Western Riverside County
Multiple Species Habitat Conservation Plan (MSHCP)
Biological Monitoring Program

Loggerhead Shrike (*Lanius ludovicianus*)
Survey Report 2010

28 March 2011

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NOTE TO READER:

This report is an account of survey activities conducted by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The Monitoring Program monitors the distribution and status of the 146 Covered Species within the Conservation Area to provide information to Permittees, land managers, the public, and the Wildlife Agencies (i.e., the California Department of Fish and Game and the U.S. Fish and Wildlife Service). Monitoring Program activities are guided by the MSHCP species objectives for each Covered Species, the information needs identified in MSHCP Section 5.3 or elsewhere in the document, and the information needs of the Permittees.

Reserve assembly of the MSHCP is ongoing and it is expected to take 20 or more years to construct the final Conservation Area. The Conservation Area includes lands acquired for conservation under the terms of the MSHCP and other lands that have conservation value in the Plan Area (called public or quasi-public lands in the MSHCP). In this report, the term "Conservation Area" refers to the Conservation Area as understood by the Monitoring Program at the time the surveys were planned and conducted.

We thank and acknowledge the land managers in the MSHCP Plan Area, who in the interest of conservation and stewardship facilitate Monitoring Program activities on the lands for which they are responsible. A list of the lands where data collection activities were conducted in 2010 is included in Section 7.0 of the Western Riverside County Regional Conservation Authority (RCA) Annual Report to the Wildlife Agencies. Partnering organizations and individuals contributing data to our projects are acknowledged in the text of appropriate reports.

While we have made every effort to accurately represent our data and results, it should be recognized that data management and analysis are ongoing activities. Any reader wishing to make further use of the information or data provided in this report should contact the Monitoring Program to ensure that they have access to the best available or most current data.

The primary preparer of this report was the 2010 Avian Program Lead, Nicholas Peterson. If there are any questions about the information provided in this report, please contact the Monitoring Program Administrator. If you have questions about the MSHCP, please contact the Executive Director of the RCA. Further information on the MSHCP and the RCA can be found at www.wrc-rca.org.

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INTRODUCTION

The loggerhead shrike (*Lanius ludovicianus*; shrike) is one of 45 bird species covered by the Western Riverside County MSHCP, and is designated as a Species of Special Concern at both the State and Federal level (Dudek & Associates 2003). Shrikes are distributed statewide except for the coastal slopes, the Coast Ranges, the Klamath and Siskiyou Mountains in the northwest, the Sierra Nevada and southern Cascades, and high elevations of the Transverse Ranges (Humple 2008). Shrikes are permanent residents within western Riverside County and are widely distributed throughout the Plan Area, occurring relatively frequently within the central portion of the Plan Area, but with few records in the montane areas (Dudek and Associates 2003).

The MSHCP identifies 3 species objectives for loggerhead shrike. The first objective requires that a minimum of 167,590 ac (67,820 ha) of suitable nesting and foraging habitat (i.e., agriculture, grassland, cismontane alkali marsh, playa and vernal pools, desert scrub, Riversidean alluvial fan sage scrub, coastal sage scrub, peninsular juniper woodland and scrub, riparian scrub, woodland and forest, and oak woodlands and forest) be conserved for the species. The second objective requires that at least 8 breeding and foraging locations be conserved and defined as Core Areas for the species: Prado Basin/Santa Ana River, Lake Mathews/Estelle Mountain, Wasson Canyon, Temecula Creek, Wilson Valley, Quail Valley, Lake Perris/Mystic Lake/San Jacinto Wildlife Area (SJWA), and the Badlands. Finally, the third species objective requires that shrikes successfully reproduce (defined as a nest producing at least 1 fledgling) in at least 75% of the aforementioned Core Areas once every 8 years (Dudek and Associates 2003). This project, our first effort to monitor loggerhead shrike, focused on documenting which Core Areas are being used by shrikes and whether they are successfully reproducing in those Core Areas.

Shrikes in California tend to nest in shrublands or open woodlands that contain some grass cover mixed with open ground (Humple 2008). They also require tall, isolated perches, such as trees or power lines, from which to hunt (Humple 2008). Such perches should ideally be located near open areas consisting of short grasses, forbs, or open ground, in which shrikes can locate and capture their prey, which consist of arthropods, reptiles, amphibians, small rodents, and birds (Craig 1978; Yosef 1996). Breeding territories on mainland California average 8.5 ha (Miller 1931). Finally, shrikes require impaling sites from which they can hang their prey, and such sites can either be natural (e.g., thorns) or man-made (e.g., barbed wire fences) (Humple 2008).

Loggerhead shrikes in southern California begin breeding in January and February and may continue through July (Unitt 2004). Nests are typically constructed 1–2 m above ground (Yosef 1996), though investigators have reported nest heights exceeding 9 m on nearby San Clemente Island (Sullivan et al. 2005). In southern California, shrike nests may be constructed in a variety of substrates, especially mesquite (Unitt 2004), though thorny or spiny substrates may be preferred if they are available (Humple 2008). Rangewide (i.e., North America, but restricted to southern Canada), shrikes typically lay 5–6 eggs (overall range of 1–9 eggs), with birds at higher latitudes or in the western U.S. laying more eggs (Yosef 1996). Females are the sole incubators and begin incubating before the last egg is laid (Sullivan et al. 2005). Hatching occurs approximately 14 days into the incubation period, at which time both parents provide food to the nestlings. Young typically fledge 17–18 days post-hatching and remain with their parents for several weeks, though they are capable of independent foraging at about 40 days post-fledging (Sullivan et al. 2005). In southern California, shrikes may undertake a second nesting attempt following a first attempt, whether successful or unsuccessful (Sullivan et al. 2005).

