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

Overwintering Raptor Survey Report 2008

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NOTE TO READER:

This report is an account of survey activities undertaken by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The Biological 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, 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.

We would like to 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 this year's data collection activities were conducted 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. We would especially like to acknowledge the Santa Ana Watershed Association, the Center for Natural Lands Management, and the Orange County Water District for their willingness to initiate or modify their data collection to complement our survey efforts in 2008.

While we have made every effort to accurately represent our data and results, it should be recognized that our database is still under development. Any reader who would like 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. All Monitoring Program data, including original datasheets and digital datasets are stored in the Monitoring Program office in downtown Riverside, CA.

The primary author of this report was the 2008 Lead Biologist, Matt Talluto. 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. For further information on the MSHCP and the RCA, go to www.wrc-rca.org.

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INTRODUCTION

The MSHCP covers 13 diurnal raptor species (order Falconiformes). Of these, 8 rarely or never breed within the Plan Area and generally only occur during overwintering or migration periods. These include: bald eagle (*Haliaeetus leucocephalus*), ferruginous hawk (*Buteo regalis*), merlin (*Falco columbarius*), osprey (*Pandion haliaetus*), peregrine falcon (*Falco peregrinus*), prairie falcon (*Falco mexicanus*), sharp-shinned hawk (*Accipiter striatus*), and Swainson's hawk (*Buteo swainsoni*).

The Biological Monitoring Program had conducted no surveys for overwintering raptor species prior to the 2008. Thus, a primary objective of this survey was to evaluate survey methods for these species. Because optimal survey methods are likely to vary among habitats, we focused this effort on ferruginous hawk, merlin, and prairie falcon; these species winter in the Plan Area in open country habitats, defined here as grassland, farmland, and low-density shrubland and woodland. Although Swainson's hawk occurs in these habitats, and is identified in the MSHCP as a potential overwintering species, other sources indicate that this is a rare event, as the winter range of the species is generally restricted to South America (England et al 1997). Thus, Swainson's hawk was not considered a focal species for this survey. Bald eagle, osprey, and peregrine falcon are primarily found in association with major water bodies, and sharp-shinned hawk is found in woodland, forest, and urban habitats, so these species were also not considered focal species for 2008.

The ferruginous hawk is a federal and state species of special concern. This species does not breed within the Plan Area, but is found in open habitats during the winter. Grassland and farmland are typical habitats for this species, but it may also use low-density shrublands and woodlands (Bechard and Schmutz 1995; Dudek & Associates 2003).

The merlin is a California state species of special concern that migrates through and overwinters within southern California, but does not breed within the Plan Area. This species utilizes a variety of habitats, including open country (grassland and agriculture), low-density shrublands, woodlands, forests, riparian areas, and wetlands. Merlins may also utilize urban habitats while overwintering (Warkentin et al 2005; Dudek & Associates 2003).

The prairie falcon is a California state species of special concern, and can be found year-round within the Plan Area. Although the species is known to breed throughout most of California (Boyce et al 1986), breeding within the Plan Area is uncommon, and the species is observed much more commonly during winter and throughout migration. A single historical breeding location near Vail Lake has been recorded for this species (Dudek & Associates 2003), although breeding status at this location has not been confirmed by the Biological Monitoring Program. Prairie falcons are primarily found in open habitats, especially in association with cliffs or bluffs during the breeding season (Steenhof 1998).

The MSHCP provides no species-specific monitoring objectives and identifies no Core Areas for any of the focal species. The general objective for species without species-specific monitoring objectives is to monitor their status and distribution at least every 8 years. As this survey was a pilot effort and the first winter raptor survey conducted by the Monitoring Program, the study goals were focused both on collecting information about the distribution of target raptor species in the Conservation Area and on developing sampling and analytical methodologies suited to studying these species. We selected methods that can estimate occupancy (ψ) adjusted for detection probability (p) < 1. Estimating p allows us to determine the likelihood of false negative – surveys that result in no detections of target species when that species was in fact present – and to estimate the survey effort required to minimize the occurrence of false negatives.

A number of sources suggest conducting raptor surveys from vehicles as a way to increase the efficiency of sampling and to cover a wider survey area (e.g., Fuller and Mosher 1981; Andersen et al 1985). Vehicle-based transects have the potential disadvantage of biasing occupancy estimates and reducing the area of inference to places that can be accessed by vehicle. For raptors, this bias may cause either high (Meunier et al 2000; Dean and Milton 2003) or low (Sergio et al 2005) estimates of occupancy, depending on the species. Alternatively, walking surveys may be less efficient and detect fewer raptors, but may provide a less biased estimate of parameters of interest (e.g., detection probability, proportion of area occupied, density).

We present here the results of a survey for overwintering raptors using open-country habitats within the MSHCP Conservation Area. We conducted vehicle-based surveys in as many areas as possible to maximize our ability to report on the distribution of covered raptor species. We also conducted walking transects on a more limited scale in order to compare walking and driving methods. Goals for the 2008 winter raptor survey were as follows:

A. Estimate winter distribution and proportion of the sampling area used by focal species (ferruginous hawk, merlin, prairie falcon) and other co-occurring raptors within open habitats in the Conservation Area,

B. Calculate detection probability for focal and co-occurring species, and determine if weather conditions at the time of sampling affect detection probability,

C. Evaluate the species objectives for the focal species, and

D. Compare efficiency and bias of walking and driving survey methods.

METHODS

Protocol Development

Survey methods for the winter raptor survey were based on repeat visits to line transects sampled randomly (for walking counts) or along roads (for vehicle transects). Survey methods were developed using techniques described in Rosenstock et al (2002), Andersen et al (1985), and Fuller and Mosher (1981). The design we used allows for the calculation of transect-level detection probability (p) as well as proportion of area occupied (PAO; ψ), and can also be used to evaluate correlations between covariates (e.g., vegetation type) and both p and ψ (MacKenzie et al 2006).

