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

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Conservation Services Division

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Hira A. Walker and Robert H. Doster, Editors

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ABSTRACT

The proceedings contain expanded abstracts of oral papers presented at the New Mexico Department of Game and Fish and the New Mexico Ornithological Society co-sponsored Gray Vireo Symposium, which was held 12–13 April 2008 at the Vagabond Inn Executive in Albuquerque, New Mexico. The symposium was chaired by Hira Walker, the Non-game and Endangered Species Ornithologist with the New Mexico Department of Game and Fish in Santa Fe, New Mexico. The symposium included presentations by invited speakers, a summation talk by the symposium chair that unified presented concepts, a roundtable discussion, and a field trip to Kirtland Air Force Base to view Gray Vireo (*Vireo vicinior*) breeding habitat and discuss management activities on the base. The symposium was well attended and brought together many people from different professional and personal backgrounds to discuss the past, present, and future directions of research and management for the Gray Vireo in New Mexico. The expanded abstracts in the proceedings discuss one or more of the following topics: 1) Gray Vireo population status and trends; 2) habitats used by the Gray Vireo at multiple scales; and 3) research and management needs for the Gray Vireo. It is hoped that the symposium will serve as a catalyst for future collaboration among researchers and land managers to improve our understanding of and management actions for the Gray Vireo in New Mexico.

Key Terms: Gray Vireo, Vireo vicinior*, habitat use, management, research, recovery*

EDITORS

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COVER

Photograph of perched Gray Vireo by G. Harper. Photographs of Gray Vireo on nest, Gray Vireo nest, and Gray Vireo fledgling by C. Nishida. Photograph of Gray Vireo nestlings in nest by M. Hilchey. Cover design by L. Cherry.

DISCLAIMER

All expanded abstracts have been peer reviewed for relevance to the subject matter of the symposium and intellectual quality. Authors and proceedings editors are responsible for the content and accuracy. Opinions expressed do not necessarily reflect the position of the New Mexico Department of Game and Fish nor the New Mexico Ornithological Society.

RECOMMENDED CITATION

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Introduction

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The Gray Vireo (*Vireo vicinior*) is a small, gray songbird found in the dry foothills and bajadas west of the Great Plains in New Mexico, and, despite the fact that "few birds are as plain as the Gray Vireo" (Kaufman 2001:505), the species draws considerable management and conservation attention in the State. Three reasons explain this attention: 1) the bird breeds throughout most of the State in one type of tree, juniper (*Juniperus* spp.); 2) its populations are geographically scattered and very small; and 3) it is little studied.

The Gray Vireo ranges from 13.0–14.8 cm (5.1–5.8 in) in total length and from 11.5–13.5 g (0.4–0.5 oz) in mass. Aptly named, the bird is entirely gray, paler on its chin, chest, and belly, and possesses the longest tail of any vireo in proportion to body size. Among the vireos, the Gray Vireo's closest relative is the Plumbeous Vireo (*V. plumbeus*).

The Gray Vireo is known to breed only in the southwestern United States, northern Mexico, and Baja California Norte, Mexico. Its wintering range is Baja California Sur, Mexico, coastal and lowland areas of Sonora, Mexico, and north into southwestern Arizona and southeastern California. A separate population winters in the Big Bend region of Texas, and might be present there year-round. Within New Mexico, the species is found throughout the State west of the Great Plains, but with an extremely patchy distribution often composed of small populations each supporting less than 10 territories. Over 80 percent of the known Gray Vireo breeding territories in New Mexico are found in just 12 sites, the largest site found in the Guadalupe Mountains west of Carlsbad, New Mexico. Other important sites include Navajo Lake, Caja del Rio near Santa Fe, and along the Sandia Mountains on Kirtland Air Force Base in Albuquerque.

Gray Vireos are found in hot, arid regions, most often associated with juniper trees, piñon (*Pinus* spp.), or oak (*Quercus* spp.). The vireo makes use of primarily three vegetation communities in New Mexico (DeLong and Williams 2006). In the northern part of the State, the species uses piñon-Utah juniper (*J. osteosperma*) stands at elevations of 1768–2195 m (5800–7200 ft). In central New Mexico, the Gray Vireo typically uses oneseed juniper (*J. monosperma*) savannas at 1676–2134 m (5500–7000 ft), although the species can occasionally be found in juniper savannas above 2195 m (7200 ft) in west-central New Mexico. In southern parts of New Mexico, the bird uses juniper-oak woodlands and desert riparian communities at 1311–2012 m (4300–6600 ft).

The Gray Vireo is insectivorous during the breeding season, but tends to be primarily frugivorous during winter, taking fruits from the Elephant Tree (*Bursera microphylla*) in southwestern Arizona, southern California, and Sonora and, likely, Baja, Mexico.

Nesting Gray Vireos are territorial, with males maintaining the territory through song and patrolling of the territory perimeter. Male Gray Vireos arrive on the breeding grounds a few days before females and begin singing. Pairs are formed within the first day of the females' arrival and pairs normally remain monogamous during the breeding season. In New Mexico, breeding commences in late April and can continue into July if nest failure has occurred. Nests are often on west or north-facing trees. Nesting trees in Colorado ranged from 1.8–4.8 m (5.9–15.6 ft) in height, with the nests ranging from 1.3–3.4 m (4.3–11.2 ft) above ground. In New Mexico, nests are placed primarily in juniper trees (DeLong and Williams 2006). The nest is typical of the vireo family in that it is a cup nest hanging from forks in the tree. Both sexes sit tightly on the nest (Barlow et al. 1999). Gray Vireos lay an average of 3 eggs, generally one egg per day until the clutch is complete, with incubation beginning after the second egg is laid. Incubation lasts 12–14 days. Nestlings are altricial, with eyes beginning to open after five to six days. All fledglings tend to leave the nest on the same day. In New Mexico, of

44 nests examined, young fledged per territory ranged from 0.7 to 3.0 fledglings (DeLong and Williams 2006). Parents will feed the fledglings 5–10 days after they leave the nest, with the young staying within 15.0–20.0 m (49.2–65.6 ft) of the nest. Subsequent dispersal by immature birds is little studied.

Brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) is a threat to Gray Vireo nests and could be a major limiting factor of the vireo in New Mexico. Both sexes of the Gray Vireo will chase off a cowbird, but, if the nest is parasitized, the parents will normally abandon the nest and try again elsewhere.

The primary threat to the Gray Vireo is alteration of its breeding habitat, mainly juniper-dominated habitat. Such activities include, but are not limited to, thinning and control of juniper, firewood collection, use of trees for biofuel energy production, and removal of trees to facilitate oil and gas production. The species will not use areas lacking trees. A second concern is the scattered, sparse distribution of the bird, leaving it vulnerable to perturbation. Due to the number of threats, the Gray Vireo was listed as endangered, group 2 (which is now termed "threatened" with changes in terminology), by the New Mexico Department of Game and Fish (NMDGF) in 1983, and as a Species of Greatest Conservation Need under the Comprehensive Wildlife Conservation Strategy of New Mexico (NMDGF 1990, 2005). In 2006–2007, with the aid of an extensive advisory committee composed of both private and government officials, NMDGF developed a recovery plan for the species (NMDGF 2007). Key recommendations for the recovery of the species were to manage it both on a statewide basis and in four management units within the State; to improve the knowledge of the biology and status of the bird; to improve communication among management agencies, such as providing guidelines for and sharing information on the management of the species; and to improve the knowledge of the impact of anthropogenic habitat alterations on the biology of the Gray Vireo.

An overriding concern throughout the development of the recovery plan was the lack of biological information about the species. While charismatic species like Bald Eagle (*Haliaeetus leucocephalus*) and Peregrine Falcon (*Falco peregrinus*) are well studied, the Gray Vireo is not. At the inaugural meeting of the Gray Vireo Recovery Team, the top recommendation for how to recover the species was to gather together all known information about the bird in New Mexico. An opportunity developed whereby researchers on the Gray Vireo could come together to present their current findings in a symposium held on 12 April 2008 in conjunction with the 46th Annual Meeting of the New Mexico Ornithological Society. These proceedings are a result of that symposium.

Gray Vireo Status and Distribution on Fort Bliss: 2007

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INTRODUCTION

Fort Bliss is a 445,154-hectare army installation straddling the Texas-New Mexico border due east-northeast of El Paso, Texas. Preservation of biodiversity and maintenance of functional ecosystems are fundamental goals of the Fort Bliss natural resources program and require planning level surveys (ACE 2001).

A 1994 survey (Mehlhop et al. 1994) for sensitive species in the Organ Mountains of Fort Bliss detected the presence of the state threatened (NMDGF 2008) Gray Vireo (*Vireo vicinior*). Recent systematic surveys in several parts of New Mexico have detected numerous previously unknown populations and clarified the status of this species in the State, including areas adjacent to Fort Bliss, such as the Guadalupe Mountains (DeLong and Williams 2006). These new data, recent incidental observations of breeding Gray Vireos in areas not previously known to be occupied by the species in the San Andres and Oscura mountains (pers. obs.), and existing knowledge of the species' presence in the Sacramento and Organ mountains (DeLong and Williams 2006, Mehlhop et al. 1994, B. Locke pers. comm.) suggested a need for an extensive systematic survey.