For this project, we surveyed within appropriate loggerhead shrike habitat in 7 of the 8 aforementioned Core Areas to locate breeding individuals and their nests. If we found active nests, we re-visited them periodically until fledging or failure occurred. We continued to search for and monitor active nests until the 2010 breeding season ended. We did not conduct surveys within the Lake Perris/Mystic Lake/SJWA Core Area because we detected 2 successful shrike nests there in 2009 and did not have enough staff in 2010 to justify surveying that large Core Area.

Goals and Objectives:

1. Determine whether loggerhead shrikes are successfully breeding in at least 75% of the Core Areas designated by the MSHCP.
    a. Locate and monitor active shrike nests, continuing to monitor nests until either fledging or failure occurs.
2. Model detection probabilities to determine whether survey methods allowed us to detect loggerhead shrikes when they were present.
    a. Conduct one-hundred-thirteen 150-m-long walking transects within appropriate habitat in shrike Core Areas.
    b. Estimate detection probabilities based on presence or absence of shrikes at defined Core Areas using a closed-capture occupancy model included with Program MARK (White and Burnham 1999).

METHODS

Survey Design

We conducted surveys within loggerhead shrike Core Areas, and more specifically within habitat types identified as likely shrike habitat by the MSHCP (see habitat types listed in Introduction). Within coastal sage scrub and riparian woodland and forest habitats, we did not survey in areas that exceeded 10% vegetation density because shrikes prefer areas composed largely of open habitats (Heath 2008). Furthermore, we eliminated from potential survey locations any area where slope exceeded 25 degrees, which would minimize the likelihood of increased erosion due to walking transects in the area repeatedly. We placed transects within shrike Core Areas at a density of approximately 1 transect/50 ha of appropriate habitat. We chose to survey 113 transects that were 150 m long and at least 450 m apart. These specifications allowed us to have a sufficient sample size for analysis, while at the same time providing adequate survey coverage within each Core Area.

A starting point for each transect was randomly generated using Hawth's Tools (Beyer 2004) in ArcGIS 9.2 Geographic Information System (GIS) software (ESRI

2006). Next, we selected a bearing (0–359) at random, and calculated the coordinates of each transect's endpoint given the length of the transect, the starting location, and the random bearing. We surveyed the Temecula Creek Core Area by doing an area search rather than walking transects because the conserved area (6 ha) was not large enough to support breeding shrikes (Yosef 1996). Following are the loggerhead shrike Core Areas, the hectares of appropriate habitat within each, and the resulting number of transects (Figure 1 - note that the transect location in Wasson Canyon appears to be in the Quail Valley Core Area due to the scale of the map).

1. Santa Ana River, 596 hectares, 11 transects
2. Lake Mathews/Estelle Mountain, 2191 hectares, 43 transects
3. Wasson Canyon, 34 hectares, 1 transect
4. Temecula Creek, 6 hectares, area search
5. Wilson Valley, 361 hectares, 7 transects
6. Quail Valley, 142 hectares, 2 transects
7. Badlands, 2482 hectares, 49 transects
8. Lake Perris/Mystic Lake/San Jacinto Wildlife Area, not surveyed

We began the first round of surveys on 25 January 2010 and conducted our final surveys on 23 July 2010. We commenced surveys within 30 min of sunrise and no later than 1400 h. Furthermore, we did not survey if temperatures exceeded 35°C, or during periods of heavy precipitation, fog, or strong winds (exceeding 5 on the Beaufort Scale, characterized by branches of a moderate size moving and small trees beginning to sway - approximately 38 km/h). Transects were surveyed 8 times during the course of this project, except for a small number of transects which were surveyed 6 or 7 times due to logistical issues. We continued to monitor all active shrike nests until they either fledged young or failed.

Field Methods

At the start of each survey, the observer navigated to one endpoint of a transect using a handheld GPS unit. Upon arrival, the observer recorded the date, their initials, and the transect visit number. Next, the observer recorded the starting sky code and temperature, followed by the start time of the survey. At this point, the observer turned on the anemometer, which recorded average and maximum wind speeds throughout the duration of the survey. Upon completion of the transect survey, the observer recorded the ending time, weather, and temperature, as well as the maximum and average wind speeds. If the observer did not observe any shrikes during the survey, they recorded "None" on the first line of the datasheet, next to "Abundance." Transects typically took 5–10 min to complete.

