# Managing Gray Vireo (*Vireo vicinior*) Breeding Habitat Based on Tree Density Selection of Oneseed Juniper (*Juniperus monosperma)* Woodlands in Central New Mexico

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## ABSRACT

Kirtland Air Force Base (AFB), located southeast of Albuquerque, New Mexico contains the second largest known breeding colony of Gray Vireos (*Vireo vicinior*) in the state. Since this species is listed as state threatened by the New Mexico Department of Game and Fish, Kirtland AFB has conducted various surveys and studies on the Gray Vireo. In 2003, a base wide survey was conducted on the base. A total of 53 territories were identified and mapped. Beginning in 2005, an annual effort to monitor nesting success was initiated. Information collected from these studies were used to determine tree density and estimated age of nest trees for each territory. Using aerial photographs and point locations, a range of tree densities used by the Gray Vireo was quantified. Results revealed a range of 14-115 trees/hectare with an average of 55.57 trees/hectare. Height and width of nest trees were also measured and used to approximate the age class of the selected tree. All trees being used for nesting were oneseed junipers (*Juniperus monosperma*) and estimated to be 60-180 years old. Since these trees were representative of the surrounding tree stand, canopy cover was estimated using these measurements and ranged from 5-14%. A state and transition model for pinyon-juniper woodlands was then used to determine the vegetative state preferred by the Gray Vireo in this habitat type. Management recommendations were made by comparing the tree density, canopy cover, and age class of the stand to a pinyon-juniper savanna state and transition model. Management is limited to mechanical methods as prescribed burns and chemical methods are either prohibited or heavily restricted by Kirtland AFB policies.



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# SECTION 1
# INTRODUCTION

## Paper Overview

This paper focuses on defining tree characteristics and preferences of Gray Vireos in nesting habitat on Kirtland Air Force Base (KAFB). Tree characteristics to be defined will include tree densities within territories and individual tree attributes of nest trees such as tree height, tree width, and tree age. Using an appropriate state and transition model, this information will be used to determine the preferred vegetative state used by Gray Vireos. Defining these attributes will assist Kirtland AFB Natural Resource Personnel in managing Gray Vireo habitat on base. Management recommendations based on tree characteristics and preferred vegetative states will be discussed. Furthermore, this information may be applicable to other resource agencies trying to manage Gray Vireo habitat similar to that found on Kirtland AFB.

## Purpose and Need

Section 7.2 of Air Force Instruction 32-7064, *Integrated Natural Resources Management*, states that "installations must prepare and maintain a current inventory of threatened and endangered (T&E) species and their habitats". According to Section 7.1.1 of the AFI, "installations must also protect and conserve candidate species, state T&E species, and other rare species when practical." Since the Gray Vireo (*Vireo vicinior*) is a state threatened species and occurs on Kirtland AFB, management of this species has been included in Kirtland AFBs Integrated Natural Resources Management Plan (INRMP). A component of the INRMP was the development of a Gray Vireo Management Plan for the base. This plan was completed in February 2007.

The goals outlined in Kirtland AFBs Gray Vireo Management Plan (KAFB 2007a) are:

- Understand the Gray Vireo's habitat needs and requirements at Kirtland AFB;
- Maintain and/or increase the Gray Vireo colony on base;
- Manage current Gray Vireo nesting habitat to ensure future use;
- Identify, change, and manage some marginal Gray Vireo habitat in a manner that encourages use for nesting by Gray Vireos in the near future (i.e. 5-10 years).

To achieve these goals several objectives were identified in the management plan. This paper will look at the following objective; "Document habitat characteristics required by Gray Vireos for nesting;". This papers primary focus is to identify tree density and nest tree characteristics preferred by the Gray Vireo. It is not an attempt to document all nesting habitat requirements of the species.

# SECTION 2
# GRAY VIREO NATURAL HISTORY & BIOLOGY

## Taxonomy

The first description of a Gray Vireo was on May 24, 1865 by Elliot Cous near Prescott Arizona (Barlow et al. 1999). The Gray Vireo is one of 52 species belonging to the Vireo Family (Vireoidae) in the order of Passiformes (NatureServe 2006). Four genuses make up the Vireo Family to which the Gray Vireo belongs to the genus, *Vireo* and has the species name of *vicinior*. Its name means neighboring, related; in allusion to close resemblance of the species to others (Barlow et al. 1999 and Terres). The Gray Vireo is most closely related to the Plumbeous Vireo (*V. plumbeus*), although the two species differ in jaw muscle configuration (Orenstein and Barlow 1981).

## Description:

Adult Gray Vireo on Nest

The Gray Vireo is a small, rather non-descript passerine. This species is sexually monomorphic in plumage color and pattern with the male slightly larger than female in bill, wing, and tail measurements (Barlow et al. 1999). Plumage is grayish overall, with the back being medium dark gray; wings grayish to brownish with one white wing bar, cheeks are a lighter gray and the belly becoming grayish-white to white (Terres 1991). Other characteristics include a narrow white eye-ring, white lore's, and a short, stout, black, and slightly hooked bill (Barlow et al. 1999). Overall, length is 5 to 5 ¾ inches. For a vireo, it has a relatively long tail which it has a habit of flicking constantly while foraging and is a distinguishing characteristic (Terres 1991, and Bent 1950).

## Distribution

The breeding distribution of the Gray Vireo includes western Colorado, southern half of Utah, southern Nevada, northern and eastern Arizona, and the western half of New Mexico. Isolated populations occur in south central California, north central Baja California, southeastern Colorado, and the Big Bend Area of Texas (NatureServe 2006) (see Figure 1). Winters are spent primarily in southern Arizona and adjacent northern Mexico, and the southern tip of Baja California. The winter range is closely tied with the

elephant trees (*Bursera microphylla*), on which they forage (Bates 1992 a). A disjunct wintering population occurs around Big Bend National Park (Bates 1992b; Barlow and Wauer 1971). They are found throughout New Mexico in appropriate habitat but are most common in the western 2/3 of the state.

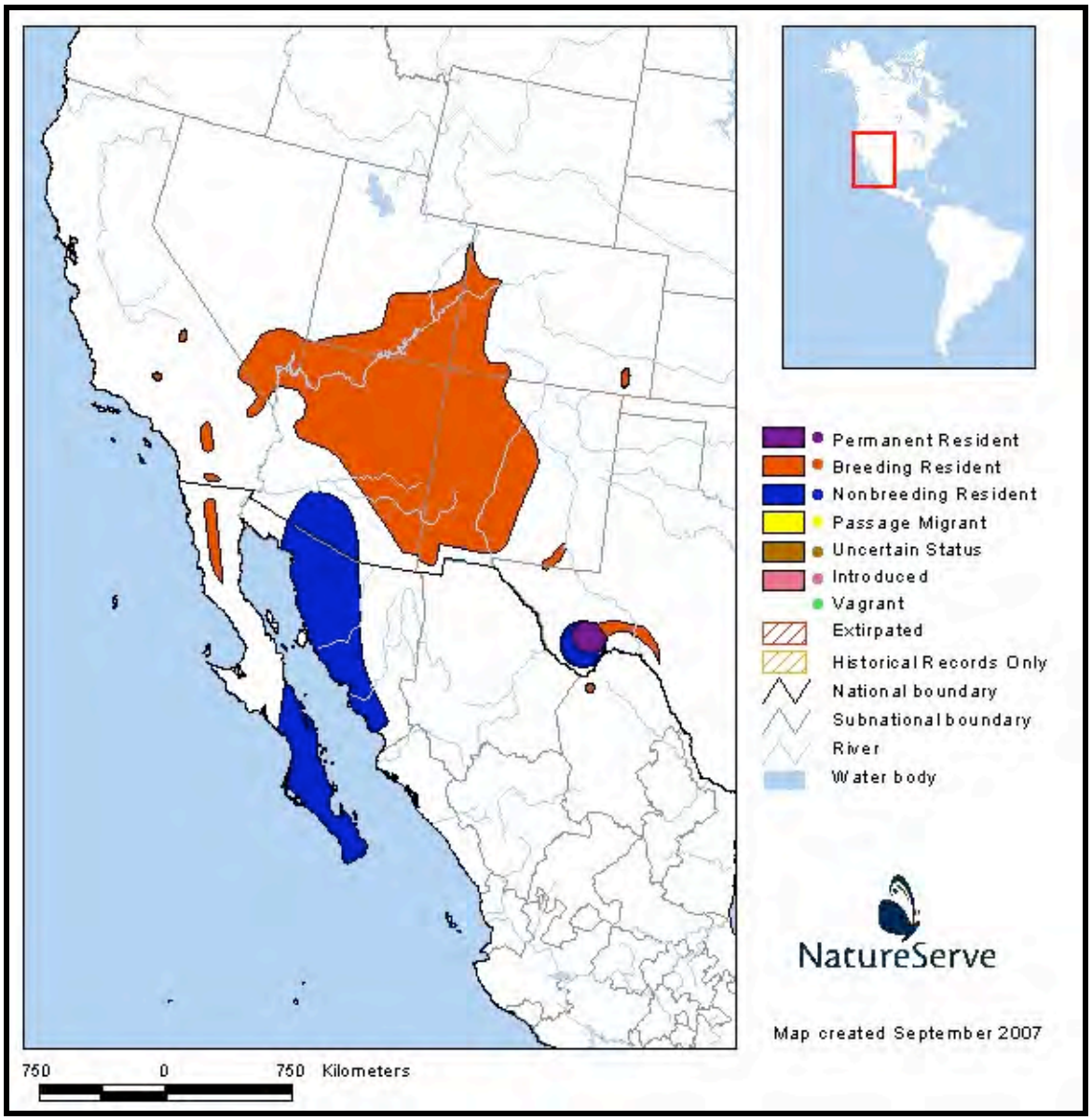



**Figure 1: Gray Vireo Habitat Distribution**

**Habitat**

The Gray Vireo inhabits dry woodlands, usually in association with steep, rocky, or rolling terrain. In California, it is found in dry chaparral. The Gray Vireo seems to avoid the denser and higher elevations of the pinyon-juniper woodland community, which are often occupied by the Plumbeous Vireo (Andrews and Righter 1992). The Gray Vireo is known to occur in three habitat types in the state of New Mexico: pinyon

pine-Utah juniper, oneseed juniper savannas, and mixed juniper/oak woodlands (Delong and Williams 2006).

