, Inc. Philadelphia, PA.

Barlow, J. C. 1978. Effects of habitat attrition on vireo distribution and population density in the northern Chihuahuan Desert. Pp. 391–596 *in* Transactions of the symposium on the resources of the

Chihuahuan Desert region—U.S. and Mexico (R. H. Wauer and D. H. Riskind, eds.). USDI, Natl. Park Serv. Trans. Proc. Ser. 3.

Barlow, J.C., S.N. Leckie, and C.T. Baril. 1999. Gray Vireo (*Vireo vicinior*). *In* The Birds of North America, No. 447 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Beyer, H.L. 2004. Hawth's Analysis Tools for ArcGIS. Available at http://www.spatialecology.com/htools.

Black, C. 1994. Unpublished field surveys of *Vireo vicinior* on Kirtland AFB. June 29 to July 6, 1994 in NMBiotics, Natural Heritage New Mexico, University of New Mexico.

Breshears, D.D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer. 2005. Regional vegetation die-off in response to global-change-type drought. Proceedings National Academy Sciences 102:15144-15148.

Britt, C. and C. Lundblad. 2009. Gray Vireo status and distribution on Fort Bliss: 2007. Pp. 3−6 *in*: Proceedings of the Gray Vireo Symposium. H. A. Walker and R. H. Doster, eds. The New Mexico Department of Game and Fish, Santa Fe, NM.

Bureau of Land Management. 2009. Restore New Mexico. Accessed 17 August 2010 at: http://www.blm.gov/nm/st/en/prog/restore_new_mexico.html.

Cain, R. and D. Parker. 1998. Conifer pests in New Mexico. Rev. ed. USDA Forest Service, Southwestern Region, Albuquerque, NM. 50 pp.

Chauvin, Y. and P. Arbetan. 2005. Threatened and endangered species survey for the New Mexico Army National Guard. Santa Fe, NM. Natural Heritage New Mexico Publ. No. 05-GTR-248. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 15 pp.

Cole, K.L., K. Ironside, S. Arundel, P. Duffy, and J. Shaw. 2007. Modeling future plant distributions on the Colorado Plateau: an example using *Pinus edulis*. Pp. 319-330 *in*: the Colorado Plateau III; Integrating research and resources management for effective conservation. C. van Riper III and M. Sogge, eds. University of Arizona Press, Tucson, AZ.

Colorado Bureau of Land Management (BLM). 1995. Analysis of the Colorado BLM nongame bird monitoring point count transects. Bureau of Land Management, Grand Junction, CO.

Colorado Division of Wildlife. 2006. Colorado's comprehensive wildlife conservation strategy and wildlife action plans. Prepared in fulfillment of Title IX, Public Law 106-553 and Title I, Public Law 107-63 (State Wildlife Grants Program).

DeBruin, E. 1995. Endangered species survey of Camel Tracks Training Site: Year 1 Report to New Mexico Army National Guard Environmental Office, Santa Fe, NM. Natural Heritage New Mexico Publ. No. 95-GTR-301. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 46 pp.

DeBruin, E. 1996. Biological Assessment of expanded Camel Tracks training site, Year II. Natural Heritage New Mexico Publ. No. 96-GTR-93.Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 23 p. + app.

DeLong, J. P. and N. S. Cox. 2005. Nesting ecology of Gray Vireos in central New Mexico: 2005 results. Unpublished report to the Bureau of Land Management and New Mexico Department of Game and Fish. SORA and Eagle Environmental, Inc., Albuquerque, New Mexico.

Delong, J.P. and S.O. Williams. 2006. Status report and biological review of the gray vireo in New Mexico. Unpubl. report to New Mexico Department of Game and Fish, Santa Fe, New Mexico. 50 pp.

Floyd, M. L., M. Clifford, N. S. Cobb, D. Hanna, R. Delph, P. Ford, and D. Turner. 2009. Relationship of stand characteristics to drought-induced mortality in three southwestern piñon–juniper woodlands. Ecological Applications 19:1223–1230.

