Gray Vireo (*Vireo vicinior*) Status Assessment and Nest Monitoring to Investigate Causes of Decline in California

Final Report

February 27, 2014

Prepared for:
California Department of Fish and Wildlife
&
Cleveland National Forest

Prepared by:
Lori Hargrove & Philip Unitt
San Diego Natural History Museum

Nongame Wildlife Program Report 2014-01

California Department of Fish and Wildlife, Wildlife Branch

Sacramento, California

Author contact information:
Lori Hargrove
Philip Unitt
Department of Birds & Mammals
San Diego Natural History Museum
1788 El Prado
San Diego, CA 92101
lhargrove@sdnhm.org
punitt@sdnhm.org

Cover photos: (left) singing male Gray Vireo, San Diego County, 15 April 2012. Photo by Matt Sadowski. (right) Gray Vireo nest containing three vireo eggs and one cowbird egg, nest placed in redshank (*Adenostoma sparsifolium*), San Diego County, 28 May 2012. Photo by Lori Hargrove.

RECOMMENDED CITATION:

Hargrove, L., and P. Unitt. 2014. Gray Vireo (*Vireo vicinior*) status assessment and nest monitoring to investigate causes of decline in California. Wildlife Branch, Nongame Wildlife Program Report 2014-01. California Department of Fish and Wildlife, Sacramento; www.dfg.ca.gov/wildlife/nongame/publications/.

Table of Contents

Summary **1**
Background **2**
Purpose of the Study 2
Breeding Status/Distribution 3
Breeding Ecology/Threats 3
Winter 5
Methods **6**
Two Proposed Tasks 6
Description of Video Camera Set-ups 7
Results **8**
Brief Summary of Major Findings 8
Statewide Status and Distribution 8
Population Status and Distribution in San Diego County 15
Population Status and Distribution in San Jacinto Mtns, Riverside County 19
Territory Monitoring 19
Nest Monitoring 21
Video Monitoring 28
Discussion **30**
Statewide Status 30
Reproductive Success in San Diego County 31
Current Threats and Management Implications 32
Future Research Needs 35
Acknowledgements **36**
Literature Cited **36**
Appendices (8) **39**

Summary

Since 1940, California populations of the Gray Vireo have collapsed, presumably because of parasitism by the Brown-headed Cowbird, which invaded the vireo's California range about 1915. The vireo is nearly extirpated from the San Jacinto Mountains, a former stronghold. Therefore, we have updated the current status and distribution of the Gray Vireo in California, and in 2012 and 2013 studied the Gray Vireo's nest success in two regions of San Diego County, sites of the largest populations known in California. We regularly monitored approximately 41 territories in 2012 and 31 in 2013. We located and monitored a total of 95 nests, 91% found during construction or early in the egg stage. We checked nests at intervals of 2–5 days and deployed video cameras on 30. The rate of nest failure was extremely high: only 17 nests fledged any young. Renesting after failure was universal, with one pair attempting at least six nests. One pair, the earliest to fledge young in 2012, successfully double brooded that year. Only one nest had an unknown outcome. Of the 77 failed nests, we confirmed 10 parasitized by cowbirds, all abandoned before hatching. One nest failed because of strong winds, and one nest was abandoned during the egg stage for unknown cause. The remaining 65 nests failed because of confirmed or probable depredation, 56 during probable egg-laying or incubation, 7 during the nestling (brooding) stage, and 2 near hatching (uncertain stage). The Western Scrub-Jay was the most frequent predator, prevalent in all Gray Vireo territories and actively searching for nests while scolded by the vireos. Video cameras documented 30 nests with the following outcomes: 7 successful, 3 parasitized by cowbirds, 5 suspected depredation (but unrecorded or uncertain), and 15 confirmed depredated, 10 by Western Scrub-Jays (eggs taken in each case), one by a gray fox (nestlings taken), one by a bobcat (adult female taken), one by a Bewick's Wren (eggs taken), and two by an unidentified predator (eggs taken in one case, nestlings taken in the other). An additional 15 nests failed during construction probably before eggs were laid so were not included in the total or in any analyses, although some of these may have failed because of depredation as well. As calculated from exposure days, the total probability of nest survival was only 9%, probably insufficient to sustain the population. Of the two regions of San Diego County included in this study, the population in the northern part of the county has decreased substantially from that recorded 1997–2001 for the San Diego County Bird Atlas: only six territories located in 2012–2013 at a single site, out of seven sites searched that were formerly occupied. The leading role of the scrub-jay rather than the cowbird in depressing nest success currently will make recovering the Gray Vireo more challenging than recovering the Least Bell's Vireo.

Background

Purpose of the Study

The Gray Vireo is one of the least-studied song birds of North America. In 1908, one of the largest populations in California occurred in the San Jacinto Mountains, where it now appears to be nearly extirpated (San Jacinto Centennial Resurvey Project). At other scattered locations from Inyo to San Diego County the species is extirpated or known from only a few intermittent recent records, suggesting tenuous persistence at best, except in two regions of San Diego County that appeared, as of 2002, to have the two largest populations, which lay mostly within the Cleveland National Forest (north of Warner Springs and the southern Laguna Mountains). Although the San Diego County Bird Atlas (1997–2001) estimated numbers in the low hundreds, droughts and extensive fires in San Diego County since 2002 may have reduced this population further.

The Gray Vireo has long passed "under the radar" of ornithologists, having a discontinuous breeding distribution of low abundance in remote, arid scrubland at middle elevations of the Southwest and a strong association in winter with the elephant tree (*Bursera microphylla*), for which it may be a primary seed disperser (Bates 1992a). The Gray Vireo is inadequately sampled by all current national censuses including the North American Breeding Bird Survey, Christmas Bird Count, and Monitoring Avian Productivity and Survivorship Program. Since the 1940s evidence suggests that populations have been in decline, most likely because of parasitism by the Brown-headed Cowbird (*Molothrus ater*), which invaded the Gray Vireo's California range about 1915, but other unknown factors may be significant.

The San Diego Natural History Museum conducted a two-year study (2012–2013) of the Gray Vireo with two aims: (1) Update the current status and distribution of the Gray Vireo in the state of California through a combination of targeted surveys and compilation of recent records, and (2) Monitor territories and nests at two of the largest populations in San Diego County to assess current threats and causes of nest failure. This report summarizes the major results of this study and discusses possible management strategies. Ancillary products include a database of all records, video collection, and additional nest-level measurements. This report along with additional analyses will be submitted for publication.

Breeding Status/Distribution

The Gray Vireo is almost exclusively a summer visitor (March to August/September) to California, except for a small portion of the Anza-Borrego Desert, where the species winters in very small numbers, perhaps irregularly.

The Gray Vireo breeds in the southwestern U.S. and northwestern Mexico and winters from southeastern California, southwestern Arizona, and southwestern Texas south into Sonora and Baja California Sur. In California, as elsewhere throughout the breeding range, the distribution is highly discontinuous and patchy, with small isolated populations. In California, there have been extirpations from several historic sites and few intermittent records from other sites, where local population sizes are often unknown but presumed small.

Grinnell and Miller (1944) reported the Gray Vireo as a summer resident in the mountains of the eastern Mojave Desert, north to the Grapevine Mountains of Inyo County, in the mountains of eastern Kern County (Bodfish, Walker Pass), and in the Transverse (San Gabriel, San Bernardino, and Little San Bernardino mountains) and Peninsular ranges. They called it "common locally…; in many parts of range to be rated as no more than fairly common." Nevertheless, the density Grinnell and Swarth (1913) estimated in the San Jacinto Mountains (at elevations 900–2000 m), 16 pairs per square mile (6.2/km^2), is low for a small landbird and suggests that the Gray Vireo may never have been very common.

Only San Diego County has substantial recent records, a result of field work for its bird atlas from 1997 to 2001; Unitt (2004) estimated its population in the low hundreds. There appear to be two major population centers, one north of Warner Springs and the other in the southern Laguna Mountains, with territory density as high as 4.3 birds per 40 ha (Hargrove 2002). However, droughts and extensive fires in San Diego County (2002, 2003, and 2007) may have reduced this population.

Breeding Ecology and Threats

Details on the length of the breeding season in California are meager, but it apparently extends from at least late April through July. The earliest date of arrival in the southern Laguna Mountains is 14 March 2001. Farther north, however, Gray Vireos may not arrive until early May. This species remains on the breeding grounds until late August or early September. Five Gray Vireos, including three singing males, were detected on 19 August 2001 in the southern Laguna Mountains, and the species has been reported in the San Jacinto Mountains as late as 27 August, and in Joshua Tree National Park as late as 10 September. Egg dates range from 20 April to 2 August, but most are from late May.

Gray Vireos typically breed in mature, arid chaparral or open pinyon–juniper woodland mixed with chaparral, desert scrub, or sagebrush. Grinnell and Miller (1944) described the habitat as

"dry chaparral, which forms a continuous zone of twig growth from one to five feet above the ground in which the birds forage, sing, and nest." The chaparral habitat used in the Transverse and Peninsular ranges is most often dominated by chamise (*Adenostoma fasciculatum*), sometimes also by redshank (*A. sparsiflora*) or cupleaf ceanothus (*Ceanothus greggii*) (Unitt 1984). Other common species may include scrub oak (*Quercus* spp.), manzanita (*Arctostaphylos* spp.), and big sagebrush (*A. tridentata*). In the mountains of the Mojave Desert, the typical habitat used is open pinyon–juniper woodland, which may be mixed with sagebrush. In southern California, Gray Vireos occur in unbroken expanses of chaparral and do not favor edges. Therefore, this species may be particularly sensitive to the effects of habitat fragmentation.

In the desert, the breeding range of the Gray Vireo appears limited by the density of suitable shrubs. On the coastal side, the limiting factor is unclear but may be related to atmospheric humidity. The areas where the vireos breed are rarely if ever touched by coastal morning low clouds (Unitt 2008).

In California, territory size has only been roughly estimated in the southern Laguna Mountains at 3–8 ha (8–20 acres) per pair on the basis of spot-mapping of unmarked singing males (Hargrove 2002). The density at this location was estimated at 14 pairs per square mile (259 ha) of suitable habitat, or 4.3 birds per 40 ha. In the San Jacinto Mountains, Grinnell and Swarth (1913) estimated density at 16 pairs per 259 ha (1 sq. mi.) of suitable habitat, or 4.9 birds per 40 ha. At Deep Canyon in the Santa Rosa Mountains, Weathers (1983) estimated density at 1.6 birds per 40 ha. In the Providence Mountains, Johnson et al (1948) estimated density at four pairs per 259 ha (1 sq. mi.) of favorable terrain (1.2 birds per 40 ha).

The Gray Vireo's site fidelity is probably very strong. In Texas, 20 of 22 birds banded returned to the same site the following year, and one returned four consecutive years (Barlow et al. 1999).

The Gray Vireo's open-cup nests are situated in the upper part of shrubs or small trees typical of the habitat. In California, nests have been reported in chamise, big sagebrush, mountain mahogany, cupleaf ceanothus, scrub oak, and pinyon pine (Grinnell and Swarth 1913, Unitt 2004).

Males sing throughout the breeding season and also in the winter range. Males begin singing shortly after sunrise and sing through the day at all stages of the nesting cycle. In southern California in April and May, males sing with equal frequency in the mornings and afternoons, often even while foraging, flying, preening, incubating, and carrying insects (Hargrove 2002). Although singing is also heard during the summer (Unitt 2004), it may be reduced.

Potential threats include the Brown-headed Cowbird, Western Scrub-Jay, other nest predators (mammals, reptiles, ants), human disturbance, habitat loss/degradation, fragmentation, drought/climate change, fire, diseases, competition, and over-winter survival.

Remsen (1978) suggested only cowbird parasitism as a reason for the Gray Vireo's decline in California. Other factors remain unknown, but the parallel of the Gray with the decline of other vireos in southern California implies that the cowbird is the primary cause, a host species with a naturally low population level being especially susceptible. Friedmann (1963) considered the Gray Vireo a frequent victim of the Brown-headed Cowbird, though he listed few actual records, from Cajon Pass, near Hesperia, and Sheep Creek Canyon in the San Gabriel Mountains. The Gray Vireo is not known to persist at any of these localities. No instances of cowbird parasitism on Gray Vireos were observed during surveys for the San Diego or Los Angeles county bird atlases. During surveys for the Arizona bird atlas (Corman 2005), only one incident was documented. In Colorado, one out of 27 nests was parasitized, and there are only two records of parasitism for the state. In Texas and Arizona, 1967–1986, 10 out of 50 nests were parasitized (Barlow et al. 1999). Parasitized nests are often abandoned. In one recent study in New Mexico, 4 out of 74 nests were parasitized, and each was abandoned during incubation (Pueblo of Santa Ana, C. Nishida pers. comm.). Much of the species' habitat in southern California is within national forests, but further development of inholdings could enhance habitat for the cowbird and increase parasitism of the vireo on public land.

Winter

The Gray Vireo is a short-distance migrant wintering in close association with the elephant tree (*Bursera microphylla*) in southern Arizona and northern Mexico (Bates 1992a). In December 1999, the San Diego County Bird Atlas resulted in the detection of 5 Gray Vireos wintering in the largest stand of elephant trees in the Sonoran desert of Anza-Borrego Desert State Park (Unitt 2000, 2004), the first record of the Gray Vireo wintering in California. However, follow-up surveys have revealed only a single individual at most per survey of the area from 1999 through 2003 (Hargrove and Rotenberry 2003) and since (Hargrove pers. obs.). Surveys with an effort equal to or greater than that of 1999 are needed.

Methods

Task #1: Determine current breeding distribution/status in California

We gathered and summarized historic and current records from throughout the state to assess current distribution/status. We also visited selected known/historic locations to determine presence/absence, focusing on San Diego County in 2012 (Appendix 1), and Centennial Resurvey sites in Riverside County from 2008 to 2013 (Appendix 2).

Protocol: Extensive survey protocol (Hargrove 2002) with a combination of driving and hiking to cover as much area as possible in/near locations with historic records. All observers are experienced with Gray Vireo identification, including by songs and calls. Surveys were conducted from early May to early June, during mornings and afternoons, but avoiding temperature extremes, rain, and strong winds. All Gray Vireo observations were recorded by GPS and plotted on maps. Historic and current records were compiled from all available references and online sources and entered into a GIS database.

Task #2: Monitor existing populations to determine current threats

We mapped and monitored territories and nests throughout the breeding season (from first arrival to last fledging, late March to late August) at two major study areas (800–1200 ha each) with relatively easy access and most likely to have a population large enough to yield multiple nests.

- Study Area 1: North of Warner Springs, Indian Flats Road/Pacific Crest Trail
- Study Area 2: Southern Laguna Mountains, from Noble Canyon northeast of Pine Valley and Lake Morena east to La Posta Road

Protocol: We conducted censuses and nest monitoring at each study site throughout the breeding season (late March to August) in 2012 and 2013. At least twice per week, we monitored each territory for evidence of breeding activity from vantage points that were unlikely to cause disturbance yet afford an unobstructed view of most of the territory. Locations and numbers of all adults and fledglings were mapped, and behaviors and potential threats were noted. As a basis for an estimate of probability of survival, all nests were documented and monitored, with nest checks as brief and unobtrusive as possible, at intervals of 2–5 days. We avoided approaching nests during construction or egg laying. For each nest where it could be determined, we also recorded clutch size and final nest outcome. Nest measurements were taken after young had fledged or the nest had failed. At approximately one-third of all nests, we deployed miniature video cameras to record causes of nest failure. Cameras were deployed as early as possible in the nest cycle. To avoid affecting depredation rates, we attempted to reduce human scent and camouflage the cameras as much as possible (Figure 1). See Appendices 3-5 for detailed protocol and field forms.

Figure 1. Camera enclosed within a protective funnel and clipped to shrub near nest (rectangle in foreground). The Gray Vireos often stayed on the nest during the set-up or otherwise returned immediately after (Gray Vireo on nest, arrow). Photo by Lea Squires.

Description of video camera set-ups:

- 940 nm Infrared Snake Camera, 0.9 × 0.3 in. (Supercircuits, Inc)
- H.264 Mini Digital Video Recorder (Supercircuits, Inc.) with 32-GB memory cards
- 2.5 Inch Color Portable Monitor (Supercircuits, Inc.)
- 25-lb rechargeable 12-volt battery
- Camera enclosed in 2-in. protective funnel, 6-ft camera cable enclosed in protective roofing tape and duct tape, 30-ft video cable enclosed in metal conduit, DVR and battery enclosed in toolbox, all spray-painted with dull green and brown colors for camouflage
- Camera clipped to stem 2 to 3 ft from nest; toolbox containing DVR and battery set in a cleared but shaded spot 25 ft from nest so that recording can be viewed and battery/memory changed without disturbing the nest
- Continuous recordings made (day and night) and saved to DVDs for long-term storage

Analysis: Results of all territory and nest monitoring were summarized descriptively, and program Mark was used to estimate daily probability of nest survival and relate that to the day within season, year, study area, and nest-level measurements.

Results

Brief Summary of Major Findings

Of the ~117 sites where the Gray Vireo has been recorded in California, it appears to be extirpated from at least half and declining at many where it persists. Statewide, the Gray Vireo population seems unlikely to exceed 300 territories, scattered across only a few counties. This likely represents a decline of 75–95%.

We documented a very high rate of failure of Gray Vireo nests in San Diego County—only 17 of 95 nests produced at least one fledgling (apparent nest-success rate of 18%). The vast majority of nest failures were due to nest predators, and video monitoring confirmed that the Western Scrub-Jay was the most common nest predator. We also documented 10 instances of nest parasitism by the Brown-headed Cowbird, and each of these nests was abandoned by the Gray Vireos shortly after being parasitized.

Statewide Status and Distribution

We compiled all available Gray Vireo records from California (Figure 2, Table 1) for a total of ~117 sites. Sites of historic occurrence where the Gray Vireo is thought to no longer occur include Kern County (Bodfish and Walker Pass), Joshua Tree National Park, and near Bob's Gap and Pallett Creek in Los Angeles County. Many other sites in Inyo, San Bernardino, and Riverside counties, have only a few, intermittent records.

In 1908 in the San Jacinto Mountains, Grinnell and Swarth (1913) described the Gray Vireo as "common in many localities from 3000 to 6500 feet" and estimated that there were 960 individuals in the San Jacinto region. Despite focused surveys of the San Jacinto and Santa Rosa mountains from 2008 to 2013 by the San Diego Natural History Museum, only three observations have been made at two sites on the northwest slope of the Santa Rosa Mountains. On the north slope of the Santa Rosa Mountains, around the upper end of Deep Canyon in the area where Weathers (1983) estimated the population density as 1.6 birds per 40 ha (4/km^2), Hargrove found only three individuals from 2005 to 2007. The five sites known in Riverside County in the past 10 years represent single, apparently inconsistent territories, so the population in that county is unlikely to exceed 20, even given the extent of rugged, inaccessible terrain, and thus implies a decline on the order of 98%—a population approaching extirpation.