On Kirtland AFB, Gray Vireos are found in rolling terrain, valleys, and at the base of steeper slopes. Open juniper woodlands are preferred, consisting of oneseed juniper (*Juniperus monosperma*), apache plume (*Fallugia paradoxa*), tree cholla (*Opuntia imbricata*), prickly pear cactus (*Opuntia phaecantha*), and grama grasses (*Bouteloua gracilis* and *B. eripoda*.). Pinyon pine (*Pinus edulis*) is occasionally present but never in high densities. Gray Vireos are found throughout the juniper woodland habitat on Kirtland AFB in an elevational belt ranging from 5,850 to 6,600 feet along the western foothills of the Manzanita Mountains (Mehlhop and Debruin 1995; Frei et al. 2006). Figure 2 shows the vegetative communities at Kirtland AFB and Figure 3 delineates Gray Vireo habitat on base, which generally overlaps the juniper woodland community.

Typical Gray Vireo Habitat in Central New Mexico

**Diet**

While on its breeding grounds, the Gray Vireo is primarily an insectivore. A thicket forager (Hamilton 1962), most prey is taken from leaves, twigs, branches and trunks of small trees of shrubby vegetation; spending most of its time foraging in the inner two-thirds of a bush or small tree (Barlow et al. 1970). Foraging primarily ranges from 1-12 feet above the ground (Terres 1991), although occasional foraging on the ground does occur (personal observation). Food items consists of tree hoppers and cicadas (Homopetra), tree crickets, short-horned grasshoppers and katydids (Othoptera; flies (Diptera); beetles (Coleoptera); moths (Lepidoptera); damselflies (Odonata) (Chaplin 1925, Terres 1991).

The winter diet varies depending on where the Gray Vireo winters. Birds wintering in the Big-Bend area of Texas are primarily insectivores (Bates 1992a). However, birds wintering in SE Arizona and along the Sonora coast consume the fruit of the elephant tree (*B. microphylla*) with insects making up a smaller portion of their diet (Bates 1992b).