Personnel and Training

All field personnel demonstrated proficiency at visual identification of all covered and co-occurring diurnal raptors. All observers practiced raptor identification for several weeks prior to the beginning of field surveys, and less experienced personnel trained with personnel with extensive experience identifying raptors. Trainings included extensive review of photographs and drawings from both general avian field guides and specialized raptor identification guides (e.g., Sibley 2003; Dunne et al 1988) as well as at least 20 h of raptor observation in the field. All personnel demonstrated proficiency with survey techniques before field surveys commenced. Once surveys had started, less experienced personnel continued to train by accompanying more experienced personnel on vehicle transects. The following personnel conducted raptor surveys in 2008:

- Matt Talluto, Avian Program Lead (Regional Conservation Authority)
- Andy Boyce (Regional Conservation Authority)
- Amanda Breon (Regional Conservation Authority)
- Conan Guard (Regional Conservation Authority)
- Theresa Johnson (Regional Conservation Authority)
- Lynn Miller (Regional Conservation Authority)
- Robert Packard (Regional Conservation Authority)
- Nicholas Peterson (California Department of Fish and Game)
- Kim Skahan (Regional Conservation Authority)
- Carol Thompson (Regional Conservation Authority)
- Joe Veverka (Regional Conservation Authority)
- Laura Weisel (Regional Conservation Authority)
- Daniel Williams (Regional Conservation Authority)

Vehicle-based raptor surveys required the participation of a driver who did not contribute to raptor observations for safety reasons. Some personnel who were not trained at raptor identification participated in winter raptor surveys as drivers. The following personnel drove vehicles during surveys but did not make raptor observations:

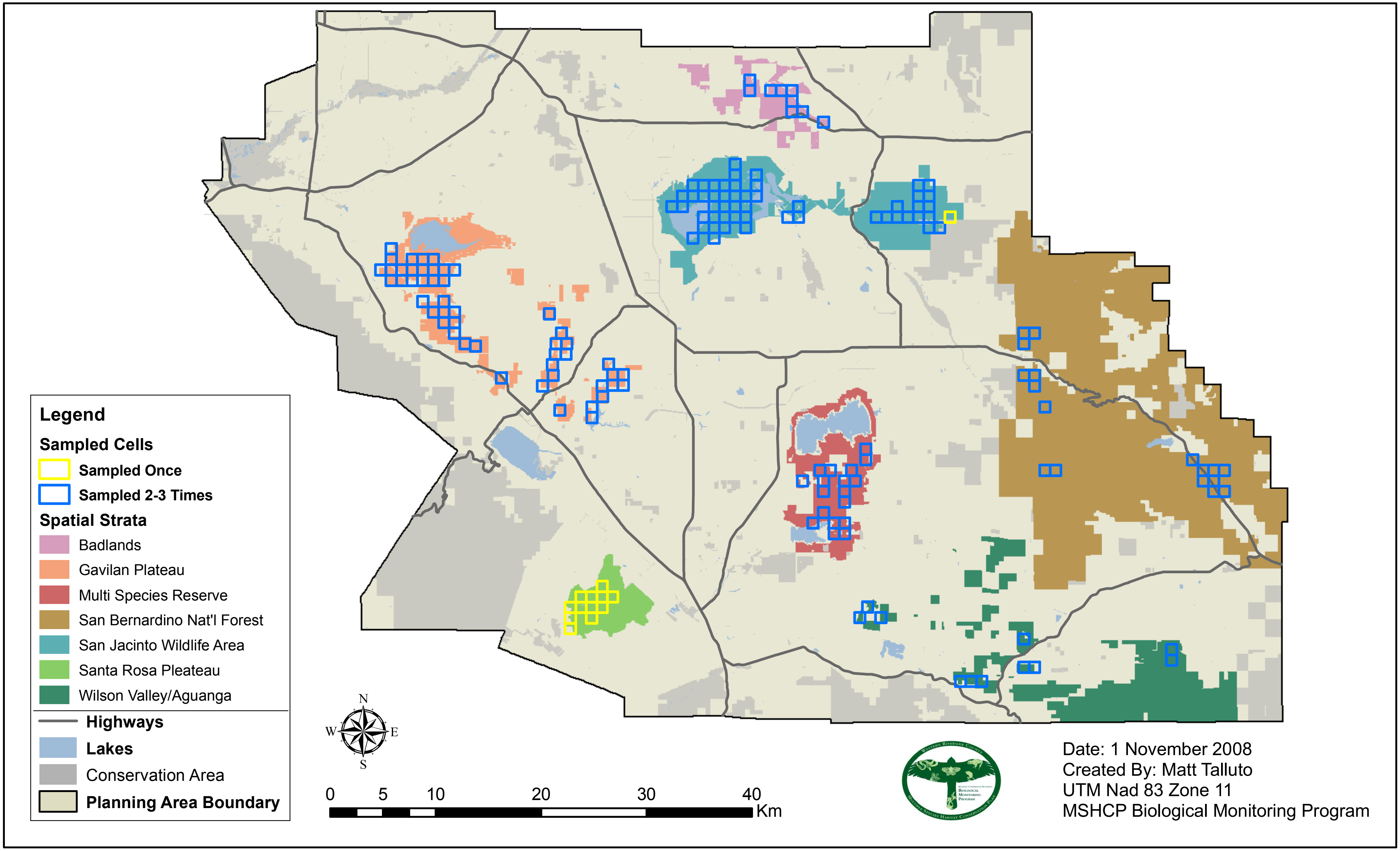
- Isaac Chellman (California Department of Fish and Game)
- Angela Coates (Regional Conservation Authority)
- Christina Greutink (Regional Conservation Authority)
- Ryann Loomis (Regional Conservation Authority)
- Joseph Moglia (California Department of Fish and Game)
- Sinlan Poo (California Department of Fish and Game)
- Lee Ripma (Regional Conservation Authority)
- Esperanza Sandoval (Regional Conservation Authority)