The lack of records from the San Gabriel Mountains since 1999, even at two sites that birders have visited regularly since (K. L. Garrett pers. comm.), suggests that the Gray Vireo is already gone from Los Angeles County. The Gray Vireo persists in the Rose Mine/Arrastre Creek area of the eastern San Bernardino Mountains, but current numbers are notably lower than before 2007 (A. Koonce). San Diego County is the Gray Vireo's last bastion in California, but even there the

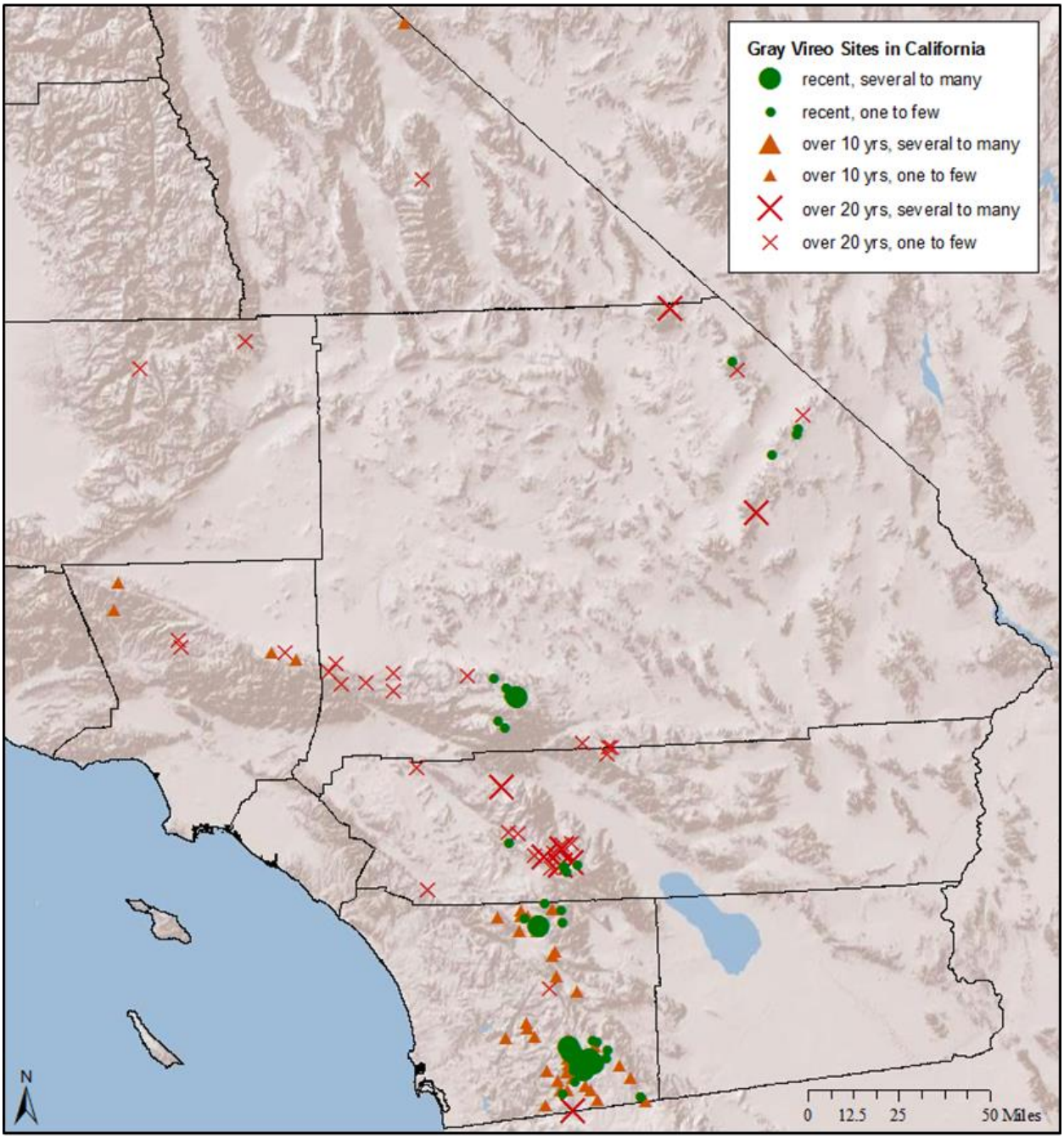


Figure 2. Historic and current distribution of the Gray Vireo in California. Smaller symbols represent sites with single to few territories; larger symbols represent larger population clusters.

Table 1. All sites in California with records of the Gray Vireo

Site	County	Most Recent Records	Source
Grapevine Mtns	Inyo	1 photographed, Phinney Canyon, 2002	C. & R. Howard, via ebird; J. L. Dunn, NAB 56:487, 2002
Panamint Mtns	Inyo	Reported to breed in pinyon-juniper woodland, but only cited record of a pair nesting in Wood Canyon (Fisher 1893) may have been from the Grapevine Mtns in Nevada	Wauer 1964; Fisher 1893
Bodfish	Kern	adult female collected, 1911	Grinnell 1922
Walker Pass	Kern	apparent pair, adult male collected, 1922	Grinnell 1922
Mint Canyon, near Acton	Los Angeles	1 singing bird, 1921	Miller 1921
Vasquez Rocks	Los Angeles	eggs collected, 1928	Willett 1933; Yale Peabody Museum and Field Museum of Natural History, via ornisnet
North of Liebre Mountain	Los Angeles	1 atlas location, 1999	L. Allen pers. comm
Just W of junction of Pallett and Big Rock creeks	Los Angeles	1 singing male, 1997 (not found since despite annual visits)	Garrett and Molina 1998
Bob's Gap	Los Angeles	3-4 pairs Apr-Jun 1985 (not found since despite annual visits)	K. L. Garrett, B. W. Keelan, AB 39:963. 1985
N. base of San Gabriel Mtns, just W. of San Bernardino line	Los Angeles	nest with three nestlings, 13 Jun 1998	S. J. Myers, AB 52:504, 1998
North of Castaic Lake	Los Angeles	2 singing males, Jun 1998	Ron Beck, AB 52:504, 1998
Sheep Creek, N side San Gabriel Mtns	San Bernardino	Eggs collected as recently as 1947	Western Foundation of Vertebrate Zoology, via ornisnet
Phelan	San Bernardino	Egg set collected, 1935; former "well-known location" (Small 1994)	Western Foundation of Vertebrate Zoology, via ornisnet
Lone Pine Canyon, San Gabriel Mts.	San Bernardino	specimen collected 1938; 2 specimens collected 1921, egg set collected 1922	FMNH; Western Foundation of Vertebrate Zoology and UCLA, via ornisnet

Site	County	Most Recent Records	Source
Cajon Pass area, including Cactus Flat	San Bernardino	Parasitized nest, 1944; eggs collected as recently as 1947	Hanna 1944; Western Foundation of Vertebrate Zoology, via ornisnet
S of Hesperia	San Bernardino	Eggs collected as recently as 1946	Western Foundation of Vertebrate Zoology, via ornisnet
Summit Valley	San Bernardino	Specimen collected 1960	Cornell University, via ornisnet
Upper Crystal Creek drainage, west of Cushenbury Canyon	San Bernardino	territorial males, 1988	S. J. Myers, fide Garrett and Molina 1998
Between Hart Bar Campground and Aspen Grove	San Bernardino	Reported 2006	K. Stitt via inlandcountybirds list-server
Cactus Flat area	San Bernardino	2 seen, 17 June 2012	via inlandcountybirds list-server
Rose Mine area	San Bernardino	Regular through 2013; before 2007, up to 8 singing individuals along 6 miles of roads 2N02 and 3N03	Garrett and Molina 1998; A. Koonce via inlandcountybirds list-server
Tip Top Mtn	San Bernardino	3 singing birds, 2013	E. Tipton, via inlandcountybirds list-server
Forest Service Rd. 3N03, 1.2 mi. downhill from 2N02	San Bernardino	1 bird, 30 May 2011	via inlandcountybirds list-server
Forest Service Rd. 3N03, 4.2 mi. from Hwy. 18	San Bernardino	1 carrying caterpillar, 11 June 2010	via inlandcountybirds list-server
Forest Service Rd. 3N03 at Arrastre Creek	San Bernardino	1 singing male, May 2010	via inlandcountybirds list-server
Forest Service Rd. 2N02 at Arrastre Creek	San Bernardino	6 eBird records, most recent 1 bird 1 June 2008	W. Moramarco, via eBird
Fish Creek trailhead	San Bernardino	1 bird, 20 Jun 2011	Luisa Serrano, Sally Freeberg, via eBird
Kingston Range, Horse Thief Springs	San Bernardino	4 specimens collected, 1939	Museum of Vertebrate Zoology, via ornisnet
Clark Mtns, N side	San Bernardino	2–3 pairs, through 2013	Remsen 1978, eBird
Clark Mtns, SE side	San Bernardino	2 specimens collected in 1939	MVZ via ornisnet
Mid Hills	San Bernardino	3-4 pairs in 1970s; 2 individuals in Cedar Canyon, 2010	Remsen 1978; eBird
New York Mtns, Keystone Cyn	San Bernardino	5-6 pairs in 1970s, 3 individuals in Keystone Canyon, 2012	Remsen 1978, L. Harter and D. Vander Pluym via eBird; D. Goodward via inlandcountybirds list-server
New York Mtns, Caruthers Cyn	San Bernardino	Caruthers Canyon, June 2010	inlandcountybird list-server

Site	County	Most Recent Records	Source
Providence Mtns	San Bernardino	“conspicuous though not abundant” in 1938; recorded at least to 1984	Johnson et al. 1948; R. Simard via eBird
Ivanpah	San Bernardino	single BBS record from 1995	Breeding Bird Survey
Joshua Tree NP, Black Rock Spring	San Bernardino	single record from September	Miller and Stebbins 1964
Joshua Tree NP, Quail Springs	San Bernardino	spring and fall records	Miller and Stebbins 1964
Joshua Tree NP, Smith Water Canyon	San Bernardino	nest	Miller and Stebbins 1964
Joshua Tree NP, above Clevenger Spring	Riverside	spring record	Miller and Stebbins 1964
10 mi. E of Riverside	Riverside	nest and eggs collected, 1889	Stephens 1890
Hall Grade below Hurley Flat	Riverside	several singing in 1908	W. P. Taylor and C. H. Richardson (field notes)
San Jacinto River canyon at about 3000 feet	Riverside	1 singing in 1908	Grinnell and Swarth 1913 (and field notes)
Divide between Garner Valley and Vandeventer Flat	Riverside	a few heard singing in 1908	Grinnell and Swarth 1913 (and field notes)
San Jacinto Mtns, Kenworthy	Riverside	In 1908: many heard in several areas (4500-6500ft), nest photographed, specimens collected, a pair on about every 40 acres, population of several hundred estimated	Grinnell and Swarth 1913 (and field notes)
Oak Tree Spring	Riverside	seen in 1908	Grinnell and Swarth 1913 (and field notes)
Below Oak Tree Spring	Riverside	In 1908: heard frequently and "characteristic of the brush belt down at least this far" (~3500 ft)	Grinnell and Swarth 1913 (and field notes)
plateau N of Asbestos Mt.	Riverside	1 seen in 1908	Grinnell and Swarth 1913 (and field notes)
Palm Canyon, 3000 feet elevation	Riverside	In 1908: 2 Gray Vireos were "probably visitors to the water from above"	Grinnell and Swarth 1913 (and field notes)
Omstott Creek	Riverside	pair seen and heard in 1908	Grinnell and Swarth 1913 (and field notes)
Head of Palm Canyon and/or Vandenventer Flat	Riverside	several seen in 1908	Grinnell and Swarth 1913 (and field notes)
Keen's Camp to Idyllwild	Riverside	1 heard in 1908	Grinnell and Swarth 1913 (and field notes)
Thomas Mt., on way up	Riverside	1 heard in 1908	Grinnell and Swarth 1913 (and field notes)
Sawmill Trail	Riverside	singing male in June 2006	Lori Hargrove

Site	County	Most Recent Records	Source
Hwy. 74 at Santa Rosa Mt. Rd., downhill side	Riverside	most recent, 22 Jun 2008, 1 singing male	via list-server and eBird
near spring above Hwy 74 (just below 5000 ft)	Riverside	pair with fledgling, 10 Jul 2010	Brad Singer and Howard King, via list-server and eBird
Garnet Queen Canyon	Riverside	1 heard in 2013; two other records in area 2005-2007	San Jacinto Centennial Resurvey Project
Bautista Canyon	Riverside	One reported "singing continuously and acting territorial," 2011	P. Temple, via eBird
"above Temecula"	Riverside	specimen collected, 1893	Carnegie Museum, via ornisnet
Bucksnort Mtn	San Diego	nest-building pair 2005	Lori Hargrove
East of Dick Spring	San Diego	2 territories (1997-2001)	San Diego Bird Atlas
Alder Canyon, South Fork	San Diego	4 singing males (1997-2001)	San Diego Bird Atlas
Sheep Canyon	San Diego	2 singing males in June 2005	Lori Hargrove
Palomar Mtn, Oak Grove Rd	San Diego	3 singing males (1997-2001)	San Diego Bird Atlas
Chihuahua Valley Rd	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Indian Flats Rd at Puerta La Cruz	San Diego	3 records in area (1997-2001)	San Diego Bird Atlas
Puerta La Cruz	San Diego	pair in June 2006	P. Unitt and J. Lovio
Pine Mountain	San Diego	2 records in area (1997-2001)	San Diego Bird Atlas
Cougar Canyon	San Diego	singing male in June 2006	Lori Hargrove
Pacific Crest Trail at Indian Flats	San Diego	6 to 7 territories (2012-2013)	this study
Aguanga Mtn, Palomar Divide Rd	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Lost Valley Rd, South	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Barrel Spring	San Diego	2 records in area (1997-2001)	San Diego Bird Atlas
Bergstrom Canyon	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Arkansas Canyon	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Julian	San Diego	location mentioned	Belding 1890
Granite Mtn	San Diego	2 records in area (1997-2001)	San Diego Bird Atlas
Tule Springs	San Diego	2 records in area (1997-2001)	San Diego Bird Atlas
North of Conejos Creek	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Goudie Road	San Diego	5 records in area (1997-2001)	San Diego Bird Atlas
El Capitan Reservoir	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Miners Road	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Noble Canyon, East	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Laguna Ridge West	San Diego	nest-building pair in 2007	Lori Hargrove

Site	County	Most Recent Records	Source
Laguna Ridge East	San Diego	2-3 territories in 2006-2007	Lori Hargrove
Laguna Mtn	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Noble Canyon	San Diego	13 to 14 territories (2012-2013)	this study
McCain Valley North	San Diego	singing male in May 2007	Lori Hargrove
Sunrise Highway just N of Laguna Junction	San Diego	8 to 9 territories (2012-2013)	this study
East of Long Valley Peak	San Diego	3 records in area (1997-2001)	San Diego Bird Atlas
Antone Canyon	San Diego	3-4 territories 2005-2008	Lori Hargrove
McCain Valley West	San Diego	1 territory in 2005-2007	Lori Hargrove
Fred Canyon Rd (and Pacific Crest Trail)	San Diego	8 to 9 territories (2012-2013)	this study
Kitchen Creek Rd North	San Diego	8 to 10 territories (2012-2013)	this study
Bear Valley	San Diego	3 records in area (1997-2001)	San Diego Bird Atlas
Fred Canyon	San Diego	3-4 territories 2006-2008	Lori Hargrove
La Posta Rd North	San Diego	4 to 6 territories (2012-2013)	this study
Horse Canyon	San Diego	9 to 12 territories (2012-2013)	this study
McCain Valley Rd, Lost Valley	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Bear Valley Road	San Diego	10 territories in spring 2002	Lori Hargrove
Corte Madera Mtn	San Diego	3 records in area (1997-2001)	San Diego Bird Atlas
Bear Valley Rd	San Diego	0 to 1 territories (2012-2013)	this study
Pacific Crest Trail at Kitchen Creek Rd	San Diego	9 to 10 territories (2012-2013)	this study
Kitchen Creek Rd South	San Diego	3 to 4 territories (2012-2013)	this study
Buckman Springs Rd	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Sacatone Spring	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Corral Canyon	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Pacific Crest Trail at Lake Morena	San Diego	1 to 2 territories (2012-2013)	this study
La Posta Truck Trail	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Lake Morena, South	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Hauser Canyon	San Diego	3 records in area (1997-2001)	San Diego Bird Atlas
La Posta Microwave Stn	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Hauser Mountain	San Diego	nest photographed in 2012	Travis Cooper
De Anza Springs	San Diego	1 singing, 10 May 2013	Bill Pulliam, via eBird
E of Shockey Truck Trail	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Jacumba Airport	San Diego	1 record (1997-2001)	San Diego Bird Atlas
Potrero Peak	San Diego	1 record (1992)	Phil Unitt
Campo	San Diego	specimens collected as recently as 1916	F. Stephens, via ornisnet.org

population has declined substantially since the field work for its bird atlas (1997–2001), especially in the northern part of the county.

Numbers in the eastern Mojave Desert, where the Gray Vireo is widely scattered on isolated mountains, are low, and the available data are too inconsistent over the years to suggest any trend. Small numbers persist at Clark Mountain, in the New York Mountains, and in the Mid Hills, but no data from the Grapevine Mountains, Kingston Range, or Providence Mountains have been reported within the past 10 years. Most sites require long hikes over rugged waterless terrain with no trails. In the Panamint Mountains, even the Gray Vireo's historical status is unclear. Wauer (1964) listed the Gray Vireo for that range and charted its elevational distribution as 5500 to 6500 feet. But the only specific record he mentioned is that of Fisher (1893) from Wood Canyon, though Fisher's Wood Canyon may have been on the Nevada side of the Grapevine Mountains.

In any case, statewide and including inaccessible areas, the population seems unlikely to exceed 300 territories, at least half of them in San Diego County. Given the greater densities and number of sites reported historically, this probably represents a decline of 75–95%.

Population Status and Distribution in San Diego County

From April to June 2012, we revisited 18 major sites in San Diego County (Appendix 1) where Gray Vireos were present during field work for the San Diego County Bird Atlas (years 1997–2001, Unitt 2004). We focused our efforts on two regions that fell within a distribution center, one in north county and the other in south county (both mostly within the Cleveland National Forest). Surveys were begun in late March to locate sites suitable for monitoring, and for sites where no Gray Vireos were found, we returned for at least two morning surveys during May and early June to confirm absences, and also searched nearby suitable habitat. Of 7 sites revisited in north county, Gray Vireos were present at only one site (Figure 3). Of 11 sites revisited in south county, Gray Vireos persisted at 10 sites (Figure 4). A total of 71 to 84 Gray Vireo territories were located across all sites visited in 2012 (Appendix 1). In 2013 we focused our efforts on repeating the nest monitoring at a reduced number of sites.

Although our survey effort was more focused and intensive than that for the Bird Atlas, there are four sites that may have had more Gray Vireos in 2012–2013 than they did from 1997 to 2001: Noble Canyon, Horse Canyon, Sunrise Highway, and Kitchen Creek Road North.

Two sites where Gray Vireos were present during both periods received a more intensive, focused survey with territory mapping in 2002 (Hargrove 2002). A comparison of territory densities in 2002 vs. 2012 suggests that abundance has declined substantially at both of these sites (Figure 5). Between 2002 and 2012, along the Pacific Crest Trail east of Kitchen Creek Road, territory density declined from 14 to 6 territories per square mile. At Bear Valley Road, territory density declined from 10 to 1 territory per square mile. At the single territory at Bear

Valley Road, we found only one singing male in 2012 that was present through 17 April but not detected on subsequent surveys in late April, May, or early June, and not detected in 2013.