A survey focusing on the distribution and habitat preferences of the Gray Vireo within the New Mexico counties of Dona Ana and Otero on Fort Bliss was conducted in 2007. The survey was intended to fill in some of the current distributional data gaps and assist land managers in making decisions regarding the management of training areas within the installation.

METHODS

Prior to the initiation of surveys for Gray Vireos on Fort Bliss, researchers utilized literature reviews, known historical locations, aerial photography, and on-the-ground reconnaissance to identify areas with potential habitat. Surveys were then conducted according to DeLong and Williams (2006) from 1 May to 3 August 2007 by researchers that were trained in the identification of Gray Vireos by sight and sound.

The vireo's primary advertisement song was broadcasted at points spaced 200 m apart while traveling through potential habitat. The song was played twice for 30 sec and was preceded and separated by listening and observation periods of one to two min. On each territory, locations of all detected vireos were recorded in field notebooks and using Garmin Global Positioning System (GPS) units, along with sex, age, and behavior when possible. Vegetation communities and abiotic characteristics of territories and nest-site characteristics were also noted.

Emphasis was placed on determining the distribution of the species and locating the maximum number of occupied territories in the area versus determining reproductive productivity on each territory. An occupied territory was identified on the basis of at least a single territorial male on site.

Observed vireos were followed within territories for as long as possible and GPS tracks and points were used to map the territory extent. The accuracy of territory mapping varied according to effort and GPS reading accuracy. We calculated the total area surveyed by buffering survey points by 200 m, which is the expected minimum range at which vireos could detect our playbacks. Locations where no vireos were detected generally were not revisited except incidentally while traveling to new areas. Known occupied territories were revisited opportunistically in order to identify the presence of pairs, nests, and young.

RESULTS

The survey effort resulted in locating 51 occupied territories and 104 Gray Vireos (Table 1). A total of 17 nests was located, as well as two

TABLE 1. Gray Vireos (*Vireo vicinior*), territories, nests, and young detected in the Organ and Sacramento mountains on Fort Bliss, New Mexico in 2007.

	Organ Mountains	Sacramento Mountains	Total
EFFORT			
Survey points	298	722	1020
Surveyor-days	44	78	122
Coverage (km^2)	15.7	54.1	69.8
TERRITORIES			
Number	14	37	51
Elevation range (m)	1719–2096	1630–1941	
Mean elevation ± standard deviation (m)	1837 ± 39	1781 ± 60	
Median elevation (m)	1830	1784	
Size range (m^2)	16206–67751	4067–113162	
Mean estimated size ± standard deviation (m^2)	41354 ± 15835	40033 ± 26875	
DEMOGRAPHICS			
Adults	24	58	82
Fledglings (minimum)	0	20	20
Nestlings (minimum)	0	2	2
Total Gray Vireos (minimum)	24	80	104
Nests	4	13	17
Incubating females	1	8	9
Territories with young (minimum)	1	12	13
Territories with ≥ 1 fledglings	0	5	5
Territories with ≥ 2 fledglings	0	6	6
Territories with ≥ 3 fledglings	0	1	1

nestlings and 20 fledglings.

In the Organ Mountains, 298 points covering a survey area of 15.7 km² were surveyed over 44 surveyor/days (Table 1). In the Sacramento Mountains, 722 points covering a survey area of 54.1 km² were surveyed over 78 surveyor/days (Table 1).

In the Organ Mountains (Table 1), nine territories were located in Soledad Canyon proper, two in a southern tributary of Soledad Canyon west of Beasley Canyon, one at the confluence of Soledad and North canyons, and two in Fillmore Canyon. A total of 24 adult Gray Vireos and no confirmed young were found.

Occupied territories in the Organ Mountains were generally localized along, and frequently at the base of, individual slopes within broad, east-west oriented, granitic/rhyolitic canyon systems. The elevation of occupied territories ranged from 1719 to 2096 m with a median and mean elevation of 1830 and 1837 m, respectively. The mean estimated territory size here was 41,354 m² (Table 1).

Only four nests were found during the Organ Mountains survey effort (Table 2). All nests were built in alligator juniper (*Juniperus deppeana*). The primary nest construction materials were mostly sideoats grama (*Bouteloua curtipendula*) with occasional leaves, conifer needles, and finer grass inflorescences as lining.

Open woodland dominated by alligator juniper was characteristic of these Organ Mountain territories. Subdominant components included gray and Sonoran scrub oak (*Quercus grisea* and *Q. turbinella*, respectively) along drainages and twoneedle piñon (*Pinus edulis*) along slopes. Apache plume (*Fallugia paradoxa*) dominated the understory along drainages, with mountain mahogany (*Cercocarpus montanus*) on mid- to upper slopes. The groundcover featured a lush cover of perennial grasses, primarily sideoats grama, and patches of forbs and sub-shrubs.

In the Sacramento Mountains (Table 1), we located one territory in West McAfee Canyon, six in El Paso Canyon, six in lower Culp Canyon, and 24 in the Grapevine Canyon complex. A minimum of 80 Gray Vireos were found, including 58 adults and 22 young. Occupied territories in the Sacramento Mountains occurred between 1630 and 1941 m with median and mean elevations of 1784 and 1781 m, respectively. The mean estimated

TABLE 2. Nesting substrate of Gray Vireo (*Vireo vicinior*) on Fort Bliss, New Mexico in 2007.

Scientific Name	Common Name	Nest Occurrences
Pinus edulis	Twoneedle piñon	4
Juniperus deppeana	Alligator juniper	4
Juniperus monosperma	Oneseed juniper	3
Cercocarpus montanus	Mountain mahogany	2
Fraxinus cuspidate	Fragrant ash	2
Rhus virens	Evergreen sumac	1
Garrya wrightii	Wright's silktassel	1

territory size in the Sacramento Mountains was 40,033 m².

Occupied territories were primarily in and along narrow to moderately broad, sinuous, limestone canyons. Nests were built in a variety of tree species (Table 2). Nest materials consisted primarily of perennial grasses with a few non-grass leaves, conifer needles, and bits of juniper bark. Vireos exhibited a preference for placing nests on or near the downhill side of the nest tree. Nest trees included twoneedle piñon, alligator and oneseed juniper, mountain mahogany, fragrant ash (*Fraxinus cuspidata*), evergreen sumac (*Rhus virens*), and Wright's silktassel (*Garrya wrightii*). Nest tree height ranged from approximately 2 to 8 m with a mean height of 2.4 m (Table 3). Nest heights ranged from 2 to 4 m. Nests averaged 0.22 m from the outer edge of the canopy.

Occupied territories featured vegetation that was heterogeneous and stratified with respect to landscape position. Territories found in the Grapevine Canyon complex and lower Culp Canyon area in the Sacramento Mountains featured three major vegetation components stratified by their position and aspect within the landscape (canyon bottom, xeric slope, and mesic slope).

Drainage bottoms in the Grapevine-Culp canyons area included a sparse to low cover of oneseed juniper (*J. monosperma*) and twoneedle piñon with some combination of Sonoran scrub oak, fragrant ash, alligator juniper, netleaf hackberry (*Celtis reticulata*), and evergreen sumac. A dense cover of shrubs dominated by Apache plume, but including a variety of other shrubs, typically lined the drainages. Viscid acacia (*Acacia neovernicosa*), ocotillo (*Fouquieria splendens*), and common sotol (*Dasylirion wheeleri*) often dominated the xeric slopes. Mountain mahogany overwhelmingly dominated the mesic slopes with a variable cover by piñon and oneseed Juniper. The mesic slopes usually also included a lush grassy groundcover dominated primarily by New Mexico feathergrass (*Hesperostipa neomexicana*).

The vegetation of the El Paso Canyon territories in the Sacramento Mountains was less stratified. The piñon-juniper woodland was open, but denser than the Grapevine-Culp canyons area. This woodland was continuous along the mesic side of the canyon bottom and extended variably onto mesic slopes and up the side drainages of xeric slopes. Apache plume was dominant along drainages, but other shrubs were featured as well. The shrub species found on the slopes included mountain mahogany (dominant) and soaptree yucca (*Yucca elata*). Xeric slopes had a smaller shrub component, but a denser, continuous and uniform

TABLE 3. Gray Vireo (*Vireo vicinior*) nest site characteristics observed on Fort Bliss, New Mexico in 2007. All values shown but ranges are mean ± standard deviation.

	Organ Mountains (n = 4)	Sacramento Mountains (n = 13)
Substrate height (m)	5.75 ± 2.25	4.9 ± 2.18
Substrate height range (to nearest m)	4–9	2–8
Nest height (m)	3.0 ± 2.04	2.4 ± 0.97
Nest height range (m)	1.5–6	1–4
Distance to canopy edge (m)	0.28 ± 0.19	0.22 ± 0.09
Habitat slope (%)	14.25 ± 4.35	43 ± 20
Slope aspect (degrees)	124 ± 83	261 ± 106
Nest aspect (degrees)	143 ± 133	179 ± 124
Nest-slope aspect difference (degrees)	39 ± 63	29 ± 22

cover of grass.

Discussion

Gray Vireos detected on Fort Bliss in 2007 utilized a range of habitats that reflected the variety of habitats occupied in southern New Mexico, ranging from dry, limestone canyons featuring varying amounts of piñon-juniper overstory and desert scrub to open juniper savanna, occurring at the base of slopes.