Study Site Selection

For the driving survey, we selected potential survey areas by developing GIS layers of accessible secondary roads and appropriate open-country raptor habitat contained within conserved lands. We defined raptor habitat using the most current digital vegetation map available (CDFG et al 2005) to select all grassland, agriculture, woodland, forest, or shrubland with a combined tree and shrub density of less than 50%. We then divided the Conservation Area into 1-km^2 cells and excluded from sampling all cells with less than 50% cover of appropriate habitat or less than 1 km of drivable road. We also excluded 12 isolated cells from sampling, as their distance (> 10 km) from other cells would have greatly reduced the efficiency of the survey. Of the remaining 235 cells, we selected 177 for survey using a spatially-stratified random sampling design. We chose the following 7 sites as strata, based on spatial proximity and similarity of habitat and topography of reserves within each site: Badlands (BL; 9 cells), Gavilan Plateau (GP; 49 cells), Southwestern Riverside County Multispecies Reserve (MSR; 24 cells), San Bernardino National Forest (SBNF; 18 cells), Lake Perris/San Jacinto Wildlife Area/Potrero (SJWA; 51 cells), Santa Rosa Plateau (SRP; 12 cells), and Wilson Valley/Aguanga (WV; 11 cells). An additional 10 cells were excluded from the survey during the first round of sampling because surveyors were unable to find a safely drivable route through the cells, and all cells at SRP were eliminated prior to the second round of sampling when rain caused the closure of roads, leaving 155 cells in 6 strata sampled sufficiently to conduct an occupancy analysis (Figure 1).

Because of the increased effort required for walking transects, we sampled only a subset of the areas sampled for the driving survey. Because raptor densities in the San Jacinto Valley are likely greater than elsewhere in the Plan Area (McCrary et al 1985), we selected the SJWA stratum for walking surveys as the area most likely to yield the highest sampling efficiency and provide the greatest statistical power when comparing sampling methodologies. We randomly (i.e., not along roads or trails) placed twenty-five 500-m transects and nine 1000-m transects within suitable habitat in the SJWA sampling area. We used the 1000-m transects to qualitatively evaluate the feasibility of longer transects; only the first half of these transects were used for quantitative analysis.

Figure 1. 2008 Winter raptor sampling locations.



Survey Methods

Methods for both walking and driving raptor surveys are detailed in the *2008 Western Riverside County MSHCP Winter Raptor Survey Protocol* (Appendix A). For driving transects, we surveyed groups of 3-8 closely-spaced cells in a single sampling bout. Groups of 2 observers and 1 driver drove at 10-20 km/h through each cell along a pre-defined route. Routes were chosen non-randomly with the goal of achieving maximum visibility in each cell. Observers studied aerial photographs, topographic maps, and evaluated conditions in the field when selecting these routes. During the survey, a single observer recorded all raptors seen by both observers. If a raptor could not be identified from the vehicle, the vehicle was stopped and observers used a spotting scope to identify the bird. Surveyors spent an average of 19.5 min (range 9-28 min) driving through each cell, not counting time spent stopped while identifying birds. If, after completing a cell, less than 15 minutes had been spent surveying that cell, the cell was searched again, driving the reverse direction, and the additional time and all additional observations were added to those from the first search. The original study design called for all transects to be surveyed 3 times during the study period. However, due to a lack of personnel and vehicles, this was not possible for all transects. When choosing which transects to survey 3 times, we assigned top priority to transects within the SJWA stratum to ensure a complete comparison of driving and walking methods. Finally, all transects within SRP were only available for sampling once, as precipitation during the study period resulted in closure of the roads at that site.

Walking transects were conducted by single observers. Transect routes were delimited using GPS waypoints. Observers walked each transect at approximately 1.4 km/h (range 0.6–3.0 km/h), stopping to scan or to identify raptors whenever necessary. Total survey time, including time spent identifying raptors, ranged from 10–50 min for 500-m transects and 20–100 min for 1000-m transects.