Frei, R. 2007. Spreadsheet of territories and nest locations for Gray vireo on Kirtland Air Force Base: dates 2003 and 2005-2006 in NMBiotics, Natural Heritage New Mexico, University of New Mexico.

Geils, B. W., J. Cibrian Tovar, and B. Moody, tech. coords. 2002. Mistletoes of North American conifers. Gen. Tech. Rep. RMRS-GTR-98. Ogden, UT: USDA, Forest Service, Rocky Mountain Research Station. 123 pp.

Grossman, D.H., D. Faber-Langendoen, A.W. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: Terrestrial Vegetation Of The United States. Volume I: The National Vegetation Classification Standard. The Nature Conservancy, Arlington, VA. 92 pp.

Forcella, F. 1981. Ovulate cone production in pinyon: negative exponential relationship with late summer temperature. Ecology 62:488-4911.

Giroir, G. 2001. Final report on the breeding bird inventory at Colorado National Monument, western Colorado. Unpublished report for Colorado National Monument. Rocky Mountain Bird Observatory, Grand Junction, CO.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K.I. Metzler, K.D. Patterson, M. Pyrne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.

Hutton, K, G. Giroir, R. Sparks, A. Panjabi, and D. Hanni. 2006. Bird monitoring in the National Park Service, Northern Colorado Plateau Network: 2005 field season report. Tech. Rep. M-NCPN05-01. Rocky Mountain Bird Observatory, Brighton, CO.

Itami, J. K. and T. P. Craig. 1989. Life history of *Styloxus bicolor* (Coleoptera: Cerambycidae) on *Juniperus monosperma* in northern Arizona. Annals of the Entomological Society of America 82: 582-587.

Johnson, K. and J. Smith. 2006. Interdependence of pinyon pines and pinyon jays, White Sands Missile Range, NM, 2004-2005 final report. Natural Heritage New Mexico Publication No. 06-GTR-309. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM.

Johnson, K. and J. Smith. 2007. Relationship of pinyon jays and pinyon pines at North Oscura Peak, White Sands Missile Range, 2006 draft report. Natural Heritage New Mexico Publication No. 07-GTR-311. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM.

Kirtland Air Force Base. 2007. Integrated natural resources management plan for Kirtland Air Force Base. Kirtland Air Force Base, Albuquerque, NM. 143 pp.

Lanner, R.M. 1996. Made for each other: a symbiosis of birds and pines. Oxford University Press, New York, NY.

Ligon, J.D. 1971. Late summer-autumnal breeding of the Piñon Jay in New Mexico. Condor 73:147-153.

Ligon, J.D. 1974. Green cones of the piñon pine stimulate late summer breeding in the Piñon Jay. Nature 250:80-82.

Ligon, J.D. 1978. Reproductive interdependence of piñon jays and piñon pines. Ecological Monographs 48:111-126.

Marzluff, J.M. and R.P. Balda. 1992. The pinyon jay: the behavioral ecology of a colonial and cooperative corvid. T & AD Poyser, London. 317 pp.

Mehlhop, P. and E. DeBruin. 1995. Threatened and endangered species survey of Kirtland Air Force Base, New Mexico. Natural Heritage New Mexico Publ. No. 95-GTR-81. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 40 pp.

Muldavin, E., Y. Chauvin, and G. Harper. 2000a. The vegetation of White Sands Missile Range, New Mexico Volume I: handbook of vegetation communities. Natural Heritage New Mexico Publ. No. 00-GTR-299. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 236 pp.

Muldavin, E., G. Harper, P. Neville, and Y. Chauvin. 2000b. The vegetation of White Sands Missile Range, New Mexico Volume II: vegetation map. Natural Heritage New Mexico Publ. No. 00-GTR-299. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 100 pp.

Muldavin, E., C. Baisan, T. Swetnam, L. DeLay, and K. Morino. 2003. Woodland fire history studies in the Oscura and northern San Andres Mountains, White Sands Missile Range, New Mexico. Natural Heritage New Mexico Publ. No. 03-GTR-256. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 35 pp.

National Agriculture Imagery Program (NAIP). 2009. USDA-FSA natural color digital aerial imagery acquired for New Mexico.