The average mapped territory size of 4.1 and 4.0 ha for the Organ and Sacramento mountains (Table 1), respectively, fell within the range of 2–10 ha reported by Barlow et al. (1999), but below the 8.0 ha reported by DeLong and Cox (2005). Inconsistent territory mapping effort might account for this difference.

The statewide review of DeLong and Williams (2006) estimated a minimum population size for Gray Vireos in New Mexico of between 549 and 827 birds and at least 418 territories. These authors calculated their lower minimums based on actual observations, their upper minimums by adding one for the assumed mate of each lone territorial male, and their maximum territories by dividing the upper minimum number of birds by two. Following this method and based on their numbers plus those of Wickersham and Wickersham (2007), we believe that the Fort Bliss survey has increased the known number of territories statewide by 8.2%, the lower minimum number of birds by 10.0%, and the upper minimum number of birds by 8.3%. Organ Mountain territories either overlap with historical locations or might have shifted and do not necessarily represent an increase in the known population. Due to these uncertainties in the Organ Mountains, the above estimate of increases in the known statewide population only includes those territories and birds we found in the Sacramento Mountains.

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Habitat Preference and Status of Gray Vireos on Kirtland Air Force Base in Albuquerque, New Mexico

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INTRODUCTION

The Gray Vireo (*Vireo vicinior)* is listed as threatened by the State of New Mexico (NMDGF 2008). Reasons for its possible decline in parts of New Mexico are not well understood. It is absent from some historical locations (e.g., Montoya and Hachita-Big Hatchet mountains), but recent surveys have found this species in "new" areas, including the foothills east of Albuquerque, Bernalillo County, New Mexico (BISON-M 2008).

The Gray Vireo is an inhabitant of dry woodlands, usually in association with steep, rocky, or rolling terrain. It seems to avoid the denser and higher elevations of the piñon (*Pinus* spp.)-juniper (*Juniperus* spp.) woodland community, which is often occupied by the Plumbeous Vireo (*V. plumbeus*) (Andrews and Righter 1992).

On Kirtland Air Force Base (AFB) in Bernalillo County, New Mexico, Gray Vireos are found in rolling terrain, valleys, and at the base of steeper slopes. Open juniper woodlands are preferred, consisting of oneseed juniper (*J. monosperma*), apache plume (*Fallugia paradoxa*), tree cholla (*Opuntia imbricata*), prickly pear cactus (*Opuntia phaecantha*), grama grasses (*Bouteloua* spp.), and an occasional piñon (Kirtland AFB 2005).

In 2003, a Kirtland AFB-wide survey for the Gray Vireo revealed 53 territories. These surveys provided Kirtland AFB with baseline data, but did not address habitat characteristics/needs, nest predation, nest abandonment, nestling mortality, nest parasitism, or nesting success determined by number of fledged young. In 2005, a subset of the population was chosen for a comprehensive monitoring program to address these data needs.

Prior to the present study, long-term monitoring of Gray Vireos on base had not been conducted. Therefore, impacts to this species from military operations, construction, land management, nest parasitism from Brown-headed Cowbirds (*Molothrus ater*), and other factors were largely unknown. In 2007, Kirtland AFB developed a Gray Vireo Management Plan that addresses the ecological needs of the Gray Vireo on the base.

METHODS

STUDY AREA

Kirtland AFB is located just southeast of Albuquerque at the foot of the Manzanita Mountains, with elevations ranging from 5200 to nearly 8000 ft above mean sea level. Land use adjacent to the base includes Cibola National Forest to the northeast and east, the Pueblo of Isleta Indian Reservation to the south, and residential and business areas of the City of Albuquerque to the west and north.

Because of limited resources, only the juniper woodland habitat, located along the boundary of the base along Coyote Springs Road, was surveyed. Only those lands owned by Kirtland AFB were included in the study. This sub-set represents 25–33% of the Gray Vireo population on base.

BIRD SURVEYS

The methods employed during this study came from the *Work Plan for Surveying Mountain Plover and Gray Vireo Populations at Kirtland Air Force Base* (Kirtland AFB 2002):

- The general survey window for the Gray Vireo at Kirtland AFB occurs between the last week in April and 15 July. Actual survey dates started as early as 12 May and extended until 14 July from 2005 through 2007 depending on field conditions.
- Surveys were conducted one-half hour before sunrise and ended at 1100 MDT.
- Field biologists walked transects through all appropriate habitat searching for Gray Vireos.
- Transects were approximately 200 m apart, although the original methods suggested 100 m between transects. This distance was changed because Gray Vireo territories are larger than

previously believed. The greater distance between transects helped prevent repeated counting of Gray Vireos. Transect length varied depending on availability of suitable habitat.

- A recorded Gray Vireo song was played using a portable CD player to call in Gray Vireos in the immediate area. Birds lured to the call were typically observed at close range (i.e., 3–10 m).
- Recorded songs were played every 200–250 m along transects.
- Recorded songs were generally played over a five min period with a one min break in the middle.
- Areas that were initially surveyed during bad weather conditions (i.e., rain or strong winds) were resurveyed when conditions were more favorable.
- Binoculars were used to identify Gray Vireos.
- Gray Vireos called in were allowed to return to their previous location before a location was mapped.
- When Gray Vireos were spotted, their location was mapped. Other related data, such as behavior and habitat, were also recorded.

Once territories were identified, biologists returned to each territory during the breeding season to look for nests. Gray Vireo nesting sites were found by following the birds, usually the males, to the nest tree. Singing males were followed until they entered a tree and stopped singing. The tree was intensively searched until the nest was located.

Once the nest was found, its location was recorded using a Global Positioning System (GPS) unit and, if possible, nest contents were viewed and recorded on datasheets. Because most nests were above eye level, viewing the nest contents usually required using a telescoping mirror. The mirror was positioned above the nest allowing biologists to view the interior of the nest by looking at the reflected image. Investigating the nest in this manner was done when both the male and female Gray Vireo were off the nest. Initial information gathered included: numbers of eggs or young in the nest, height of the nest above ground level, and height and width of the tree. A photograph of each nest tree was taken. Nests were revisited to determine if a nest failed or was successful. Nests were observed at least twice a week until the young approached the fledgling stage, at which time nests were checked daily. During each visit, general notes were taken on brood parasitism by Brown-headed Cowbirds and occurrences of potential predation.

The heights of Gray Vireo nests, along with the height and width of nest trees, were measured from 2005–2007. Nest and tree height were measured with clinometers. A total of 27 trees, 16 from 2005 and 11 from 2007, were used in determining nest tree selection by Gray Vireos on Kirtland AFB. Nest tree data from 2006 were not used due to inconsistencies in data collection.

RESULTS AND DISCUSSION

The number of nesting pairs of Gray Vireos within the study area varied from year to year (Table 1). A high of 14 breeding territories was recorded in 2005 and a low of 8 were observed in 2006. Breeding territories were identified by the presence of a constructed or partially constructed nest. Occasionally, a single pair would construct two nests within a breeding season. This occurred twice in 2005.

Nesting success was defined by at least one fledged young per nest. Nesting success ranged from 15–66% over the three-year period (Table 1). Reasons for failed nesting attempts include brood parasitism by Brown-headed Cowbirds, predation,

TABLE 1. Summary of Gray Vireo (*Vireo vicinior)* nest monitoring results on Kirtland Air Force Base, New Mexico from 2005–2007.

Monitoring year	Number of nests	Number of territories with nests	Number of nests used[a]	Number of nests parasitized by cowbirds	Number of failed nesting attempts[b]	Number of nests fledging young
2005	16	14	13	8 (62%)	8–11 (62–85%)	2–5 (15–38%)
2006	8	8	6	1 (17%)	2–3 (33–50%)	3–4 (50–66%)
2007	11	11	10	2 (20%)	5 (50%)	5 (50%)
Average	11.7	11.0	9.6	3.6 (38%)	N/A	N/A

[a] Defined as nests that contained Gray Vireo eggs or Gray Vireo young

[b] Includes all causes of nest failure, such as parasitism by Brown-headed Cowbirds (*Molothrus ater*), suspected predation, weather, and unknown

and weather events (e.g., strong winds destroying nests). Brood parasitism accounted for 17–62% of failed nesting attempts. Most nests that were brood parasitized were abandoned. However, in 2005, one pair of Gray Vireos raised a cowbird chick to the fledgling stage, but failed to hatch any of its own eggs. Similar to nest parasitism, predation was a major factor that affected nest success; these two factors combined reduced the Gray Vireos nesting success typically to less than 50%. Although predation on nests was never directly observed, it was assumed to have occurred when young or eggs disappeared from the nest between observations for no other apparent reason (i.e., nestlings were too young to have fledged). Potential predators included jays (such as Western Scrub-Jay [*Aphelocoma californica*] and Steller's Jay [*Cyanocitta stelleri*]), Scott's Oriole (*Icterus parisorum*), coyote (*Canis latrans*), rock squirrel (*Spermophilus variegates)*, chipmunks (*Neotamias* spp.), bullsnake (*Pituophis melanoleucus*), and other avian and mammalian predators. Although to a lesser extent than nest parasitism and predation, weather events also reduced nesting success. In 2005, a nest was destroyed from high winds from a strong thunderstorm.