For both driving and walking transects, observers recorded the presence of all individuals of all diurnal raptor species (order Falconiformes), as well as any members of the families Strigidae (owls), Tytonidae (barn-owls), Cathartidae (new-world vultures), and Laniidae (shrikes). Observers also recorded the sex and age of the birds, what cues were used to identify the birds, and the weather conditions (wind speed, temperature, cloud cover, precipitation) at each site. We conducted surveys between 20 December 2008 and 19 March 2008, and we conducted all surveys between 1.5 h after sunrise and 1300 h. To maximize detection probabilities, surveys were terminated early if temperatures exceeded 35 C, if wind speeds exceeded a 3 on the Beaufort wind scale (> 19 km/h), or if there was any precipitation or fog. For safety and logistical reasons, driving surveys were not conducted for 48 h following significant precipitation or any time there was snow or ice accumulation on the roads.

Data Analysis

We used program MARK (White and Burnham 1999) to develop models for estimating p and ψ for each raptor species observed on ≥ 15 transects (regardless of the number of individuals present). We examined some models with < 15 observations during exploratory data analyses and found that most models failed to converge and all had very poor precision.

Occupancy analyses can be problematic for raptors because the sampling units are generally small enough that focal species can easily move among them during the study period. This movement violates the assumption that a species detected on at least 1 visit to a transect was present during all visits, even if not detected during all visits. MacKenzie et al (2006) suggest that the presence of random movement (i.e., not biased in favor of immigration or emigration) among sites does not bias the estimate of ψ, but does necessitate the interpretation of ψ as the proportion of the area *used* by the target species, rather than the proportion occupied. Hereafter, we use "proportion of area used" and "use" rather than "proportion of area occupied" and "occupancy" to reflect this interpretation. Used habitat differs from occupied habitat in that used habitat need not be occupied throughout the study season.

Another critical assumption of occupancy sampling, independence among sample units, is likely to have been violated in our driving study. Many sample cells were adjacent or very close together, and adjacent cells were sampled by the same observers on the same day. The close proximity of sampling units is a function of the limited number of potential sampling units within the Conservation Area; we sampled every sampling unit that was accessible by vehicle at the time of our study. The result of nonindependence of sampling units is likely to be an underestimation of the variance of both p and ψ. The walking study, with its random placement of transects and large potential study area, did not have this problem.

We evaluated models that allowed estimates of p to vary among the 3 survey periods as well as models that assumed p was constant among survey periods. For driving surveys, we also compared models that estimated ψ individually for each stratum to constant ψ models. When estimates of ψ were similar among strata (i.e., standard errors of the estimates overlapped), we lumped those strata *post-hoc*. Because the walking survey was not stratified, we only considered constant ψ models. Due to small sample sizes, we were unable to evaluate models that estimated p separately for each stratum. Finally, we performed an additional analysis of the driving data using only data from the SJWA stratum for comparison with the results of the walking survey.

Models were evaluated using Akaike's Information Criterion (AIC), adjusted for small samples (AIC_c). For models testing constant vs. time-specific p and constant vs. stratum-specific ψ, we report the results of the model with the lowest AIC_c. If multiple models were very similar in explanatory power to this model ($\Delta AIC_c < 2$), we report all of the similar models (Burnham and Anderson 2002). For models testing covariates, we used the best of the initial models as a starting point to develop candidate models using a forward stepwise procedure based on minimizing AIC_c at each step. Models that showed evidence of convergence failures or singularities (parameters fixed at a single value or confidence intervals encompassing all possible values) were excluded from the candidate set. We then assessed the importance of each individual covariate by summing the Akaike weight of all models containing that covariate. Covariates appearing in many highly-weighted models can be inferred to be important predictors of p or ψ (Burnham and Anderson 2002). We assessed the effect of each covariate on p or ψ using the parameter estimates in the model with the highest Akaike weight.

To determine whether survey efficiency for walking transects was comparable to that of driving transects, we calculated an encounter rate for individual raptor species, all raptor species, and raptor species richness (defined as the total number of species observed at a transect). This was done by summing the number of observations (i.e., number of individuals of each species, total number of individuals, or number of species) across all visits at each transect and dividing by the total number of observer-hours spent at that transect. The results for walking and driving transects were then compared using Wilcoxon rank-sum tests. We also recorded the efficiency of the multiple observer approach on vehicle transects to determine if the second observer makes a significant contribution to the transect. We did this by recording which observer sighted each individual bird for all transects within the SJWA stratum. We then compared the number of raptors observed by the primary observer to the number observed by the secondary observer using a paired Wilcox signed-rank test. Finally, we used ArcGIS 9.1 (ESRI 2006) to compare the area of inference of walking transects to that of driving transects. We calculated the total area of available open-country habitat located within the Conservation Area as the measure of the area of inference for a hypothetical walking survey; we assumed that we would be able to access all potential study site locations within this area on foot. We then calculated the area of available habitat located within 500 m of safely drivable secondary roads within the Conservation Area. This is likely an overestimate of true inference area, as visibility was considerably less than 500 m on many of these roads.

RESULTS

Distribution of target species within Plan Area

We detected all 3 focal species on driving transects, and merlin and ferruginous hawk on walking transects. All 3 species were detected infrequently, resulting in sample sizes that were too small for quantitative analysis. We detected ferruginous hawks 8 times during driving surveys and 2 times during walking surveys, merlin 11 times during driving surveys and 1 time during walking surveys, and prairie falcon 5 times during driving surveys.