If an observer encountered a shrike during a survey, they recorded the age (if determined), and sex (if determined) of the shrike(s). If the shrike flew out of the observer's sight, the observer left the transect to follow the bird in an attempt to find an active nest. If an observer did this, they recorded when they left the transect ("Obs. Start Time" on the datasheet) as well as when they returned to the transect ("Obs. End Time"). Observers always returned to the exact spot where they left the transect after following a

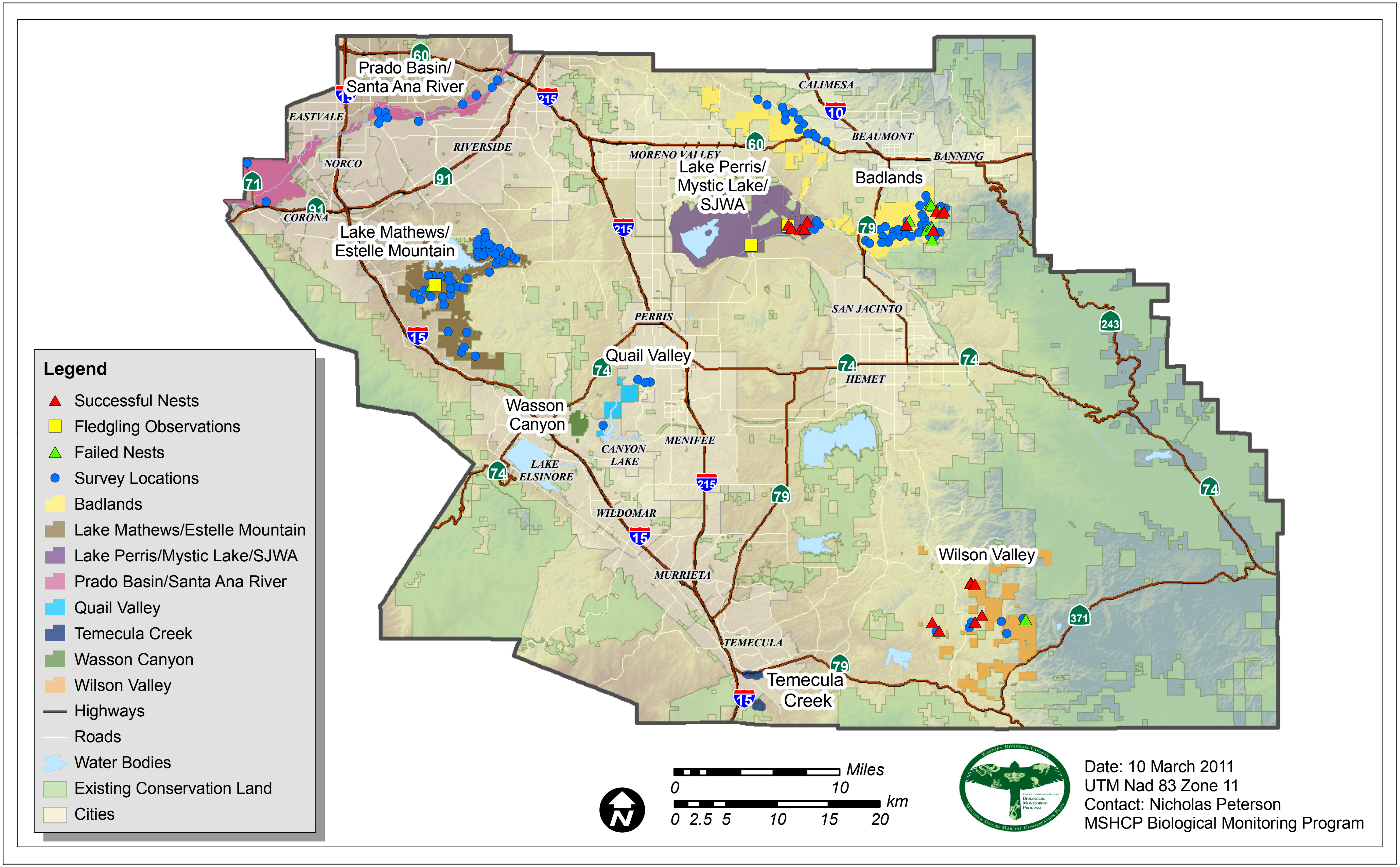

Figure 1. Core areas, survey locations, and nest sites for loggerhead shrikes in 2010.

shrike; this was ensured by the observer using their GPS to mark the exact location from which they left the transect before pursuing the shrike. Observers always completed the full length of each transect, regardless of how much time they spent following a shrike or whether they located an active nest while doing so.

If an observer saw a shrike behaving in a manner that indicated an active nest (e.g., food carries, begging calls, etc.), the observer maintained a safe distance (> 50 m) from the potential nest site. This reduced stress on the shrikes and minimized the likelihood of potential nest predators being drawn to the area. Relevant shrike behaviors were recorded on the observer's datasheet. Upon identifying a potential nest site, observers approached the nest site and attempted to determine if an active nest was present. Such approaches to the nest were circuitous and involved the observer making mock searches for nests into nearby vegetation both before and after investigating the nest site. Doing this prevented potential nest predators from being able to establish a direct route to the nest site and minimized the risk of nest failure.

Investigation of the actual nest was as brief and non-intrusive as possible. The observer kept in mind that the primary focus of this project was to document successful shrike nests; gathering information about clutch size, incubation stage length, etc. was of secondary importance. As such, if investigating a nest's contents would lead to damaging the nest substrate, or unnecessarily stressing the parents (e.g., because the nest was in dense foliage or was too high off the ground), the observer did not assess the nest's contents and instead observed whether it was active by watching the behaviors of the parents from a safe distance (Heath et al. 2008). We re-visited active nests 1–2 times/week (Heath et al. 2008), and during these follow-up visits, observers determined whether the nest was active by watching the behavior of the adults from a safe distance. This allowed observers to determine the nest's stage (i.e., incubation or nestling) while minimizing stress on the adult shrikes. We conducted follow-up visits until the nest fledged young or failed. To make relocating nests on follow-up visits easier, we marked their locations using a GPS unit.