Breeding activity varied widely across years. During the first year of the study, a total of 14 breeding territories was identified. The number of breeding territories dropped to 8 in the following year and then rebounded to 11 breeding territories in 2007. Two factors likely contributed to these swings in breeding activity. The first was weather. Years 2005 and 2007 were fairly typical weather years. However, in 2006, the spring and early summer were incredibly dry and might have influenced the breeding biology of the local Gray Vireo population. The dry period extended through the nest building portion of the season, but it was quickly followed by one of the wettest summers on record for the Albuquerque area. This shift in precipitation likely attributed to the decrease in the number of nesting attempts. Secondly, field personnel in 2006 differed from those in 2005 and 2007. Thus, there might have been some bias based on the biologists' ability to locate active nests.

Reasons for the apparent decrease in cowbird nest parasitism from 2005 to 2007 are unknown. Two possible explanations might include that the Gray Vireo learned how to better avoid or conceal their nests from cowbirds based on previous experiences with past nest parasitism episodes, or there might have been factors that suppressed the cowbird population during the last two years of the study.

Currently, the sample size for nest tree characteristics is too small to analyze rigorously. Excluding data collected in 2006 due to inconsistent data collection, mean nest tree height and width both appeared similar among years (Table 2). Mean nest tree height was 10'7" and 10'6" in 2005 and 2007, respectively. Mean nest tree width was 15'2" and 15'1" in 2005 and 2007, respectively. Mean nest height varied among years, ranging from 6'10"–8'2" (Table 2). Over the three years of the study, mean nest height was lower in 2007 (6'10") than in both 2005 (8'2") and 2006 (7'6"). As more vegetation data are added in future years, we will focus not only on identifying habitat characteristics important to nest selection, but also on those that might influence nest success.

In 2007, Kirtland AFB completed a Gray Vireo Management Plan that identified goals and objectives for managing the species on base. Some of these goals and objectives include identifying and defining habitats preferred by the Gray Vireo, leg-banding adults and juveniles to determine site fidelity and survivorship, and identifying areas on base that could be modified or restored to provide additional Gray Vireo habitat. Additionally, one of the goals of the plan is to make available gathered information to individuals and agencies interested in

TABLE 2. Gray Vireo (*Vireo vicinior)* nest tree characteristics on Kirtland Air Force Base, New Mexico from 2005–2007.

Monitoring year	Number of nests	Mean nest tree height	Mean nest tree width	Mean nest height in tree
2005	16	10'7"	15'2"	8'2"
2006[a]	7	–	–	7'3"
2007	11	10'5"	15'0"	6'10"
Average	NA	10'6"	15'1"	7'6"

[a] Nest height was recorded for only 7 of the 8 nests constructed in 2006

Gray Vireo conservation.

In 2008, a study was completed that used nest tree data from Kirtland AFB (Table 2) and aerial photographs of Gray Vireo territories to define habitat based on tree density and nest tree characteristics. The results of the study showed that Gray Vireos most commonly used oneseed juniper savannas that had tree densities ranging from 31–90 trees per hectare (56 trees/hectare average) that provided an estimated canopy cover of 5–15% (average 8.5%) (Frei 2008). Juniper stands used were estimated to be 60–180 years old, with average nest tree approximated at 120 years of age. Management decisions were then outlined for Kirtland AFB based on this new information.

Gray Vireo Monitoring in Northwestern and Southeastern New Mexico

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INTRODUCTION

The Gray Vireo (*Vireo vicinior*) is a Bird of Conservation Concern (USFWS 2002), inhabiting low-elevation piñon (*Pinus* spp.)-juniper (*Juniperus* spp.) woodlands in the southwestern United States, particularly where junipers predominate over piñon (Barlow et al. 1999, Schlossberg 2006). Although the Gray Vireo is not federally listed, the New Mexico Department of Game and Fish (2008) lists Gray Vireo as threatened in the State. In New Mexico, piñon-juniper habitat is widespread, but junipers are frequently cleared in an attempt to restore historical ecological conditions, increase forage production for livestock, or to conserve watersheds. In northwestern New Mexico, thousands of oil and gas wells dot the landscape, many in Gray Vireo habitat (Reeves 1999, Wickersham and Wickersham 2006). It is unknown to what extent oil and gas leasing and local juniper treatments affect Gray Vireos in New Mexico.

Because Gray Vireo habitat, threats, and/or management concerns vary regionally, we conducted monitoring projects in several locations in New Mexico from 2005–2007. During this time, we monitored a small number of Gray Vireo pairs in the Guadalupe Mountains of southeastern New Mexico; in 2007, we also monitored vireos in northwestern New Mexico, near Bloomfield. We presented three objectives at the 2008 Gray Vireo Symposium. First, we presented territory monitoring results for our sites in northwestern and southeastern New Mexico, including nest success, nest parasitism, and productivity. Second, we identified regional differences and evaluated regional threats. Finally, we presented results of point count surveys in juniper woodland, near Lybrook, New Mexico, that was slated for vegetation treatments (particularly sagebrush thinning). Although our projects were small and, perhaps, not indicative of regional associations, often what we learn with small projects can help us understand a variety of different situations and contribute to the formation of management guidelines.

METHODS

TERRITORY MONITORING

In the Guadalupe Mountains of southeastern New Mexico, we monitored 10–14 Gray Vireo territories from 2005–2007 in the Lincoln National Forest along Highway 137, about 10 km east of Queen, Eddy County. In northwestern New Mexico, we selected 10 Gray Vireo territories to monitor in 2007 on Bureau of Land Management land in Gobernador Canyon, about 25 km east of Bloomfield, San Juan County. We visited territories approximately every 10 days between early May and mid-July, or as often as necessary to determine nesting outcome. During each monitoring visit, we noted the number of Gray Vireo eggs and nestlings present, as well as the number of Brown-headed Cowbird (*Molothrus ater*) eggs and nestlings in each Gray Vireo nest. In this expanded abstract, we present nest success as the percentage of nests fledging at least one Gray Vireo. We present nest parasitism as a percentage of parasitized nests, defining a parasitized nest as a nest observed to contain a cowbird egg or nestling at any time while the nest was active. We present productivity as the average number of Gray Vireos fledged from successful nests.

POINT COUNT SURVEYS

We conducted point count surveys at 48 survey points in three proposed vegetation treatment plots and one control plot totaling 340 ha on Crow Mesa, along Highway 550 near Lybrook, New Mexico. Thirty-five survey points were on treatment plots and 13 survey points were on the control plot. The

size of the plots and our spacing of points at least 250 m apart prevented the establishment of more than 48 points. Treatment plots were generally restricted to mesa tops that contained juniper savanna; one plot contained substantial sagebrush. We visited each point once in June 2007 and recorded all birds seen or heard for five min while standing at the point. We began surveys within 30 min after sunrise and concluded within four hrs; completion of surveys at all 48 points took three mornings. We present the number of Gray Vireos detected and all other federal or state-listed species, and United States Fish and Wildlife Service Birds of Conservation Concern (2002).

RESULTS

TERRITORY MONITORING

In the Guadalupe Mountains, we located 32 nests from 2005–2007 and documented parasitism by Brown-headed Cowbirds at 16 of the 26 (62%) nests where parasitism could be determined (Table 1). At both sites, parasitism could not be determined at all nests because some nests apparently failed before we could verify that a full clutch was laid. Of the 27 nests in which the outcome was determined, 8 (32%) fledged at least one Gray Vireo young (Table 1). An average of 1.7 Gray Vireo young fledged per successful nest.

In northwestern New Mexico, we monitored 11 Gray Vireo nests in 2007 (Table 1). Unlike the Guadalupe Mountains site, we found only one case of nest parasitism (1 of 9 nests; 11%). Three Gray Vireo nests (27%) fledged young and eight nests (73%) apparently failed. Successful nests fledged an average of 2.7 vireos. Gray Vireos nested an average 338 m from the nearest gas well pad (range = 120–636 m, n = 11).

TABLE 1. Summary of Gray Vireo (*Vireo vicinior*) territories monitored in the Guadalupe Mountains of New Mexico from 2005–2007 and in northwestern New Mexico in 2007.

	Guadalupe site	Northwestern site
Territories monitored	10–14 / year	10
Nests monitored	32	11
Nests parasitized	16 of 26, 62%	1 of 9, 11%
Nests fledging vireos	8 of 27, 32%	3 of 11, 27%
Vireo productivity	1.7 young / successful nest	2.7 young / successful nest

In addition to higher parasitism and lower average productivity at Gray Vireo nests in the Guadalupe Mountains, we noted several differences between regions. Gray Vireos at the northwestern site nested almost exclusively in junipers (10 of 11; 91%), whereas vireos at the Guadalupe Mountains site regularly nested in either oaks (13 of 32; 41%) or junipers (17 of 32; 53%). Gray Vireos at the northwestern site nested higher (averaged about 3 m above the ground) than vireos at the Guadalupe Mountains site (averaged < 2 m).