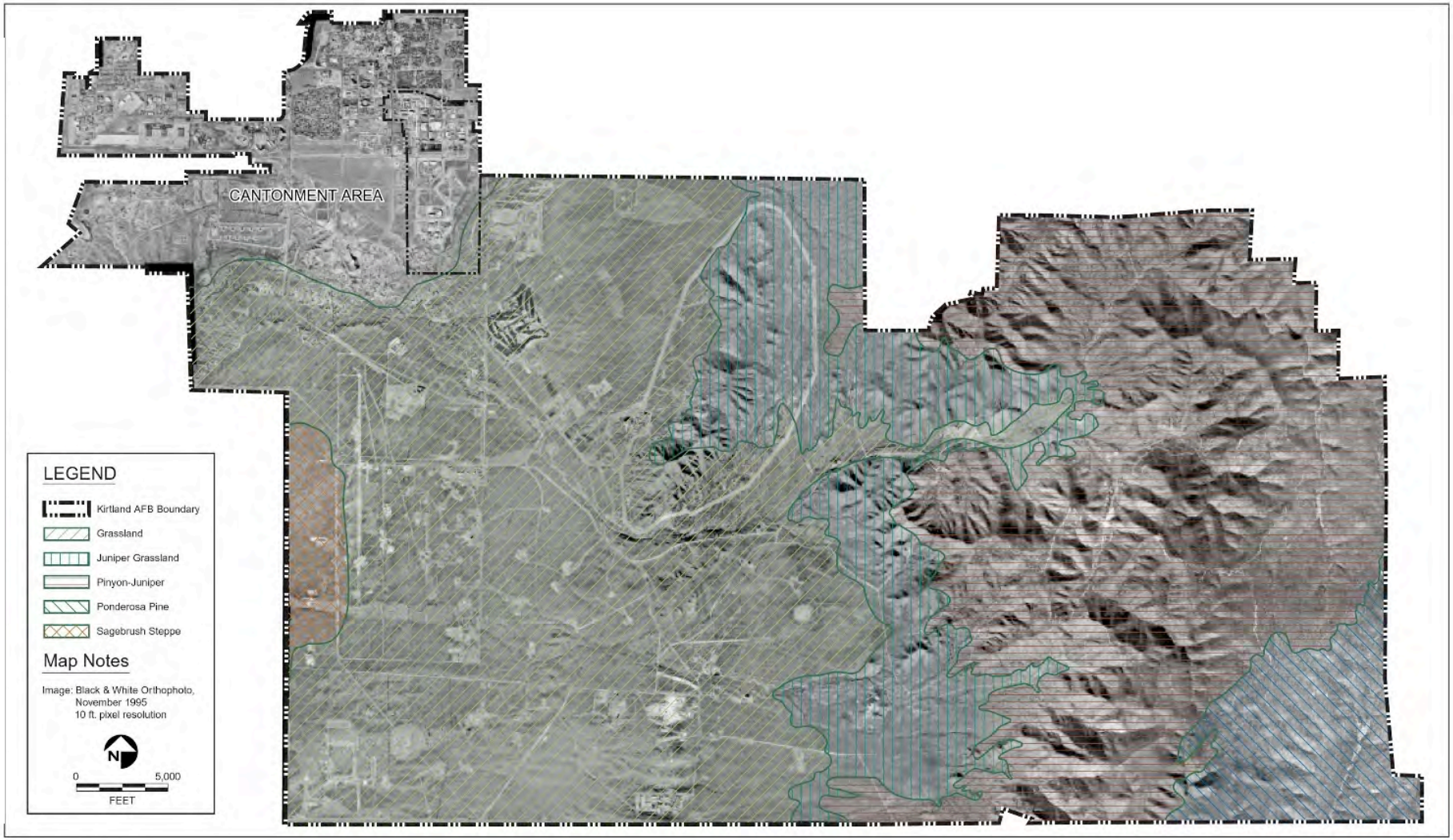



**Figure 2: Vegetation Communities on Kirtland Air Force Base**

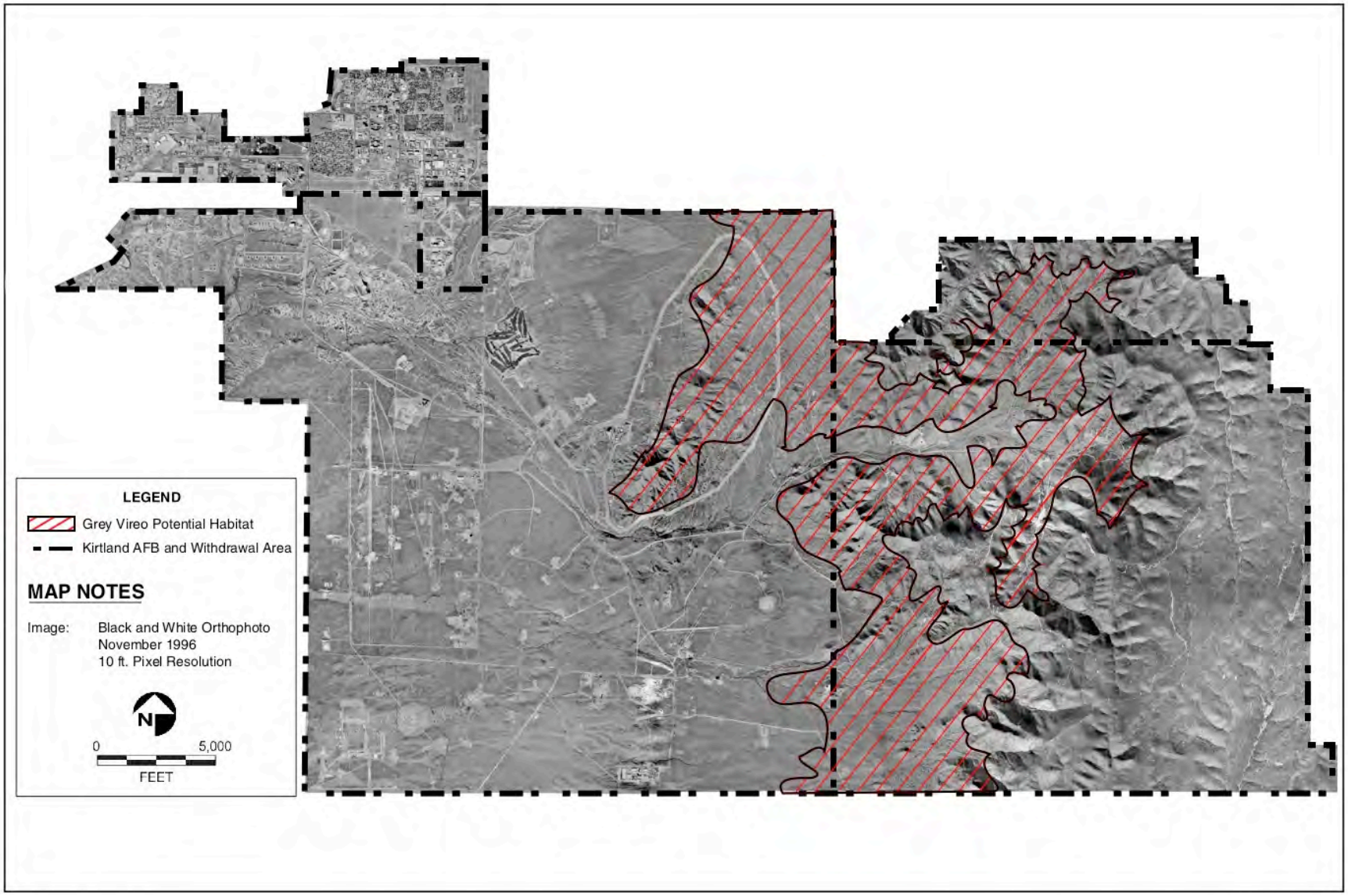



**Figure 3: Gray Vireo Habitat Distribution on Kirtland Air Force Base**

**Breeding and Reproductive Biology**

Males arrive at breeding grounds in New Mexico around the first week in May, with females arriving a few days later (Bartlow et al. 1999 , Mehlhop and Debruin 1995). Pairs are usually formed within a couple of weeks with males defending a territory by singing and occasional fighting. Territory size in the northern Chihuahuan Desert and in Yavapai County, Arizona ranged from 2.4 to 8 hectares (NatureServe 2006).

Once paired, the female selects a nest site with both birds constructing the nest (Barlow et al. 1999). Nests are built near the outer edge of a tree or shrub, usually hanging from a forked branch 2 to 13 feet above the ground (Terres 1991 and Frei et al. 2005). The cup shaped nests are made from plant fibers, leaves, spider silk, and cocoons and lined with fine grass (Terres 1991) and are often located on west or north facing tree forks (Barlow et al. 1999). Three to five rosy pink eggs, which turn white within a few days after laying, with brown spots are laid in the nest (Bent 1950). Both sexes incubate and tend young; incubation takes 13-14 days; young fledge in 13-14 days (Ehrlich et al. 1988). Two broods per year are probable in Texas and Arizona (Barlow et al. 1999) and suspected in New Mexico as well (Frei et al. 2005, Delong and Williams 2006) Most Gray Vireos have left the breeding grounds by August and the state by September (Mehlhop and Debruin 1995).

**Predators/Brood Parasitism**

Little information about predators of the Gray Vireo is known. Probable predators of adults include Loggerhead Shrike (*Lanius ludovicianus*) and Copper's Hawk (*Accipiter cooperii),* with the Western Scrub Jay (*Aphelocoma califonica*), Mexican Jay (*A. ultramarine*), Northern Mockingbird (*Mimus polyglottos*), Scotts's Oriole (*Icterus parisorum*) and Hooded Orioles (*I. cucullatatus*) eating eggs or nestlings (Barlow et al. 1999). Other nest predators may include rats, chipmunks and reptiles (Hanna 1944), coyotes (*Canis latrans*) and gray foxes (*Urocyon cinereoargenteus*) (Barlow et al. 1999). At Colorado National Monument, jays, rock squirrels (*Citellus variegates*), and chipmunks destroyed one-half of the nest found in 1995 (Dexter 1998).

Brood Parasitized Gray Vireo Nest (cowbird egg on top)

Brown-headed Cowbirds (*Molothrus ater*) are known to brood parasitize the Gray Vireo. Cowbirds don't raise their own young. Rather they lay an egg in a host species nest and leave the brooding and rearing to the host species. Gray Vireos may either abandon the nest or raise the cowbird chick as if it was

their own. The more aggressive cowbird chick generally out competes its nest mates, resulting in a failed nesting attempt for the vireo. In four studies in New Mexico, cowbird brood parasitism of Gray Vireos ranged from 24-71% of nests, of which three quarters of the nests were abandoned (Delong and Williams 2006). Habitat quality and connectivity heavily influence the rates of both nest predation and brood parasitism, particularly the later; cowbirds are often associated with disturbed landscapes and/or the presence of cattle (Tewksbury et al. 2006 and Lowther 1993).

**Threats**

Habitat alteration is the primary threat facing the Gray Vireo. Activities that reduce or eliminated trees such as chaining, juniper control, firewood collection, clearing for oil and gas production or increased fire regimes have an obvious affect as Gray Vireos are not found in areas absent of trees (Schlossberg 2006; NatureServe 2006). Gray Vireos are also impacted as a host species to the brown-headed cowbird. Brood parasitism of Gray Vireo nest may be facilitated by the presence of cattle or fragmented habitat as cowbirds are associated with both of these factors (NatureServe 2006; Lowther 1993). Juniper has been implicated in soil erosion in some parts of its distribution through exclusion of native grasses that help retain the soil (Davenport et al 1998, Miller et al. 2000). In the majority of the Gray Vireo's range in New Mexico, juniper is the species of tree in which the bird nests, such erosion or desertification might negatively impact other aspects of the Gray Vireo's natural history, such as through a loss of prey base (Delong and Williams 2006). Overgrazing of pinyon-juniper woodlands may have similar impacts as well.

# SECTION 3
# METHODOLOGY

## Methodology

Existing literature and unpublished field reports from Kirtland AFB are the primary data sources used for the development of this paper. In 2003, an installation wide inventory for the Gray Vireo was conducted by Kirtland AFB. During the Gray Vireo nesting seasons of 2005, 2006, and 2007, studies of Gray Vireo nesting success for the base were performed. Each of these surveys recorded central point locations for Gray Vireo territories or nest tree locations. Nest tree data including tree species, tree width and tree height. This information provides the foundation of investigating tree characteristics and preferences used as nesting habitat by Gray Vireos on Kirtland AFB.

## Tree Density of Gray Vireo Habitat

The first set of tree characteristics to be defined is the number of trees per acre occurring in a typical Gray Vireo territory. This was done by plotting Gray Vireo point locations onto aerial photographs from Google Earth (http://earth.google.com). All point locations were cross referenced with field maps that plotted each Gray Vireo location on the appropriate 7.5 USGS quadrangle map. Point locations were taken using UTM coordinates from a hand-held GPS system (Datum:NAD27 CONUS in Zone 13).

Once the location was accurately plotted on an aerial photograph, a circle with a 150 meter radius was drawn around the data point (see Figure 4). The circle represents a Gray Vireo territory totaling 7.06 ha (17.66 acres). This falls within the range (2.4-8 ha) of documented Gray Vireo territory sizes and based on multiple years of field observations at Kirtland AFB seems to be a reasonable representation of a typical territory size for Gray Vireos on base. Representative territories were necessary as delineations of actual territories were not performed due to time and funding constraints. The representative territory of 7.06 hectares (17.66 acres) is also large enough to encompass the natural variation in tree densities throughout any given territory. Once a representative territory was drawn on the aerial photograph, the circle was divided into four equal quadrants. The number of trees occurring in each quadrant was then counted and summarized to provide a total number of trees per territory.

The number of trees in a territory was standardized to the number of trees per hectare. The purpose of dividing the territory into quadrants was to determine if tree density was evenly distributed throughout a given territory. Only trees that were greater than 3 feet in diameter, as measured using the scaling tool of Google Earth, were counted. This was done for several reasons. Firstly, trees less than three feet in diameter are closer in structure and function as native shrubs (i.e. rabbit brush, sand sagebrush, and apache


**Figure 4: Representative Gray Vireo Territory**

plume). Second, counting these trees would give a false picture of the actual openness of Gray Vireo habitat. Additionally, accurately counting all trees less than three feet in diameter can be difficult if aerial photographs were taken early or late in the day. Shadows of larger trees can obscure the presence of smaller trees given the resolution of the photograph.

**Nest Tree Characteristics**

Nest tree characteristics were recorded in the field during the 2005, 2006, and 2007 field seasons. Tree data include tree species, tree height, tree width, and height of the nest in each tree. These data were compiled and a frequency index was created. Based on the structure of the trees they were assigned to age classes. Assigning them to age classes will assist Kirtland AFB natural resource personnel in managing and ensuring that Gray Vireo habitat contain trees of the appropriate age class preferred as nesting structures for this species.

**State and Transition Modeling**

Various state and transition models for pinyon-juniper woodlands were investigated. Several models were reviewed during this process with careful attention paid to similarity between habitats at Kirtland AFB and those habitats that the model was representing. Since several different types of pinyon-juniper vegetation communities exists, much emphasis was given to those models that best represented Gray Vireo habitat

conditions at Kirtland AFB. Additional selection criteria included choosing a model that contained the same influences (i.e. drought, insects, and fire intensities) to the vegetative communities as those influencing Gray Vireo habitat at Kirtland AFB.

**Assumptions**

In the process of defining tree characteristics of Gray Vireo territories, several assumptions were necessary. First, Gray Vireo territories at Kirtland AFB are circular in shape and contain 7.06 ha. This was necessary for several reasons. As mentioned earlier, individual territories were not delineated thus a standardized territory was needed. Standardizing also allows for easier comparison of results. Second the size needed to be large enough as to contain most of the natural variances in tree densities within and/or surrounding the territory. Location points used are also assumed to be taken within the center of a territory. While the exact center of each territory probably wasn't taken every reasonable effort was made in the field to record point locations from the center of a defended area. Whenever possible, point locations of nest trees were used as the center point as the assumption is being made that nest are generally not located on the periphery of a territory.