Beginning in August, when all nests were empty and we had completed the transect survey and nest-monitoring portion of this project, we re-visited nest sites and collected habitat and vegetation data to determine any differences between successful and failed nest sites. At each nest site, we first recorded the plant species of the substrate, measured the substrate height (using either a meter stick or clinometer), and measured the nest height above ground. Next, we centered a 100-m measuring tape directly below the nest and extended the tape 50 m in each of the cardinal and inter-cardinal directions. Along each 50-m extension, at 1-m intervals starting at the 1 m mark and ending at the 50 m mark, we counted the number of times that the canopy of a tree or shrub > 1 m tall intercepted the tape. This gave us a baseline index of tree and shrub cover at 400 points within 50 m of the nest. Next, we placed a 2.5-m tall tent pole vertically alongside the nest, with the pole resting on the ground. The length of the pole was divided into 10-cm intervals with red tape. We counted the number of times vegetation contacted the pole within each 10-cm interval from 0 to 100 cm, then within the 100–150-cm interval as a whole, and, finally, above 150 cm. Next, we counted the number of trees and shrubs > 1 m tall that were within 50 m of the nest substrate. We included the nest substrate as one such tree or shrub, and any contiguous clumps of trees or shrubs within 50 m counted as one "individual." We did not record species-level information for vegetation. Finally, we measured the distance from the nest to the nearest road, fence, or utility wire, because the presence of any of these may influence the decision of a shrike to nest in a particular area (Yosef 1996).

Training

Field personnel participating in this study demonstrated the ability to identify loggerhead shrikes both visually and aurally. They also demonstrated an understanding of the field methods associated with the study, as well as the desired methods of approaching and observing potential shrike nest locations.

While learning to identify shrikes by sight and sound, personnel studied avian field guides (e.g., Sibley 2000) and computer software (e.g., Thayer's Guide to Birds of North America, v. 3.5). When they felt they were prepared, personnel took a quiz, administered by the Avian Program Lead, which consisted of both photographs and sound recordings of birds that could be encountered during the shrike surveys. Personnel had to correctly identify all covered bird species, including shrikes, and could not incorrectly identify non-covered species as covered.

Following completion of the above quiz, personnel were required to read the field protocol and discuss with the Avian Program Lead any questions they had. The Avian Program Lead then discussed the proper ways of approaching and observing shrike nests to ensure continuity among personnel. All personnel who participated in this study had extensive previous experience with nest searching and monitoring.

Training Results

Participants who successfully completed the above training were able to correctly identify loggerhead shrikes by both sight and sound. Additionally, they were able to conduct surveys, specifically transects, for shrikes and their nests as described above. Participants were also able to accurately collect field data in a manner that was similar to previous projects in which they participated. Finally, participants were able to monitor shrike nests in a manner that minimized stress on the adult birds and minimized the likelihood of attracting potential nest predators.

Biological Monitoring Program staff are funded either by the Regional Conservation Authority or the California Department of Fish and Game; volunteers are noted. The following personnel conducted shrike surveys in 2010:

- Nicholas Peterson (Avian Program Lead, Biological Monitoring Program)
- Masanori Abe (Biological Monitoring Program)
- Jill Coumoutso (Volunteer, Santa Ana Watershed Association)
- David McMichael (Volunteer, Orange County Water District)
- Lynn Miller (Biological Monitoring Program)
- Terry Reeser (Volunteer, Santa Ana Watershed Association)
- Nate Zalik (Biological Monitoring Program)

Data Analysis

We defined individual survey efforts by the 150-m-long transects. We estimated per-visit detection probabilities (*p*) using a closed-capture occupancy model available in Program MARK (White and Burnham 1999; MacKenzie et al. 2006). Next, we constructed a candidate set of models that examined the time-varying (i.e., among visits) effect on *p*, but modeled estimates of use ($\hat{\psi}$) as being constant across visits because we assumed a closed population of loggerhead shrikes within each of our study areas.

We then ranked models in each candidate set according to Akaike's Information Criterion (AIC_c) for small samples, calculated Akaike weights (w_i), and averaged estimates of *p* across the entire candidate set (Burnham and Anderson 2002). We then calculated cumulative detection probabilities (P^*) across visits according to the following formula, where p_i is the detection probability on a given visit or shift: $P^* = 1 - (\prod_{i=1}^{8} 1 - p_i)$.

For each nest, we recorded the date the nest was found, estimated fledge date, and the status of the nest on each visit. We analyzed these data using the nest survival module in Program MARK (White and Burnham 1999), which produces a maximum likelihood-based estimator of mean daily nest survival.

RESULTS

We conducted 8 survey rounds for shrikes and their nests in 2010, during which we detected shrikes in 5 of 8 Core Areas (62.5%), including incidental observations. We detected shrikes most frequently in the Badlands Core Area (70.6% of transects with shrike detections), less frequently in the Lake Mathews-Estelle Mountain and Wilson Valley Core Areas, and only incidentally in the Lake Perris/Mystic Lake/SJWA and Prado Basin/Santa Ana River Core Areas (Table 1). Additionally, we detected successful shrike nests in the following 4 (50%) Core Areas: Badlands, Lake Mathews/Estelle Mountain, Lake Perris/Mystic Lake/SJWA, and Wilson Valley (Figure 1).