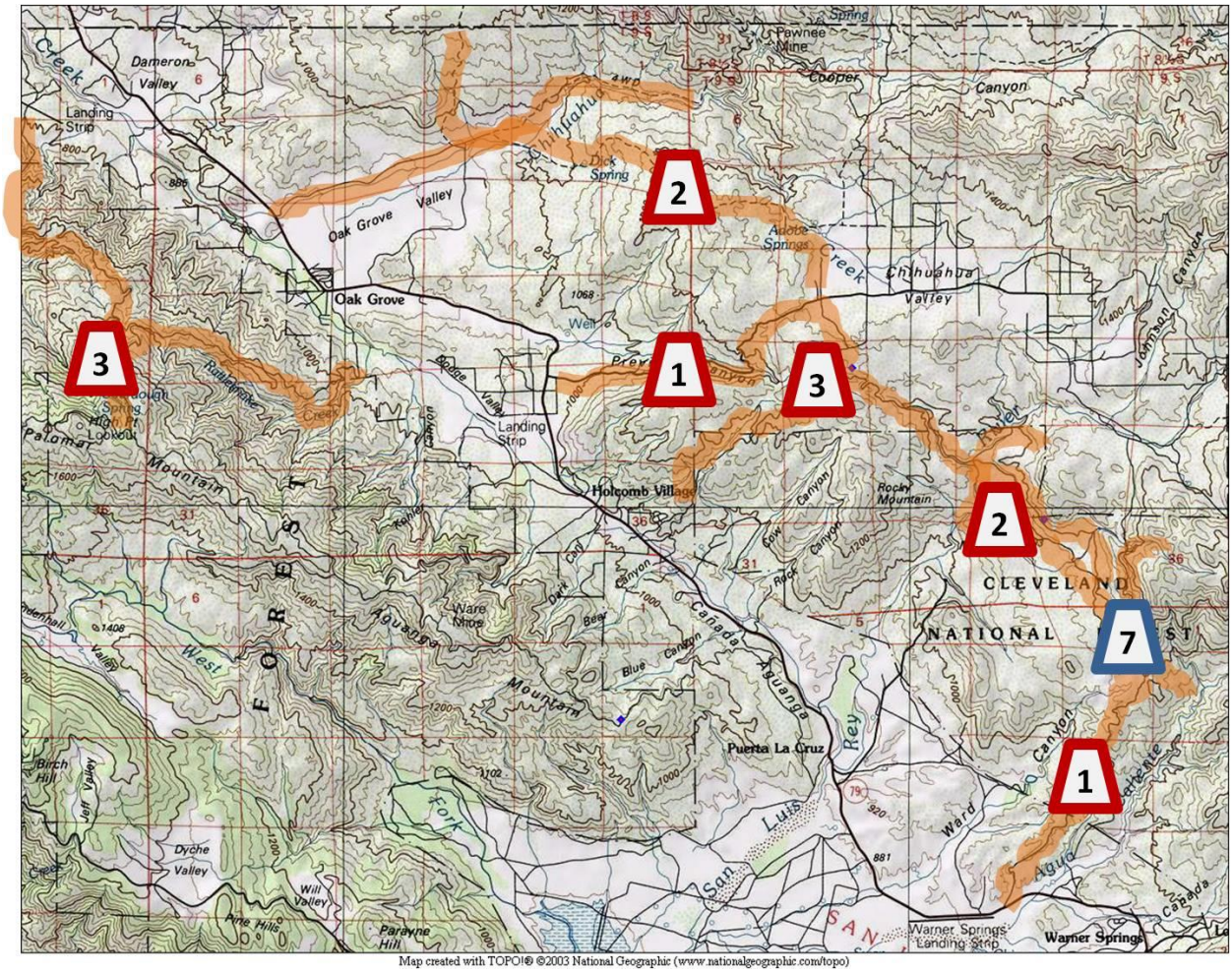


Figure 3. Seven sites with Gray Vireo records during field work for the San Diego County Bird Atlas (years 1997–2001) that were each resurveyed in 2012. Each trapezoid represents a site, and the number within the trapezoid indicates the number of singing males detected at that site 1997–2001. Red outline indicates that Gray Vireos were not present at that site in 2012. The only site where Gray Vireos persisted (blue outline) was also the site where the highest number of singing males was detected 1997–2001 (7 singing males). Orange highlighting indicates additional suitable habitat that was surveyed, but no Gray Vireos were detected at any other sites.

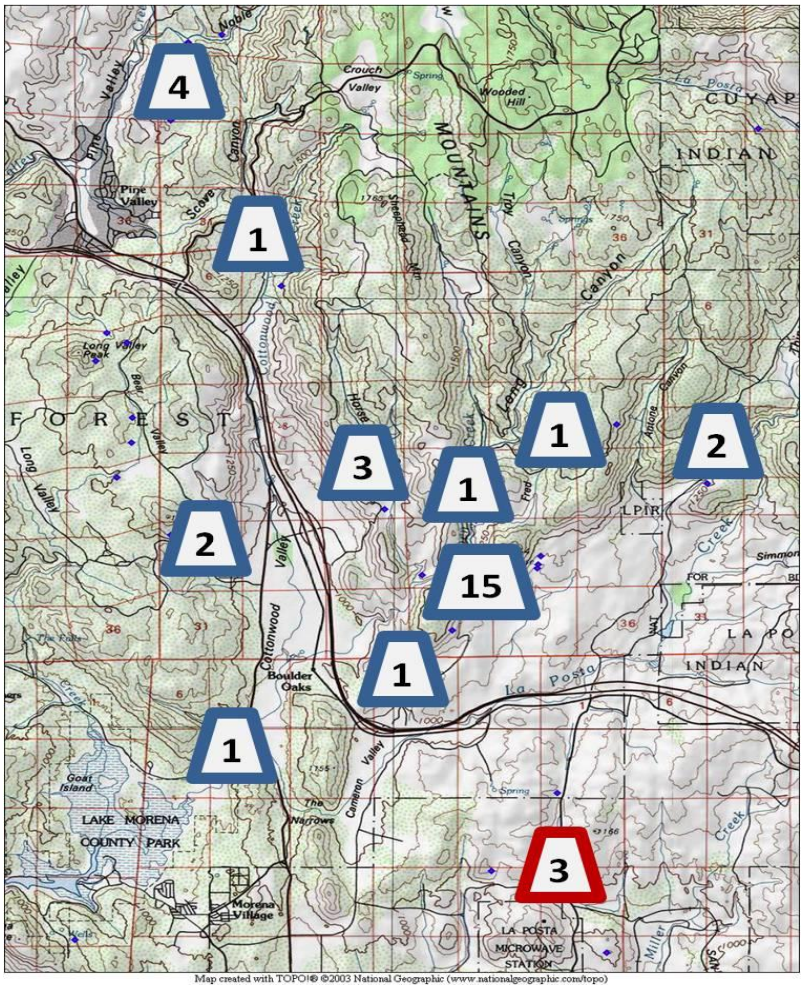


Figure 4. Eleven sites with Gray Vireo records during field work for the San Diego County Bird Atlas (1997–2001) that were each resurveyed in 2012. Each trapezoid represents a site, and the number within the trapezoid indicates the number of singing males detected at that site during the Bird Atlas. Blue outline indicates that Gray Vireos were persistent at that site in 2012. The only site where Gray Vireos were absent (red outline) was La Posta Road south.

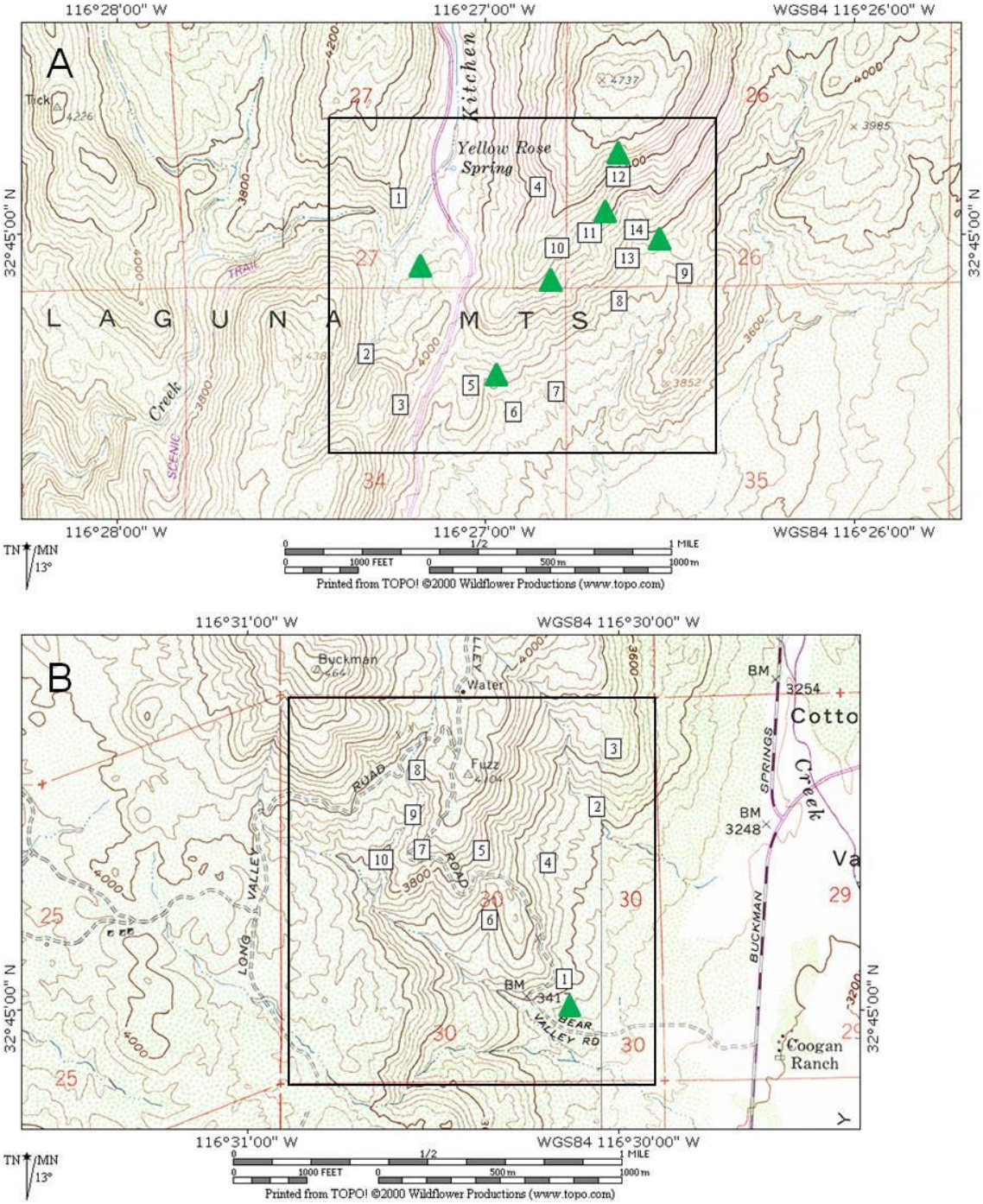


Figure 5. Numbers of Gray Vireo territories estimated for two sites in 2002 (numbered boxes) vs. 2012 (green triangles): (A) Pacific Crest Trail at Kitchen Creek Road, and (B) Bear Valley Road South.

Population Status and Distribution in the San Jacinto and Santa Rosa Mountains, Riverside County

From 2008 to 2013, we revisited 20 sites in Riverside County that were each thoroughly surveyed in 1908 (Grinnell and Swarth 1913). This was for the Centennial Resurvey Project, but we also conducted focused presence/absence surveys for Gray Vireos at all sites where Gray Vireos were present in 1908 and at other nearby areas with potentially suitable habitat (Appendix 2). Across the same areas where Grinnell and Swarth (1913) estimated a population size of nearly 1000, we found only 1–2 territories on the north slope of the Santa Rosa Mountains.

Territory Monitoring

Territory monitoring extended from late March through early August in San Diego County. Gray Vireos began arriving by the last week of March. Two Gray Vireos were found on the first survey date in 2012, 25 March, and two were also found on the first survey date in 2013, 24 March. However, the majority of Gray Vireos appeared to arrive within the first two weeks of April. In both years there was a delay between arrival and nesting, and in 2013 nesting was shifted earlier than in 2012 (Table 2 and Figure 6). In 2012, the first observation of nest construction was 20 April and earliest egg laying was 30 April, approximately one month after arrival. In 2013 an early outlier began nest construction on 7 April, but earliest egg laying was not until approximately 19 April. The average egg-laying date was approximately 16 days earlier in 2013 than in 2012, with nesting both starting and ending earlier (Figure 6). In 2012 the latest fledging of a nestling was 1 August, while in 2013 it was 12 July. Latest fall records were 12 September 2012 and 10 September 2013.

Table 2. Earliest and latest dates of breeding-season activities observed in 2012 and 2013 for Gray Vireos, San Diego County.

Activity	2012		2013	
	Earliest Date	Latest Date	Earliest Date	Latest Date
Singing	25 March	12 September	24 March	10 September
Nest construction	20 April	3 July	7 April	14 June
Egg laying	30 April	5 July	19 April	12 June
Fledging	6 June	1 August	29 May	12 July

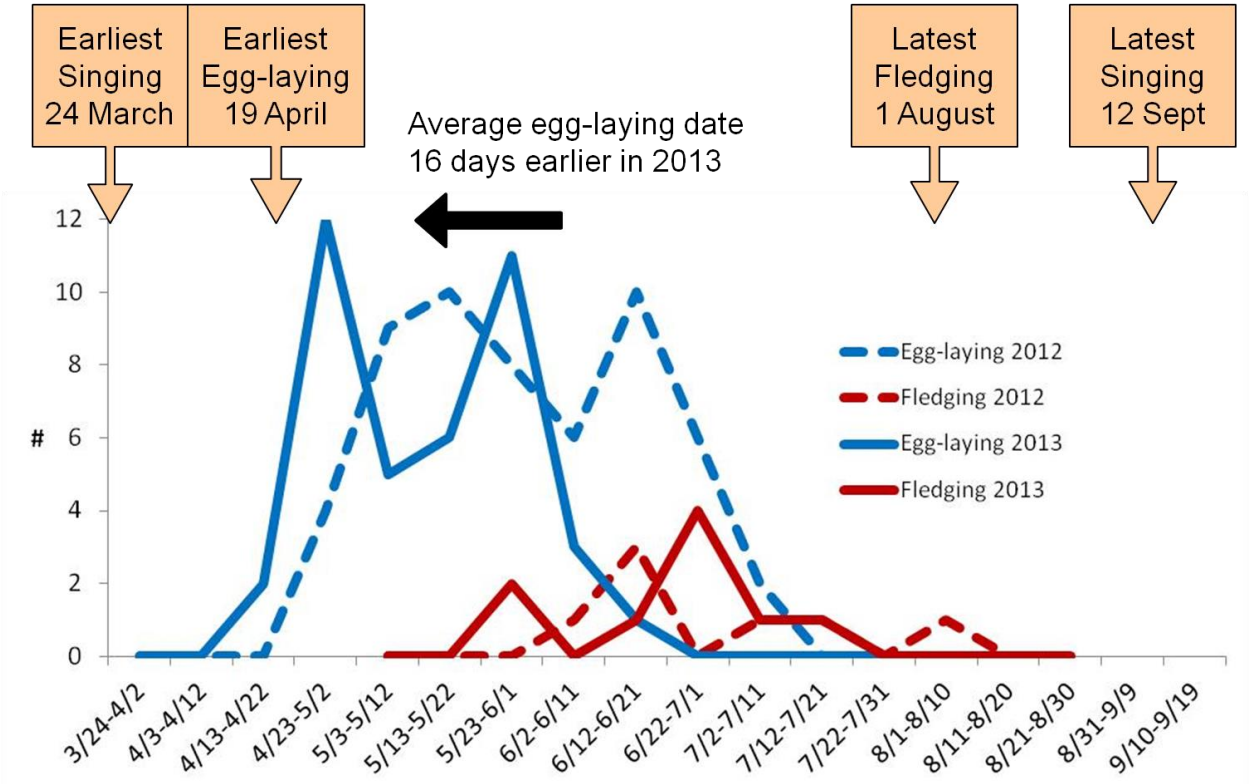


Figure 6. Nesting chronology showing number of nests by egg-laying and fledging dates, 2012-2013.

In 2012 we monitored a total of 41 territories on a regular basis at a total of 12 sites (Appendix 6), and in 2013 we monitored a total of 31 territories at a total of 8 sites, including Bear Valley Rd., which was unoccupied in 2013 (Appendix 7). Regular monitoring consisted of visiting each territory at intervals of 2–5 days (rarely up to 8 days) and mapping and noting all Gray Vireo observations during each visit. Visits became less frequent as evidence of nesting waned by late July.

Territory sizes were very large for a small passerine, varying by site and ranging from about 6 to 24 hectares. Although birds were not banded, most territories were very consistent and obvious through the season, but some territory shifting was also evident (Appendix 8). A few sites appeared to have extra floating males, and a few territories were abandoned mid-season. Although females are much more cryptic than males, there appeared to be more males than females, with several territories occupied by apparently solo singing males. At these territories, females appeared rarely or intermittently, sometimes after a nest failure at a neighboring site, suggesting that females may shift between different males' territories, as is known in the Least Bell's Vireo (Greaves 1987).

Most nest locations were found by observing the pair from a vantage point and witnessing the pair carrying nest material (80%), or otherwise observing a pair return to the same shrub. Nests of neighboring pairs were sometimes placed surprisingly close, as little as 80 m between neighboring active nests. Although individuals could not be distinguished, it was generally straightforward to assign nests to particular territories because of our frequent monitoring, large territory sizes, and consistency of territories. Very shortly after a nest failed, pairs were often observed nearby constructing a new nest.

Nest Monitoring

Nest outcomes:
Of the 95 total Gray Vireo nests found, only 17 successfully fledged at least one chick for an apparent nest-success rate of 18% (Table 3). Of the failed nests, 10 were parasitized by Brown-headed Cowbirds (11%). All parasitized nests were abandoned, and the adults were usually seen constructing a new nest soon after. Only one other nest was abandoned after eggs were laid and without evidence for cause of failure (subsequent visits revealed only a solo singing male).

One nest had an unknown outcome (single nestling, then later no activity in the territory), and one failed because of strong winds (adult seen on video abandoning nest during strong winds, and eggs were later found cracked inside and below the nest). The remaining 65 nests failed because of confirmed or probable depredation, 56 during probable egg-laying or incubation, 7 during the nestling stage (brooding), and 2 near hatching (uncertain). The Western Scrub-Jay was the most frequent predator, prevalent at all sites and frequently scolded by the vireos.

There were an additional 15 nests found that were apparently abandoned prior to completion, and so were not included in any totals or analyses. However, these are included in Appendices 6-7 for a complete summary of all monitored nests and territories.

Table 3. Gray Vireo nest outcomes, 2012 and 2013. A nest was considered successful if at least one nestling fledged. "Depredated" nests failed because of a suspected or confirmed predator during probable egg-laying or later.

Nest Outcome	2012		2013		Total	
	N	%	*N*	%	*N*	%
Successful fledging	8	14.5%	9	22.5%	17	17.9%
Parasitized by cowbird	7	12.7%	3	7.5%	10	10.5%
Other failure/unknown	0	0.0%	3	7.5%	3	3.2%
Depredated	40	72.7%	25	62.5%	65	68.4%
Total	55		40		95	

Nest survival:
Using the number of exposure days (Mayfield 1975), we estimated the probability that a nest survives one day (daily survival rate) and the probability that a nest survives from first egg to fledging (nest-survival rate). The daily survival rate was 92%, and under the assumption that the minimum period from laying the first egg to fledging of the first chick is 30 days, the nest-survival rate was 8.8%. We modeled daily survival rate in program Mark (White and Burnham 1999; Rotella et al. 2004) and found that there was little change in the probability of nest survival over the nesting season (Figure 7), with late nests almost as likely to survive as early nests. However, the two study areas differed substantially—north county had a much lower nest-survival rate both years—with average for 2012–2013 of 1.8%, compared to south county at 12.6% (Figure 8).