The total number of trees counted for each territory is assumed to have an error rate of less than 5%. Providing an absolute number of trees per territory is complicated by several factors. As mentioned above, only trees that were greater than three feet in diameter were counted. If a tree was suspected of being near this diameter range, it was measured using the software provided. The edges of small trees were generally blurred and complicated with shadows. A best guess estimate was needed to measure the diameter of the tree. Additionally, shadows of larger trees had the potential to conceal smaller trees when photographs were taken early or late in the day. Counting individual junipers within dense stands coupled with shadows also increases the error rate. Human error of counting trees is also likely. However, this was managed by grouping trees in sets of 10 and circling them and counting the trees within the boundary a second time. With all of these factors, providing an absolute number of trees per territory proves difficult. Territories that could not be accurately counted due to picture quality or deep shadows were excluded from the results. It should also assumed that as tree density per territory increases so does the error rate.

# SECTION 4
# RESULTS & DISCUSION

## Tree Densities of Gray Vireo Territories

Tree densities of Gray Vireo territories at Kirtland AFB were calculated for years 2003, 2005, 2006, and 2007 using the methods described in the previous section. The numbers of trees per territory are presented in Appendix A. A summary of the results are presented in this section. Not all territories recorded were evaluated due to discrepancy of field notes vs. mapped location, poor or fuzzy aerial photographs that made counting trees difficult, or deep shadows obscuring smaller trees. In order to present the best available information, these locations were not included in this analysis. The following results are presented using mean and standard deviation (n-1 method), range, and frequency distribution ( see Table 4-1 and 4-2)

**Table 4-1: Mean ± SD and Range of Trees per Hectare of Gray Vireo Territories at Kirtland AFB**

| Survey Year | 2003 | 2005 | 2006 | 2007 |
|---|---|---|---|---|
| Sample Size | 46 | 19 | 15 | 12 |
| Mean ± SD | 55.57 ± 22.77 | 62.14 ± 21.43 | 55.58 ± 24.77 | 54.27 ± 20.03 |
| Range | 14-115 trees/ha | 34-117 trees/ha | 21-121 trees/ha | 22-93 trees/ha |

**Table 4-2: Frequency Distribution of Trees per Hectare of Gray Vireo Territories at Kirtland AFB**

| Trees per Hectare | 2003 Number of Territories (%) | 2005 Number of Territories | 2006 Number of Territories | 2007 Number of Territories | Territories containing nests (All Years) |
|---|---|---|---|---|---|
| ≥ 30 | 5 (10.8%) | 0 (0.0%) | 2 (13.3%) | 1 (8.3%) | 2 (6.1%) |
| 31-45 | 11 (23.9%) | 3 (15.8%) | 3 (20.0%) | 3 (25%) | 8 (24.2%) |
| 46-60 | 14 (30.4%) | 8 (42.1%) | 5 (33.3%) | 5 (41.7%) | 16 (48.5%) |
| 61-75 | 6 (13.0%) | 5 (26.3%) | 3 (20.0%) | 1 (8.3%) | 4 (12.1%) |
| 76-90 | 7 (15.2%) | 1 (5.3%) | 1 (6.7%) | 1 (8.3%) | 2 (6.1%) |
| 91-105 | 1 (2.2%) | 0 (0.0%) | 0 (0.0%) | 1 (8.3%) | 0 (0.0%) |
| ≤ 106 | 2 (4.3%) | 2 (10.5%) | 1 (6.7%) | 0 (0.0%) | 1 (3.0%) |

Results from 2003 are used as a baseline for comparison as the data came from a base wide inventory of Gray Vireos throughout Kirtland AFB (Figure 3 shows the survey area). In other words, the survey area was greater in size and contained more potential habitat ranging between grasslands to densely treed pinyon-juniper woodlands. Data from 2005-2007 only includes territories from the study area (Figure 5), and doesn't contain as much variation in habitat as the baseline survey. Therefore, when making comparisons from the results of the base wide survey (2003) and the nesting study area (2005-2007) it should be used with some caution.

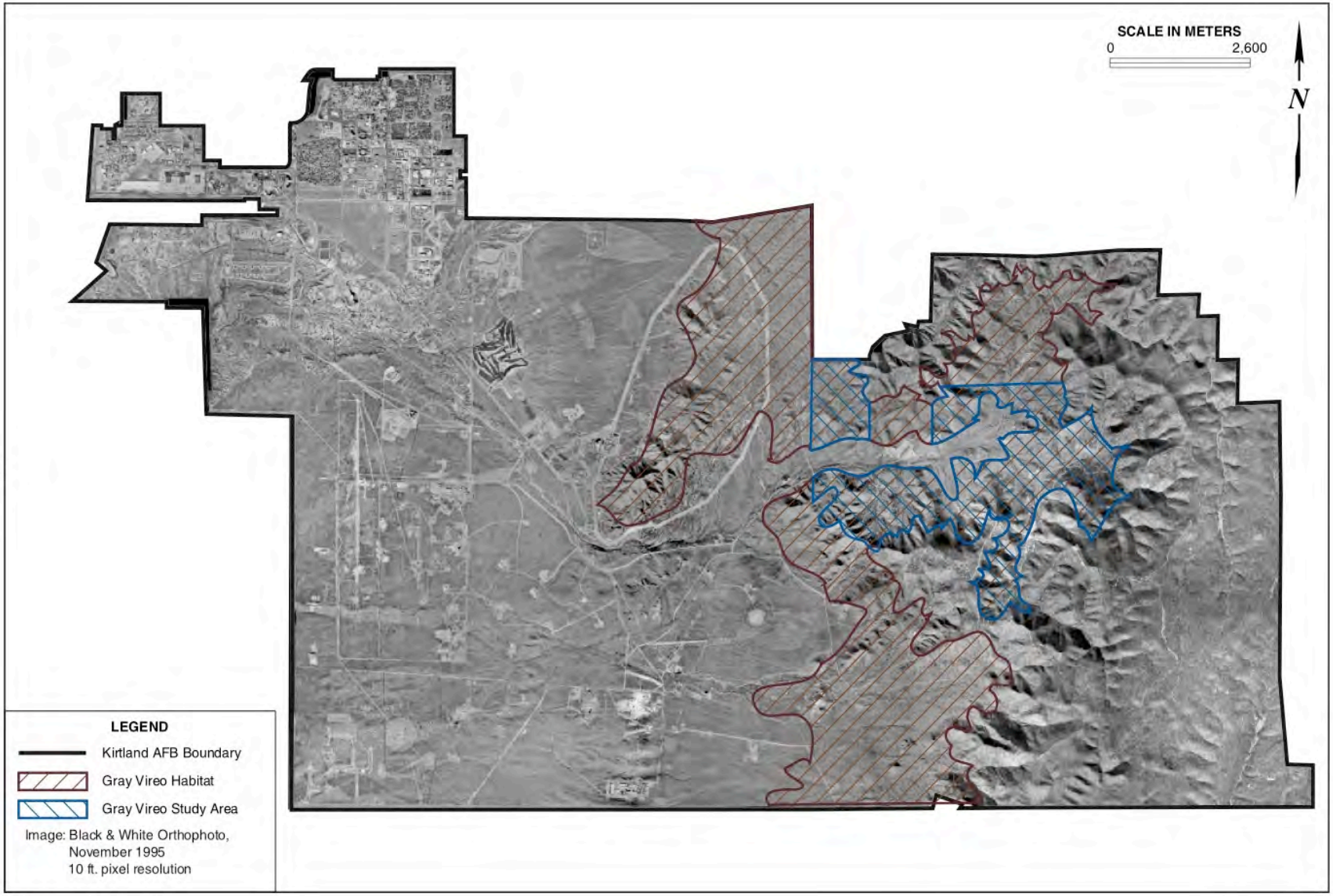



**Figure 5: Gray Vireo Nesting Success Study Area on Kirtland Air Force Base**

With data from 2003 being used as the baseline, the mean and standard deviation of trees/ha of Gray Vireos on Kirtland AFB is 55.57 ±22.77 trees/ha with a range of 14-115 trees/ha. Comparing this with the mean and standard deviation and range of the study areas shows similar results. This indicates that the study area is a fair representation of Gray Vireo habitat across Kirtland AFB. Monitoring of nesting Gray Vireos of the study area should therefore continue. Trends or changes in habitat use within the study area may therefore be expressive of the remaining Gray Vireo habitat on base.

Reviewing the frequency distribution of trees/ha in Table 4-2 provides additional insight of Gray Vireo selection of breeding territories. Again using 2003 data as a baseline shows that the three frequency classes (31-45, 46-60, and 61-75) account for 67.3% of Gray Vireo territories with 46-60 trees/hectare being the most commonly selected. Similar results occur for each year of the study area. Territories containing nests also showed a strong preference for these three frequency classes (84.8%) with 46-60 trees/hectare accounting for 48.5% of territories containing nests.

Tree density throughout a Gray Vireo territory is not even distributed (see Appendix A). Each territory was divided into four equal quadrants. The numbers of trees per quadrant were counted. Looking at the results, it is clear that tree density varies throughout a given territory. For example, territory 53-03 has a density range of 21-35 trees/quadrant while territory 21-03 has a tree density range of 92-236 trees/quadrant. Thus a mosaic of tree densities appears to be part of any Gray Vireo habitat landscape.