Table 1. Number of transects along which we observed loggerhead shrike, by Core Area in 2010. Shading reflects Core Areas in which we detected shrikes.

Core Area	Number of transects completed during 8 survey rounds	Number of transects with shrikes (% of transects in Core Area)
Badlands	391	24 (6.1)
Lake Mathews/Estelle Mountain	331	1 (0.3)
Lake Perris/Mystic Lake/SJWA	Did not survey	n/a[a]
Prado Basin/Santa Ana River	86	0 (0)[b]
Quail Valley	16	0 (0)
Temecula Creek	Area search only	No shrikes detected
Wasson Canyon	8	0 (0)
Wilson Valley	56	9 (15.5)
Overall	**888**	**34 (3.8)**

[a]We detected shrikes here incidentally in 2009/2010.
[b]We detected a shrike here incidentally in 2010.

Detection Rates

We conducted 8 survey rounds from 25 January through 23 July 2010 (Table 2). End dates and start dates for some consecutive survey rounds occurred on the same day due to scheduling necessities. We detected shrikes during every survey round, with a low of 1 occupied transect (1%) and a high of 8 occupied transects (7.1%). The number of transects on which we detected shrikes did not vary significantly by survey round.

Table 2. Frequency of shrike detections by survey round in 2010. We made multiple detections of shrikes on 21 transects. Detections indicate the presence of shrikes, not the number of individuals observed.

Survey Round	Survey period	Number of transects completed	Number of transects with shrikes per survey round [a] (% of total no. of transects/round)
1	25 January – 22 February	105	3 (2.9)
2	23 February – 23 March	113	3 (2.7)
3	24 March – 19 April	113	5 (4.4)
4	20 – 30 April	105	1 (1.0)
5	30 April – 20 May	113	2 (1.8)
6	21 May – 9 June	113	8 (7.1)
7	9 June – 2 July	113	4 (3.5)
8	6 – 23 July	113	8 (7.1)
Total		**888**	**34 (3.8)**

[a]We detected shrikes on 21 of the 113 different transects (18.6%).

Detection Probability Analysis

Program MARK identified the p(.) model (with an AIC_C weight of 0.80) and the p(t) model (with an AIC_C weight of 0.20) as the best-fit models. We eliminated the p(g) model from analysis because it failed to run due to our lack of shrike detections in some Core Areas. Next, we model-averaged the p(.) and p(t) models to determine detection probabilities [nightly, or per-visit, (*p*) and cumulative (*P**)] for our survey (Table 3).

Table 3. Detection probabilities for shrikes across 8 survey rounds.

Survey Round	Estimate (*p*)	± SE
1	0.14	0.04
2	0.13	0.04
3	0.15	0.05
4	0.12	0.05
5	0.13	0.05
6	0.17	0.08
7	0.14	0.04
8	0.17	0.08
Cumulative (*P)**	**0.71**	**0.15**

Nest Success

We found evidence of 33 nesting attempts by shrikes in 2010, distributed among the following 4 Core Areas: Badlands, Lake Mathews/Estelle Mountain, Lake Perris/Mystic Lake/SJWA, and Wilson Valley. We observed shrike fledglings in all of those Core Areas as well. Of the 33 nesting attempts, 13 resulted in fledglings (39%), 11 failed due to depredation (33%), 3 nests were found after we detected fledglings (9%), 1 failed for unknown reasons (3%), and 1 nest was abandoned during the construction phase (3%). For the remaining 4 observations (12%), we detected fledglings but never located the nests (Figure 1).

We calculated a daily nest survival rate of 0.960 (95% CI: 0.931–0.977), implying a nest success rate of 19.9%, assuming an average of 40 days from the initiation of incubation until fledging (Yosef 1996). We did not have enough nest data from nest re-visits to calculate variations in nest survival based upon nest stage.

Timing of Nesting

We observed nests in the laying stage from 26 February 2010 to 11 May, the incubation stage from 28 February to 18 May, and the nestling stage from 16 March to 26 May. We observed fledglings beginning on 6 April and continuing through July.

Nest Site Habitat and Vegetation

We measured the heights of 25 shrike nests and 26 shrike nest substrates in 2010. (One shrike nest was destroyed before we could collect height information). Nests were an average of 121 cm above ground (range = 42–232 cm) and nest substrates were an average of 3.80 m tall (range = 1.95–6.28 m). There was no significant difference between either of these variables when we compared successful and unsuccessful nests.

Nesting substrates used by shrikes seemed to vary by Core Area. Overall, the most commonly used nest substrate was *Quercus berberidifolia* (*n* = 12 nests, or 46.2%, 11 of which were within the Badlands Core Area, and 1 was in the Estelle area). The remaining nests were constructed in *Rhus ovata* (*n* = 7, or 26.9%, all in Wilson Valley), *Atriplex lentiformis* (*n* = 4, or 15.4%, all in the Mystic Lake area), *Malacothamnus fasciculatus* (*n* = 2, or 7.7%, both in the Badlands), and *Lycium* spp. (*n* = 1, or 3.8%, in Wilson Valley). All nests constructed in *A. lentiformis* and *Lycium* spp. were successful; most (71.4%) nests constructed in *R. ovata* were successful; half of the nests constructed in *M. fasciculatus* were successful; and 33.3% of nests in *Q. berberidifolia* were successful (Table 4).