Nest success in 2013 was higher than in 2012, although the difference was not statistically different (Figure 9), and 2013 was also drier than 2012 (Figure 10).

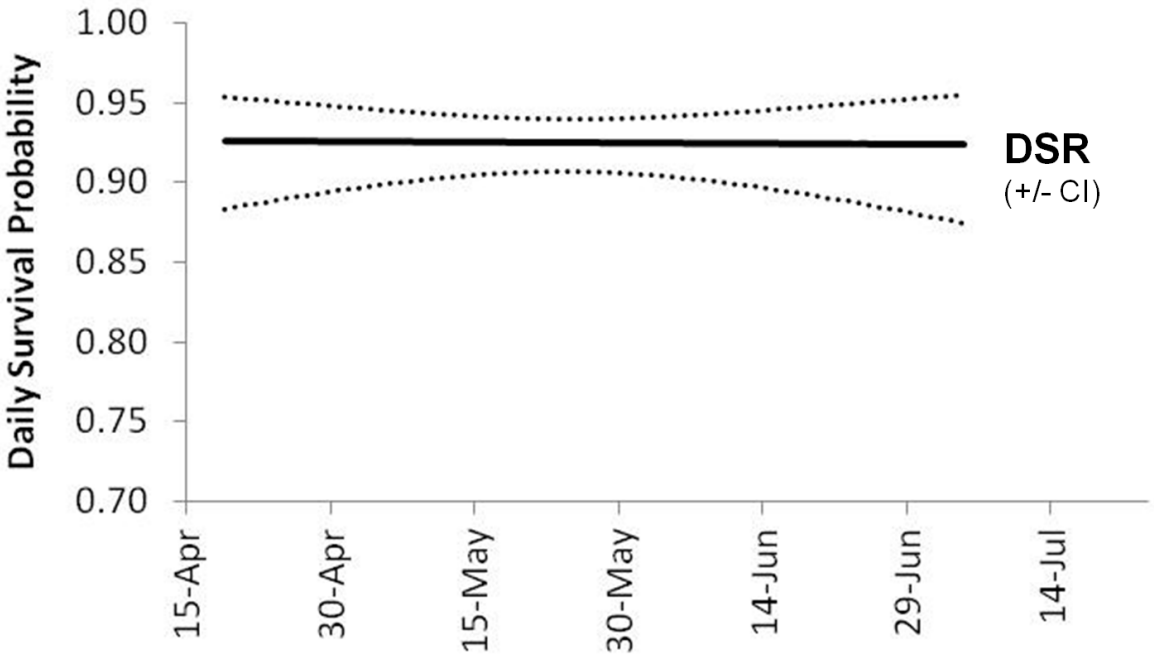


Figure 7. Little to no change in daily survival rate of Gray Vireo nests over the breeding season, 2012 and 2013 combined (model created with program Mark, based on 95 nests). Assuming 30 days required from laying of the first egg to fledging, this translates to an average nest-survival rate of 8.8%.

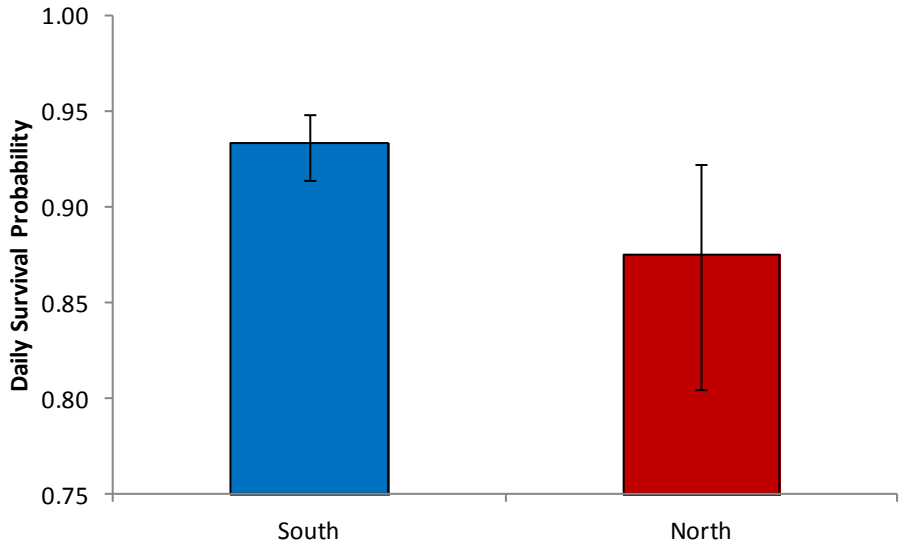


Figure 8. Difference in daily survival rate of Gray Vireo nests in the two study areas (south county vs. north county, ±95% confidence intervals), 2012 and 2013 combined (daily survival probability estimated with program Mark from 95 nests). Assuming 30 days required from laying of the first egg to fledging, this translates to a nest-survival rate of 12.6% for south county and 1.8% for north county, although the sample size for north county is smaller.

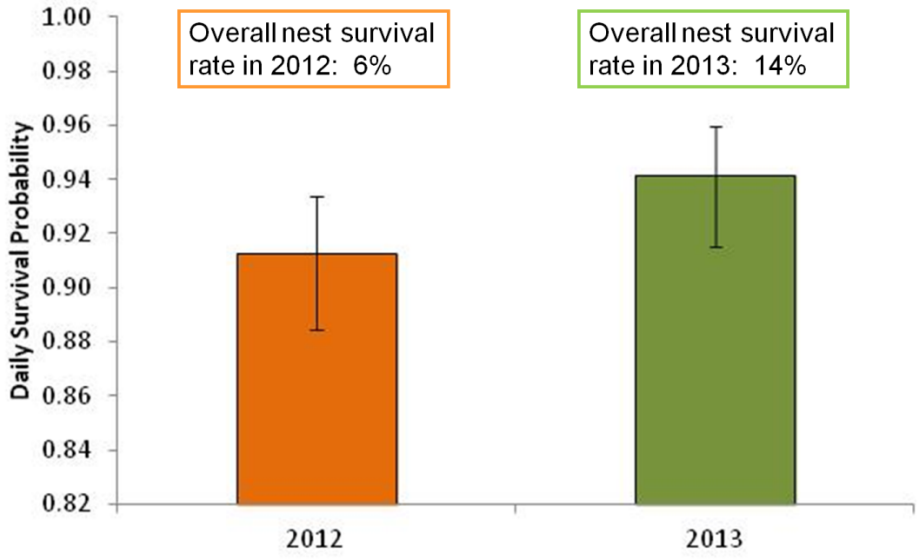


Figure 9. Difference in probability of daily survival of Gray Vireo nests in the two years (2012 vs. 2013). Error bars represent 95% confidence intervals (the difference between years was not statistically significant).

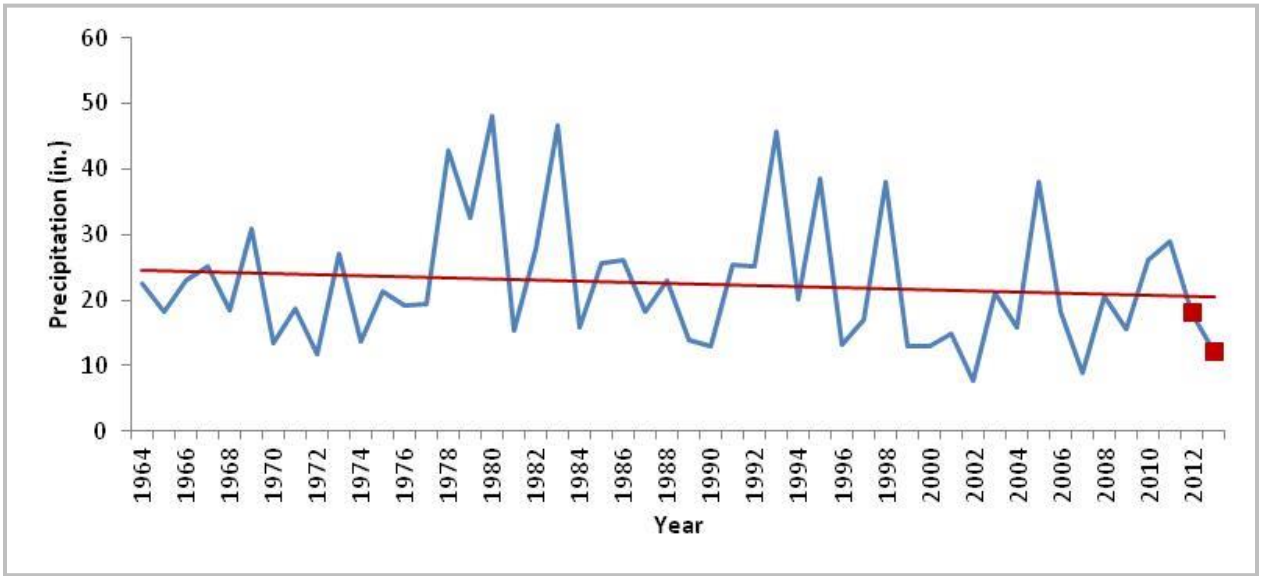


Figure 10. 50-year average precipitation (red line, cumulative July to June) was 22.5 inches. Precipitation during study year 2012 was 22% lower than the 50-year average, and during 2013 was 60% lower. 2.5-minute resolution data retrieved from PRISM on 18 October 2013, (http://prismmap.nacse.org/nn/), and averaged for three sites: Pacific Crest Trail at Indian Flats, Kitchen Creek Rd., and Noble Canyon.

Nest placement and clutch size:

Nests were all placed in shrubs, most frequently chamise (73%, Figure 11). Average shrub height was 1.8 m, while average nest height was 1.2 m (Table 4). On the basis of nests for which final clutch size could be determined (n = 45), average clutch size was 3.4 (range 1 to 4).

Table 4. Nest height, nest shrub height, and clutch size observed for the Gray Vireo, 2012–2013.

Variable	Mean	Range	*N*
Nest height	1.2 m	0.6-2.3 m	86
Shrub height	1.8 m	1.1-2.9 m	90
Clutch size	3.4	1 to 4	45

Nest shrubs were often on steep slopes, generally facing south (Figure 12). Nests were also most often on the south side of the shrub (Figure 13), which was also generally the downslope side of the shrub.

Incubation and Brooding:
Eggs typically appeared to be laid at one-day intervals, and incubation commenced with the first egg. However, adult birds were sometimes seen sitting on nests for long periods before the first egg was laid. Incubation typically lasted 16 to 18 days (notably longer than reported by Barlow et al. 1999), while brooding lasted 12 to 14 days.

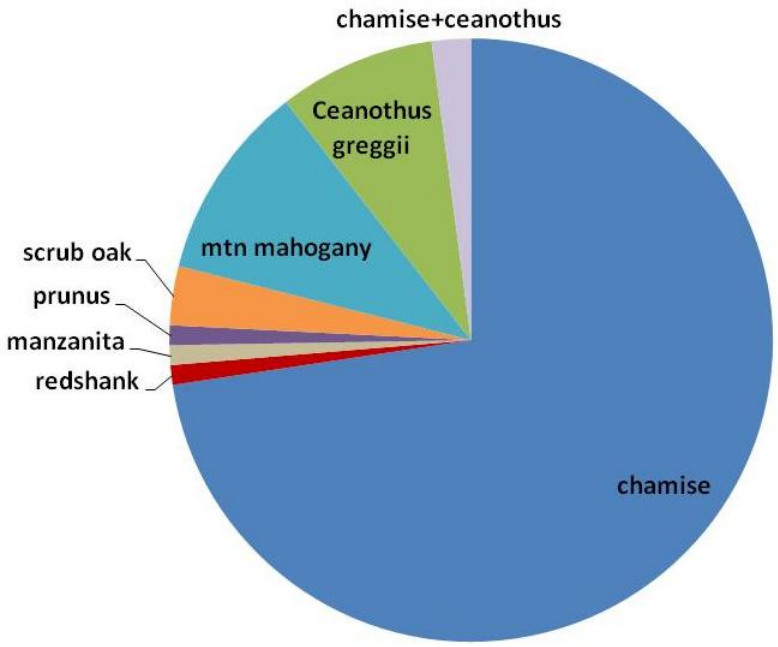


Figure 11. Relative use of shrub species in which Gray Vireos nested, 2012–2013 (*n* = 95). Chamise was the most frequently used (73%).

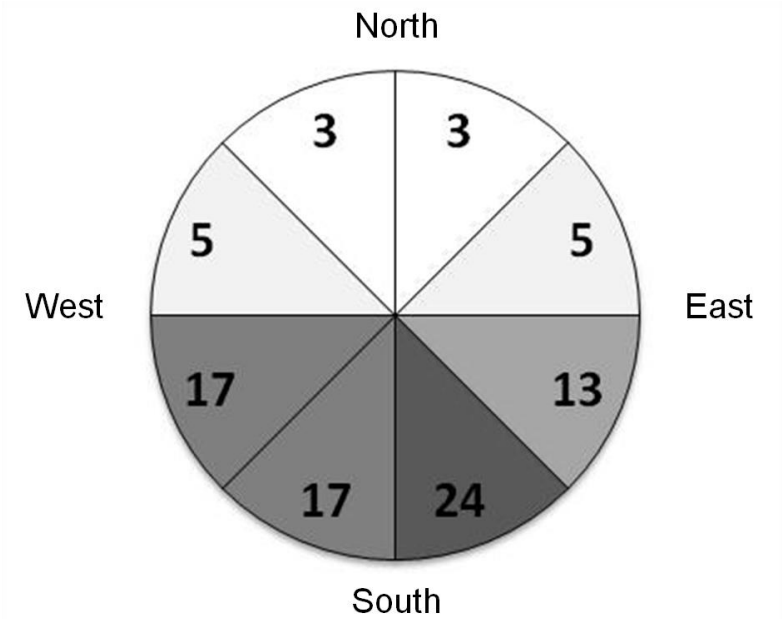


Figure 12. Number of nests by aspect of slope as measured at the nest shrub, 2012–2013 (*n* = 87).

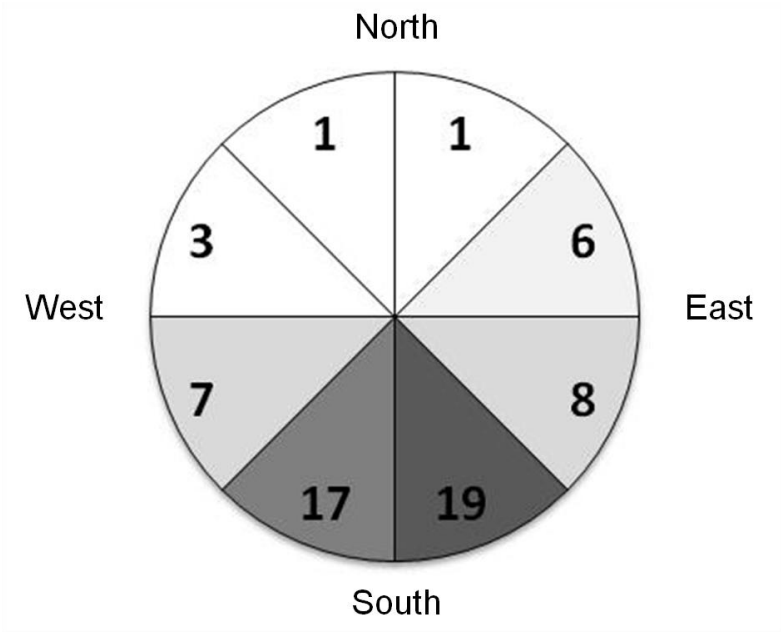


Figure 13. Approximately 81% of nests were placed away from the center of the shrub; of these nests, figure shows orientation within the shrub, 2012–2013 (*n* = 62).

Re-nesting:
Although birds were not banded, many territories were fairly obvious and consistent through the breeding season. At one territory at Sunrise Highway, the pair attempted at least 6 nests in 2012, all of which failed during or prior to incubation. At the neighboring territory in 2012, the pair successfully double brooded, the single instance of double brooding observed. The first nest fledged at least one chick on 6 June, and the pair was seen constructing a new nest within five days. The pair was seen moving repeatedly between the fledgling and the new nest, and at one point we observed the fledgling beg from the adult female as she incubated on the new nest. The second nest fledged one chick on 12 July, and both older and younger fledglings were subsequently observed in the territory. In 2013 we also observed a pair with a fledgling construct a new nest, but the second nest failed, most likely depredated during egg-laying.

Territory-level reproductive success:
Overall reproductive success is very difficult to estimate, but during this study, even with re-nesting and imperfect detection of nests, clearly fewer than one-third of territories produced any fledglings. Despite our intensive survey methods, in two cases we suspected that a pair had a nest but did not find it, then later confirmed fledglings in the territory. However, the number of fledglings produced per nest was low, often only one. In two cases, the birds incubated a clutch of only one egg, then brooded the single chick. Possibly, these atypically small clutches were the result of partial depredation. In one case, video revealed that a scrub-jay removed eggs from a nest, and the vireos abandoned it, but after abandonment one egg remained in the nest for at least one week. In another case, we documented protracted depredation: a scrub-jay gradually removed eggs over two days, and the Gray Vireos returned to incubate between the jay's visits. In at least three cases, partial depredation also appeared to occur near fledging. This was suspected when we observed a nest with nestlings, then on subsequent visit the nest was empty with one premature fledgling nearby.

Banded nestlings:
In 2012 Kevin Clark banded 13 Gray Vireo nestlings (Figure 14), of which at least 8 were confirmed to fledge. In 2013, one banded bird was re-sighted, less than 500 meters from where 4 nestlings had been banded in 2012.

Figure 14. Gray Vireo nestling being banded. Photo by Kevin Clark.

Video Monitoring

We placed cameras on a total of 30 Gray Vireo nests and recorded over 4,500 hours of video of nests while they were active. The Gray Vireos often stayed on the nest the entire time the cameras were set up (typically 10–20 minutes) or returned to the nest and resumed normal activity very shortly after the set up. On two occasions, the bird pecked at the camera after it was set up, but this behavior lasted a maximum of 20 seconds before the bird returned to the nest and resumed normal activity.

Of 30 nests video-recorded, 7 successfully fledged young, 3 were parasitized by cowbirds, 5 were probably depredated (but event not recorded or unclear), and 15 were confirmed depredated (Table 5). Of the 15 confirmed cases of depredation, 10 were by the Western Scrub-Jay, 1 was by a gray fox that took the nestlings, 1 was by a bobcat that took the adult female off the nest as she incubated, 1 was by a Bewick's Wren taking eggs, and 2 were by unidentified predators (1 large mammal that approached behind the nest and took the nestlings, and 1 that appeared to approach the nest from below and took 1 egg but left 2 that were subsequently abandoned).

Table 5. Outcomes of video-recorded Gray Vireo nests, 2012 and 2013 combined.

Video Outcome	*N*	%
Successful fledging	7	23.3%
Parasitized by cowbird	3	10.0%
Depredated, unrecorded/unconfirmed	5	16.7%
Depredated, recorded/confirmed	15	50.0%
Western Scrub-Jay	10	66.7%
Gray Fox	1	6.7%
Bobcat	1	6.7%
Bewick's Wren	1	6.7%
Not identified	2	13.3%

Further analysis of video recordings is needed to examine Gray Vireo behavior at the nest and its possible influence on depredation. There was no evidence that predators used the camera as a cue (i.e., approaching the camera before approaching the nest), and in each case of mammalian depredation, the predator appeared to directly attack the nest without any searching in the area (i.e., suggesting that scent was not a cue). There appeared to be no relationship between camera deployment and cases of depredation (Figure 15), with only one case of possible association where a scrub-jay went to the nest 95 minutes after deployment. Video cameras also documented that there was no apparent relationship between nest checks and depredation (Figure 16).