POINT COUNT SURVEYS

We observed 35 bird species during point count surveys in 2007, including 20 Gray Vireos. Seven Gray Vireos were recorded during surveys on the control plot and 13 were recorded during surveys on the treatment plots. In the plot with substantial sage, we observed two United States Fish and Wildlife Service Birds of Conservation Concern (2002), both sage-obligate species: Brewer's Sparrow (*Spizella breweri*) and Sage Sparrow (*Amphispiza belli*).

DISCUSSION

Our results demonstrate regional differences in Gray Vireo nesting ecology and the need to formulate management guidelines that are responsive to this variation. In northwestern New Mexico, gas and oil development should be considered as a potential future threat to Gray Vireos. Gas and oil wells probably have little effect on Gray Vireo nest-site selection, or at least do not deter breeding by the species, but continued leasing and development might affect territory selection by reducing and fragmenting suitable habitat in the future. In this current period of almost certain oil and gas expansion in northwestern New Mexico, annual Gray Vireo studies are strongly advised to identify current nesting population size, potential population changes, and evaluate current levels of threat.

Juniper reduction is potentially a more widespread threat, although the Guadalupe Mountains, with its more rugged topography and greater shrub species diversity, might be less vulnerable than other areas. Juniper reduction likely affects Gray Vireo and other breeding birds strongly associated with junipers, including Gray Flycatcher

(*Empidonax wrightii*) and Juniper Titmouse (*Baeolophus griseus*). Generally, we recommend that land managers avoid treating junipers in occupied Gray Vireo habitat during the nesting season (late April through August) or do so only after thorough surveys for nesting birds. At our point count monitoring site, we extend this recommendation to sagebrush habitats to avoid impacts to other listed and sensitive species.

CONCLUSIONS

- The variety of threats and unique characteristics of Gray Vireo breeding ecology demands different solutions and management guidelines to accommodate this variety.
- Gray Vireos might still be locally common, and even numerous in limited areas, but we should not underestimate current and future threats in occupied habitats.

ACKNOWLEDGMENTS

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Density and Habitat Use of Gray Vireos in the San Juan Basin Natural Gas Field in Northwestern New Mexico

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INTRODUCTION

Probably the greatest threat to the Gray Vireo (*Vireo vicinior*) in New Mexico is habitat degradation due to land management activities (Barlow et al. 1999) and clearing for development. In the San Juan Basin, natural gas development has fragmented habitats that were once relatively undisturbed by stripping areas of vegetation for the construction of well pads, roads, and pipelines. Natural gas development in the San Juan Basin has accelerated in recent years and is projected to continue. Therefore, it is important that wildlife managers assess how these activities affect breeding bird communities.

The objectives of this study were to establish baseline estimates of Gray Vireo density in northwestern New Mexico, where natural gas wells are present at relatively high densities, and to identify habitat characteristics that might be important to vireos during the breeding season.

METHODS

The study was conducted in 2006 and 2007 on Bureau of Land Management (BLM) lands in San Juan and Rio Arriba counties, New Mexico. Each year, we randomly established 29 1.75-km transects in piñon (*Pinus* spp.)-juniper (*Juniperus* spp.) habitat and conducted distance sampling using the line-transect method (Buckland et al. 1993) to estimate Gray Vireo density and identify occupied habitat. Surveys were conducted between mid-May and late-June and occurred between about sunrise and 1100 MDT.

Habitat sampling followed a modified BBIRD protocol (Martin et al. 1997). We measured elevation, slope, aspect, mean tree height, tree and snag density, canopy cover, mean tree diameter at ankle height (DAH), shrub density, and percentage of various types of live and non-live groundcover at Gray Vireo locations and randomly selected locations. Live groundcover categories included shrubs, grasses and forbs; non-live groundcover included bare ground, rock, litter, and woody debris that was ≥ 8 cm diameter at breast height. Using ESRI ARCMAP Version 9.2 (ARCMAP), we measured the distance from each vireo detection and random point to the nearest: 1) natural gas well; 2) road; and 3) habitat edge. We also quantified the number of wells within 2-km and 5-km radii of each detection and random point using Geographic Information System (GIS) files of well locations obtained from the New Mexico Department of Natural Resources, Oil Conservation Division.

We analyzed line transect data using program DISTANCE (Thomas et al. 2003) and selected the best model to estimate density using Akaike's Information Criterion for small sample size (AIC_c). Model fit was evaluated using a Chi-square goodness-of-fit test where higher *P*-values indicated that the data were a good fit to the model.

Habitat and GIS data were analyzed using SYSTAT 12. For continuous variables, we compared means of detection and random plots as well as effect size and 95% confidence interval (CI) around effect size (Anderson et al. 2001, Di Stefano 2004). For categorical variables, we used a Chi-

TABLE 1. Best models generated in DISTANCE for Gray Vireo (*Vireo vicinior*) survey data collected in San Juan and Rio Arriba counties, New Mexico in 2006 (n = 23) and 2007 (n = 29).

Year	Model	Density (birds/ha ± SE)	95% CI	% CV	AIC_c
2006	Uniform	0.044 ± 0.013	0.025−0.080	29.80	70.31
2007	Hazard	0.066 ± 0.028	0.029−0.151	42.40	84.20

TABLE 2. Results of significant ($P \leq 0.15$) univariate logistic regression analysis for habitat variables at Gray Vireo (*Vireo vicinior*) detection plots (n = 46) and randomly selected plots (n = 50) in San Juan and Rio Arriba counties, New Mexico.

Habitat Variable	Estimate ± SE	Z	*P*
Elevation (m)	0.004 ± 0.002	2.082	0.037
Number of trees 0.5–2.0 m tall	0.153 ± 0.103	1.485	0.138
Number of trees > 4.0 m tall	-0.151 ± 0.090	-1.674	0.094
Downed woody debris	-0.728 ± 0.429	-1.699	0.089

square test of association to compare detection and random plots. We used binary logistic regression to identify habitat variables that might be important to Gray Vireos. We reduced the number of candidate variables using univariate logistic regression (Hosmer and Lemeshow 1989), retaining variables that differed between occupied and random plots ($P \leq 0.15$). We performed multiple logistic regression on the full model and all subsets and used AIC_c to rank the models (Anderson et al. 2001).

RESULTS

The best density estimates for Gray Vireo were 0.044 vireos/ha (± 0.013 SE) in 2006 and 0.066 vireos/ha (± 0.028 SE) in 2007 (Table 1). Chi-square goodness-of-fit tests indicated the data were a good fit in the 2006 ($\chi^2 = 1.916$, df = 4, $P = 0.751$) and 2007 ($\chi^2 = 0.531$, df = 2, $P = 0.767$) models.

Habitat sampling and GIS analyses were conducted at 46 Gray Vireo detection and 50 random sites. Elevation (m) was the only variable that differed between detection (1964.0 ± 16.2 [SE]) and random plots (1917.7 ± 14.2 [SE]; Effect Size = 46.3, 95% CI = 3.5−89.2).

We retained four habitat variables for multiple logistic regression analysis including elevation, number of trees 0.5−2.0 m tall, number of trees > 4.0 m tall, and the percent of the ground covered by downed woody debris (Table 2). The four best models ($AIC_c < 2$) indicated that occupied Gray Vireo habitat was likely to be slightly higher in elevation than randomly selected habitat (Table 3). Three of these models also indicated that occupied habitat was likely to contain less downed woody debris than randomly selected habitat. Two models indicated that vireo habitat was likely to have fewer trees > 4.0 m tall, and one model showed that vireo habitat was likely to contain more trees between 0.5 and 2.0 m than randomly selected habitat (Table 3).

DISCUSSION

Our density estimates are similar to other recent studies conducted using similar survey techniques in Colorado, Arizona, and Utah (Table 4). Therefore, our data suggest that Gray Vireo density in the San Juan Basin is similar to that across much of the species' range.

Our habitat data suggests that Gray Vireos might be selecting younger piñon-juniper stands than the proportion of available habitat in the study area, as occupied habitat contained fewer tall trees (> 4 m) and more, shorter trees (< 2 m) compared with random locations. Occupied habitat also contained less downed woody debris than the randomly selected habitat. Woody debris might be related to stand age, and younger stands likely contain fewer dead and decaying trees. None of these trends was reported by Schlossberg (2006),

TABLE 3. Logistic regression models predicting Gray Vireo (*Vireo vicinior*) use areas (n = 46) compared with random habitat (n = 50) in Rio Arriba and San Juan counties, New Mexico.

Model [a]	AIC_c	ΔAIC_c	-2loge(L)	*w* [b]	*P* [c]
-10.099+(0.006 E)+(-1.113 W)	128.758	0.000	122.158	0.098	0.005
-10.545+(0.006 E)+(-0.130 T4)+(-0.878 W)	129.342	0.584	120.316	0.073	0.006
-9.809+(0.006 E)+(0.116 T2)+(-1.101 W)	129.942	1.184	120.916	0.054	0.007
-9.433+(0.005 E)+(-0.187 T4)	130.328	1.570	123.728	0.045	0.010

[a] E = Elevation; T2 = number of trees 0.5−2.0 m tall; T4 = number of trees > 4 m tall; and W = % of woody debris

[b] Akaike weight

[c] Probability values from χ^2 test of model significance

TABLE 4. Comparison of Gray Vireo (*Vireo vicinior*) density estimates from Wickersham and Wickersham (2006, 2007) with four recent studies in the United States Southwest utilizing distance sampling.