*Management Implications*

Using either the three most common frequency distributions or the mean ± 1 SD provide similar management implications. One standard deviation from the mean of 55.57 provides a range of 33-78 trees/ha verses 31-75 trees/ha using frequency distribution results. Therefore, management of Gray Vireo habitat can use the results of either method. Management of nesting habitat based on trees/ha should include the full range (33-78 trees/ha or 31-75 trees/hectare) in order to provide Gray Vireos with choices of individual tree density preferences. Management should focus on maintaining this tree density range rather than attempting to manage some optimal tree density number (i.e. 55 trees/hectare or 46-60 trees/hectare). Furthermore, managing habitat based on the greater range of tree density preferences requires less time, energy and resources and probably provides little if any additional benefit.

Tree distribution, in general, is highly variable throughout a given territory, thus management should keep this in mind as well. Biotic and abiotic features of the local environment such as aspect, topography, and soils should ensure natural variation in juniper distribution among the landscape, thus requiring little management intervention.

**Tree Characteristics**

Trees selected by Gray Vireos for nesting had their height and width measured as well as the height of the nest in the tree during the 2005-2007 survey seasons. Nest tree data from 2006 was not used since there were inconsistencies with the collection of data. A total of 27 nests trees, 16 from the 2005 survey and 11 from the 2007 survey were used in determining nest tree selection by Gray Vireos at Kirtland AFB. All trees selected for nesting were oneseed junipers. Table 4-3 provides a frequency distribution for tree measurements selected by Gray Vireos in the study area. Appendix B provides data for each individual nest tree. Measurements were taken to the nearest ½ foot for tree height and tree width. Nest height within the tree was measured to the nearest inch. Since width of an individual tree varies on its axis, width measurements were taken by using professional judgment that best represented the individual juniper.

**Table 4-3: Frequency Distribution of Nest Tree Characteristics**

| Height/Width in Feet | Tree Height* (n=27) | Tree Width* (n=26) | Height of Nest in Tree* (n=27) |
|---|---|---|---|
| 3.5-6 ft | -0- | -0- | 7 |
| 6.5-9 ft | 10 | 2 | 15 |
| 9.5-12 ft | 11 | 6 | 5 |
| 12.5-15 ft | 4 | 6 | -0- |
| 15.5-18 ft | 1 | 7 | -0- |
| $\geq$ 18.5 ft | 1 | 5 | -0- |

*Number in this column denotes the number of trees or nests that were found to occur within the range distribution of the far left hand column.

Nest tree heights ranged from 8.5-24.5 feet, with a mean of 11 feet, and nest tree widths ranged 10-24.5 feet with a mean of 14.5 feet. Nest height within the tree ranged from 3’ 8” to 11’ 9” with a mean of 7’ 5”. Table 4-3 indicates that Gray Vireos typically selected trees that were 6.5-12 feet in height (21 of 27 trees) and 9.5-18 feet in width (19 of 26). Nests were most commonly built between 6.5 and 9 (15 of 27). Oneseed junipers selected for nesting, are generally wider then they are tall. Using nest tree measurements, junipers assigned to an age class.

*Management Implications*

Knowing what a typical nest tree looks like can provide us with an age class of trees typically used by Gray Vireos. First, the age class of oneseed juniper needs to be defined. To do this, a general understanding of oneseed juniper biology is required. This species of juniper is long lived with individuals exceeding 300 years. It is a slow growing species that typically attains heights of 10-25 feet (Little 1995) with some

individuals reaching 40 feet under ideal conditions (Johnson 2002). A study in the northern Sacramento Mountains of New Mexico reported an increase in height of approximately 16cm (6.3 inches) per decade (Johnson 2002).

Using the life history of oneseed junipers, Table 4-4 was created and defines four separate age classes. It needs to be kept in mind that local soils, aspect, climatic conditions (i.e. periods of drought or wet periods), and other site conditions may promote greater or less growth then what is described in Table 4-4. Its intent is not to be definitive but rather establish a guideline for making management decisions.

**Table 4-4: Oneseed Juniper Age Class Description**

| Age Class | Age Description | Approx. Height (ft) | General Tree Description |
|---|---|---|---|
| 0-60 yrs | Young | 0-8 ft | Relatively slender with pointed crown and appearance of being full |
| 61-120 yrs | Young Mature | 6-15 ft | More rounded becoming wider with a full crown |
| 121-180 yrs | Mature | 10-20 ft | Rounded with a more open crown |
| 181+ yrs | Old Mature | 15-25 ft | Rounded with open crown. |

Using the frequency data from Table 4-3 and comparing it to Table 4-4, Gray Vireos prefer young mature to mature oneseed junipers. This indicates a general preference for junipers between the age of 61-180 years. From a management perspective, stands that are approaching an average age class of 60 years is in the early state of providing potential Gray Vireo habitat. Where as those averaging 180 years are likely becoming too dense and less desirable. Optimal habitat is probably near the middle of this range at approximately 120 year old stands. This is supported by the characteristics of the average nest tree which is 11 feet in height. A tree of this height is approximately 120 yeas old.

Why Gray Vireos select these tree age classes isn't known and deserves further investigation. It may be that stands in this age class provide the perfect balance of cover and openness desired by the Gray Vireo. Additionally, the individual tree may be providing a suitable nest site not found in younger or older trees. For example, young trees are shorter and more slender than older trees and may not provide the preferred protection and cover that a larger tree provides. Additionally older trees, having a more open canopy, may not provide the protection and concealment desired by Gray Vireos for nesting. Young mature and mature trees on the other hand may possibly provide the

Gray Vireo with a size that offers them protection and a canopy that provides concealment of their nest.

# SECTION 5
# STATE & TRANSITION MODELS
# IMPACT ON MANAGEMENT DESECISIONS

State and transition models for vegetation communities can be an important management decision making tool. Kirtland AFB has not had an ecological site description (ESD) developed for it by the Natural Resource Conservation Service of the USDA. A search of other ESDs in New Mexico with similar vegetation communities was conducted. While a couple of oneseed juniper/pinyon pines ESDs were done in New Mexico, review of these ESDs showed differences between the ESD site and Gray Vireo habitat at Kirtland AFB. Firstly, most of the sites had tree densities greater than those preferred by the Gray Vireo on Kirtland AFB. Second, the state and transition models contained tree densities that were much greater than expected for the vegetation community selected by the Gray Vireo. For example, ESD # FO35XB004NM describes the first state containing juniper/pinyon pine trees as having a 25-35% canopy cover (CC) (20-50 trees per acre) and describing it as "savannah-like" (Gonzalez 2006). While canopy cover wasn't measured at Kirtland AFB, using the data from Section 4, a general canopy cover class was estimated. Using the average width of a nest tree (14.5 feet across or a radius of 7.25 feet), and the average number of trees per acre (22.5 trees/acre or 55.57 trees/ha) the typical CC is 8.5 % (i.e. $\pi r^2$(# trees/acre)/1acre = $[3.14(7.25ft)^2]$(22.5 trees/acre)/43,560 sq/ft) . This is a sharp contrast to the 25-35% CC described by Gonzalez.

Additionally, livestock grazing was identified as a factor affecting the transitions between vegetative states. Vegetation communities at Kirtland AFB have been precluded from grazing since the early 1940s and current policy prevents livestock from grazing any portion of the base well into the future (Kirtland AFB 2007b). Since livestock grazing has been excluded for over 60 years and will not be used as a management tool in the future, the need for grazing in a state and transition model for vegetation communities on Kirtland AFB becomes irrelevant.