Table 4. Nesting substrates used by loggerhead shrikes in 2010, and frequency of successful nests built within each substrate species.

Substrate species	Number of nests constructed in the substrate species	Percent of nests constructed in substrate species that were successful
Atriplex lentiformis	4	100
Lycium spp.	1	100
Malacothamnus fasciculatus	2	50
Quercus berberidifolia	12	33.3
Rhus ovata	7	71.4

Within 50 m of nest sites, the amount of tree and shrub canopy cover did not differ significantly between successful and unsuccessful nests. Overall, we observed that an average of 54.9 of the 400 sampling points (13.7%) within 50 m of nests were under tree or shrub canopy.

Vertical cover, measured as the number of vegetative "hits" along a vertical axis centered at the nest, did not differ significantly between successful and unsuccessful nests, though cover tended to be slightly less dense from 20–100 cm above ground at unsuccessful nests versus successful nests (Table 5).

Table 5. Vegetation density at shrike nests measured along vertical axis centered on the nest.

	Average number of vegetative "hits" within each height category (cm)											
	0–10	**10–20**	**20–30**	**30–40**	**40–50**	**50–60**	**60–70**	**70–80**	**80–90**	**90–100**	**100–150**	**>150**
Successful nests (n = 14)	2.4	1.5	1.1	0.9	0.8	0.7	0.7	0.8	1.0	0.8	3.8	26
Unsuccessful nests (n = 11)	2.2	1.4	0	0.3	0.4	0.5	0.4	0.3	0.5	0.3	3.6	26
All nests (n = 25)	2.3	1.4	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6	3.7	26

The number of trees or shrubs within 50 m of nest sites did not differ significantly between successful and unsuccessful shrike nests. Overall, there was an average of 83.5 trees and shrubs within 50 m of shrike nests.

Lastly, distances to the nearest road, fence, and utility wire did not differ significantly between successful and unsuccessful nests, though unsuccessful nests tended to be closer to all 3, on average, than did successful nests (Table 6).

Table 6. Average distance (m), as well as ranges [m], to nearest road, fence, and utility wire from shrike nests.

	Road	**Fence**	**Utility wire**
Successful nests	181 [9–690] (*n* = 15)	356 [20–1059] (*n* = 15)	448 [55–1200] (*n* = 11)
Unsuccessful nests	98 [4–490] (*n* = 11)	266 [39–780] (*n* = 10)	293 [20–1079] (*n* = 10)
All nests	146 [4–690] (*n* = 26)	320 [20–1059] (*n* = 25)	374 [20–1200] (*n* = 21)

DISCUSSION

We detected shrikes most frequently (70.6% of all detections) in the Badlands Core Area, which consisted mostly of Potrero, but also included a non-contiguous area immediately southeast of Mystic Lake and another non-contiguous area along San Timoteo Canyon Road (Figure 1). Potrero was the largest survey area that we would consider ideal shrike habitat as it contained large expanses of relatively flat grassland of short and intermediate height, with isolated trees and shrubs suitable for nesting scattered throughout. Indeed, all but 2 of our Badlands shrike detections (91.7%) were within Potrero. The area southeast of Mystic Lake also consisted of grassland with scattered shrubs, but the area also had large tracts of grasses that were in excess of 1 m tall, which is not preferred by shrikes (Yosef 1996). Not surprisingly, only 2 of our Badlands shrike detections (8.3%) were within this area. Finally, the area along San Timoteo Canyon Road in which we surveyed for shrikes was too topographically diverse to support shrikes. In addition to the hilly landscape, there was a shortage of large tracts of grassland, and the stands of shrubs were often dense and situated on hillsides. None of these features are conducive to nesting shrikes (Yosef 1996), which may explain why we incidentally detected only 1 wintering shrike in the area in January 2010, and we did not detect the species again during our breeding surveys.

We detected shrikes on fewer occasions within the Wilson Valley Core Area than we did within the Badlands Core Area, but we actually detected them relatively more frequently (during 15.5% of surveys) in Wilson Valley than anywhere else. Wilson Valley is a smaller Core Area than Badlands, which may explain the fewer shrike detections, but the habitat that is present appears to be a dense concentration of ideal shrike habitat, namely open grasslands with scattered shrubs (usually *R. ovata*) suitable for nesting and foraging.

The Lake Mathews/Estelle Mountain Core Area contains some ideal shrike foraging habitat (i.e., grasslands of low and moderate height), but there is a shortage of shrubs and trees that could support shrike nests or serve as hunting perches. Much of the survey area east of Lake Mathews was grassland that contained few shrubs > 1 m tall. As a result, there was a shortage of hunting perches and nest sites for shrikes (Yosef 1996).

The survey areas around Estelle Mountain were also lacking in potential nesting and hunting perch substrates, though there appeared to be abundant suitable grassland that could support foraging shrikes. The only shrike nest that we detected within this Core Area was in an area that used to be an orchard and now contains snags (i.e., shrike hunting perches) and a few *Q. berberidifolia* (i.e., nesting substrates) scattered throughout. Management for shrikes in these areas should focus on providing nesting substrates as well as hunting perches, which could be artificial or natural, that would improve territory quality and nesting success (Yosef and Grubb 1994).