New Mexico Department of Game and Fish. 2005. Threatened and endangered species of New Mexico, 2004 biennial review. New Mexico Department of Game and Fish, Conservation Services Division, Santa Fe, New Mexico. March 2005. 112 pp.

New Mexico Department of Game and Fish. 2006. Comprehensive Wildlife Conservation Strategy for New Mexico. New Mexico Department of Game and Fish. Santa Fe, New Mexico. 526 pp. + appendices.

New Mexico Partners in Flight. 2007. New Mexico Bird Conservation Plan, version 2.1. C. Rustay and S. Norris, compilers. Albuquerque, NM.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Iñigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, and T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Romme, W.H., C.D. Allen, J.D. Bailey, W.L. Baker, B.T. Bestelmeyer, P.M. Brown, K.S. Eisenhart, M.L. Floyd, D.W. Huffman, B.F. Jacobs, R.F. Miller, E.H. Muldavin, T.W. Swetnam, R.J. Tausch, and P.J. Weisberg. 2009. Historical and modern disturbance regimes, stand structures, and landscape dynamics in piñon-juniper vegetation of the western United States. Rangeland Ecology and Management 62:203-222.

Sauer, J.R., J.E. Hines, and J. Fallon. 2007. The North American Breeding Bird Survey, Results and Analysis 1966 - 2005. Version 6.2.2006. US Geological Survey, Laurel, MD.

Schlossberg, S. 2006. Abundance and habitat preferences of gray vireos (*Vireo vicinior*) on the Colorado Plateau. Auk 123:33-44.

Sutter, J.V., M.E. Anderson, K.D. Bunnell, M.F. Canning, A.G. Clark, D.E. Dolson, and F.P. Howe. 2005. Utah comprehensive wildlife conservation strategy. Utah Divison of Wildlife, Salt Lake City, Utah.

Thompson, R.S., S.E. Hostetler, P.J. Bartlein, and K.H. Anderson. 1998. A strategy for assessing potential future changes in climate, hydrology, and vegetation in the western United States. USGS Circular 1153. Accessed 6 August 2010 at: http://pubs.usgs.gov/circ/1998/c1153/.

Walker, H.A., and R.H. Doster. 2009. Proceedings of the Gray Vireo Symposium co-sponsored by the New Mexico Department of Game and Fish and the New Mexico Ornithological Society. 12−13 April 2008; Albuquerque, New Mexico. The New Mexico Department of Game and Fish, Santa Fe, New Mexico.

Wauer, R.H. 1983. Checklist of birds of the Big Bend. Big Bend Natural History Association, Big Bend National Park, Brewster Co., TX.

Weathers, W.W. 1983. Birds of southern California's Deep Canyon. University of California Press, Berkeley, CA.

Western Regional Climate Center. 2010. Albuquerque WSFO Airport, New Mexico. Period of record monthly climate summary. Accessed on 17 August 2010 at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nmalbu.

White Sands Missile Range Climate Stations. 2009. Excel spreadsheets from Thomas Blaine for stable WSMR climate stations.

Wickersham, L.E. and J.L. Wickersham. 2007. Density and habitat use of gray vireo (*Vireo vicinior*) in northwestern New Mexico: 2006-07 final report. Prepared for the New Mexico Department of Game and Fish, Santa Fe, NM. 15 pp. + appendix.

Wickersham, L.E., and J.L. Wickersham. 2009. Gray vireo (*Vireo vicinior*) population monitoring project: 2008 annual report. Prepared for Kirtland Air Force Base, Albuquerque, NM. 20 pp. + appendices. Animas Biological Studies, Durango, CO.

Zlotin, R.I. and R.R. Parmenter. 2008. Patterns of mast production in pinyon and juniper woodlands along a precipitation gradient in central New Mexico (Sevilleta National Wildlife Refuge). Journal of Arid Environments 72:1562-1572.

Appendix A1. Gray Vireo Color Banding at CTTA.

Summary of Gray Vireo color banding conducted at CTTA, 2009-2010.