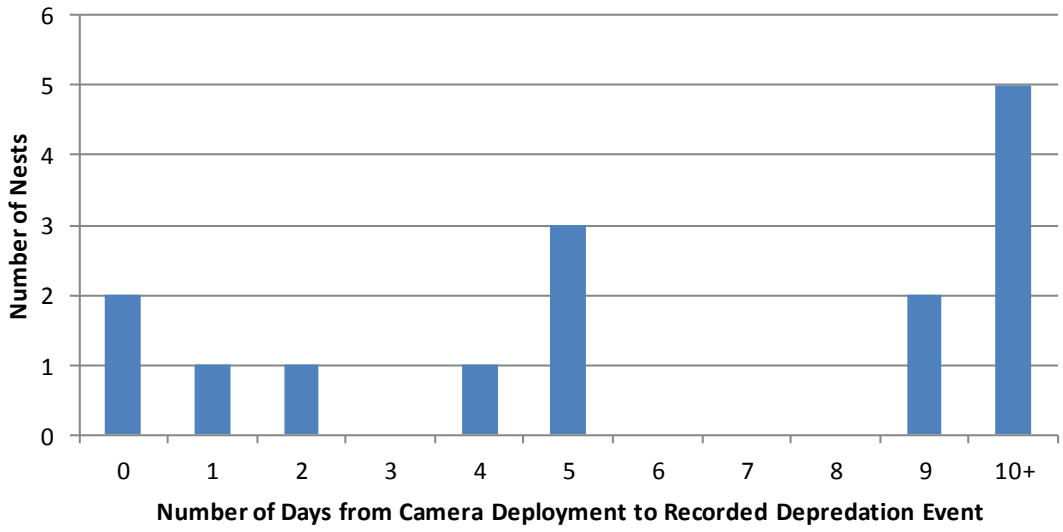


Figure 15. Distribution of periods in days between camera deployment and recorded depredation, where “0” is within the first 24 hours, “1” is 24–48 hours, etc.

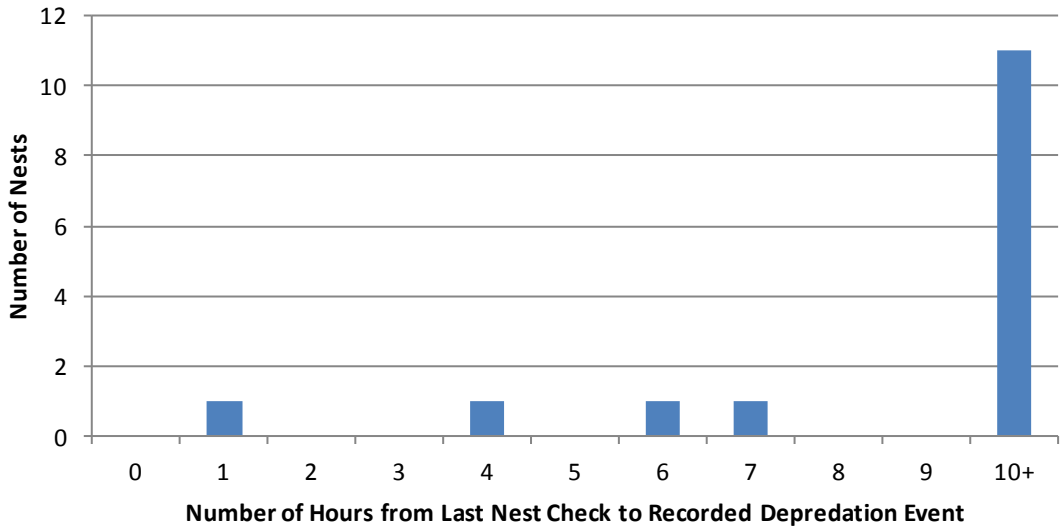


Figure 16. Distribution of periods in hours between last nest check (nest approached and/or contents checked) and recorded instances of depredation, where "0" is 0–60 minutes, "1" is 60–120 minutes, etc.

Discussion

Statewide status

The Gray Vireo is a California Bird Species of Special Concern and has been experiencing range retraction and population extirpations due to unknown causes. Despite its rarity in California, California may represent a substantial proportion of its total population. Throughout the species' rather limited range, the Gray Vireo population appears sparse and patchily distributed; recent surveys in other states have also found only isolated small populations. For example, in Arizona it was observed scattered in only 17% of atlas blocks (Corman 2005), and in New Mexico (DeLong and Williams (2006) estimated the total population at 549 to 827 birds within isolated clusters. Although any accurate census is difficult because of the species' preference for remote, rugged habitat, the Gray Vireo is highly detectable because of its loud and persistent song. However, because of the patchy distribution pattern with absence from vast areas of apparently suitable habitat, most modeling techniques tend to produce exaggerated population estimates.

The Gray Vireo is rarer than many other species recognized as endangered and threatened by the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, such as the Least Bell's Vireo and California Least Tern, but has never received any management in the state of California previously. Though the species' distribution has never been known in detail, and

many remote sites are not visited often, it has contracted or disappeared at least from northeastern Kern County, the San Gabriel Mountains of Los Angeles County, the Cajon Pass area, Joshua Tree National Park, the San Jacinto Mountains, the Santa Rosa Mountains, and north-central San Diego County.

In 1908 in the San Jacinto Mountains, Grinnell and Swarth (1913) described the Gray Vireo as common in many localities from 3000 to 6500 feet elevation and estimated that there were 960 individuals in the San Jacinto region. Despite focused surveys of the San Jacinto and Santa Rosa mountains since 2008 by the SDNHM at 9 sites where Gray Vireos were present in 1908 and at additional areas with suitable habitat, only three observations have been made on the north slope of the Santa Rosa Mountains.

Only San Diego County has substantial recent records, a result of field work for its bird atlas from 1997 to 2001; Unitt (2004) estimated its population in the low hundreds. There are two major population centers, one north of Warner Springs and the other in the southern Laguna Mountains. Our two-year study of these two population centers in San Diego County (2012–2013) revealed substantial reductions since 2002, especially in the northern center where Gray Vireos persist at only 1 of 7 sites checked that were formerly occupied, and we documented a very high rate of nest failure, insufficient to sustain the population.

Yet vast tracts of the Gray Vireo's habitat remain intact. Even though documentation is modest (Hanna 1944), Remsen (1978) suggested only cowbird parasitism as a reason for the Gray Vireo's decline in California, and the parallel of the Gray with the decline of other vireos in southern California implies that the cowbird was the primary cause of the decline (Unitt 2008). It was our goal to investigate the contribution of cowbird parasitism and other possible factors to the Gray Vireo's demographic crisis.

Reproductive success in San Diego County

Many factors can contribute to the decline of a species, and these factors can vary greatly from site to site and from year to year. During this two-year study, we documented very poor nest success, likely insufficient to sustain the population. Nest success was lowest in the northern part of the county, where there has also been strong declines since the field work for the Bird Atlas just over 10 years ago. The northern part of San Diego County is also adjacent to Riverside County, where we confirmed a dramatic decline since 1908. One possibility is that pressure from Brown-headed Cowbirds has been greater in these areas than in the southern part of San Diego County. Although we detected cowbirds at each site where there were Gray Vireos, proximity to habitat suitable for cowbird foraging (cattle pastures) may be an important factor. The sites in Riverside County that were formerly occupied by the largest population in the state all border Garner Valley, which has been heavily used for cattle grazing since 1908. Gray Vireo sites in northern San Diego County lie within 12 km of Warner Valley, a major cattle grazing area, and also the smaller-scale areas of Oak Grove Valley and Chihuahua Valley. The sites in the

southern part of the county are adjacent to the smaller-scale areas of Cottonwood and Cameron valleys, and farther to the south is the major cattle-grazing area of Campo Valley. Horse corrals in Garner Valley, Pinyon Flat, Pine Valley, and doubtless other areas also offer habitat for cowbird foraging near Gray Vireo sites.

Observer effects in the form of disturbance, scent, and visual cues may introduce bias by increasing or decreasing the likeliness of nest predation and parasitism. They should therefore always be minimized for the purposes of comparative study and to avoid any reduction of nesting success. In this study we located nest locations by observing the pair's behavior from distant vantage points. Any nest checks were as brief and unobtrusive as possible. Cameras were designed to be small, camouflaged, easily and quickly deployed, and the battery and memory card were stored well away from the nest. Video documentation suggested that predators did not use the cameras as a cue, and there was no apparent association between camera placement or nest checks and instances of depredation.

Current Threats and Management Implications

Nest success was extremely low with 18% apparent success and 9% probability of success, much lower than reported for most passerines or in other studies of the Gray Vireo. On the basis of 27 nests at Colorado National Monument, Hutchings and Leukering (in Barlow et al. 1999) reported apparent nest success of 33%, and a recent study in New Mexico has found an apparent nest-success rate of 54.7%, or, by the Mayfield (1975) method, 43.6% probability of success (C. Nishida, pers. comm.). Despite frequent re-nesting, this success rate is likely too low to sustain the population in San Diego County, which is currently the largest known population in the state.

The Western Scrub-Jay was the most frequent cause of nest failure. Jays most often took eggs rather than nestlings, and they appeared to find the nests often before eggs were even laid. The jays actively searched for nests, systematically searching through shrubs or perching nearby, while the Gray Vireos spent a significant amount of time scolding and chasing the jays. Videos often showed protracted depredation. For example, a jay took 1 of 4 eggs in the evening, then returned the following morning to gradually take the rest of the eggs (still being incubated).

Although the Gray Vireo's two main population centers in San Diego County fall within the protected Cleveland National Forest, scrub jays may be benefiting from rural development and campgrounds, possibly spreading into the more arid chaparral favored by the Gray Vireo where there are fewer oaks. However, it is possible that depredation pressure from jays could vary year to year, perhaps with variation in the acorn crop (Koenig et al. 2009).

Other possible threats observed include off-road vehicle tracks (prevalent at Horse Canyon and Bear Valley Road), evidence of target shooting (most prevalent at Bear Valley Road), and frequent biking, hiking, and/or camping at many sites. Given the Gray Vireo's apparent preference for remote habitat, it may be sensitive to human disturbance or to secondary effects

related to human settlement—predation or parasitism may decrease with distance from human settlement. Other predators may be more common than detected by the cameras. Rodent scat was found inside three depredated nests, snakes were observed near active nests (Striped Racer, Gopher Snake), and other avian predators were observed in territories (Cooper's Hawk, Greater Roadrunner, Common Raven).

In this region, summers are predicted to be increasingly hot and dry, and fires increasingly frequent (Cayan et al. 2008, Hayhoe et al. 2004, Lenihan et al. 2008, Loarie et al. 2008), which could drive down the population further. None of the Gray Vireo sites we studied had burned within the last 10 years, and many have very old growth with a high percentage of dead shrubs.

Interesting differences between our two years of study included a shift to earlier nesting dates in the drier year of 2013, with slightly better nesting success. Because this difference did not reach the level of statistical significance, however, more years of study are needed for the level of annual variation and the influence of climate to be quantified.

If a high rate of nest failure is pervasive in California, one possibility is that populations breeding in Mexico are acting as a source population refilling a sink in California. This could explain the steeper declines farther north of the border. However, very little is known about the status of Gray Vireo populations in Mexico. Surveys of the sierras Juárez and San Pedro Mártir are needed for an adequate perspective on the Gray Vireo's status in California. Studies of over-winter survival are also needed.

We documented 10 nests that failed because of cowbird parasitism, but many instances of parasitism probably went undetected because of the high rate of depredation. In one case, we documented cowbird parasitism on video, the nest was subsequently abandoned, and on the next visit the nest was empty. Without the camera, we would have attributed the failure only to depredation. In two cases we found nests with punctured eggs, one of which had already been parasitized (Figure 17). Trapping of the Brown-headed Cowbird has been critical to the recovery of the Least Bell's Vireo. It is unknown if such trapping would be enough to tip the scales in favor of the Gray Vireo even if the cowbird is not the biggest source of nest failure.

These data will form a valuable baseline for assessing the efficacy of any management that may be undertaken. Three levels of "breeding success" can be tested for an effect of management in a comparison of sites before vs. after and control vs. treatment. (1) Population-level: territory density tested by nonparametric 2-way analysis of variance with a site-type by year interaction terms; (2) Territory-level: breeding success based on highest stage of progression for each territory to include non-nesting and re-nesting, tested by nonparametric analysis of variance (PROC MIXED with anovaf, SAS 9.2); and (3) Nest-level: daily probability of nest survival by maximum-likelihood estimates for each site and year (program Mark, version 5.1).

Figure 17. Gray Vireo nest with two cowbird eggs and one vireo egg, all punctured. Photo by Kevin Clark.

We recommend testing possible management techniques, and initiation of controlled tests of cowbird and scrub-jay trapping at selected sites in conjunction with continued monitoring. Trapping of cowbirds and scrub-jays will likely have a positive effect on other sensitive species, such as Bell's Sage Sparrow and the Blue-gray Gnatcatcher. Cowbird trapping has been an effective method for the recovery of the Least Bell's Vireo (Kus 1999, 2002) and is likely to have positive benefits even if not the primary cause of nest failure. In this study we documented 10 instances of cowbird parasitism, and suspect that many more went undetected.

Scrub-jays depress passerines' nest success substantially (e.g., Preston and Rotenberry 2006), and in this study we documented the scrub-jay as the most frequent predator of Gray Vireo nests. Possible management strategies for the scrub-jay will need to be explored. It is unknown if there are any effective direct or indirect means of reducing scrub jay numbers, though Marzluff and Neatherlin (2006) suggested reducing access to food in rural areas and campgrounds. It is not known whether scrub-jay trapping would be an effective management method, but scrub-jays have been trapped successfully on Santa Cruz Island (Boyce et al. 2011).

Another possible management strategy is to provide supplementary food for scrub-jays, which has been shown to reduce their rates of predation on nests of other passerines (Preston and Rotenberry 2006), but at the same time also reduce or control the reproductive output of supplemented scrub-jay pairs by monitoring their nests and reducing their effective clutch size (e.g., addle all but one egg). Controlled experiments are necessary to determine effectiveness of any management undertaken.

Scrub jays may be benefiting from rural development and campgrounds, possibly spreading into the more arid chaparral favored by the Gray Vireo where there are fewer oaks. There is some evidence for numbers of scrub-jays in arid chaparral increasing over historic levels (San Jacinto Centennial Resurvey Project). However, it is possible that depredation pressure from jays could vary year to year, possibly with variation in the acorn crop (Koenig et al. 2009). Therefore, we recommend monitoring territories, nest timing, and productivity of the scrub-jay in conjunction with any future Gray Vireo surveys or management efforts, and we recommend longer-term study of the relationship between scrub-jay predation pressure, acorn productivity, and human activity.

Future Research Needs

- Experiment with cowbird control, comparing rate of success of Gray Vireo nests in areas with and without cowbird control.
- Experiment with scrub-jay control, comparing rate of success of Gray Vireo nests in areas with and without scrub-jay control.
- Investigate current breeding status and distribution of the Gray Vireo in northern Baja California.
- Overlay fire-history maps with Gray Vireo distribution to identify the ages of chaparral the Gray Vireo occupies.
- Investigate factors that may be affecting over-winter survival. Though the Gray Vireo's association in winter with *Bursera microphylla* has been identified (Bates 1992a), it raises the questions of over-winter survival in relation to the tree's fruit production and the environmental factors that may contribute to variation in this production. Yet another question is winter site fidelity and territoriality (reported by Bates 1992b): what is the Gray Vireo's flexibility in selection of winter habitat in response to variation in fruit production or habitat loss? The winter distribution of the Gray Vireos breeding in California remains uncertain: do populations breeding east and west of the Colorado River winter on opposite sides of the Gulf of California, or do the populations mix in their winter range, crossing the gulf? Are there specific regions of Baja California critical to the Gray Vireo?

Acknowledgments

This research was possible only thanks to a $75,000 start-up grant from California Department of Fish & Game, which funded all camera equipment and the majority of field work in 2012. Matching funds of $13,719 from Cleveland National Forest in 2012 and $15,542 in 2013 allowed us to increase sample sizes and expand the effort into a second year. Field work was performed by the following personnel: Lea Squires, Lori Hargrove, Tom Myers, Philip Unitt, Kevin Clark (including banding of the nestlings under permit), Matt Sadowski, and Christine Harvey. Rulon Clark, Josh Culver, and Scott Tremor helped with the development of the video camera systems. Thanks to the Pueblo of Santa Ana and others for providing data from their Gray Vireo studies.

Literature Cited

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

Bates, J. M. 1992. Frugivory on *Bursera microphylla* (Burseraceae) by wintering Gray Vireos (*Vireo vicinior*, Vireonidae) in the coastal deserts of Sonora, Mexico. Southwest. Nat. 37:252–258.

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

Belding, L. 1890. Landbirds of the Pacific District. Occ. Pap. Calif. Acad. Sci. 2:1-174.

Boyce, W. M., W. Vickers, S. A. Morrison, T. S. Sillett, L. Caldwell, S. S. Wheeler, C. M. Barker, R. Cummings, and W. K. Reisen. 2011. Surveillance for West Nile virus and vaccination of free-ranging Island Scrub-Jays (*Aphelocoma insularis*) on Santa Cruz Island, California. Vector-Borne and Zoonotic Diseases 11:1063–1068.

Cayan, D. R., E. P. Maurer, M. D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climatic Change 87:S21–S42.

Corman, T. E. 2005. Gray Vireo, in Arizona Breeding Bird Atlas (T. E. Corman and C. Wise-Gervais, eds.), pp. 340–341. Univ. of New Mexico Press, Albuquerque.

DeLong, J. P. and S. O. Williams III. 2006. Status report and biological review of the Gray Vireo in New Mexico. New Mexico Department of Fish and Game.

Fisher, A. K. 1893. Report on the ornithology of the Death Valley Expedition of 1891, comprising notes on the birds observed in southern California, southern Nevada, and parts of Arizona and Utah. N. Amer. Fauna 7:7-158.

Friedmann, H. 1963. Host relations of the parasitic cowbirds. U.S. Natl. Mus. Bull. 233.

Garrett, K.. L, and Molina, K. C. 1998. Gray Vireo (*Vireo vicinior*), species account in the West Mojave Plan, Bureau of Land Management, 22835 Calle San Juan De Los Lagos, Moreno Valley, CA 92553 (http://www.ca.blm.gov/cdd/speciesaccounts.html).

Greaves, J. M. 1987. Nest-site tenacity of Least Bell's Vireos. Western Birds 18:50–54.

Grinnell, J. 1922. Northward range of the Gray Vireo in California. Condor 24:211–212.