We observed an additional 11 Covered Species and 5 non-covered species during our winter raptor survey (Table 1). Covered Species detected included: bald eagle (n = 5 observations), Cooper's hawk (n = 11), golden eagle (n = 12), loggerhead shrike (n = 41), northern harrier (n = 90), osprey (n = 14), peregrine falcon (n = 2), sharp-shinned hawk (n = 8), Swainson's hawk (n = 1), turkey vulture (n = 42), and white-tailed kite (n = 4). Most (71%) observations of Covered Species occurred in the SJWA stratum, while an additional 15% occurred in GP; other strata ranged from 0.4 – 4.7% of observations each (Table 1).

PAO Analyses

Of the 19 observed raptor species, 5 (American kestrel, loggerhead shrike, northern harrier, red-tailed hawk, and turkey vulture) were observed on ≥ 15 transects during driving surveys, and 2 (northern harrier and red-tailed hawk) were observed on ≥ 15 transects during walking surveys (Table 1). All of the best-supported models ($\Delta AIC_c < 2$) estimated a single, constant p, indicating that detection probability likely did not vary among survey periods.

With the exception of turkey vulture, models that incorporated stratum-specific estimates for ψ outperformed constant-ψ models. For American kestrel, loggerhead shrike, and northern harrier, use estimates at SJWA were considerably higher than at all other strata (Table 2). For red-tailed hawks, occupancy estimates were lowest at SBNF and WV, and highest in all other strata (Table 2). Models for turkey vulture that incorporated strata-specific estimates for ψ failed to converge, likely due to small sample size.

We compared PAO results for walking and driving transects at SJWA using data from northern harrier and red-tailed hawk. We selected these species because they were the only species with sufficiently large sample sizes on both walking and driving transects. Estimates of both p and ψ were greater on walking surveys for northern harrier, although the confidence intervals overlapped ($\psi_w = 0.63$, $\psi_d = 0.45$; $p_w = 0.51$, $p_d = 0.64$; Table 3). For red-tailed hawk, ψ and p were similar ($\psi_w = 0.98$, $\psi_d = 0.93$; $p_w = 0.54$, $p_d = 0.65$; Table 3).

Sampling Efficiency

Encounter rates were significantly higher on walking transects than on driving transects when comparing all individuals, species richness, red-tailed hawks, northern harriers, and turkey vultures (Table 4). Other species were encountered too infrequently to detect differences in encounter rate. We found no significant difference in the number of raptors observed by each individual observer on driving surveys (observer 1 mean = 3.59 individuals/transect, observer 2 mean = 2.52 individuals/transect, Wilcox $p = 0.06$). Finally, the potential area of inference for a walking survey was 44,986 ha, compared to 9845 ha for surveys restricted to drivable roads.

Table 1: Number of raptor observations on winter transects in 2008, separated by survey strata, and sample sizes for use analyses (the number of occupied transects; *n*) for both survey methodologies.

Species	BL[a]	GP	MSR	SBNF	SJWA Driving	SJWA Walking	SRP	WV	Total	$n_{driving}$	$n_{walking}$
American kestrel *Falco sparverius*	21	17	10	3	31	12	4	1	99	45	7
Bald eagle *Haliaeetus leucocephalus*	0	0	1	0	2	2	0	0	5	3	2
Barn owl *Tyto alba*	1	0	0	0	0	0	0	0	1	1	0
Cooper's hawk *Accipiter cooperii*	1	2	1	1	5	1	1	0	12	10	1
Ferruginous hawk *Buteo regalis*	2	3	2	0	1	2	0	0	10	8	1
Great-horned owl *Bubo virginianus*	0	0	0	0	1	0	0	0	1	1	0
Golden eagle *Aquila chrysaetos*	2	1	1	1	7	0	0	0	12	10	0
Loggerhead shrike *Lanius ludovicanus*	4	7	6	0	18	3	2	1	41	28	2
Merlin *Falco columbarius*	2	4	0	0	4	1	1	0	12	9	1
Northern harrier *Circus cyaneus*	3	7	0	0	35	45	0	0	90	25	19

[a]Strata names are as follows: BL: Badlands; GP: Gavilan Plateau; MSR: Southwestern Riverside County Multiple Species Reserve; SBNF: San Bernardino National Forest; SJWA: Lake Perris, San Jacinto Wildlife Area, and Potrero; SRP: Santa Rosa Plateau; WV: Vail Lake/Wilson Valley/Aguanga.

Table 1 (continued). Number of raptor observations on winter transects in 2008, separated by survey strata, and sample sizes for use analyses (the number of occupied transects; n) for both survey methodologies.

					SJWA						
Species	BL[a]	GP	MSR	SBNF	Driving	Walking	SRP	WV	Total	$n_{driving}$	$n_{walking}$
Osprey *Pandion haliaetus*	0	1	1	0	11	1	0	0	14	10	1
Peregrine falcon *Falco peregrinus*	0	0	0	1	0	1	0	0	2	1	1
Prairie falcon *Falco mexicanus*	1	0	0	0	4	0	0	0	5	5	0
Red-shouldered hawk *Buteo lineatus*	1	0	0	0	6	0	3	0	10	7	0
Red-tailed hawk *Buteo jamaicensis*	56	80	31	13	146	90	12	10	438	111	30
Sharp-shinned hawk *Accipiter striatus*	0	4	0	1	2	1	0	0	8	7	1
Swainson's hawk *Buteo swainsoni*	0	0	0	0	0	1	0	0	1	0	1
Turkey vulture *Cathartes aura*	0	9	0	0	12	20	1	0	42	16	11
White-tailed kite *Elanus leucurus*	1	0	0	0	2	1	0	0	4	3	1
Unknown raptors	1	1	0	1	0	6	0	0	9	3	5

[a]Strata names are as follows: BL: Badlands; GP: Gavilan Plateau; MSR: Southwestern Riverside County Multiple Species Reserve; SBNF: San Bernardino National Forest; SJWA: Lake Perris, San Jacinto Wildlife Area, and Potrero; SRP: Santa Rosa Plateau; WV: Vail Lake/Wilson Valley/Aguanga.