We did not survey for shrikes in the Lake Perris/Mystic Lake/SJWA Core Area in 2010, though we did incidentally detect shrikes and their nests there in 2009 and 2010. As a whole, the Core Area is similar to Potrero in that it consists of large tracts of grassland with trees and shrubs scattered throughout. We detect shrikes incidentally within this Core Area on a regular basis, so management for shrikes within this Core Area should seek to maintain or expand the grassland habitat while ensuring that dense shrubs such as *Q. berberidifolia* and *A. lentiformis* are scattered throughout the habitat to provide nesting habitat.

The only shrike that we detected within the Prado Basin/Santa Ana River Core Area was likely a wintering bird, because we did not detect the species after January 2010. This Core Area consists mostly of riparian habitat, with some grassland areas scattered throughout. The grassland areas are typically too small to support nesting shrikes, and contain few isolated shrubs or trees in which shrikes could nest. Management for nesting shrikes within this Core Area would probably require the expansion of grassland areas at the cost of riparian habitat, which is an unlikely scenario.

We did not detect shrikes in the Quail Valley, Temecula Creek, or Wasson Canyon Core Areas in 2010. Both Quail Valley and Wasson Canyon contain small, fragmented areas of grassland habitat, but these are probably too small to support nesting shrikes and did not contain any ideal nesting shrubs or trees in 2010. Etterson (2003) reported that shrikes tend to select breeding territories based on the presence of breeding conspecifics. Fragmented pieces of habitat such as those in Quail Valley and Wasson Canyon are unlikely to support any shrikes, let alone multiple pairs, so management for nesting shrikes in these 2 Core Areas should aim to conserve large tracts of shrike habitat and plant isolated nesting substrates such as *Q. berberidifolia*, in which shrikes nested in the nearby Lake Mathews/Estelle Mountain Core Area. The Temecula Creek Core Area does not currently contain any substantial tracts of open/grassland habitat, and is instead almost entirely riparian habitat. Yosef (1996) stated that riparian habitat is sometimes favored by shrikes, but we have never detected the species in such habitat in western Riverside County. Management for shrikes in the Temecula Creek Core Area should seek to conserve lands adjacent to the riparian areas that are open/grassland habitat, and planting isolated trees or shrubs where necessary.

Detection Rates

The number of transects on which we detected shrikes did not vary significantly by survey round, though there were slight fluctuations that are worth noting. First, we detected shrikes on just 1 transect during the fourth survey round, which lasted from 20–

30 April. Many shrike nests were in the nestling stage at the time, when shrike territories may shrink slightly (Kridelbaugh 1982), thereby reducing the number of transects along which we detected shrikes.

We also detected shrikes along an increased number of transects during the final 3 survey rounds, which lasted from 21 May through 23 July. During this time, many shrike nests were progressing from the nestling stage into the fledgling stage, a period when shrike territories may expand (Kridelbaugh 1982), thereby increasing the number of transects along which we detected shrikes.

Detection Probability Analysis

Program MARK identified slight variations in our shrike detection probabilities by survey round; however, this variation was assigned just 20% model weight by Program MARK. Program MARK assigned the remaining 80% model weight to the p(.) model, suggesting that, for the most part, detection probabilities did not vary much by survey round and instead remained relatively constant. After we model-averaged these 2 models [i.e., the p(t) and p(.) models] in MARK, we saw that the per-visit, or per-survey, detection probability for shrikes in our study was always 0.12–0.17.

The lowest detection probability (0.12) occurred during the fourth survey round. As discussed above, this could be explained by a couple of factors. First, this was a time during which we observed a peak in the number of shrike nests in the nestling stage. During this time, shrike territories may shrink slightly (Kridelbaugh 1982), thereby reducing the probability of us being able to detect shrikes from a survey transect. Furthermore, female shrikes typically spend a lot of time brooding young nestlings and are thus very difficult to detect from transects. If we are most likely to detect only male shrikes during this time, the probability of detecting shrikes in general will decrease slightly.

The highest detection probabilities (0.17) occurred during the sixth and eighth survey rounds. As discussed previously, this was a period during which several shrike nests were progressing from the nestling stage into the fledgling stage. During this time, shrike territories may expand slightly (Kridelbaugh 1982), thereby increasing the probability of us detecting them while surveying. Furthermore, shrike fledglings are typically quite vocal while begging for food, and are usually conspicuous while learning to fly and forage independently, further increasing the probability that we were able to detect the species from transects. Lastly, in areas that contained successful shrike nests, there were simply more shrikes (adults and fledglings) for us to detect, further increasing detection probabilities.

Our cumulative detection probability for shrikes (0.71) was somewhat low. This could be a result of transects that were too short and did not necessarily come within a reasonable distance of active shrike territories. If we lengthened transects, perhaps to 400 or 500 m, we may increase the likelihood of the transect intersecting a shrike territory, thereby potentially increasing detection probabilities throughout the survey. The 150-m transects used in this study may have only intersected the periphery of shrike territories in some cases, reducing the probability of detecting the species. Increasing the number of transects in smaller Core Areas such as Wasson Canyon and Quail Valley may also help to improve detection probabilities by increasing the likelihood that we will encounter breeding shrike territories. If adding transects is not logistically feasible within those Core Areas, thorough area searches of suitable habitat may be preferable to transect surveys.