Date	USGS Band No.	Sex	Age [a]	Color Bands [b] Right Leg	Left Leg
2009					
06/01/09	2391-64101	M	AHY	K/W	O/A
06/09/09	2391-64105	M	SY	A/K	K/Y
06/11/09	2391-64107	M	ASY	K/P	K/A
06/11/09	2391-64108	M	ASY	K/G	R/A
07/01/09	2391-64121	M	SY	K/A	R/O
2010					
06/09/10	2391-64125	M	SY	H/A	G/G

[a] AHY = After Hatch Year, ASY = After Second Year, and SY = Second Year.

[b] A = Aluminum, B = Light Blue, G = Green, H = Hot Pink, K = Dark Blue, O = Orange, P = Pink, R = Red, W = White, and Y = Yellow.

Appendix A2. Gray Vireo Territories at CTTA

Estimates of Gray Vireo territory size at CTTA from 2009-2010, based on Minimum Convex Polygon (MCP) and GIS territory delineation analyses.

Year	Territory	Locations [a]	MCP Area (ha)	Territory Delineation Area (ha)
2009	1	8	4.7	15.6
2009	2	7	1.6	16.9
2009	3	4	0.1	10.4
2009	4	5	0.6	14.6
2009	5	10	5.4	15.0
2009	6	4	0.3	11.8
2009	7	5	2.2	14.5
2009	8	13	8.0	17.0
2009	9	4	5.8	16.3
2009	10	2	[b]	9.8
2009	11	3	1.7	10.1
2010	1	7	1.1	12.2
2010	2	8	5.3	11.3
2010	3	9	4.1	10.3
2010	4	21	10.7	15.6
2010	5	3	<0.1	11.7
2010	6	10	0.5	9.6
2010	7	3	0.1	11.7
2010	8	7	3.8	17.3
2010	9	4	0.3	12.0
2010	10	16	2.3	9.2
2010	11	10	3.7	10.9
2010	12	6	0.5	15.8
2010	13	13	4.3	17.9
2010	14	3	0.3	12.0
Mean	**-**	**7.4**	**2.8**	**13.2**

[a] Number of gray vireo locations used to create MCPs.

[b] Not enough data points to create a MCP.

Appendix A3. Gray Vireo Color Banding at KAFB

Summary of Gray Vireo color banding conducted at KAFB, 2008-2010. For 2008, only those birds returning to the study area in 2009 or in 2010 are listed.

Date	USGS Band No.	Sex	Age [a]	Color Bands [b] Right Leg	Left Leg
2008					
05/27/08	2311-69502	M	AHY	K/G	A/Y
06/03/08	2311-69503	M	AHY	K/O	A/G
06/04/08	2311-69505	M	AHY	R/Y	K/A
06/10/08	2311-69506	M	AHY	K/A	O/P [c]
06/16/08	2311-69507	M	AHY	K/A	G/W
06/17/08	2311-69508	M	AHY	R/W	K/A
06/18/08	2311-69509	M	AHY	K/Y	A/W
07/09/08	2311-69511	M	AHY	K/A	G/R
07/09/08	2311-69510	F	AHY	Y/H	A/R [c]
2009					
05/21/09	1601-86306	M	TY	A/P	K/W [d]
05/21/09	1601-86393	M	SY	Y/A	K/Y [d]
05/21/09	1601-86395	F	ASY	A/H	Y/H [d]
05/26/09	2311-69523	M	ASY	W/K	A/G [e]
05/26/09	2311-69524	F	ASY	B/A	G/H [e]
06/01/09	1601-86398	F	ASY	P/A	H/W [d]
06/02/09	2391-64103	M	SY	O/K	A/P
06/04/09	2311-69515	M	SY	K/A	Y/B [e]
06/04/09	2391-64102	M	ASY	K/R	R/A
06/05/09	2391-64104	F	ASY	A/G	G/H
06/05/09	2391-64106	M	SY	A/K	O/G
06/15/09	2391-64109	M	ASY	K/A	W/O
06/17/09	2391-64110	F	SY	W/H	O/A
06/17/09	2391-64111	M	ASY	K/A	O/Y
06/30/09	2391-64120	M	SY	K/R	A/G
07/09/09	2391-64124	F	SY	H/W	A/G
07/28/09	1601-86916	U	HY	Y/A	W/O [d]
08/05/09	1601-86917	U	HY	R/A	R/R [d]
2010					
06/01/10	2391-64127	F	SY	H/H	A/H
06/01/10	1601-86972	M	ASY	A/K	W/P [d]
06/01/10	1601-86973	F	SY	H/A	Y/W [d]
06/07/10	2391-64130	M	SY	A/G	G/K
06/07/10	2391-64131	M	ASY	K/Y	R/A
06/08/10	2311-69562	F	ASY	H/A	B/O [e]
06/16/10	2391-64128	M	AHY	A/Y	K/K
07/02/10	1601-86981	M	SY	A/O	R/K [d]
08/03/10	1601-86989	U	HY	P/K	A/O [d]
08/25/10	1601-86999	F	AHY	P/O	W/A [d]
08/25/10	1601-86998	U	HY	R/H	A/O [d]