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pac. Coast

Avifauna 27.
Grinnell, J. and H. S. Swarth. 1913. An account of the birds and mammals of the San Jacinto area of southern California. Univ. Calif. Publ. Zool. 10:197–406.
Hanna, W. C. 1944. The Gray Vireo as a victim of the cowbird. Condor 46:244.
Hargrove, L. 2002. Gray Vireo status, distribution, and habitat requirements in southern California: A preliminary study and protocol for the Cleveland National Forest. Unpublished report. Cleveland National Forest, San Diego, CA.
Hargrove, L. and J. T. Rotenberry. 2003. Ecology and status of the Gray Vireo (*Vireo vicinior*) and the elephant tree (*Bursera microphylla*) in the Anza-Borrego Desert State Park: A preliminary study. Unpublished report. University of California, Riverside for Anza-Borrego Desert State Park.
Hayhoe, K., D. Cayan, C. B. Field, et al. 2004. Emissions pathways, climate change, and impacts on California. Proc. Natl. Acad. Sci. 101:12422–12427.
Johnson, D. H., M. D. Bryant, and A. H. Miller. 1948. Vertebrate animals of the Providence Mountains area of California. Univ. Calif. Publ. Zool. 48:221–376.
Koenig, W. D., A. H. Krakauer, W. B. Monahan, J. Haydock, J. M. H. Knops, and W. J. Carmen. 2009. Mast-producing trees and the geographical ecology of Western Scrub-Jays. Ecography 32:561–570.
Kus, B. E. 1999. Impacts of Brown-headed Cowbird parasitism on productivity of the endangered Least Bell's Vireo. Studies Avian Biol. 18:160–166.
Kus, B. E. 2002. Fitness consequences of nest desertion in an endangered host, the Least Bell's Vireo. Condor 104:795–802.
Lenihan, J. M., D. Bachelet, R. P. Neilson, and R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change 87:S215–S230.
Loarie, S. R., B. E. Carter, K. Hayhoe, S. McMahon, R. Moe, C. A. Knight, and D. D. Ackerly. 2008. Climate change and the future of California's endemic flora. PLoS One 3(6):e2502; http://www.plosone.org/article/info:doi/10.1371/journal.pone.0002502.
Marzluff, J. M., and E. Neatherlin. 2006. Corvid response to human settlements and campgrounds: causes, consequences, and challenges for conservation. Biological Conservation 130:301–314.
Mayfield, H. F. 1975. Suggestions for calculating nest successs. Wilson Bulletin 87:456–465.
Miller, A. H., and R. C. Stebbins. 1964. The Lives of Desert Animals in Joshua Tree National Monument. Univ. of Calif. Press, Berkeley.
Miller, L. 1921. The Gray Vireo in Los Angeles County, California. Condor 23:194.
Preston, K. L. and J. T. Rotenberry. 2006. Independent effects of food and predator-mediated processes on annual fecundity in a songbird. Ecology 87:160-168.
Remsen Jr., J. V. 1978. Bird species of special concern in California, California Department of Fish and Game, Wildlife Mgmt. Branch Admin. Rep. 78-1.
Rotella, J. J., S. J. Dinsmore, and T. L. Shaffer. 2004. Modeling nest-survival data: a comparison of recently developed methods that can be implemented in MARK and SAS. Animal Biodiversity and Conservation 27:1–19.

Stephens, F. 1890. A new vireo from California. Auk 7:159–160.
Unitt, P. 1984. The birds of San Diego County. San Diego Society of Natural History Memoir 13.
Unitt, P. 2000. Gray Vireos wintering in California elephant trees. Western Birds 31:258–262.
Unitt, P. 2004. San Diego County bird atlas. San Diego Society of Natural History Proceeding 39.
Unitt, P. 2008. Gray Vireo (*Vireo vicinior*), in California Bird Species of Special Concern (W. D. Shuford and T. Gardali, eds.), pp. 284–288. Studies in Western Birds 1. W. Field Ornithol., Camarillo, CA, and Calif. Dept. Fish & Game, Sacramento.
Wauer, R. H. 1964. Ecological distribution of the birds of the Panamint Mountains, California. Condor 66:287-301.
White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 (Supplement):120–139.
Willett, G. 1933. A revised list of the birds of southwestern California. Pac. Coast Avifauna 21.
Winter, K. and L. Hargrove. 2004. Gray Vireo (*Vireo vicinior*), in The Coastal Scrub and Chaparral Bird Conservation Plan: a strategy for protecting and managing coastal scrub and chaparral habitats and associated birds in California. California Partners in Flight; http://webcache.googleusercontent.com/search?q=cache:http://www.prbo.org/calpif/htmldocs/species/scrub/gray_vireo.htm.

Appendix 1. All sites surveyed in San Diego County 2012 by presence/absence surveys (at least two morning visits during May to early June) or by routine monitoring, with numbers of Gray Vireo territories observed. Seven major sites were surveyed in north county and 11 in south county, based on previous bird atlas records (Unitt 2004). See Appendix 8 for mapped locations of sites.

Sites	Presence/Absence Survey Locations	# Territories	Routine Monitoring Survey Locations	# Territories	Total Territories
North County					
Pacific Crest Trail at Indian Flats	1 mile further north and 0.5 miles further south of routine monitoring	0	From trailhead north 1.5 miles to "spring" and 1 mile south to where trail descends	6 to 7	6 to 7
Indian Flats Rd	From Hwy 79 to PCT trailhead	0			0
Indian Flats Camp	Indian Flats Campground and road above and below	0			0
Puerta La Cruz Rd	Intersection of Puerta La Cruz Rd and Indian Flats Rd to Chihuahua Valley Rd, Indian Flats Camp, and Hwy 79	0			0
Chihuahua Valley Rd	Hwy 79 to Puerta La Cruz Rd	0			0
Oak Grove CDFG Property and Dick Spring	Perimeter of Oak Grove Valley and jeep trail between Dick Spring and Adobe Springs	0			0
Palomar Mtn	Oak Grove Rd to Palomar Divide Trail and spot checks along High Point Rd to Hwy 79	0			0

Sites	Presence/Absence Survey Locations	# Territories	Routine Monitoring Survey Locations	# Territories	Total Territories
South County					
Sunrise Highway	Pullout 1.7 miles north of I-8, SE toward Cottonwood Creek and NW into Scove Cyn	2	Pullout 1 mile north of I-8, SE side	6 to 7	8 to 9
Noble Canyon (South & North)	Pine Creek Rd to Noble Mine and Miners Road to 1 mile north of Pine Creek Rd	0	Noble Cyn Natl Recreation Trail from Pine Valley trailhead to Noble Cyn	13 to 14	13 to 14
Horse Canyon (South & North)	Horse Cyn from near Kitchen Creek to 1.5 miles north	2 to 3	Sheephead Mtn Rd from base of road near I-8 to 0.5 miles above "Wind"	7 to 9	9 to 12
Pacific Crest Trail at Kitchen Creek Rd (East & West)	PCT from 0.3 miles west of Kitchen Ck Rd to descent near I-8	3 to 4	PCT from 0.3 miles west of Kitchen Ck Rd to 0.75 miles east of Kitchen Ck Rd	6	9 to 10
Kitchen Creek Rd North	From PCT to hairpin turn 0.75 miles above Cibbets Flat (and northernmost section of Rd to Sunrise Hwy spot-checked)	2 to 3	From hairpin turn 0.75 miles above Cibbets Flat to 1.75 miles further north	6 to 7	8 to 10
La Posta Rd North	I-8 to sideroad to Antone Cyn	3 to 4	Above Antone Cyn sideroad to Thing Valley Rd	1 to 2	4 to 6
Pacific Crest Trail at Lake Morena			PCT from Buckman Springs Rd to 1.5 or 2 miles south	2	2
Bear Valley Rd	Bear Valley Rd from Long Valley Rd to I-8 at Pine Valley (brief spot checks only)	0	From Buckman Springs Rd to Long Valley Rd	1	1

Sites	Presence/Absence Survey Locations	# Territories	Routine Monitoring Survey Locations	# Territories	Total Territories
Kitchen Creek Rd South	I-8 to PCT and canyon NNW of Cameron Fire Station	3 to 4			3 to 4
Fred Canyon Rd (and PCT)	Fred Cyn Rd from Cibbets Flat to Thing Valley Rd, and PCT from 0.5 miles south of Fred Cyn Rd to 2.5 miles north	8 to 9			8 to 9
La Posta Rd South	I-8 south to Microwave Station	0			0
Total					71 to 84

Appendix 2. Locations surveyed in Riverside County (San Jacinto Centennial Resurvey Project 2008-2013). Sites are ordered by increasing elevation, with potentially suitable habitat mainly between the elevation zones of upper Snow Creek to Thomas Mountain.

Sites	Survey Locations	# Gray Vireo Territories
Palm Canyon	Andreas Canyon, Murray Canyon, Wentworth Canyon, and Palm Canyon up to elevation 1460 ft	0
Whitewater	San Gorgonio River south of Hwy 111 from Fingal to Windy Point, and north of Hwy 111 to Whitewater River	0
Snow Creek	Snow Creek Canyon and Pacific Crest Trail to elevation 3250 ft	0
Cabazon	San Gorgonio River and Twin Pines Creek; Halls Grade Road to elevation 2350 ft and upper Twin Pines Creek	0
Valle Vista	San Jacinto River and hills to north up to Bee Canyon Road at elevation 2680 ft; Rouse Hill Road to elevation 2650 ft	0
Banning	Smith Creek and hills to elevation 2620 ft; Old Banning-Idyllwild Rd	0
Little Paradise	Asbestos Spring to Potrero Spring; Potrero Canyon; Little Paradise; Dutch Charlie Canyon; Palm Canyon elev 2000-2950 ft; trail to Hidden Falls and Rock House Spring at elevation 4145 ft	0
Carrizo Creek	Carrizo Creek elev 2000-3400 ft; Black Hill; Deep Canyon near Hidden Palms	0
Dos Palmas Spring	Carrizo Creek elev 3500-3860 ft; to Grapevine Creek; Carrizo Rd	0
Pinyon Flat	base of Asbestos Mtn to Sugarloaf Mtn to Omstott Creek elev 4350 ft; Sawmill Truck Trail to 4450 ft	0
Lake Hemet	Lake Hemet north side to dam, south side drainage up to elev 4430 ft	0
Kenworthy	Fobes Ranch Rd; Quinn Flat; Morris Ranch Rd; trail loop from East Canyon to Little Desert, Pyramid Peak, Lion Peak, Martinez Creek, Pipe Creek, Goff Flat; Ramona Trail to elev 5880 ft; road through Penrod Canyon to Gold Shot Mine; Pacific Crest Trail from Hwy 74 to elev 5160 ft	0

Vista Grande	From Ranger Peak down to Hurley Flat; 3S08; 4S06; Bay Tree Spring; Black Mountain Trail to elev 6390 ft	0
Strawberry Valley	Strawberry Creek to elev 6660 ft; Idyllwild County Park; May Valley; Johnson Meadow; South Ridge Trail	0
Fuller's Mill	Dark Canyon; Fuller Mill Creek; Black Mountain; old Hall-Decker road from 4S01 across Mountain Creek to Hall Canyon; Seven Pines Trail to elev 8000 ft	0
Garnet Queen Mine	7S02 from Hwy 74 to Garnet Queen Creek and Mountain Home Spring	2
Thomas Mountain	5S15 from elev 5000 ft up to Tool Box Spring, Magee Spring, Thomas Peak, Little Thomas Mtn, and down to Willow Valley	0
Santa Rosa Mountain	7S02 from elev 7338 ft to Santa Rosa Spring, Santa Rosa Peak, Stump Spring, Virgin Spring, Toro Peak, and drainage below Virgin Spring and Stump Spring Campground down to elev 7220 ft	0
Tahquitz Valley	Humber Park to Saddle Junction, Skunk Cabbage Meadow, Tahquitz Meadow, Little Tahquitz Valley, Tahquitz Peak, Red Tahquitz Peak, Reeds Meadow, Willow Creek Crossing, Laws Camp, Caramba	0
Round Valley	Palm Springs Tram to Long Valley Creek, Hidden Lake, Round Valley, Wellman Cienega, San Jacinto Peak, Tamarack Valley	0

Appendix 3. Detailed protocol reviewed with all personnel prior to surveys.

GRAY VIREO STUDY
TERRITORY AND NEST MONITORING PROTOCOLS
SAN DIEGO COUNTY 2012-2013

General objectives: Very little is known about the Gray Vireo's natural history, behavior, nesting, etc., but populations within California may be crashing. We will observe and document Gray Vireo nesting behavior and ecology at two study areas in San Diego County that may hold the largest populations in the state. Documentation will include nest-success rates, timing, possible causes of failure, habitat relationships, and general behavior notes and breeding ecology. We will also video-record nests to help determine nest timing, outcome, and causes of nest failure.

General strategy: Two large study areas based on bird atlas: north-county study area is centered around Indian Flats Campground, south-county study area is centered around Kitchen Creek (±10 miles). Targeted survey sites within these areas will be determined depending on where Gray Vireos establish territories and relative accessibility. Regular scouting trips will begin by April 1 to document territory establishment and determine targeted survey sites. Monitoring will continue throughout the breeding season, with visits to each territory every 2–6 days.

First Goal: **Territory monitoring** of 10–20 territories at each study area (20–40 total per year, minimum). We expect more territories at the S-county study area, but hopefully we can successfully monitor at least 10 in N-county and as many as we can reasonably monitor at both study areas (assuming at least 1 person regularly covering N-county and 2 people in S-county).

Successfully monitored territories:
1. Date that singing male was first detected (this should be within 1 week of when nest building is first documented for the season).
2. Minimum weekly visits with:
  A. Plotting on maps of locations of birds.
  B. Documentation of behavior and any breeding activity (minimum 30 min observation per week, preferably 2× per week).
  C. Documentation of predators and other potential threats or disturbances.
3. Final date that activity was detected in summer (this should be within 1 week of when fledging is last documented for the season).
4. Habitat quantification.

Although birds will not be banded, we will target areas where multiple singing males are detected and map locations of birds on a weekly basis. Patterns of likely territories should emerge over the season. Gray Vireos tend to have very large territories with high site fidelity,

usually next to neighboring territories. On a weekly basis we will try to determine the breeding status of each monitored territory and record general notes on observed behaviours.

Other notes to record on a weekly basis: Activity of any predators or other potential threats, including: BHCO, WSJA, CORA, COHA, snakes, lizards, mammals, humans, etc, and any evidence of competition with other passerines (e.g., chasing). Also note if you cause any disturbance, either inadvertently or setting up cameras, etc.

Second Goal: Nest-monitoring. We will attempt to locate and monitor ALL Gray Vireo nests within targeted study sites, and also other incidental nests as time allows (especially BGGN). Each nest will be carefully documented on nest monitoring forms. We will attempt to find nests as early as possible (ie. nest-building). To minimize disturbance, nest status will be determined from a distant vantage point without approaching the nest, whenever possible. Status will be checked apx 2x per week, and an effort will be made to determine transition dates (first egg, first nestling, first fledgling), and any causes of failure. Nests will be approached only after it is confirmed that no predators are in the immediate vicinity, and preferably when the adults are away from the nest. To avoid predator discovery or abandonment, it is preferable to quickly walk by a nest with only a glance. Adults MUST be away from the nest during early stages (nest-building and early incubation), or the nest could be abandoned. Do not approach any nests with late-stage nestlings to avoid forcing early fledging. For failed nests, first check for early fledging, and then carefully check for tracks, egg shell fragments, rodent feces, ants, dishevelled nest material, feathers, broken branches, and other clues as to possible causes of failure. Exact measurements of nest height, substrate, etc, will be made after the breeding season is over. (It is possible that birds could attempt to re-use a failed nest, or re-use nest material.)

If BHCO eggs are found in nests, eggs will be addled and replaced. (Observe adult behavior before/after.) If BHCO chicks are found in nests, they will be left undisturbed with observations carefully recorded.

Third Goal: Video-recording nests. We will attempt to collect digital video recordings and photographs of as many nests as possible, beginning as early as possible (ie. nest-building), but minimizing disturbance. We will use two types of cameras depending on the height and concealment of the nest: (1) motion-detection “deer camera” placed 10-20 ft from nest, and (2) continuously recording mini-camera placed 2-3 ft from nest. It is anticipated that the mini-cameras will be difficult to set up and maintain, but any video clips or photos documenting causes of nest failure will be an especially valuable product of this study. Continuous recording will potentially allow for quantification of % of time the birds spend on the nest, M vs. F behavior at the nest, feeding of nestlings (rates and food types), and help to determine transition dates and causes of nest failure (including BHCO parasitism).

FORMS:

1. Map: Plot the locations of areas surveyed, territories monitored, nests, and other observations. Use cross-reference codes with territory monitoring log "MapID" (eg. Pair2, SM#3, canyon PR) to distinguish between territories.

2. Site Visit Log: A simple log of visits to a site, with date, time, initials, weather, and summary of activities/observations.

3. Territory Monitoring Log: A log of more detailed notes of observations made of territories at a site. For each territory monitored at a site, record date, time, initials, highest rank observed (SM, PR, NB, NE, NN, FL), and notes including behavior and any potential predators/threats.

4. Nest Monitoring Form: 2-sided form for each nest found (or possible nest). This is to document the location of the nest, vantage point, camera type/location, and to record nest observations made each visit (status, # eggs, nestlings), notes on adult behavior, and dates/time camera memory or batteries are replaced.

PHASE I	Late-March to Mid-April	General P/A surveys to determine study sites Record areas surveyed and P/A results on maps
PHASE II	Mid-April to Early-July	Intensive monitoring and nest searching at each site Apx 2x per week site visits
PHASE III	Early-July to August	Reduce monitoring, measure habitat/nests Apx 1x per week site visits (2x for nests)

WHEN A NEST OR SUSPECTED NEST LOCATION IS FOUND:

1. Do not approach the nest.
2. Choose a vantage point from where the adults won't be disturbed but the general location of the nest can be seen and adult behavior can be observed. (It is not necessary to see the nest.)
3. Take a waypoint at the vantage point and mark the vantage point with flagging tape. Fill out a nest form including the coordinates of the vantage point, apx distance and direction to nest, nest substrate, apx nest height, apx shrub height, and a sketch. Also fill out the first line of "observations".
4. Try to determine the status of the nest by observing adult behavior, and if needed, quickly walk by the nest with a glance. Only approach a nest after ensuring that no predators are in the immediate area, and preferably when adults are away from the nest. (Adults must be away from the nest during nest building and early egg laying or it will most likely be abandoned.) The status will need to be checked apx 2x per week to document transition dates, clutch size, and nest outcome. (Record total # eggs and nestlings, and of those, #s of cowbird "CB" eggs and nestlings.)
5. Record if/when a camera is placed, the type of camera, location of camera, ID of memory card, and record each time the camera is checked or the batteries and/or memory are changed.

Appendix 4. Form used for all nest monitoring (visit rows continue onto back of form).

NEST MONITORING FORM

NEST ID _____ DATE _____ SITE _____

SPECIES _____ METHOD _____

SUBSTR _____ APX NEST HEIGHT _____ APX SUBST HEIGHT _____

DIRECTIONS/NOTES

SKETCH

Rem to note: apx distance and direction of nest from flagging, flagging height and substrate, coordinates of flagging, nest visibility, how flagging should be approached, draw arrow to nest in sketch, locations and types of any cameras.

DATE	TIME	INITS	TTL EGGS	CB	TTL NESTL	CB	ACTIONS, OBSERVATIONS, and NOTES (OK to use multiple lines)

Especially note all evidence of possible depredation or fledging: nest damage, fragments below nest, tracks, distance of FL to nest, #, age of FL, and adult behavior. Also note description/age of nestlings. Put additional notes on territory form, incl. evidence of 2nd nest attempt.

Appendix 5. Form used for detailed nest measurements at end of season.

NEST-LEVEL MEASUREMENT FORM

NEST ID ____ ORIG DATE ____ SITE ____

SPECIES ____ NEST COND ____

NEST COORDS: N ____ W ____ Elev ____ Err ____

% CONCEAL (10 ft): N ____ E ____ S ____ W ____ "N" = you are facing north. Also place stakes and take photos.