Table 2. Results of occupancy analysis with 95% confidence intervals.
Models shown only include those where the difference in Akaike's Information Criterion (ΔAICc) < 2. When describing models, we indicate that strata have been lumped (and thus a single parameter estimated) using the + symbol (e.g., SBNF+WV). When a single parameter has been estimated for all strata, we use the (.) symbol. Although models for time-specific p were evaluated, none performed as well as constant-p models, thus only a single p is reported here. Reported results include the number of transects where each species was present (*n*), the number of parameters estimated by each model (*K*), the proportion of area occupied (ψ), detection probability (*p*), and the cumulative detection probability (probability of observing the species at least once in 3 surveys; $p*$).

	n	K	ΔAIC_c	ψ_{BL}	ψ_{GP}	ψ_{MSR}	ψ_{SBNF}	ψ_{SJWA}	ψ_{WV}	p	$p*$
American kestrel											
ψ(SJWA, All Others), p(.)	45	3	0	0.30 0.20-0.43	0.30 0.20-0.43	0.30 0.20-0.43	0.30 0.20-0.43	0.62 0.39-0.80	0.30 0.20-0.43	0.45 0.33-0.57	0.83
Loggerhead shrike											
ψ(SJWA, All Others), p(.)	28	3	0	0.34 0.16-0.71	0.34 0.16-0.71	0.34 0.16-0.71	0.34 0.16-0.71	0.81 0.41-1.0	0.34 0.16-0.71	0.19 0.083-0.36	0.46
Northern harrier											
ψ(SJWA, All Others), p(.)	25	3	0	0.16 0.075-0.36	0.16 0.075-0.36	0.16 0.075-0.36	0.16 0.075-0.36	0.70 0.40-1.0	0.16 0.075-0.36	0.27 0.14-0.45	061
Red-tailed hawk											
ψ(SJWA, All Others), p(.)	111	3	0	0.55 0.34-0.77	0.55 0.34-0.77	0.55 0.34-0.77	0.55 0.34-0.77	0.93 0.84-1.0	0.55 0.34-0.77	0.58 0.51-0.65	0.92
ψ(BL+SJWA, GP+MSR,SBNF+WV), p(.)	111	4	0.97	0.97 0.85-1.0	0.88 0.74-1.0	0.88 0.74-1.0	0.54 0.33-0.77	0.97 0.85-1.0	0.54 0.33-0.77	0.58 0.51-0.65	0.93
Turkey vulture											
ψ(.), p(.)	16	2	0	0.60 0.17-1.0	0.60 0.17-1.0	0.60 0.17-1.0	0.60 0.17-1.0	0.60 0.17-1.0	0.60 0.17-1.0	0.074 0.011-0.37	0.21

Stratum names: BL: Badlands; GP: Gavilan Plateau; MSR: Southwestern Riverside County Multiple Species Reserve; SBNF: San Bernardino National Forest; SJWA: Lake Perris, San Jacinto Wildlife Area, and Potrero; WV: Vail Lake, Wilson Valley, and Aguanga.

Table 3: Occupancy models for walking data, with driving results (from SJWA only) for comparison.

	n	*y*	*p*	*p**
Northern harrier				
Walking - *y*(.), *p*(.)	19	0.63 0.42-0.81	0.51 0.36-0.67	0.88
Driving - *y*(.), *p*(.)	16	0.45 0.24-0.68	0.34 0.19-0.54	0.71
Red-tailed hawk				
Walking - *y*(.), *p*(.)	30	0.98 0.82-1.0	0.54 0.43-0.66	0.90
Driving - *y*(.), *p*(.)	44	0.93 0.81-1.0	0.65 0.55-0.73	0.96

DISCUSSION

We detected all 3 focal species, plus an additional 11 Covered Species and 5 other raptor species. Sample sizes for most species, including all 3 focal species, were too small for quantitative analysis. Increased future sampling effort may provide enough observations for quantitative analysis, particularly for ferruginous hawk and prairie falcon, both of which inhabit open habitats exclusively. Estimation of PAO and detection probability for merlin may require both increased survey effort within open habitats and inclusion of forested habitat. We also found no evidence that either walking or driving transects provided biased estimates of p or ψ; however, our inference for this comparison was limited to SJWA. Walking transects at SJWA were considerably more efficient than driving transects in terms of the number of raptor observations per observer-hour of survey effort.

Occupancy Analysis

We detected 5 species (American kestrel, loggerhead shrike, northern harrier, red-tailed hawk, and turkey vulture) on enough transects to perform a PAO analysis. Detection probabilities ranged from a low of $p = 0.185$ for loggerhead shrike during driving surveys to $p > 0.5$ for red-tailed hawks, northern harriers, and turkey vultures (Table 2). Cumulative detection probability (p^*; the probability of seeing the species at least once over multiple visits) was less than 0.95 for all species, indicating that 3 visits is likely not sufficient to ensure that any observed species are detected with 95% confidence.