[a] AHY = After Hatch Year, ASY = After Second Year, HY = Hatch Year, and SY = Second Year.

[b] A = Aluminum, B = Light Blue, G = Green, H = Hot Pink, K = Dark Blue, O = Orange, P = Pink, R = Red, W = White, and Y = Yellow.

[c] Not observed in 2009 but returned to the study area in 2010.

[d] Banded by Steve Cox.

[e] Banded 5 km south of the study area.

Appendix A4. Gray Vireo Territories at KAFB

Gray Vireo territory sizes at KAFB, 2009-2010, based on Minimum Convex Polygons (MCP) and GIS territory delineation analyses.

Year	Territory	Locations [a]	MCP Area (ha)	Territory Delineation Area (ha)
2009	1	9	6.9	18.2
2009	2	5	1.5	13.9
2009	3	4	0.8	12.1
2009	4	2	[b]	12.3
2009	5	6	1.3	16.2
2009	6	14	12.4	22.1
2009	7	5	1.5	27.7
2009	8	3	1.1	21.9
2009	9	5	1.3	10.9
2009	10	5	1.9	13.7
2009	11	4	1.5	11.3
2009	12	8	5.4	13.1
2009	13	2	[b]	11.9
2009	14	4	0.2	10.0
2009	15	10	7.1	15.7
2009	16	6	1.5	9.5
2009	17	6	1.9	9.8
2009	18	7	8.3	23.5
2009	19	12	0.8	8.2
2009	20	11	9.2	16.8
2009	21	6	1.4	7.8
2009	22	13	8.7	11.5
2009	23	6	1.4	11.8
2009	24	11	6.2	14.1
2009	25	6	1.6	22.3
2009	26	6	3.0	11.4
2009	27	5	1.8	17.6
2010	1	3	1.4	8.0
2010	2	4	1.1	6.0
2010	3	2	[b]	7.9
2010	4	13	6.6	11.2
2010	5	4	0.8	3.3
2010	6	8	4.8	9.3
2010	7	9	4.5	16.3
2010	8	13	9.8	17.2
2010	9	7	1.8	17.0
2010	10	11	9.0	17.7
2010	11	16	6.2	10.8
2010	12	11	1.5	7.5
2010	13	14	1.8	5.5
2010	14	19	5.1	12.2
2010	15	3	0.3	8.8
2010	16	16	3.6	13.5
2010	17	4	0.1	10.8
2010	18	7	1.6	8.7
2010	19	5	4.0	10.1
2010	20	3	2.6	10.9
2010	21	12	4.3	14.4
2010	22	1	[b]	12.7
2010	23	10	0.8	7.5
2010	24	7	1.6	5.8
2010	25	4	<0.1	4.2
2010	26	6	1.4	6.1

Year	Territory	Locations [a]	MCP Area (ha)	Territory Delineation Area (ha)
2010	27	4	0.3	4.5
2010	28	3	0.2	7.1
2010	29	5	<0.1	1.3
2010	30	1	[b]	3.4
Mean	**-**	**7.1**	**3.2**	**11.8**

[a] Number of gray vireo locations used to create MCPs.

[b] Not enough data points to create a MCP.