SUBSTR ____ SUBSTR HEIGHT ____ SUBSTR WIDTH ____

SLOPE ____ ASPECT ____ NEST HEIGHT ____ NEST ORIENT ____

NEST DIMENS: OUTER HEIGHT ____ OUTER WIDTH ____ INNER HEIGHT ____ INNER WIDTH ____

NEST PLACEMENT ____

NEST CONSTRUCT ____

10-FT RADIUS	EC%
Non-Herb Veg	
Herb Veg	
Rocks	
Soil/Sand	
Litter/CWD	

Non-herb Species:	RelSpCov%:	%Die-Back:	Other Notes:

List indiv shrubs for avg height:

Species:	Height:

Photo Log:

Description:	Original ID	File Name
Facing N, nest at 10 ft		
Facing E, nest at 10 ft		
Facing S, nest at 10 ft		
Facing W, nest at 10 ft		

Predators/Disturbance/Other Notes:

CAMERA DISTANCE ____ MEAS DATE ____ INITS ____ FLAGS COLL? ____ NEST COLL? ____

Appendix 6. All Gray Vireo territories and nests monitored in 2012.

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Pacific Crest Trail at Indian Flats	1	N009	5/3/2012	5/5/2012	no	Failed: depredated after clutch completed (4 eggs)	33.34092	116.63798	chamise
		N028	5/14/2012	5/20/2012	no	Failed: 2 cowbird eggs and 1 vireo egg, all punctured	33.34092	116.63783	chamise
		N070	6/17/2012	6/20/2012	no	Failed: parasitized by cowbird; abandoned	33.34034	116.63902	chamise
	2	N016	5/5/2012	n/a	no	Failed: abandoned during early nest-building, many Scrub-Jays in area	33.33606	116.63672	chamise
		N039	5/23/2012	5/24/2012	no	Failed: probably depredated during or after egg-laying	33.33711	116.63637	chamise
	3/4	N015	5/5/2012	5/17/2012	yes	Failed: probably depredated during egg-laying or shortly after (started video after probable event)	33.32831	116.63875	chamise
		N040	5/23/2012	5/24/2012	no	Failed: 1 cowbird egg and 3 vireo eggs, abandoned	33.32678	116.63822	redshank
		N062	6/12/2012	6/14/2012	no	Failed: 2 vireo eggs and 1 cowbird egg, abandoned	33.33036	116.63728	mtn mahogany
	5	N017	5/7/2012	5/9/2012	no	Failed: nest probably depredated during egg-laying (torn apart)	33.32636	116.63511	chamise
		N046	5/28/2012	5/21/2012	yes	Successful: at least 2 fledglings confirmed (on video 6/19/12)	33.32800	116.63509	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
	6	N003	4/20/2012	n/a	no	Failed: probably abandoned during nest-building; Scrub-Jay nest with 4 eggs found 50 m from nest.	33.32794	116.63184	chamise
		N013	5/5/2012	5/3/2012	yes	Failed: depredated (4 eggs); missed by video due to incorrect settings	33.32652	116.63342	chamise
		N041	5/24/2012	5/21/2012	no	Failed: depredated after clutch completed (4 eggs), feathers on ground below nest.	33.32693	116.63114	chamise
		N052	6/4/2012	6/4/2012	no	Failed: 4 eggs depredated	33.32740	116.62982	chamise
Sunrise Highway	1	N005	4/24/2012	4/30/2012	no	Failed: probably depredated during egg-laying	32.82229	116.50173	chamise
		N019	5/9/2012	5/7/2012	no	Failed: depredated after clutch completed (4 eggs)	32.82279	116.50173	chamise
		N032	5/19/2012	5/24/2012	yes	Failed: 4 eggs depredated? At least 1 taken by a Bewick's Wren (on video)	32.82249	116.50163	chamise
		N054	6/6/2012	6/11/2012	yes	Failed: eggs depredated by Scrub-Jay (on video 6/16/12)	32.82191	116.50323	chamise
		N072	6/21/2012	6/23/2012	no	Failed: cowbird parasitized; abandoned	32.82244	116.50147	chamise
		N077	7/3/2012	7/5/2012	no	Failed: nest probably depredated during egg-laying	32.82193	116.50184	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
	2	N011	5/4/2012	5/7/2012	no	Partial success: at least 1 fledgling confirmed, premature	32.82144	116.50050	chamise
		N061	6/11/2012	6/13/2012	no	Partial success: 2 nestlings banded, 1 fledged, 1 died in nest unknown cause	32.82212	116.50089	chamise
	3	N055	6/8/2012	6/11/2012	no	Failed: eggs depredated (after at least 1 egg)	32.81957	116.49957	chamise
	4	n/a	n/a	n/a	n/a	No nest: Very consistent singing male; well-observed; female only observed on 5/27 and 6/3.	n/a	n/a	n/a
Noble Canyon North	1	n/a	n/a	n/a	n/a	No nest: Irregular singing male; territory not well-observed; female never seen.	n/a	n/a	n/a
	2	n/a	n/a	n/a	n/a	No nest: fairly consistent singing male; well-observed; female only observed on 5/2 and 5/29.	n/a	n/a	n/a
	3	n/a	n/a	n/a	n/a	No nest: Irregular singing male; territory not well-observed; female only observed on 6/16 moving between territories.	n/a	n/a	n/a
	4	n/a	n/a	n/a	n/a	No nest: consistent singing male; well-observed; female only observed on 6/16 moving between territories.	n/a	n/a	n/a

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Noble Canyon South	1	n/a	n/a	n/a	n/a	No nest: Fairly consistent singing male; territory difficult to observe; female only observed on 5/17 so possibly shifted.	n/a	n/a	n/a
	2	N043	5/27/2012	5/22/2012	no	Probably failed: 4 nestlings banded, observed in nest later near fledging age, but fledglings not observed and adult behavior suggested no fledglings.	32.84303	116.51886	mtn mahogany
	3	N026	5/14/2012	n/a	no	Failed: probably abandoned during nest-building	32.84333	116.51698	chamise
		N036	5/22/2012	5/25/2012	yes	Failed: 4 eggs depredated by Scrub-Jay (on video 5/30/12)	32.84239	116.51846	Ceanothus greggii
	4	N007	4/27/2012	5/2/2012	yes	Failed: nest completed, video showed Scrub-Jay visit nest	32.84072	116.51897	chamise
		N067	6/14/2012	6/19/2012	no	Failed: eggs depredated	32.84095	116.51777	mtn mahogany
		N073	6/24/2012	6/25/2012	no	Failed: nest found destroyed, probably depredated during egg-laying or shortly after.	32.84202	116.51780	not recorded
		N079	7/3/2012	7/1/2012	no	Failed: nest depredated after full clutch (3+ eggs)	32.84024	116.51759	mtn mahogany
	5	N044	5/27/2012	5/30/2012	yes	Failed: 4 eggs depredated by Scrub-Jay (on video 6/3/12)	32.84149	116.51363	Ceanothus greggii

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
		N064	6/12/2012	6/12/2012	yes	Successful: 2 fledglings confirmed (on video 7/12/12 but poor quality)	32.84180	116.51225	Ceanothus greggii
	6	N066	6/14/2012	n/a	no	Failed: possibly abandoned or depredated before complete	32.84406	116.51270	chamise
		N078	7/3/2012	7/1/2012	no	Failed: nest depredated, probably at egg stage (after full clutch of 3 eggs)	32.84432	116.51273	chamise
Horse Canyon North	1	N031	5/18/2012	5/21/2012	no	Failed: 3 nestlings depredated	32.76548	116.47215	scrub oak
	2	N010	5/3/2012	4/30/2012	yes	Failed: depredated by Scrub-Jay after clutch completed and close to hatching (4 eggs); on video	32.76776	116.47332	chamise
		N030	5/18/2012	5/23/2012	no	Failed: exact nest location not determined until 8/5/12. Based on behavior, probably failed during egg stage; jays prevalent in area.	32.77037	116.47222	chamise
		N053	6/6/2012	6/10/2012	no	Successful: fledglings observed (4 nestlings banded)	32.76683	116.47343	chamise
	3	N014	5/5/2012	5/6/2012	no	Failed: depredated (4 nestlings)	32.76986	116.47472	chamise
		N068	6/17/2012	6/19/2012	yes	Failed: eggs presumed depredated, but video inconclusive	32.76923	116.47512	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
		N076	6/28/2012	6/29/1930	yes	Failed: partially depredated from below by unidentified predator, only 1 egg taken, then abandoned (on video 7/3/12)	32.76753	116.47394	chamise
	4	N012	5/5/2012	n/a	no	Failed: possibly already depredated before found, or abandoned during nest-building	32.77363	116.47562	chamise
		N024	5/13/2012	5/20/2012	yes	Partial success: 1 fledgling confimed by video 6/17/12. (The final clutch size of this nest was only 1 egg.)	32.77155	116.47443	mtn mahogany
	5	N057	6/8/2012	6/13/2012	no	Failed: depredated (after at least 1 egg)	32.77544	116.47475	mtn mahogany
Horse Canyon South	1	n/a	n/a	n/a	n/a	No Nest: irregular singing male on 5 occasions in April then not until 6/22; female only observed on 4/10 and 4/22 so possibly shifted.	n/a	n/a	n/a
	2	n/a	n/a	n/a	n/a	No nest: fairly regular singing male, female observed on 5/15, 5/20, 5/23, and 5/29 so suspect unsuccessful nesting attempt and possibly shifted.	n/a	n/a	n/a
Kitchen Creek Rd North	1	N027	5/15/2012	n/a	no	Failed: possibly abandoned before complete or depredated early	32.78504	116.44843	Ceanothus greggii

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
	2	N008	4/28/2012	5/1/2012	no	Failed: depredated during egg-laying or shortly after	32.78252	116.44667	chamise
		N058	6/9/2012	6/12/2012	no	Failed: probably depredated during egg-laying or shortly after	32.78361	116.44627	chamise
	3	N023	5/13/2012	5/14/2012	yes	Failed: depredated by Scrub-Jay (4 eggs); on video 5/20/12	32.78313	116.44373	chamise
	4	N059	6/9/2012	n/a	no	Failed: probably abandoned during early nest-building	32.78721	116.44450	scrub oak
		N071	6/19/2012	6/18/2012	yes	Failed: depredated by Scrub-Jay after clutch completed, at least 2 eggs (on video 7/1/12)	32.78788	116.44369	chamise
	5	N074	6/26/2012	n/a	no	Failed: abandoned or depredated during nest building	32.78999	116.44292	chamise
		N080	7/14/2012	7/2/2012	no	Failed: nest depredated (3+ eggs)	32.78976	116.44235	scrub oak hybrid
	incid	N048	6/2/2012	5/10/2012	no	Probable success: fledglings likely, based on adult behavior and fecal sacs in nest; territory not regularly monitored.	32.75798	116.45348	chamise
Kitchen Creek Rd PCT West	1	N060	6/9/2012	6/11/2012	yes	Failed: 1 cowbird egg and 1 vireo egg, abandoned (on video)	32.74806	116.45418	mtn mahogany
	incid	N042	5/25/2012	5/28/2012	yes	Failed: After clutch completed (4 eggs), adult female taken by bobcat (on video 6/11/12)	32.74161	116.46360	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Kitchen Creek Rd PCT East	1	n/a	n/a	n/a	n/a	No nest: Singing male on 9 occasions in April and early May only, female only observed 4/17 and 4/19 so possible switching.	n/a	n/a	n/a
	2	n/a	n/a	n/a	n/a	No nest: Fairly regular singing male, possibly shifted from SE to NW in late April (or different males); female observed only 5/13 and 6/19 in NW part of territory so probably shifting.	n/a	n/a	n/a
	3	N018	5/8/2012	5/7/2012	yes	Failed: depredated by Scrub-Jay after at least 2 eggs laid, 1 egg left, abandoned (on video)	32.75056	116.44540	chamise
		N029	5/18/2012	5/20/2012	no	Failed: probably depredated during egg-laying, nest torn out of shrub but intact, small broken branch above nest	32.75082	116.44563	chamise
		N037	5/23/2012	5/26/2012	yes	Failed: After clutch complete (4 eggs), parasitized by cowbird (2 vireo eggs + 1 cowbird egg); abandoned (on video)	32.75068	116.44508	chamise
	4	N049	6/4/2012	6/6/2012	no	Failed: Clutch of at least 3 eggs depredated, broken shells in nest; later visit revealed hole in bottom of nest and woodrat scat directly below nest	32.75261	116.44495	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
		N065	6/13/2012	6/17/2012	no	Failed: depredated after at least 1 egg laid	32.75189	116.44424	chamise
	5	N050	6/4/2012	n/a	no	Failed: fresh but disheveled nest, probably recently depredated, pair nearby	32.74916	116.44099	chamise
		N075	6/26/2012	6/29/2012	yes	Successful: 3 chicks banded and fledglings confirmed (on video, last fledgling 8/1/12).	32.75104	116.44344	chamise
La Posta Rd North	1	N006	4/27/2012	5/4/2012	no	Failed: depredated after eggs were laid (at least 1 egg)	32.78457	116.39586	chamise
		N035	5/21/2012	n/a	no	Failed: nest torn up, appears incomplete	32.78305	116.39741	chamise
	incid	N069	5/30/2012	?	no	Probable failure: found on ground by construction worker during nestling stage?	32.73300	116.42940	mtn mahogany
Bear Valley Rd South	1	n/a	n/a	n/a	n/a	No nest: singing male only observed on 3/27, 4/8, and 4/17.	n/a	n/a	n/a
Lake Morena PCT	1	N021	5/6/2012	5/6/2012	no	Failed: probably depredated during incubation	32.70549	116.49477	Ceanothus greggii
		N025	5/12/2012	n/a	no	Failed: nest incomplete	32.70599	116.49491	chamise
		N038	5/23/2012	5/18/2012	no	Successful: at least 1 fledgling confirmed (photographed)	32.70576	116.49472	chamise

Appendix 7. All Gray Vireo territories and nests monitored in 2013.

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Pacific Crest Trail at Indian Flats	1	N097	4/28/2013	4/23/2013	no	Failed: depredated clutch of 3 eggs; suspect later nest attempt also failed	33.33939	116.63787	chamise
	2	N103	5/8/2013	n/a	no	Failed: probably abandoned during nest-building	33.33620	116.63464	chamise
		N122	5/24/2013	n/a	no	Failed: probably abandoned during nest-building	33.33672	116.63431	chamise
		N133	6/5/2013	6/7/2013	no	Failed: cowbird parasitized; abandoned	33.33553	116.63730	chamise
	3	N089	4/21/2013	4/28/2013	no	Failed: depredated after at least 1 egg laid	33.33054	116.63635	chamise
	4	N098	4/28/2013	5/3/2013	no	Failed: clutch of 4 eggs depredated	33.32749	116.63946	redberry
	5	N085	4/15/2013	n/a	no	Failed: possibly failed during construction or early stage (found near trail early in season, empty)	33.32653	116.63375	chamise
		N086	4/17/2013	4/27/2013	no	Successful: at least 1 fledgling confirmed on 5/29/13 (clutch of only 2 eggs)	33.32682	116.63538	chamise
		N130	6/1/2013	6/4/2013	no	Failed: probably depredated during egg-laying	33.32685	116.63534	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
	6	N095	4/24/2013	n/a	no	Failed: probably abandoned during nest-building (many jays in area); pair later observed nest-building much further upslope (too difficult to monitor)	33.32739	116.62826	chamise
Sunrise Highway	1	N083	4/14/2013	4/19/2013	yes	Failed: eggs depredated by scrub-jay 5/5/13 (on video)	32.82210	116.50283	chamise
		N107	5/14/2013	5/11/2013	no	Failed: probably depredated during early incubation	32.82276	116.50153	chamise
		N113	5/17/2013	5/26/2013	no	Failed: probably depredated during egg-laying or early incubation	32.82249	116.50172	chamise
		N128	6/2/2013	5/31/2013	no	Failed: probably depredated during incubation	32.82281	116.50175	chamise
	2	N084	4/14/2013	4/20/2013	no	Failed: probably depredated during egg-laying or early incubation	32.82173	116.50030	Ceanothus greggii
		N108	5/14/2013	5/15/2013	yes	Failed: eggs depredated by scrub-jay 5/19/13 (on video)	32.82219	116.50076	chamise
		N129	6/2/2013	5/25/2013	no	Failed: clutch of 4 eggs depredated	32.82212	116.49981	chamise
		N135	6/9/2013	6/12/2013	no	Successful: fledglings confirmed on 7/12/13 (clutch of 2)	32.82249	116.50172	chamise
	3	N123	5/24/2013	5/25/2013	yes	Successful: fledglings confirmed on 6/25/13 (on video)	32.81977	116.49880	chamise
	4	N094	4/23/2013	4/27/2013	no	Failed: cowbird parasitized; abandoned	32.82062	116.50054	chamise

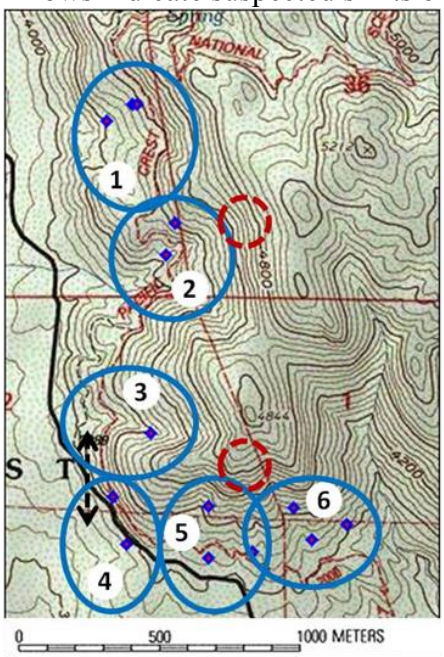
Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Noble Canyon South	1	N100	4/29/2013	5/3/2013	no	Failed: abandoned after clutch of 4 eggs, solo singing male on subsequent visit	32.84441	116.51984	manzanita
	2	N099	4/29/2013	5/1/2013	no	Failed: clutch of at least 3 eggs depredated	32.84310	116.52002	Ceanothus greggii
	3	n/a	n/a	n/a	n/a	No nest: singing male regularly observed, female only seen 1-2 times	n/a	n/a	n/a
	4	n/a	n/a	n/a	n/a	No nest: pair only observed later in season	n/a	n/a	n/a
	5	N087	4/20/2013	4/29/2013	no	Successful: fledglings confirmed on 5/29/13	32.84222	116.51201	chamise + ceanothus
	6	N106	5/13/2013	5/13/2013	yes	Successful: fledglings confirmed on 6/14/13 (on video)	32.84533	116.51133	chamise + ceanothus
	7	n/a	n/a	n/a	n/a	No nest found but successful: pair irregularly observed, fledgling confirmed on 12 July	n/a	n/a	n/a
	8	N102	5/3/2013	5/12/2013	no	Failed: at least one egg probably depredated	32.84898	116.51307	Ceanothus greggii
		N110	5/17/2013	5/21/2013	no	Failed: probably depredated, punctured egg found below nest	32.84821	116.51285	mtn mahogany
		N126	5/29/2013	6/1/2013	no	Failed: clutch of 3 eggs depredated	32.84940	116.51389	scrub oak