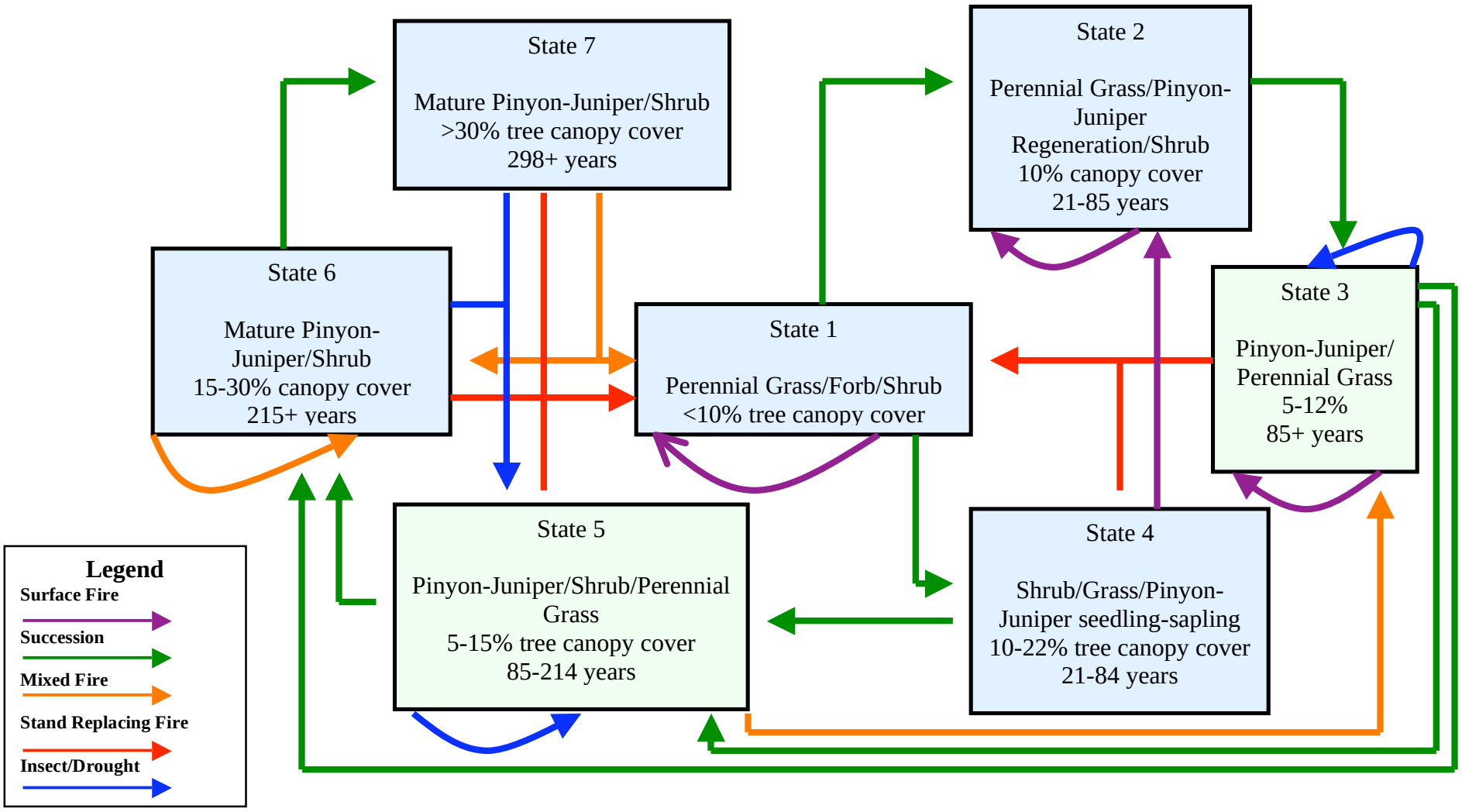
Because of these differences, other state and transition models were reviewed. The Nature Conservancy developed three different state and transition models for pinyon-juniper woodlands for the southwestern United States. The three models developed were: Pinyon-Juniper Savanna Vegetation Dynamics, Pinyon-Juniper Shrub Woodland Vegetation Dynamics, and Pinyon-Juniper Persistent Woodland Vegetation Dynamics (Gori and Bates 2007). For a variety of reasons the pinyon-juniper savanna model was selected as it best represents Gray Vireo habitat at Kirtland AFB. Firstly, various Gray Vireo reports for Central New Mexico describe Gray Vireo habitat as a juniper savanna (Frei et al. 2007, Cox and Cox 2002, New Mexico Department of Game and Fish 2007). Photographs from these reports confirm this description. Furthermore, review of aerial photographs based on site locations also indicates a juniper savanna community. For example, at Kirtland AFB, Gray Vireos occupy the lowest elevations of

the pinyon-juniper community as it transitions into the adjacent grasslands. In other parts of Central New Mexico, aerial photographs show that the Gray Vireo is found in pockets of juniper savanna otherwise surrounded by grasslands. Gray Vireos at Kirtland AFB, are found in open juniper savannas that contain relatively few pinyon pines, yet have trees that are estimated to be between 61-180 years old with a CC of 8.5%. The Nature Conservancy pinyon-juniper savanna state and transition model is described as "most often occurring as juniper savanna" (Gori and Bates 2007) with tree densities ranging from 60-122 trees per hectare and canopy cover values ranging from 5-12% (Fflooliott and Gottfreid 2002; Landis and Bailey 2005).

A distinction between pinyon-juniper savanna and persistent woodlands seems appropriate for several reasons. This community is located at either the lower elevational belt of the pinyon-juniper community or occupies slightly higher areas surrounded by grasslands. Generally, the pinyon-juniper community found on lower mountainous slopes receives less precipitation than those at higher elevations. Additionally, those found at slightly higher elevations than the surrounding grasslands likely exist due to a slight increase in precipitation coupled with rockier or more gravelly soils. Junipers are more drought tolerant than pinyon pines ( Gonzalez 2006, Gori and Bates 2007). In areas with marginal precipitation, pinyon pines may be present only in limited numbers and only in isolated areas where moisture, aspect and soils permit their existence. Therefore, a juniper savanna/pinyon-juniper savanna may have only a very limited potential for reaching a persistence woodland state. Therefore, the pinyon-juniper savanna woodland model is appropriate and used in this paper. Figure 6 is the pinyon-juniper savanna state and transition model developed by the Nature Conservancy (Gori and Bates 2007). Minor changes were made for clarity and relevance to this paper. The number of years given for each state is approximate based on a variety of assumptions, model parameters, and sources. Further discussion can be found by reviewing *Historical Range of Variation and State and Transition Modeling of Historical and Current Landscape Conditions for Pinyon-Juniper of the Southwestern U.S.* (Gori and Bate 2007).

As noted earlier the estimated CC for the average Gray Vireo territory is 8.5%. One standard deviation provides a range of 5-12% CC or using the four most common tree density frequency data (31-90 trees per hectare) a 4.8-13.8% CC is calculated. Estimated age class of nest trees by the Gray Vireo range between 60-180 years old. Personal observations noted that nest trees were typical of the surrounding stand. Therefore, the estimated stand age of the trees in a typical Gray Vireo territory can be estimated at 60-180 years old. Gray vireo habitat at Kirtland AFB is also described as being open juniper woodland. Shrubs may or may not be a major component of the vegetation within a typical Gray Vireo Territory. If present, shrubs generally occur along arroyos, drainages, or on floodplain benches. Taking this information and comparing it to Figure 6 indicates that the Gray Vireo at Kirtland AFB prefers State 3 and State 5 of the pinyon-juniper savanna vegetation model. State 3, is described as a Pinyon-Juniper/Perennial Grassland with a 5-12% CC and being greater than 85 years

Figure 6: Pinyon-Juniper Savanna State and Transition Model



since first disturbance. State 5 is described as Pinyon-Juniper/Shrub/Perennial Grassland with a 5-15% Cc and ranging from 85-214 years since first disturbance.

Based on the Gray Vireos preference for States 3 and 5, Gray Vireo management at Kirtland AFB should first focus on maintaining existing habitat within these states. As indicated in Figure 6, influences on these two states are insects/drought and mixed and surface fires. Therefore, management should attempt to replicate these directional changes. In general, all juniper woodland communities at Kirtland AFB should be considered as occurring in State 3 or State 5. Manipulation of other vegetative states toward a State 3 or State 5 is also possible but before any work is initiated, the community being managed needs to be defined to a specific vegetative state so appropriate strategies can be implemented.

Brush control and tree management at Kirtland AFB is severely restricted. The use of fire is prohibited and chemical application is limited (KAFB 2003; KAFB 2007b). For all practical purposes, this only leaves mechanical methods for manipulating habitat on Kirtland AFB. Mechanical methods may include chain sawing, chaining, bulldozing, or using a hydro-axe. The purpose of employing mechanical methods is to reduce the CC of a given stand of trees in order to simulate the affects of insects/drought, and/or different intensities of fire. Chain-sawing is recommended only for minor management activities as it can be very labor intensive. Using a hydro-axe to remove trees is probably the most versatile mechanical method that can be used. They are easy to operate, maneuver, and can accomplish a job quickly. Bulldozing and chaining are used to remove or knock down vast areas of trees. Bulldozing can be somewhat selective where chaining is not. Bulldozing and chaining are only recommended in areas not currently used by Gray Vireos. Generally these two methods are very destructive and would revert the community back to a vegetative community representative of State 2 or State 4. It may take 50 or more years after implementing these activities before the site becomes suitable for Gray Vireos. Table 5-1 provides recommendations of possible management activities based on the vegetative state described in Figure 6.

When implementing any management activities for the benefit of the Gray Vireo, Natural Resource Managers at Kirtland need to be aware that managing juniper woodlands between 5-15% CC and maintaining young mature to mature (i.e. approx. 60-180 years) stands of trees is only part of the overall Gray Vireo habitat requirement. Other factors not discussed in this paper, but require attention include type and amount of ground cover, foraging habitat, influences affecting nest parasitism by cowbirds, population dynamics, site fidelity, fire suppression, and impacts to and from the military mission at Kirtland AFB. Additionally, land management needs to be holistic taking into consideration the needs of other wildlife and plant communities that may or may not

benefit from certain management practices. Gray Vireo habitat management should be done in a manner that promotes not only this species, but others that share the differing vegetative states of the pinyon-juniper savanna community.

**Table 5-1: Management Recommendations Based on Vegetation State of Pinyon-Juniper Savanna.**

| State | Description | Recommendation |
|---|---|---|
| 1 | Perennial Grass Forb/Shrub<br><10% CC | No management recommendations. Let succession occur. |
| 2 | Perennial Grass/Pinyon-Juniper Regeneration/Shrub<br><10% CC 21-85 yrs | No management recommendations. Let succession occur. |
| 3 | Pinyon-Juniper/Perennial Grass<br>5-12% CC 85+ yrs | Generally, no management of habitat is suggested unless it is approaching State 6. If approaching State 6, reduction of trees using a chainsaw or hydro-axe may be appropriate. |
| 4 | Shrub/Grass/Pinyon-Juniper seedling-sapling<br>10-22% CC 21-84 yrs | No management recommendations. Let succession occur. |
| 5 | Pinyon-Juniper/Shrub/Perennial Grass<br>5-15% CC 85-214 yrs | Generally, no management of habitat is suggested unless it is approaching State 6. If approaching State 6, reduction of trees using a chainsaw or hydro-axe may be appropriate. |
| 6 | Mature Pinyon-Juniper/Shrub<br>15-30% CC 215+ yrs | If managing for Gray Vireo habitat, a reduction of CC is required. Hydro-axe or bulldozer. Chain sawing not recommended due to the amount of labor involved. |
| 7 | Mature Pinyon-Juniper/Shrub<br>> 30% CC 298+ yrs | Generally not recommended for habitat manipulation as resources are better spent in State 6. However, hydro-axe, bulldozing, or chaining could be used. |

# BIBLIOGRAPHY


Andrews, R., Righter, R. 1992. Colorado Birds – A Reference to Their Distribution and Habitat. Denver Museum of Natural History.