Table 4. Encounter rates (standard errors) for walking (n=34) and driving (n=51) transects.
Significance values (p) are from a two-sample t-test.

	Encounter rate (individuals or species-observer^{-1}-hour^{-1})		
Species	Walking	Driving	p
All individuals	4.09 (0.54)	2.35 (0.26)	0.006
Species richness	1.73 (0.20)	1.02 (0.08)	0.002
Red-tailed hawks	1.92 (0.26)	1.24 (0.16)	0.032
Northern harriers	1.01 (0.24)	0.24 (0.074)	0.004
Turkey vultures	0.40 (0.13)	0.079 (0.029)	0.024

Proportion of area used for all species except turkey vulture was greatest at SJWA (Table 2). This supports the contention by McCrary et al (1985) that raptor densities are higher in the San Jacinto Valley than in other areas in the region. We also detected more raptors at the Gavilan plateau than in other areas, although this did not translate into higher occupancy estimates for any species except red-tailed hawk, possibly due to low statistical power for most species. Conservation efforts targeting wintering raptors should seek to improve and conserve open habitats in these 2 areas, as they appear to be important wintering grounds for raptors in the Plan Area.

Models for turkey vulture using driving survey data had convergence problems, with only the simplest model (constant ψ and constant p) successfully converging. This model performed poorly, with a particularly imprecise estimate of ψ (95% CI: 0.17, 1.00), possibly due to low samples size (n = 16 transects) combined with the fairly low estimated detection probability (Table 2). Models with detections on 25 or greater transects all performed considerably better.

Comparison of walking and driving methods

Although roadside driving surveys are commonly used for studying raptors (e.g., Fuller and Moser 1981; Andersen et al 1985; Williams et al 2000), we found walking transects to produce similar, and in some cases, better results. Proportion of area used and detection probability estimates were very similar for both methods when using data from red-tailed hawks and northern harriers, the only 2 species with large enough walking-transect sample sizes for PAO analyses. This suggests there was no systematic bias in the estimates from the driving survey despite the inability to infer to areas not accessible by road. However, as this comparison was only made in SJWA, an area with high raptor densities and very good road access, this result is not applicable to other areas with lower densities and poor road access. Indeed, one of the primary problems with vehicle-based surveys is the inability to make inferences away from roads. Much of the conservation area is characterized by steep topography with few roads; we were able to survey only 9845 of 44,986 ha (22%) of potential habitat when using vehicle-based transects..

Walking transects were much more efficient than driving transects. Per observer-hour, walking observers encountered more individual raptors, a greater number of species, and more individuals of the most commonly observed species. This increased efficiency is almost certainly due in part to the necessity of including a non-observing driver in vehicle-based transects. The efficiency of these transects could be improved by eliminating 1 observer and allowing the driver to make observations. However, this would introduce several problems. First, there would be a necessary tradeoff between the completeness of sampling on the driver's part and the safety of those in the vehicle. Second, because the driver's attention to sampling would vary depending on road conditions, total sampling effort could vary considerably both among transects and among individual observers within transects; furthermore, this effect would be difficult or impossible to estimate.

A second possibility to improve vehicle-based transects would be to remove the second observer, and have a single observer record all raptors. Because each observer in our study viewed a different area, reducing the effort to a single driver and a single observer would likely result in a corresponding reduction in the encounter rate. For transects in the SJWA stratum, we found no significant difference in the number of unique observations attributed to each observer. Single-observer walking transects will likely be more efficient than driving transects for areas outside SJWA, although some reduction in efficiency is possible due to the difficulty of accessing some areas on foot.

Species Objectives

The 3 species targeted by the 2008 survey do not have species-specific monitoring objectives or Core Areas; therefore once a survey has been conducted detailing the distribution of these species within the entire Conservation Area, monitoring for these species will be complete for the current 8-year period. We detected other covered raptors during this survey (Table 1), but they either occur in habitats not directly targeted by this study, or have breeding season-specific objectives that must be addressed during an appropriately-timed survey.

Recommendations for Future Surveys

Given the greater efficiency (i.e., lower cost for a given sample size) of walking transects, and the ability to infer to habitat throughout the Conservation Area, we recommend avoiding vehicle-based transects for future raptor surveys. To complete the required monitoring for open-country wintering raptors, monitoring using walking transects should occur across the entire Plan Area. This effort should include reserves that have already been sampled using the driving methodology as well as areas that have not yet been sampled. Consideration should also be given to the inclusion of multiple habitats in future studies, allowing forest/riparian species (such as Cooper's hawk, sharp-shinned hawk, and, to some extent, merlin) and lake species (including osprey, bald eagle, and peregrine falcon) to be included in the analyses. Inclusion of these species may require adjustment of survey methodologies (e.g., shorter transects or use of points in forested habitats, use of stationary lakeside sampling stations for species associated with water bodies) to make them appropriate in a variety of habitats.

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Appendix A: 2008 Western Riverside County MSHCP Winter Raptor Survey Protocol

Goals

Document the distribution and species composition of open country wintering raptors in western Riverside County, focusing on the following covered species: Ferruginous Hawk (FEHA), Merlin (MERL), and Prairie Falcon (PRFA). Examine potential habitat covariates for the occurrence of these covered species. Determine detection probabilities and available habitat use for wintering raptors in the Conservation Area.

Timing

Wintering Raptor surveys will be conducted twice a month from December to March to coincide with most raptor species wintering periods.