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
		N137	6/14/2013	n/a	no	Failed: incomplete	32.84813	116.51324	coast live oak
Horse Canyon North	1	n/a	n/a	n/a	no	No nest: singing male on 3-4 occasions early in season, banded	n/a	n/a	n/a
	2	N091	4/22/2013	4/24/2013	no	Failed: probably depredated during nestling stage	32.76746	116.47411	chamise
		N116	5/20/2013	n/a	no	Failed: incomplete	32.76693	116.47239	chamise
		N132	6/4/2013	5/28/2013	no	Successful: fledglings confirmed on 7/1/13	32.76770	116.47322	chamise
	3	N096	4/25/2013	4/27/2013	no	Failed: depredated after full clutch or near hatching	32.76839	116.47513	chamise
		N111	5/17/2013	5/15/2013	no	Failed: clutch of at least 2 eggs depredated	32.77150	116.47473	chamise
		N119	5/24/2013	5/26/2013	yes	Failed: nestlings depredated by large mammalian predator, unidentified, 6/20/13 (on video)	32.77051	116.47493	chamise
	4	N118	5/24/2013	5/15/2013	no	Unknown outcome: One nestling, then no activity in territory	32.77361	116.47635	chamise
	5	N090	4/22/2013	4/23/2013	yes	Failed: nestlings depredated by gray fox (on video)	32.77500	116.47570	Ceanothus greggii
		N117	5/24/2013	5/26/2013	no	Failed: probably depredated after clutch of at least 3 eggs	32.77429	116.47544	mtn mahogany
		N131	6/4/2013	6/6/2013	no	Successful: fledgling photographed on 7/9/13	32.77513	116.47460	mtn mahogany

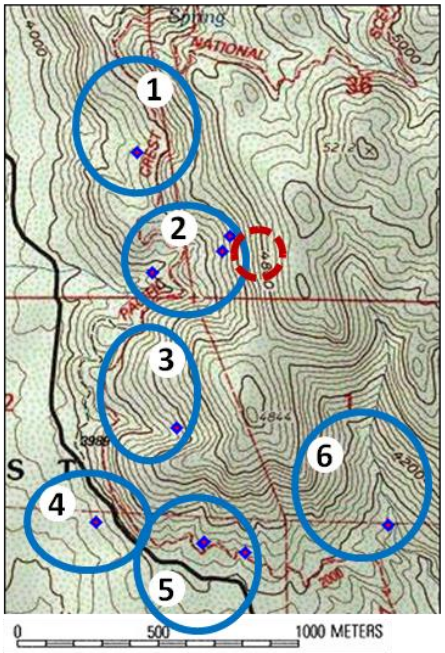
Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
Horse Canyon South	1	N120	5/24/2013	5/27/2013	no	Successful: fledgling confirmed on 6/26/13	32.76073	116.47193	chamise
Kitchen Creek Rd PCT West	1	N082	4/7/2013	4/23/2013	no	Failed: early outlier nest-building; probably depredated during egg-laying or early incubation (1 egg, later gone) Later successful: later nest not located but fledglings confirmed on 15 July	32.74773	116.45413	chamise
	2	n/a	n/a	n/a	no	No nest: singing male on several occasions, female observed once; territory not well-monitored	n/a	n/a	n/a
Kitchen Creek Rd PCT East	1	N092	4/23/2013	4/29/2013	yes	Failed: eggs damaged/abandoned due to strong winds on 5/1/13 (on video)	32.74587	116.45083	chamise
	2	n/a	n/a	n/a	n/a	No nest: singing male on few occasions only early in season	n/a	n/a	n/a
	3	N093	4/23/2013	4/26/2013	no	Failed: depredated near hatching (nest knocked out of shrub, feathers below nest)	32.74996	116.44605	chamise
	4	N124	5/28/2013	5/26/2013	yes	Successful: fledglings confirmed on 6/25/13 (on video)	32.75246	116.44456	chamise
	5	N101	5/3/2013	5/11/2013	yes	Failed: eggs depredated by jay (on video)	32.75057	116.44298	chamise

Site	Terri-tory	Nest ID	Found Date	Apx Lay Date	Video	Outcome/Notes	N	W	Shrub
		N109	5/16/2013	5/19/2013	yes	Failed: cowbird parasitized, abandoned (on video); later found empty	32.75089	116.44355	chamise
		N125	5/28/2013	5/31/2013	no	Failed: depredated after at least 1 egg laid	32.75048	116.44365	chamise
Bear Valley Rd South	n/a	n/a	n/a	n/a	n/a	Unoccupied	n/a	n/a	n/a
Lake Morena PCT	n/a	n/a	n/a	n/a	no	Pair present, not regularly monitored	n/a	n/a	n/a

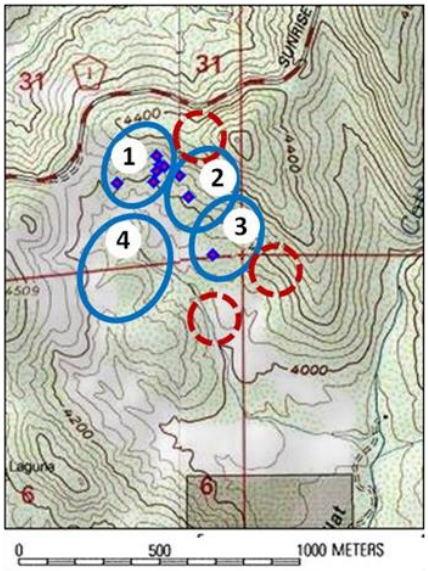
Appendix 8. Approximate locations of monitored Gray Vireo territories (numbered blue ovals) at 12 sites in 2012 vs. 2013 (A-X). Red circles indicate territories that were irregular or not routinely monitored (perimeter of the survey area). Small diamonds represent nest locations. Arrows indicate suspected shifts of a female between two males' territories.



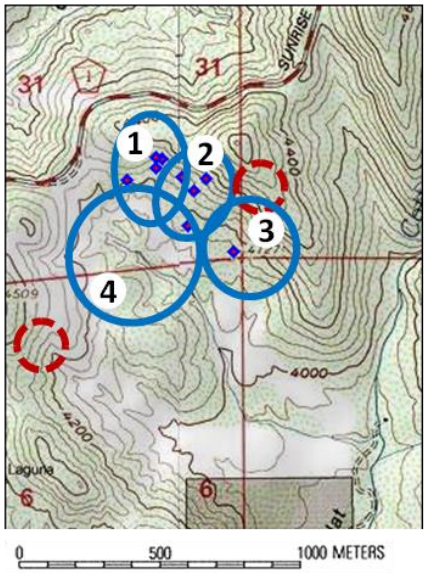
A. PCT near Indian Flats (2012)



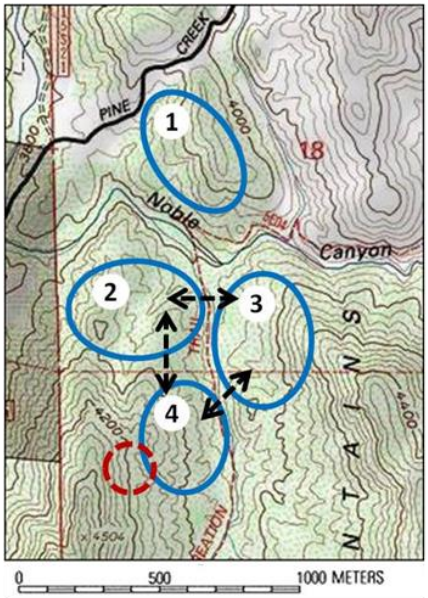
B. PCT near Indian Flats (2013)



C. Sunrise Highway (2012)



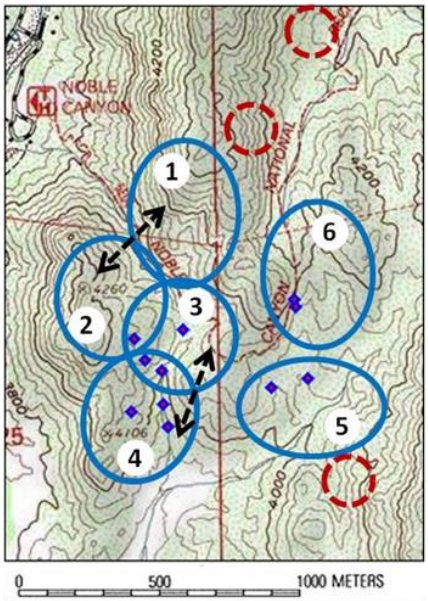
D. Sunrise Highway (2013)



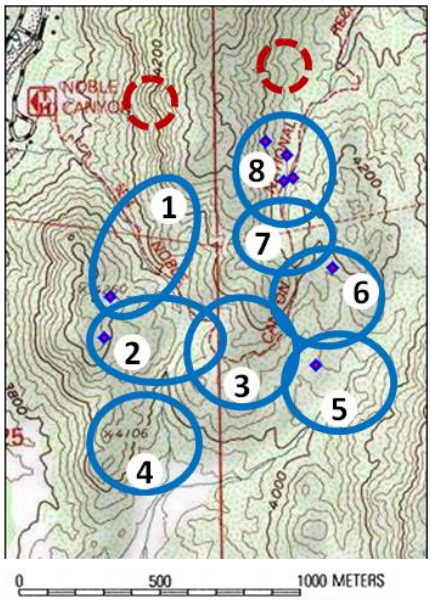
E. Noble Canyon North (2012)

Not surveyed in 2013

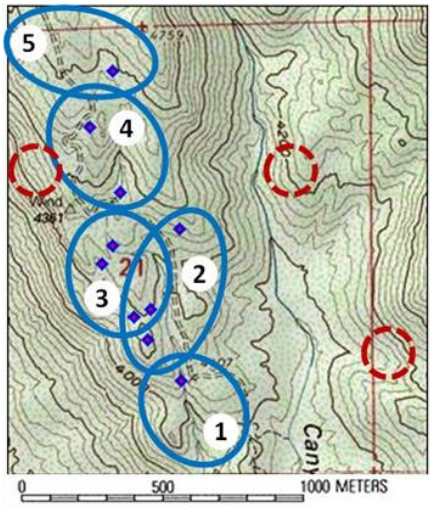
F. Noble Canyon North (2013)



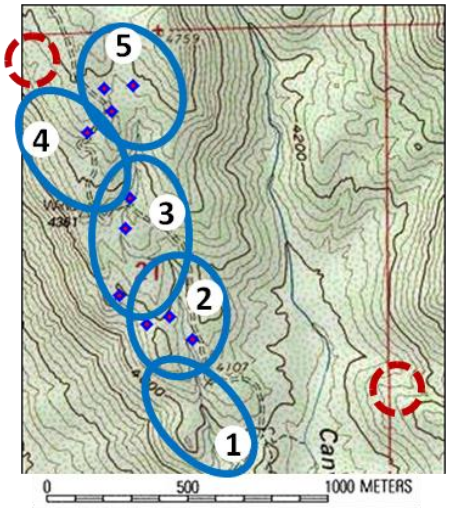
G. Noble Canyon South (2012)



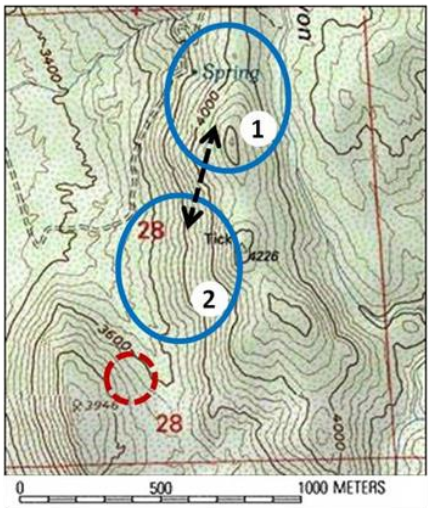
H. Noble Canyon South (2013)



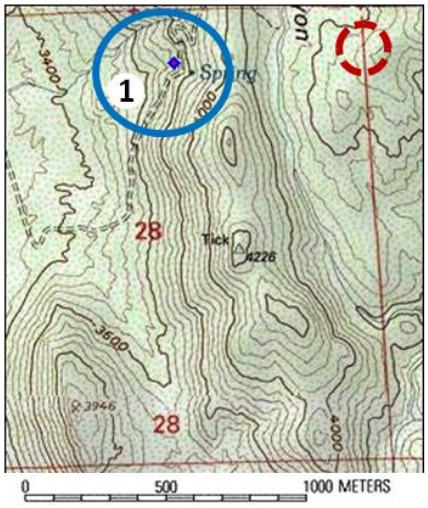
I. Horse Canyon North (2012)



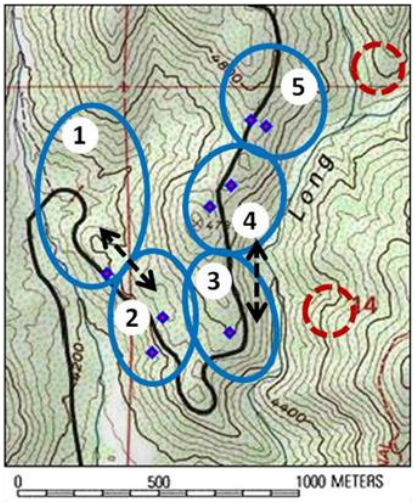
J. Horse Canyon North (2013)



K. Horse Canyon South (2012)



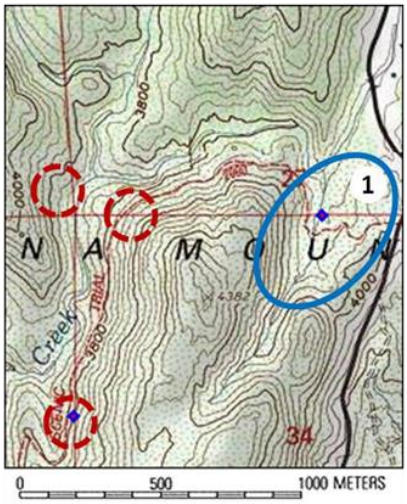
L. Horse Canyon South (2013)



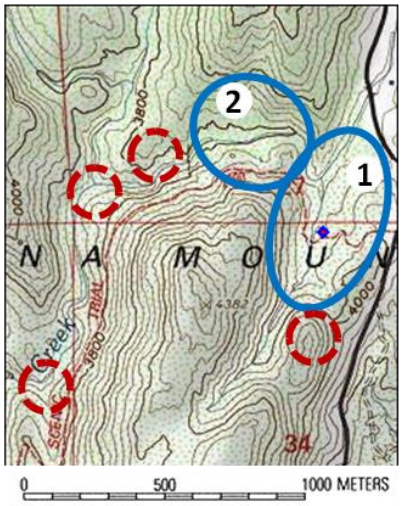
M. Kitchen Ck Rd North (2012)

Not surveyed in 2013

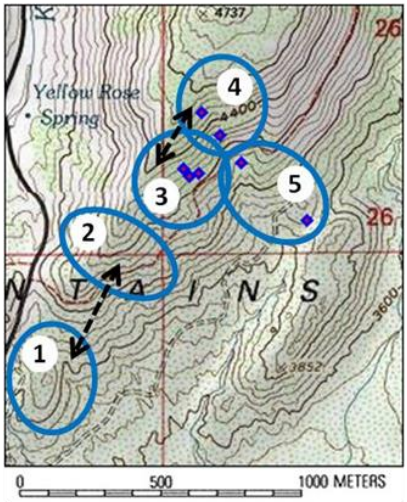
N. Kitchen Ck Rd North (2013)



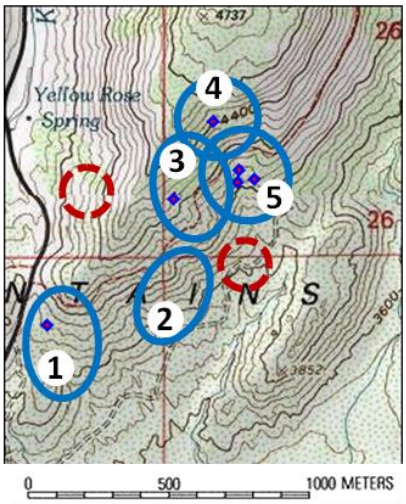
O. Kitchen Ck Rd PCT West (2012)



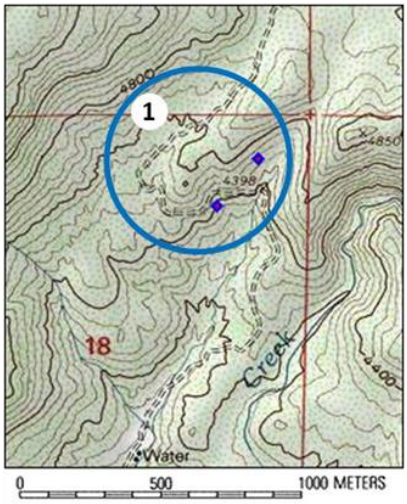
P. Kitchen Ck Rd West (2013)



Q. Kitchen Ck Rd PCT East (2012)



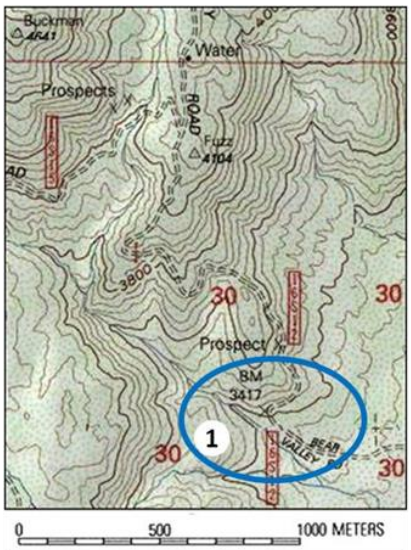
R. Kitchen Ck Rd PCT East (2013)



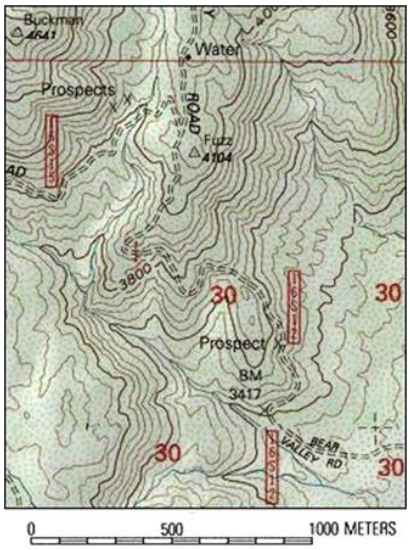
S. La Posta Rd North (2012)

Not surveyed in 2013

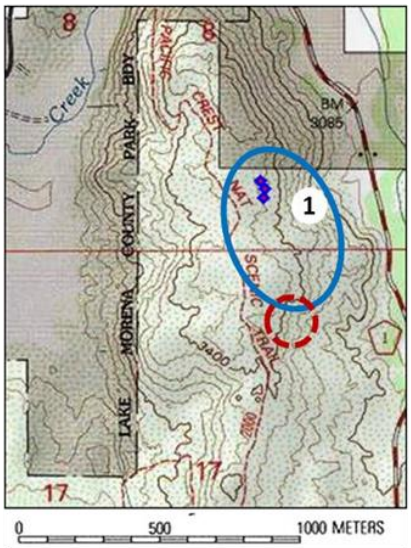
T. La Posta Rd North (2013)



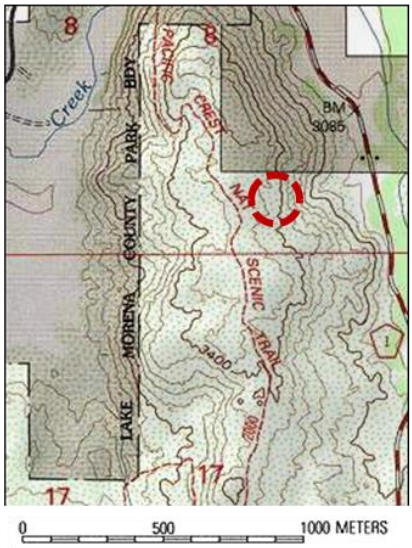
U. Bear Valley Rd South (2012)



V. Bear Valley Rd South (2013)



W. Lake Morena PCT (2012)



X. Lake Morena PCT (2013)