Location	Density (birds/ha)	Reference
Northwest New Mexico	0.044	Wickersham and Wickersham 2006
Northwest New Mexico	0.066	Wickersham and Wickersham 2007
Arizona and southern Utah	0.064	Schlossberg 2006
Western Colorado and southern Utah	0.069	Hutton et al. 2006
Western Colorado	0.055	Giroir 2001
Colorado	0.060	Colorado BLM 1995

who conducted the only other extensive study of Gray Vireo habitat use across the species' range.

Our habitat models also indicated that Gray Vireos might prefer habitat slightly higher in elevation than the average elevation in our study area. Schlossberg (2006) also reported a relationship between elevation and Gray Vireo density in Arizona and Utah. However, density was lower at higher elevations (> 1900 m) in his study area compared with lower elevations (1500−1900 m). Although habitat was similar, elevation was slightly lower in his study area (approximately 1550−2100 m) compared with our study area (1725−2228 m); and, in our study, 74% of Gray Vireo detections occurred above 1900 m. Johnson (1972) also reported a higher elevation range (1830−2100 m) for Gray Vireos in Nevada.

Density of natural gas wells and proximity of wells and roads did not appear to influence Gray Vireo distribution in the San Juan Basin; or, if so, the effect has already been realized within the breeding population. However, well density was relatively high (39 wells/2-km radius and 244 wells/5-km radius). Therefore, there might be few places to establish a relatively undisturbed territory.

CONCLUSIONS

Gray Vireo density in the San Juan Basin appears to be similar to that across much of its breeding range. In addition, structural habitat characteristics appear to have more influence on occupancy than infrastructure associated with natural gas development. There are no historical data on Gray Vireo distribution, density, or abundance prior to the natural gas exploration boom in the San Juan Basin. Thus, additional studies comparing relatively contiguous piñon-juniper habitat with that of the San Juan Basin are needed to determine if natural gas exploration has any measurable impacts on distribution, density, and habitat use. Potential comparison sites with larger, relatively undisturbed tracts of piñon-juniper woodlands include the adjacent Navajo Indian Reservation to the west, some of which occurs within the San Juan Basin gas field. Alternatively, if no measurable contiguous habitat can be identified, our study provides baseline data to which further studies in the San Juan Basin might be compared over time.

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Modeling Gray Vireo Habitat – General Considerations

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INTRODUCTION

The development of robust models of Gray Vireo (*Vireo vicinior*) habitat would permit management agencies to better assess population health and conservation status. Construction of a Geographic Information System (GIS) habitat model for a species appears relatively straight forward: determine the consistent characteristics of known habitat and, through manipulation of those characteristics, predict habitat in known and unknown areas. To develop site specific models for the Gray Vireo, we reviewed nest locations and habitat at four Department of Defense (DoD) installations in New Mexico: the New Mexico Army National Guard Camel Tracks Training Site, Kirtland Air Force Base, White Sands Missile Range, and Fort Bliss Military Range (Arbetan et al. 2006, Johnson et. al. 2007, Natural Heritage New Mexico unpubl. data). These sites cover diverse geographic areas of the Caja del Rio Plateau west of Santa Fe, the west slope of the Manzano Mountains, and the San Andres and Organ mountains. At these locations, Gray Vireos seem to prefer a specific range of juniper (*Juniperus* spp.) or piñon (*Pinus* spp.)-juniper nesting tree densities that are dominant over competing tree species and that are found in the vicinity of moderate slopes that form open bowl or drainage topographies.

METHODS

For the four New Mexico DoD installation sites, modeling Gray Vireo habitat requires GIS layers of vegetation type, vegetation density, bowls, and drainages. Our methods were generally to use current GIS layers with these characteristics and construct new layers of habitat quality. Locations with juniper or juniper and piñon at specific densities found in rolling hills with bowl or shallow drainage topographies are classified as habitat. Other combinations, such as low tree densities found outside of rolling topographies, are classified as non-habitat. However, automated and interactive modeling techniques rely on GIS layers that are surrogates of biophysical landscape characteristics. Thus, modeling Gray Vireo habitat employs GIS layers that are themselves models of vegetation type, vegetation density, bowls, and drainages. When these models do not exist at the appropriate scale, they must be made from GIS layers that do exist. For example, Kirtland Air Force Base had high-precision field-survey data, but no vegetation map for distinguishing plant communities. At Kirtland, we used 10-m digital elevation models to delineate topographic features and photo interpreted 1-m color infra-red orthophotography to delineate plant community characteristics (Fig. 1). At larger sites, such as the San Andres Mountains, a lack of specific site locations together with the large extent of the area of interest required us to scale up spatially to derive the model using existing vegetation maps (Muldavin et al. 2000).

RESULTS AND DISCUSSION

The consistent habitat characteristics at the four DoD installations suggest a general model with wide applicability, perhaps across the Gray Vireo breeding range, is possible. However, there are nesting sites on flat mesa tops in northern New Mexico (Reeves pers. comm.) and in areas dominated by other tree species in southern New Mexico. This suggests that, at the four installations, nest tree density and topography are indicators of a more fundamental characteristic.

Thermoregulation is a critical physiological and behavioral feature of organisms, and birds have evolved a host of features to regulate both their own body temperature and that of their eggs and nestlings. We postulate that Gray Vireos establish nests in areas that have a particular thermal zone. At the New Mexico Army National Guard's Camel

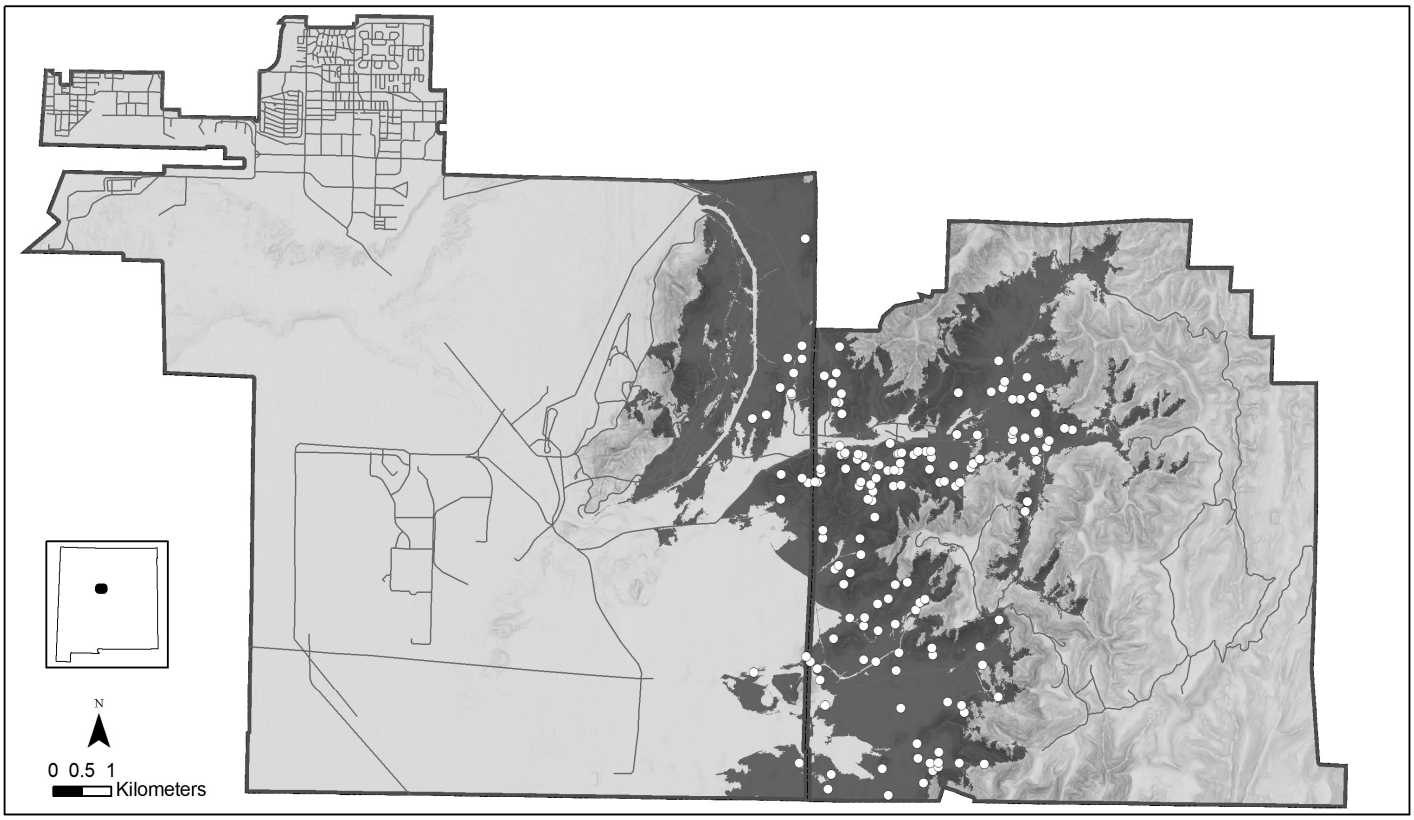

FIGURE 1. Potential Gray Vireo (*Vireo vicinior*) habitat on Kirtland Air Force Base, New Mexico shown in black. White circles are use sites.