Survey Locations

Surveys will be conducted on accessible lands in appropriate habitat within the conservation area. Appropriate habitat will consist of habitat types identified in the MSHCP species accounts for the target species, including all open country (grasslands, agriculture, bare ground) as well as shrubland and woodland habitats of less than 60% density (Dudek & Associates 2003). Habitat types will be identified using CDFG et al. (2005). All study sites will be located along accessible and navigable roads and tracks.

METHODS

Protocol Development

Survey methods are based on techniques described in Andersen et al. (1985) and Fuller and Mosher (1981). We selected an analytical model based on repeat sampling of the same transects, following the techniques described in MacKenzie et al (2006), a design which provides for the computation of proportion of area occupied (PAO).

Sampling Design

The survey area will be defined by dividing the conservation area into 1-km^2 grid cells and selecting all cells containing at least 50 % appropriate wintering raptor habitat and at least 1 km of drivable secondary road. A total of 235 cells were selected using these criteria. All of these cells will be sampled during the survey period. Cells will be excluded from sampling if no accessible roads provide a view of the cell, if accessible roads are too dangerous to drive. or if cells are isolated (> 10 km from other cells). Transects will consist of 3-8 adjacent or nearby cells that will be sampled during the same day.

Driving routes through each cell on a transect will be selected in an initial field visit. Routes with superior visibility and central location (within the individual cell) will be preferred. These routes will be marked with GPS units and followed for each field visit.

Because this method relies on the presence of roads, no inference can be made to cells not containing sufficient roads. Approximately 70% of the available cells with adequate raptor habitat do not have sufficient roads for sampling with this protocol. This area should be sampled with a walking survey to provide complete coverage of the plan area.

We will compare the driving method above with a walking method performed away from roads by a single observer. For this comparison, we randomly placed 500-m transects (n = 20) and 1000-m transects (n = 9) within the San Jacinto Wildlife Area (both Davis and Potrero units). This area was selected to reduce the total effort required for this comparison, and because anecdotal observations (including previous observations made by Monitoring Program staff) suggest raptor densities may be higher in this area, allowing a greater sample size for comparison with a relatively small field effort. Transects of two sizes were walked to determine if longer transects could be performed without logistical difficulties (e.g. reserve boundaries or topography preventing transect placement).

Survey Techniques

All observers must demonstrate the ability to visually and acoustically identify all the probable raptor species that can be seen in the area. Observers will receive at least 20 hours of field and office training in raptor identification, and at least 10 hours field protocol training prior to beginning surveys.

All sites will be surveyed beginning 1.5 h after sunrise and will terminate at 1300 h. Surveys will be terminated early if the temperature exceeds 35 degrees C, if wind speed exceeds 3 on the Beaufort Wind Scale (>19 km/hr), or during precipitation or fog. Additionally, no surveys will be conducted for 48 h following a significant precipitation event, any time vehicles leave significant ruts in the roads, and any time there is significant snow or ice accumulation on the roads to be surveyed.

Waypoints and routes for each transect will be downloaded into a GPS unit prior to the beginning of the survey. At the beginning of each transect, observers will record the transect start time, temperature, wind speed (estimated on the Beaufort scale if no wind gauge is available), and weather conditions. For vehicle transects, observers will also record the total time spent in each individual cell.

During vehicle transects, two observers will survey the transect from the front passenger seat and behind the driver's seat of a moving vehicle. Vehicle drivers will be responsible for navigation only and will not participate in raptor location or identification. Drivers will not mention any raptors seen to observers, even if the observers appear to have missed the bird. The pre-determined route through each cell will be driven at 10-20 km/hr. Observers should spend approximately 20 minutes surveying each cell. The driver will call out the time and the cell identification number each time the vehicle passes into a new cell. This time should be recorded on the datasheet. When the end of the transect is reached, if less than 15 minutes have been spent in each cell, the vehicle will turn around and drive the same route backwards, again noting the time whenever a new cell is entered. For walking transects, single observers will walk a pre-determined route while watching for raptors with binoculars. Observers will travel at an average speed of approximately 1 km/hr.

During the transect, observers will record all raptors, including all Falconidae, Accipitridae, Cathartidae, Tytonidae, Strigidae, and Laniidae. Care must be taken to avoid recording the same bird twice. If identification is not possible from the moving vehicle, the vehicle will stop and observers will use a spotting scope to confirm the identification of all species. Drivers may assist with identification during these stops, provided that all birds are initially spotted by the designated observers. Observers will also record all cues used in detection and identification (call, plumage, shape, flight pattern) and, if known, the sex and age of the bird. Covered raptors that are observed within the survey area between transect counts will be recorded as incidental observations.

All transects will be sampled 4 times during the survey season. Each survey period will last 2-3 weeks.

Equipment

Handheld GPS Unit
Thermometer
Binoculars
Spotting Scope
Data Sheets
Anemometer
Rangefinder
Compass
Field Guide

Data analysis:

Occupancy and detection probability for all species will be determined using occupancy models in Program PRESENCE (Hines 2006). These models will incorporate the effect of habitat type at a broad scale (determined using GIS) on occupancy of selected species. The sampling unit of this analysis will be the 1-km^2 cell, and the occupancy analysis will report the proportion of cells used by the species of interest. Although cells are sampled as a group within a transect, the individual cells were selected independently, and thus can be analyzed as independent units. If sufficient sample sizes are obtained, analyses will be stratified by Core Area.

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