Barlow, J.C., James, R.D., and Williams, N. 1970. Habitat co-occupancy among Vireos Of the subgenus Vireo (Aves: Vireonidae). Canadian Journal of Zoology 48: 395-398

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

Barlow, J.C. and Wauer, R.H., 1971. The Gray Vireo (Vireo vicinior Coues; Aves :Vireonidae) wintering in the Big Vend Region, west Texas. Can. J. Zool. 49: 953-955

Bates., J.M. 1992a. Winter territorial behavior of Gray Vireos Wilson Bull. 104: 425-433

Bates, J.M. 1992b. Frugivory on Bursera microphylla (Burseraceae) by wintering Gray Vireos (Vireo vicinior, Vireonidae) in costal deserts of Sonara Mexico. Southwest Nat. 37: 252-258.

Bent, A.C., 1950. Life histories of North American wagtails, shrikes, vireos and their allies. U.S. National Bull. 197

Chaplin, E.A., 1925 Food habits of Vireos: a family of insectivorous birds. U.S. Dept. of Agricultural Bull 1355

Cox, N., Cox, S. 2002. Year 2002 Annaul Report for Gray Vireo (Vireo Vicinior) Surveys Within the Socorro Resource Area Prepared for the Bureau of Land Reclamation, Socorro, New Mexico. October

Davenport, D.D>, Breshears, D.D., Wilcox, B.P., and Allen, C.D. 1998. Viewpoint: sustainablily of pinon-juniper ecosystems – a unifying perspective o fsoil erosion thresholds. Journal of Range Management 51: 231-240

Delong, J.P., Williams, S.O. 2006. Status Report and Biological Reviw of the Gray Vireo in New Mexico. New Mexico Department of Game and Fish. 1 December

Dexter. C. 1998. Gray Vireo in Colorado Breeding Bird Atlas. (H.E. Kingery ed.) Pgs 304-305. Colorado Bird Atlas Partnership and the Colorado Div. of Wildlife. Denver

Ehrlich, P.R, Dobkin. D.S., and Wheye, D. 1998. The birder's handbook: A field guide to the natural history of North American birds. Simon and Schuster Inc., New York

Ffolliott, P.F., and Gottfried, G.J. 2002. Dynamics of a pinyon-juniper stand in northern Arizona: a half century history. For Collins, Co, USDA, Forest Service, Rocky Mountain Research Station. RMRS-RP-35

Frei, R.D., Moore, W. L., Riebe, C.A. 2004. Final Surveying Report for Mountain Plover and Gray Vireo Populations at Kirtland Air Force Base Albuquerque, New Mexico. April.

Frei, R.D., Moore, W.L. 2005. Final Surveying Report for Mountain Plover and Gray Vireo Populations at Kirtland Air Force Base. Albuquerque, New Mexico. August

Frei, R.D., Moore, W.L. Cummer, M. 2006. Final Surveying Report for Gray Vireo Populations at Kirtland Air Force Base. Albuquerque, New Mexico, October

Frei, R.D., Allen, M. 2007. Surveying Report for Gray Vireo Populations at Kirtland Air Force Base Albuquerque, New Mexico. October

Gonzalez, N. 2006. Ecological Site Description: Site ID Fo35XB004NM USDA, Natural Resources Conservation Service. http://efotg.nrcs.usda.gov/references/public/NM/f035xb004nm.pdf accessed 5 April 2008

Gori, D., Bate, J. 2007. Historical Range of Variation and State and Transition Modeling of Historical and Current Landscape Conditions for Pinyon-Juniper of the Southwestern U.S. Prepared for the USDA, Forest Service, Southwestern Region by the Nature Conservancy, Tucson, AZ 141pp.

Hamilton, T.H., 1962. Species relationships and adaptations for sympatry in avian genus Vireo. Condor 64: 40-68.

Hanna. W.W., 1944. Gray Vireo as a victim of the cowbird. Condor 46: 244

Johnson. K.A. 2002. Juniperus monosperma. In: Fire Effects information System U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences laboratory. Http://www.fs.fed.us/database/feis accessed 6 June 2008

Kirtland Air Force Base (KAFB) 2003 Brush Control Plan for Kirtland Air Force Base Albuquerque, New Mexico. Prepared by LopezGarcia Group. February

Kirtland Air Force Base (KAFB) 2007a Gray Vireo Management Plan Kirtland Air Force Base Albuquerque, New Mexico. Prepared by Clover Leaf Environmental Services. February

KAFB 2007b Integrated Natural Resource Management Plan for Kirtland Air Force Base Albuquerque, New Mexico. Prepared by LopezGarcia Group. April

Landis, A.G., and Bailey, J.D. 2005. Reconstruction of age structure and spatial arrangement of pinyon-juniper woodlands and savannas of Anderson Mesa, Arizona. Forest Ecology and management. 204:221-236

Little, E.L. 1995. National Audubon Society Field Guide to North American Trees, Western Region. Chanticleer Press Inc., New York.

Lowther, P.E., 1993 Brown-headed Cowbird (Molothrus ater). The Birds of North America, No, 447. (A Poole and F. Gill, eds) The Birds of North America, Inc., Philadelphia, PA

Mehlhop, D., Debruin, E. 1995. Threatened and Endangered Species Survey of Kirtland Air Force Base, New Mexico New Mexico Natural Heritage Program

Miller R.F., Svejcar, T.J., and Rose. J.A 2000. Impacts of western juniper on plant community and structure. Journal of Range management 53: 574-585

Nature Serve 2007. Vireo vicinior Gray Vireo. NatureServe Explorer at http:www.natureserve.org/explorer. Updated February 2007 accessed 21 March 2007.

New Mexico Department of Game and Fish 2007. Gray Vireo (Vireo vicinior) recovery Plan. New Mexico Department of Gama and Fish, Conservation Services Division, Santa Fe, New Mexico 30 pp.

Orenstein, R.I., and Barlow, J.C. 1981. Variation in the jaw musculature of the avian family Vireonidae. Life Sci. Contrib. R. Ont. Mus 128

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

Terres, J.K 1991. The Audubon Society Encyclopedia of North American Birds. Random House Company. Avenel, New Jersey.

Tewksbury, J.J., Garner, L., Garner, S., Lloyd, J.D., Saab, V., and Martin T.E. 2006. Tests of landscape influence: nest predation and brood parasitism in fragmented ecosystems. Ecology 87: 759-768.

# APPENDIX A

# Nest Tree Densities
# of
# Gray Vireo Territories

# Number of Trees per Gray Vireo Territory in 2003

| Territory ID (#-Year) | Nest Y/N | Number of Trees per Quadrant | | | | Total Number of Trees (Q1-Q4) | Trees/Hectare |
|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | | |
| 01-03 | N | 43 | 104 | 104 | 158 | 409 | 57.93 |
| 02-03 | N | 112 | 109 | 37 | 60 | 318 | 45.04 |
| 03-03 | N | 55 | 63 | 127 | 127 | 372 | 52.69 |
| 04-03 | N | 96 | 52 | 66 | 71 | 285 | 40.37 |
| 05-03 | N | 82 | 70 | 33 | 46 | 231 | 32.72 |
| 06-03 | N | 34 | 51 | 89 | 29 | 203 | 28.75 |
| 08-08 | N | 64 | 38 | 39 | 80 | 221 | 31.30 |
| 09-03 | N | 43 | 55 | 27 | 20 | 145 | 20.54 |
| 10-03 | N | 33 | 106 | 76 | 44 | 259 | 36.69 |
| 13-03 | N | 88 | 59 | 132 | 123 | 402 | 56.94 |
| 15-03 | N | 73 | 32 | 77 | 71 | 253 | 35.84 |
| 16-03 | N | 159 | 233 | 174 | 217 | 783 | 110.91 |
| 17-03 | N | 62 | 26 | 162 | 114 | 364 | 51.56 |
| 18-03 | N | 69 | 98 | 156 | 105 | 428 | 60.62 |
| 19-03 | N | 63 | 142 | 94 | 66 | 365 | 51.70 |
| 20-03 | N | 151 | 76 | 120 | 153 | 500 | 70.82 |
| 21-03 | N | 100 | 92 | 236 | 229 | 657 | 93.06 |
| 22-03 | N | 103 | 222 | 143 | 105 | 573 | 81.16 |
| 23-03 | N | 51 | 176 | 203 | 119 | 549 | 77.76 |
| 24-03 | N | 100 | 163 | 174 | 166 | 603 | 85.41 |
| 25-03 | N | 117 | 58 | 125 | 102 | 402 | 56.94 |
| 26-03 | N | 95 | 80 | 121 | 128 | 424 | 60.06 |
| 27-03 | N | 83 | 64 | 118 | 168 | 433 | 61.33 |
| 28-03 | N | 91 | 63 | 87 | 59 | 300 | 42.49 |
| 29-03 | N | 66 | 74 | 128 | 77 | 345 | 48.87 |
| 31-03 | N | 48 | 30 | 51 | 38 | 167 | 23.65 |
| 32-03 | Y | 81 | 104 | 84 | 26 | 295 | 41.78 |
| 33-03 | Y | 86 | 66 | 79 | 116 | 347 | 49.15 |
| 34-03 | N | 164 | 81 | 64 | 63 | 372 | 52.69 |
| 37-03 | N | 79 | 50 | 53 | 165 | 347 | 49.15 |
| 38-03 | N | 46 | 85 | 65 | 98 | 294 | 41.64 |
| 41-03 | N | 45 | 105 | 103 | 121 | 374 | 52.97 |
| 42-03 | N | 67 | 47 | 98 | 144 | 356 | 50.42 |
| 43-03 | Y | 133 | 128 | 209 | 133 | 603 | 85.41 |
| 44-03 | N | 39 | 144 | 98 | 51 | 332 | 47.03 |
| 45-03 | N | 36 | 23 | 10 | 30 | 99 | 14.02 |
| 46-03 | N | 109 | 182 | 123 | 172 | 586 | 83.00 |
| 47-03 | N | 208 | 168 | 217 | 223 | 816 | 115.58 |
| 48-03 | N | 112 | 102 | 148 | 129 | 491 | 69.55 |
| 49-03 | N | 120 | 115 | 73 | 130 | 438 | 62.04 |
| 50-03 | N | 103 | 198 | 99 | 96 | 496 | 70.25 |
| 51-03 | N | 113 | 125 | 177 | 166 | 581 | 82.29 |
| 52-03 | N | 144 | 113 | 161 | 116 | 534 | 75.64 |
| 53-03 | N | 21 | 30 | 28 | 35 | 114 | 16.15 |
| 54-03 | N | 63 | 80 | 108 | 54 | 305 | 43.20 |
| 55-03 | N | 106 | 95 | 43 | 33 | 277 | 39.24 |