Tracks Training Site, where we have seven years of Gray Vireo monitoring data, we quantified solar radiation over the time of nest establishment and used these data as indicator metrics. These metrics correlate well with attempted nesting (Fig. 2). We hope to use these metrics, together with tree species metrics, to test nest location data across New Mexico. Also, protocols for measuring solar radiation in the field are needed to understand what the model-derived metrics are explaining, other than demonstrating a positive correlation with known and currently unknown breeding sites and negative correlation with poor habitat.

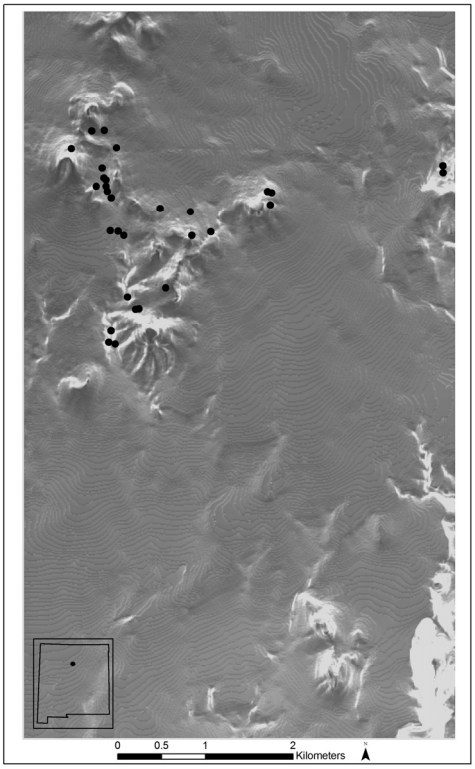

FIGURE 2. Gray Vireo (*Vireo vicinior*) solar radiation model for Camel Tracks Training Site, New Mexico. White areas identify potential solar suitability. Black circles are nest sites.

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Conclusions and Next Steps

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Overview

This symposium was organized as a forum for disseminating current scientific information necessary for making decisions directed at ensuring the long-term persistence of the Gray Vireo (*Vireo vicinior*) in New Mexico. In addition, an attempt was made during the roundtable discussion to encourage dialogue and promote problem-solving discussions among land managers, scientists, and other stakeholders. The symposium contributors reported salient results from their current research on the Gray Vireo in New Mexico. They also identified threats to the Gray Vireo at their study areas, and they proffered some research and management needs. These topics were further explored during the roundtable discussion (Appendix 1).

Research Results: Population Status and Trends

In DeLong and Williams (2006), the authors concluded that there was little evidence of increasing or decreasing population trends for the Gray Vireo in New Mexico. Information presented during the symposium did not increase our knowledge of the status of the Gray Vireo in the State; none of the studies included in the symposium were of sufficient duration to determine population status and trends at the respective study areas.

However, the symposium contributors did validate that population sizes vary across the State, likely in relation to availability of suitable habitat and survey effort. Population sizes ranged from 37 territories in the Sacramento Mountains (Britt and Lundblad) to 8 territories in 2006 on Kirtland Air Force Base (Frei and Finley). We also learned that breeding effort varies from year to year, likely influenced by such factors as weather patterns (Frei and Finley).

DeLong and Williams (2006) estimated a minimum population size for Gray Vireos in New Mexico of between 549 and 827 birds and at least 418 territories. As new populations, such as those on Fort Bliss (Britt and Lundblad), are discovered with increasing survey effort, our estimates of the statewide Gray Vireo population will increase in size and accuracy.

Research Results: Habitat Use

Information was presented on breeding habitat use by the Gray Vireo at three spatial scales: landscape (where in New Mexico the species occurs), macrohabitat (where territories are placed on the landscape), and microhabitat (where nests are located within a territory).

At the landscape scale, we learned that Gray Vireos breed across most of New Mexico, from the southeastern part of the State (such as in the Organ, Sacramento, and Guadalupe mountains) to the northwestern part of the State (such as in the Four Corners area).

At the macrohabitat scale, we learned that Gray Vireos will occupy a variety of vegetation community types, including desert riparian communities along drainages in southern New Mexico (Britt and Lundblad), juniper (*Juniperus* spp.)-oak (*Quercus* spp.) woodland in southeastern New Mexico (Stake and Garber), juniper woodland and savanna in central and western New Mexico (Frei and Finley), and piñon (*Pinus* spp.)-juniper woodland in north and northwestern New Mexico (Stake and Garber, Wickersham and Wickersham). Although vegetation community type can be a useful indicator of whether Gray Vireos occur in an area, vegetation communities vary geographically. We learned that there are a number of variables that potentially can predict Gray Vireo occupancy across vegetation community types, including:

- Tree and shrub density;
- Tree and shrub height;
- Forest stand age;
- Presence of downed woody debris;

- Elevation;
- Topography, such as drainages and bowls; and
- Energy inputs.

Occupancy of habitats by Gray Vireo was not found to be related to density of natural gas wells nor to proximity of wells and roads in northwestern New Mexico.

At the microhabitat scale, we found out that Gray Vireos primarily build their nests in juniper, but that they also will nest in other trees and shrubs, such as piñon, oak, mountain mahogany (*Cercocarpus montanus*), and sumac (*Rhus virens*). Furthermore, we learned that Gray Vireos will build their nests at various heights and locations within a tree, but that they tend to build their nests 1 to > 6 m high in the outermost section of vegetation.

THREATS

Several threats to Gray Vireo were identified by the symposium contributors, including habitat loss due to such human activities as juniper removal, disturbance on military lands, and, potentially, the development of biofuel energy power plants. Another identified threat to the vireo was brood parasitism by the Brown-headed Cowbird (*Molothrus ater*). However, prevalence of brood parasitism varied among sites. For example, Stake and Garber reported that 62% of the nests found in the Guadalupe Mountains were parasitized, while only 11% of nests near Farmington were parasitized. The effects of oil and gas development on Gray Vireos were not clear. Density of natural gas wells and proximity of wells and roads did not appear to influence Gray Vireo breeding abundances in the northwestern part of the State, but such anthropogenic disturbance might indirectly negatively affect Gray Vireo nesting success by influencing population parameters of predators and Brown-headed Cowbirds.

RESEARCH NEEDS

The wealth of scientific information presented at the symposium is a good indication of the progress that has been made towards understanding Gray Vireo biology and ecology in New Mexico. Nonetheless, a number of information gaps remain. Specifically, more information is needed on Gray Vireo: 1) distribution across the State; 2) population trends; 3) dietary requirements; 4) habitat requirements at multiple spatial scales; and 5) tolerances for a wide spectrum of human activities. Furthermore, which factors currently most limit Gray Vireo populations throughout their annual cycle and the effects of climate change on Gray Vireo population parameters need to be elucidated.

MANAGEMENT NEEDS

Although Gray Vireos have begun to be included in management discussions and decisions, targeted and effective conservation strategies for the Gray Vireo have not been implemented statewide. Factors identified as most limiting to management and conservation progress were the lack of 1) standardized survey protocols and 2) sound management guidelines that specify disturbance limits, buffer requirements, and habitat condition (e.g., tree density) requirements.

NEXT STEPS

In order to fulfill its mandate to protect the Gray Vireo, the New Mexico Department of Game and Fish (NMDGF) has supported the creation of a working database of sighting and nest site locations (DeLong and Williams 2006). NMDGF also supported the preparation of a report (DeLong and Williams 2006), which reviewed the distribution, status, and biology of the Gray Vireo in New Mexico and suggested a survey protocol for clearance-type inventories (see Appendix 2). In 2007, the *Gray Vireo (Vireo vicinior) Recovery Plan* (Pierce 2007) was completed.

This symposium was another benchmark in the recovery process. In order to best manage and protect the Gray Vireo in New Mexico, we need to build upon the success of the symposium by taking steps to fill information gaps and address management needs. It was the intent of the symposium to inspire collaborative efforts to protect the vireo, and we now need to:

- Maintain high levels of cooperation and coordination among interested parties.
- Complete studies that go beyond documenting presence or absence and improve our knowledge of the vireo's biology and status. Specifically, multi-year studies are needed that involve both proven methods and new technologies.

- Encourage wide scale sharing of information and data.
- Develop land management guidelines, and effective agreements and strategies for recovering the Gray Vireo in New Mexico.

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Appendix 1. Roundtable Discussion Minutes

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TABLE 1. Name, affiliation, and E-mail addresses of the two facilitators and 19 participants of the Gray Vireo Symposium roundtable discussion held 1300 to 1500 MDT on 12 April 2008 in Albuquerque, New Mexico.

Name	Affiliation	E-mail
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BACKGROUND

The roundtable discussion was well attended by people from different professional and personal backgrounds (Table 1). During the roundtable discussion, the symposium chair posed a series of questions to the participants to generate responses useful for developing future research on and management actions for the Gray Vireo (*Vireo vicinior*). A common thread of the roundtable discussions was that there is much to learn about the Gray Vireo and that scientists, researchers, and land management agencies alike are looking for guidance and effective strategies for action.

TOPIC 1: GRAY VIREO RESEARCH AND MONITORING NEEDS

WHAT ARE THE MONITORING PRIORITIES?