Nest Success

The daily survival rate (DSR) of nests in our study (0.960) is similar to DSR values reported by other investigators. In Illinois, Walk et al. (2006) reported DSR values for shrike nests of 0.957–0.973. In central Kentucky, Peterson (2006) reported DSR values ranging from 0.972 to 0.990. Finally, Etterson et al. (2007) reported a slightly higher overall DSR value (0.978) for shrike nests in Oklahoma.

The primary way for us to potentially observe increased DSR values in future studies would be to visit nests more frequently. We were usually able to visit nests only 1–2 days per week in this study, and it is possible that DSR values were low as a result (e.g., if a nest failed between visits that were several days apart, Program MARK must make a "best guess" as to when failure occurred, which can potentially lead to inaccurately low survival estimates). The benefit of more frequent nest visits, however, must be balanced against the potential increased risk of attracting nest predators while monitoring nests.

Timing of Nesting

Rangewide, the laying and incubation stages tend to occur from mid-March to mid-June. The nestling stage tends to occur from early April to late June (Yosef 1996). During our study, all of these nesting stages occurred a few weeks earlier than the rangewide average for shrikes. This difference can be explained by the fact that most shrike nesting data cited by Yosef (1996) come from investigators that studied nesting shrikes at higher latitudes within North America, where the species is known to initiate nesting attempts later in the season than its southerly conspecifics (Yosef 1996). Indeed, Fraser and Luukkonen (1986) report that resident shrikes in southeastern United States start breeding as early as February.

Nest Site Habitat and Vegetation

Nest heights in our study (mean = 121 cm) were within rangewide averages reported for the species, which range from 80 cm in Idaho (Woods 1994) to 9 m on San Clemente Island (Sullivan et al. 2005). Similarly, the heights of nesting substrates in our study (mean = 3.80 m) were within rangewide averages reported for the species, ranging from 1.62 m in a sagebrush community (Woods and Cade 1996) to 5.0 m in central Kentucky (Peterson 2006).

We did not find any significant difference between nest height and substrate height for successful and unsuccessful nests. Likewise, Woods and Cade (1996) determined that nest success was not related to the height of a nest within its substrate, and Peterson (2006) reported that nest height and substrate height did not differ significantly for successful and unsuccessful nests.

Rangewide, shrikes are eclectic in their choice of nest substrates, selecting sites based upon degree of cover (Yosef 1996) and presence of thorns for protection from predators (Porter et al. 1975). In San Diego County, Unitt (2004) reported that shrikes most commonly nest in mesquite, whereas shrikes on San Clemente Island tended to use *R. integrifolia*, *Artemesia* spp., and *Baccharis pilularis*. Shrikes in our study selected several different substrate species as well, all of which appeared to confer some potential degree of protection from predators via foliage density (e.g., *R. ovata*) or thorn-like projections (e.g., *A. lentiformis*). Shrike nests in our study that were constructed in the thorniest substrates (i.e., *A. lentiformis* and *Lycium* spp.) were successful 100% of the time (Table 4).

None of the habitat variables that we quantified within 50 m of shrike nests differed between successful and unsuccessful nests. These results are similar to those reported by previous investigators such as Collins (1996), Peterson (2006), and Walk et al. (2006), all of whom found that habitat surrounding successful shrike nests did not differ significantly from habitat surrounding unsuccessful nests. This suggests that habitat variables we measured do not seem to influence whether shrike nests will succeed or fail. Instead, factors such as nest predator abundance may be more influential on nest success than nest-site characteristics (Peak et al. 2004).

The distances from shrike nests in our study to the nearest road, fence, or utility wire did not differ significantly between successful and unsuccessful nests, though unsuccessful nests tended to be slightly closer to all 3 features than did successful nests. These results are similar to those reported by Gawlik (1988), who found that nesting success of shrike nests near linear habitats, such as fencelines and roadways, did not differ significantly from nests in isolated sites. Some investigators, however, have reported different trends. Esely and Bollinger (2001) reported that interior shrike nests (i.e., those far from linear habitats) fared better than roadside nests with respect to clutch size, number of eggs hatched per nest, and number of young fledged per nest. Additionally, Yosef (1994) reported that shrikes nesting farther from linear habitats suffered fewer nest losses due to predation than nests constructed along fencelines, possibly because nest predators tend to forage along such linear habitats and are thus more likely to find nests constructed along them. Most of the shrike nests in our study were on conserved lands that contained few roadways or fencelines, which may explain why we did not find any significant differences in nest success based upon distances to linear habitats.

Recommendations for Future Surveys

Subsequent shrike surveys may be more successful at detecting shrikes on repeat visits, thereby increasing detection probabilities, if transects are longer than 150 m. Shrikes tend to have large breeding territories (e.g., 8.5 ha in California; Miller 1931) relative to other Passerines (Yosef 1996), and 150-m-long transects may not be long enough to allow observers to detect shrikes within such expansive territories. It may be beneficial to lengthen transects to 400 or 500 m if we are able to maintain a suitable sample size. Additionally, we should either increase the sample size of transects in smaller Core Areas such as Quail Valley and Wasson Canyon, or consider conducting area searches for loggerhead shrikes there instead.

If we quantify nest site characteristics in future surveys, we may want to compare the characteristics of used nest sites to nearby (i.e., within 100 m; DeGeus 1990) unused, though apparently suitable, potential nest sites. Doing so may help to discern whether shrikes appear to be choosing particular habitat qualities when selecting nest sites, which could aid land managers in managing or creating habitat suitable for nesting shrikes.

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