# Number of Trees per Gray Vireo Territory in 2005

| Territory ID (#-Year) | Nest Y/N | 0 Number of Trees per Quadrant | | | | Total Number of Trees (Q1-Q4) | Trees/Hectare |
|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | | |
| 01-05 | N | 79 | 143 | 123 | 158 | 503 | 71.25 |
| 02-05 | Y | 67 | 87 | 109 | 109 | 372 | 52.69 |
| 03a-05* | Y | 125 | 60 | 66 | 99 | 350 | 49.58 |
| 03b-05* | Y | 115 | 163 | 110 | 156 | 544 | 77.05 |
| 04-05 | Y | 33 | 97 | 138 | 138 | 406 | 57.51 |
| 05-05 | Y | 54 | 24 | 50 | 109 | 237 | 33.57 |
| 06a-05* | Y | 106 | 87 | 174 | 117 | 484 | 68.56 |
| 06b-05* | Y | 161 | 27 | 83 | 115 | 386 | 54.67 |
| 07-05 | N | 147 | 61 | 154 | 112 | 474 | 67.14 |
| 09-05 | Y | 59 | 133 | 113 | 81 | 386 | 54.67 |
| 10-05 | Y | 103 | 64 | 82 | 72 | 321 | 45.47 |
| 11-05 | Y | 140 | 60 | 131 | 127 | 458 | 64.87 |
| 12-05 | N | 209 | 202 | 211 | 204 | 826 | 117.00 |
| 13-05 | Y | 167 | 225 | 271 | 123 | 786 | 111.33 |
| 14-05 | Y | 112 | 132 | 93 | 113 | 450 | 63.74 |
| 15-05 | N | 116 | 62 | 60 | 141 | 379 | 53.68 |
| 16-05 | Y | 52 | 114 | 86 | 123 | 375 | 53.12 |
| 17-05 | Y | 55 | 92 | 149 | 39 | 335 | 47.45 |
| 18-05 | Y | 40 | 46 | 51 | 127 | 264 | 37.39 |

***Gray Vireo pair nested twice, therefore a & b designation denote first and second nesting attempt**

# Number of Trees per Gray Vireo Territory in 2006

| Territory ID (#-Year) | Nest Y/N | Number of Trees per Quadrant | | | | Total Number of Trees (Q1-Q4) | Trees/Hectare |
|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | | |
| 01-06 | Y | 66 | 62 | 150 | 113 | 391 | 55.38 |
| 02-06 | Y | 67 | 104 | 93 | 105 | 369 | 52.27 |
| 03-06 | N | 32 | 110 | 99 | 75 | 316 | 44.76 |
| 04-06 | N | 20 | 45 | 198 | 160 | 423 | 59.92 |
| 05-06 | Y | 115 | 177 | 86 | 90 | 468 | 66.29 |
| 07-06 | N | 227 | 193 | 212 | 223 | 855 | 121.10 |
| 08-06 | Y | 156 | 202 | 140 | 107 | 605 | 85.69 |
| 09-06 | N | 169 | 90 | 84 | 63 | 406 | 57.51 |
| 10-06 | N | 73 | 88 | 96 | 183 | 440 | 62.32 |
| 11-06 | N | 28 | 13 | 47 | 63 | 151 | 21.39 |
| 12-16 | N | 111 | 114 | 155 | 75 | 455 | 64.45 |
| 14-06 | Y | 67 | 119 | 25 | 62 | 273 | 38.67 |
| 15-06 | N | 18 | 140 | 39 | 20 | 217 | 30.74 |
| 16-06 | Y | 54 | 16 | 68 | 49 | 187 | 26.49 |
| 17-06 | Y | 78 | 141 | 92 | 19 | 330 | 46.74 |

# Number of Trees per Gray Vireo Territory in 2007

| Territory ID (#-Year) | Nest Y/N | Number of Trees per Quadrant | | | | Total Number of Trees (Q1-Q4) | Trees/Hectare |
|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | | |
| 01-07 | Y | 65 | 101 | 101 | 100 | 367 | 51.98 |
| 02-07 | N | 97 | 112 | 151 | 98 | 458 | 64.87 |
| 03-07 | N | 136 | 196 | 171 | 152 | 655 | 92.78 |
| 04-07 | Y | 68 | 83 | 76 | 19 | 246 | 34.84 |
| 05-07 | N | 108 | 186 | 152 | 131 | 577 | 81.73 |
| 06-07 | Y | 70 | 148 | 139 | 66 | 423 | 59.92 |
| 07-07 | Y | 18 | 156 | 108 | 115 | 397 | 56.23 |
| 09-07 | Y | 14 | 73 | 44 | 23 | 154 | 21.81 |
| 10-07 | Y | 79 | 59 | 52 | 187 | 377 | 53.40 |
| 11-07 | Y | 65 | 19 | 144 | 18 | 246 | 34.84 |
| 13-07 | Y | 148 | 137 | 76 | 53 | 414 | 58.64 |
| 14-07 | Y | 40 | 69 | 83 | 92 | 284 | 40.23 |

# APPENDIX B

# Gray Vireo Nest Tree Measurements and Estimated Age Class

# Gray Vireo Nest Tree Data for Years 2005 & 2007

| Territory ID (#-Year) | Estimated Tree Width of Nest Tree | Estimated Tree Height of Nest Tree | Estimated Height of Nest in Tree | Estimated Tree Age** |
|---|---|---|---|---|
| 02-05 | 10 | 8.5 | 7' 1" | Young Mature |
| 03a-05* | 14 | 8.5 | 5' 9' | Young Mature |
| 03b-05* | 19 | 13.5 | 11' 9" | Young Mature/Mature |
| 04-05 | 13.5 | 9.5 | 8' 9" | Young Mature |
| 05-05 | 19 | 12.5 | 5' 7" | Young Mature/Mature |
| 06a-05* | 14 | 11.5 | 10' 0" | Young Mature/Mature |
| 06b-05* | 19 | 10 | 5' 10" | Young Mature/Mature |
| 08-05 | 17 | 10 | 8' 3" | Young Mature/Mature |
| 09-05 | 17.5 | 14 | 9' 11" | Young Mature/Mature |
| 10-05 | 13 | 11.5 | 9' 0" | Young Mature/Mature |
| 11-05 | 11 | 9 | 7' 2" | Young Mature |
| 13-05 | 12 | 8.5 | 7' 2" | Young Mature |
| 14-05 | 18 | 10.5 | 8' 4" | Young Mature/Mature |
| 16-05 | 16 | 8.5 | 6' 8" | Young Mature |
| 17-05 | 0 | 8.5 | 6' 8" | Young Mature |
| 18-05 | 14 | 11.5 | 9' 10" | Young Mature/Mature |
| 01-07 | 8 | 9 | 5' 4" | Young Mature |
| 04-07 | 9.5 | 15.5 | 7' 10" | Mature |
| 06-07 | 19 | 11 | 8' 10" | Young Mature/Mature |
| 07-07 | 8.5 | 9 | 6' 9" | Young Mature |
| 08-07 | 18 | 14.5 | 9' 8" | Young Mature/Mature |
| 09-03 | 11 | 8.5 | 5' 5" | Young Mature |
| 10-07 | 11.5 | 10 | 7' 3" | Young Mature/Mature |
| 11-07 | 16 | 10 | 3' 8" | Young Mature/Mature |
| 12-07 | 24.5 | 24.5 | 4' 9" | Old Mature |
| 13-07 | 12.5 | 9.5 | 6' 11" | Young Mature |
| 14-07 | 15.5 | 9 | 7' 4" | Young Mature |

***Gray Vireo pair nested twice, therefore a & b designation denote first and second nesting attempt**

**** See Table 4-4 for description of oneseed juniper age classes**