The top monitoring priority is to conduct surveys to determine all the locations where the Gray Vireo occurs in New Mexico. To best coordinate and facilitate monitoring across the State, perhaps a statewide Gray Vireo monitoring program should be developed by the Gray Vireo Recovery Team and peer reviewed by partners. To be successful, a statewide Gray Vireo monitoring program should define which variables should be measured, which data should be captured, and

whether emphasis should be placed on extensive versus intensive monitoring. Furthermore, areas for targeted surveys should be prioritized; areas that haven't been previously surveyed (e.g., Navajo Nation lands, Pueblo lands) are a survey priority.

Complimentary to developing a statewide Gray Vireo monitoring program, the database initiated by DeLong and Williams (2006) needs to be expanded to include new data from monitoring efforts, management activities, and research investigations across New Mexico. Accordingly, an information/data warehouse needs to be identified (possibly the Natural Heritage New Mexico) that can analyze the data and reach out to potential partners to acquire new data.

WHAT ARE THE MONITORING PRIORITIES?

The following research topics are a priority for investigation (the top three priority research topics are indicated by *):

- *Important predictors (e.g., patch size, tree density) of habitat selection at multiple scales;
- *Threats, on the breeding grounds, e.g., parasitism by the Brown-headed Cowbird (*Molothrus ater*), habitat loss, predation, grazing;
- Threats on wintering grounds, e.g., contaminants;
- Location of wintering grounds, which could involve employing banding and stable isotopes to link banding sites on the wintering and breeding grounds;
- Migration routes and stopover ecology;
- Population connectivity among the Western States;
- *Population viability, trends, and causes of any declines;
- Important predictors of reproductive biology, including nest success;
- Site fidelity;
- Diet;
- The effects of juniper (*Juniperus* spp.) encroachment on Gray Vireo and whether it is associated with increasing or decreasing Gray Vireo populations; and
- Associated/sympatric species (birds, mammals, herps, etc.) across regions and how they are affected by protection of the Gray Vireo and its habitats. E.g., will species, such as Pinyon Jay (*Gymnorhinus cyanocephalus*), Black-throated Gray Warbler (*Dendroica nigrescens*), and Gray Flycatcher (*Empidonax wrightii*), be positively affected? Will cavity nesters that need snags, such as Juniper Titmouse (*Baeolophus ridgwayi*), Bewick's Wren (*Thryomanes bewickii*), and Ash-throated Flycatcher (*Myiarchus cinerascens*), be negatively affected?

WHAT ARE THE POTENTIAL FUNDING SOURCES?

Potential funding sources for research and monitoring efforts include the United States Department of Defense Legacy Grant, the United States Department of Defense Strategic Environmental Research and Development Program, The New Mexico Department of Game and Fish Share with Wildlife Grant, the United States Bureau of Land Management, and the United States Fish and Wildlife Service (e.g., funding under the Neotropical Migratory Bird Conservation Act, State Wildlife Grants, and Section 6).

TOPIC 2: THREATS TO THE GRAY VIREO

WHAT ARE THE PRIMARY THREATS?

- Habitat loss;
- Brood parasitism by the Brown-headed Cowbird; and
- Nest predators.

HOW DO WE BEST ADDRESS THE THREATS?

- A regional approach is needed to determine which areas with juniper encroachment can be restored to grasslands and savanna woodlands and which areas need to be protected (e.g., from juniper thinning) for the Gray Vireo.
- Guidance is need regarding how many acres of used and potential Gray Vireo habitat across New Mexico per region are needed to maintain flourishing Gray Vireo populations.

WHO ARE THE LAND MANAGERS PROPOSING OR IMPLEMENTING ACTIONS THAT POSE THREATS?

- A pie chart is needed quantifying the percentage of the known Gray Vireo population or potential Gray Vireo habitat by land management agency.
- It is likely that the United States Bureau Land Management has the largest stewardship role for the Gray Vireo in New Mexico.
- The Navajo Nation might also have a large stewardship role for the Gray Vireo in New Mexico.

How do we best coordinate with Land Management agencies to protect the Gray Vireo?

- Through the on-line forum, in emailings to the Gray Vireo Recovery Team, and in press releases.
- There needs to be a consistent commitment to information dissemination.
- Perhaps requests should be made to land management agencies to sign letters of concurrence stating that they will consider the Gray Vireo in their management actions.

Topic 3: Adaptive guidelines to protect and improve Gray Vireo habitat

Who should develop The Guidelines?

- The Gray Vireo Recovery Team.

Which elements should the adaptive guidelines include?

- Guidance on completing surveys and nest searches prior to and after management actions;
- Buffers required for various management actions;
- Tree thinning prescriptions; and
- Priority areas for research, monitoring, and management.

Appendix 2. Recommended Protocol for Surveying for Gray Vireos in New Mexico

Adapted From: DeLong, J. P. and Williams, S. O., III. 2006. Status Report and Biological Review of the Gray Vireo in New Mexico. New Mexico Department of Game and Fish, Santa Fe, New Mexico.

Habitats to Survey

The Gray Vireo (*Vireo vicinior*) uses three main types of habitats in New Mexico. In the northern part of the State and on the Colorado Plateau, the species uses piñon (*Pinus* spp.)-Utah juniper (*Juniperus osteosperma*) stands 5800–7200 ft in elevation. In the central and western parts of the State, Gray Vireos typically use oneseed juniper (*J. monosperma*) savannas 5500–7000 ft in elevation. In the southern and southeastern parts of the State, the species uses mixed juniper-oak (*Quercus* spp.) woodlands and desert riparian communities 4300–6600 ft in elevation. Any project site that falls into these habitat types and elevations should be surveyed for Gray Vireos prior to conducting project or management activities.

When to Survey

The species arrives on breeding areas in New Mexico in late April in the south and early May in the north. Surveys can begin early May in the south and central parts of the state, and by mid-May in the north. Surveys can be conducted through July, but the most reliable period is May and June. Some pairs can be hard to detect later in the breeding season because they have failed in their nesting attempts and abandoned their territories by July (DeLong and Cox 2005).

Time of Day

Gray Vireos can sing all day, but, during the hottest parts of the breeding season, they can be considerably quieter after noon. Thus, the best time to survey for this species is between dawn and noon.

How Many Times to Survey

Ideally, one set of surveys should be conducted during May. If vireos are found, then the surveys can be considered complete. However, if no Gray Vireos are detected, then a second set of surveys should be conducted in mid- to late June[1]. This recommendation derives from our observation that, in dry years, Gray Vireos can delay nesting and be fairly difficult to detect. A second set of surveys increases the chances that a population would be detected if surveys were conducted during a time when vireos were not particularly vocal.

Survey Methods

Tape-playback surveys should be conducted. Purely listening surveys can allow detection of Gray Vireos, but tape-playback surveys can locate as many as twice the number of territories.[2] In addition, although Gray Vireos are known for being vociferous, they can be quiet for considerable periods of time during the day. The quiet periods can be long enough for a passive listener to conclude the species is not present in a spot and move on. In addition, after the arrival and courtship portion of the breeding season, the birds can be less vocal and, therefore, harder to detect without the use of tape-playback methods. Therefore, when clearance-type surveys are required for pre-project activities, tape-playback methods should be used.

The standard song of the Gray Vireo should be played from points spaced 200–300 m apart, depending on habitat quality, topography, and locations of other Gray Vireos. The closest spacing of Gray Vireo territories (territory center to territory center) in New Mexico is about 200–300 m, suggesting that point-spacing of 200–300 m will allow detection of most territories. In addition, Gray Vireos can respond to the tape-playback calls from distances of 100 m or more, indicating that broadcast stations can effectively locate birds within about 150 m or so of the station.

[1] The current recommendation is that at least two additional surveys be completed May – late June.

[2] The question of whether the use of tape-playback methods causes undo disturbance is currently unanswered. There are no studies to demonstrate a negative effect of tape-playback surveys on the Gray Vireo, and the currently available data suggest that sites surveyed without the use of tape-playback experience similar levels of nest success as sites surveyed with tape-playback methods.

Each survey stop should begin with a listening period of 1–2 min, followed by 20–30 sec of broadcast, another 1–2 min of listening, 20–30 sec of broadcast, and end with 1–2 min of listening. Longer listening times after broadcasting can be helpful at times. The direction of broadcasting should rotate 360 degrees during the survey.

DATA COLLECTION

The following information should be recorded for each Gray Vireo survey:

- Site name, county, and distance and direction from nearest town;
- Date;
- Start and stop time;
- Observer's full name;
- Weather (e.g., wind-speed, temperature, cloud cover, precipitation);
- Habitat type;
- Location of each point surveyed whether Gray Vireos were detected or not (Universal Transverse Mercator coordinates or latitude/longitude coordinates of each point should be determined with a Global Positioning System [GPS] unit if possible), along with county and approximate distance to the nearest town;
- Number of Gray Vireos heard or seen;
- Age and sex of individuals seen (e.g., 2 adults with 1 fledgling);
- Exact location of birds seen (preferably using a GPS receiver);
- If exact location cannot be obtained, the distance and direction of the bird from the survey point;
- Presence of Brown-headed Cowbirds (*Molothrus ater*) and cattle at each point; and
- Habitat of survey area, including observations of habitat manipulations (cutting, burning, or development) at each point.

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