

Site Occupancy by Mexican Spotted Owls (*Strix occidentalis lucida*) in the US Forest Service Southwestern Region, 2014



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EXECUTIVE SUMMARY

The Mexican Spotted Owl (MSO) was listed as threatened under the Endangered Species Act in 1993. A revised recovery plan for MSO was completed in 2012, recommending that the population be monitored via estimating the rate of site occupancy. In August 2013, the US Forest Service Southwestern Region contracted with Rocky Mountain Bird Observatory (RMBO) to refine the site occupancy monitoring protocol recommend in the revised recovery plan, and to pilot test the protocol on Forest Service lands in Arizona and New Mexico in 2014.

The first step in developing a protocol for monitoring site occupancy of MSO was to define a sampling frame so that survey effort would be focused in areas of potentially suitable MSO habitat. In consultation with the US Forest Service and US Fish and Wildlife service, I used two sources of data to identify areas containing potentially suitable habitat: (1) Potential vegetation cover types, based on US Forest Service Ecological Response Unit classifications, and (2) a geophysical model of potential MSO habitat developed by Terry Johnson using data from MSO locations in Arizona and New Mexico.

Within the sampling frame, I defined sampling units as 1-km² areas (sites), each containing 5 survey points. RMBO employees conducted broadcast surveys at the survey points to locate Spotted Owls within the sampling units. We attempted to make two visits to each sampling unit between early April and mid-July 2014. We successfully surveyed 276 sampling units at least once, with 139 of those sampling units receiving two surveys each.

Using the resulting broadcast survey data, I estimated detection probability ($p = 0.725$; $SE(p) = 0.053$) and the probability of site occupancy ($\Psi = 0.378$; $SE(\Psi) = 0.038$) with Program MARK. I also used Program MARK to simulate the number of sampling units needed to estimate MSO site occupancy rates with sufficient precision to meet the guidelines of MSO monitoring as outlined in the 2012 MSO Recovery Plan. Simulation results based on a single year of data suggest that surveying 150 sampling units two times each year would be sufficient for monitoring the MSO population trend. Because we do not yet know the annual variation in detection probability nor site occupancy rates, I recommend that the US Forest Service survey 200 sampling units two times each year until we can evaluate more sophisticated simulation models that include annual variation.

In summary the sampling frame and survey methods used in 2014 provided the framework needed to continue to monitor site occupancy by Mexican Spotted Owls in the Southwestern Region of the US Forest Service. This framework may be expanded or adapted for monitoring Mexican Spotted Owls in additional areas of their range.

ACKNOWLEDGEMENTS

Designing this broad-scale project would not have been possible without the assistance and support of numerous people. The initial framework for monitoring the MSO through site occupancy was developed by the MSO Recovery Team and described in the MSO Recovery Plan, First Revision, Appendix E. Current Recovery Team members Bill Block and Joe Ganey of the US Forest Service Rocky Mountain Research Station, and Shaula Hedwall and Steve Spangle of the US Fish and Wildlife Service provided critical guidance in designing and executing this project, as did Karl Malcolm of the US Forest Service Southwestern Region.

Several employees of the US Forest Service Southwestern Regional office were key to securing funding and helping me to develop the sampling frame, especially Bobbi Barrera, Candace Bogart, Rick Crawford, Ronnie Maes and Karl Malcolm. Many Forest and District biologists in the Region, too numerous to list here, were very helpful with field logistics.

My colleagues Rob Sparks and Brittany Woiderski of Rocky Mountain Bird Observatory (RMBO) provided essential GIS support. The 2014 RMBO Spotted Owl crew successfully collected a tremendous amount of data, often alone, often in rugged terrain, while staying safe. Paul Doherty of Colorado State University kindly assisted me in simulation modeling using Program MARK.

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INTRODUCTION

The Mexican Spotted Owl (MSO) is one of three subspecies of Spotted Owl. It was listed as threatened under the Endangered Species Act in 1993. The first recovery plan for the MSO (USDI FWS 1995) recommended that the population be monitored via multiple demographic studies randomly located throughout the range of the subspecies, which involved capturing, banding and re-sighting owls each year. The demographic study design proved to be logistically impractical and too expensive. A revised recovery plan was completed in 2012 (USDI FWS 2012), recommending that the population be monitored via estimating the rate of site occupancy, which does not involve capturing/banding of owls.

Monitoring site occupancy in its most basic form relies on repeated visits to sampling locations in order to estimate the probability of detecting the organism of interest (MacKenzie et al. 2002). In accounting for detection probability, we are able accurately estimate site occupancy and to evaluate the precision of our estimate.

The two criteria for delisting MSO; one pertains to owl population trend, and the other pertains to the owl's habitat. This study addresses the first criterion (USDI FWS 2012):

“Owl occupancy rates must show a stable or increasing trend after 10 years of monitoring. The study design to verify this criterion must have a power of 90% (Type II error rate $\beta = 0.10$) to detect a 25% decline in occupancy rate over the 10-year period with a Type I error rate (α) of 0.10.”

The vast majority of MSO in Arizona and New Mexico live on land administered by the US Forest Service. In August 2013, the Forest Service contracted with Rocky Mountain Bird Observatory (RMBO) to refine the site occupancy monitoring protocol recommend in the revised recovery plan, and to pilot test the protocol in Arizona and New Mexico in 2014.

Objectives

The primary objectives were to:

1. Define a sampling plan for monitoring Mexican Spotted Owls (MSO) in the US Forest Service Southwestern Region.
2. Conduct field work to:
 - a. test the logistical aspects of conducting MSO broadcast surveys at hundreds of randomly-located sites throughout the US Forest Service Southwestern Region;
 - b. collect data necessary to evaluate the quantitative/analytical aspects of the sampling design.
3. Analyze the 2014 and provide recommendations for long-term monitoring of the MSO in the Southwestern Region.

METHODS

Study Area and Sampling Design

The extent of study area included all US Forest Service Lands in the Southwestern Region (Region 3), excluding National Grasslands and Valles Caldera National Preserve (Figure 1).

Sampling Frame

USFS biologists worked for 30 years to locate Spotted Owls on the National Forests of Region 3, and established Protected Activity Centers (PACs, $n = 1074$) in 1984 - 2013. Consequently, the types of habitats used by MSO throughout USFS Region 3 were well known, with respect to topography and cover types, even though all *locations* of MSO in the region were not necessarily known. Rather than survey for Spotted Owls on all Forest Service Lands, I used empirical data from the PACs to confine the sampling frame to areas of potentially suitable habitat.

In a meeting with US Forest Service Region 3 and the Fish and Wildlife Service in September 2013, we chose to use Region 3 “Ecological Response Units” (ERU) to represent potential vegetation cover types (ERU Version 4). I selected a subset of ERU types to define important MSO vegetation types (Table 1; Figure 2) based on quantification of cover types within MSO PACs.

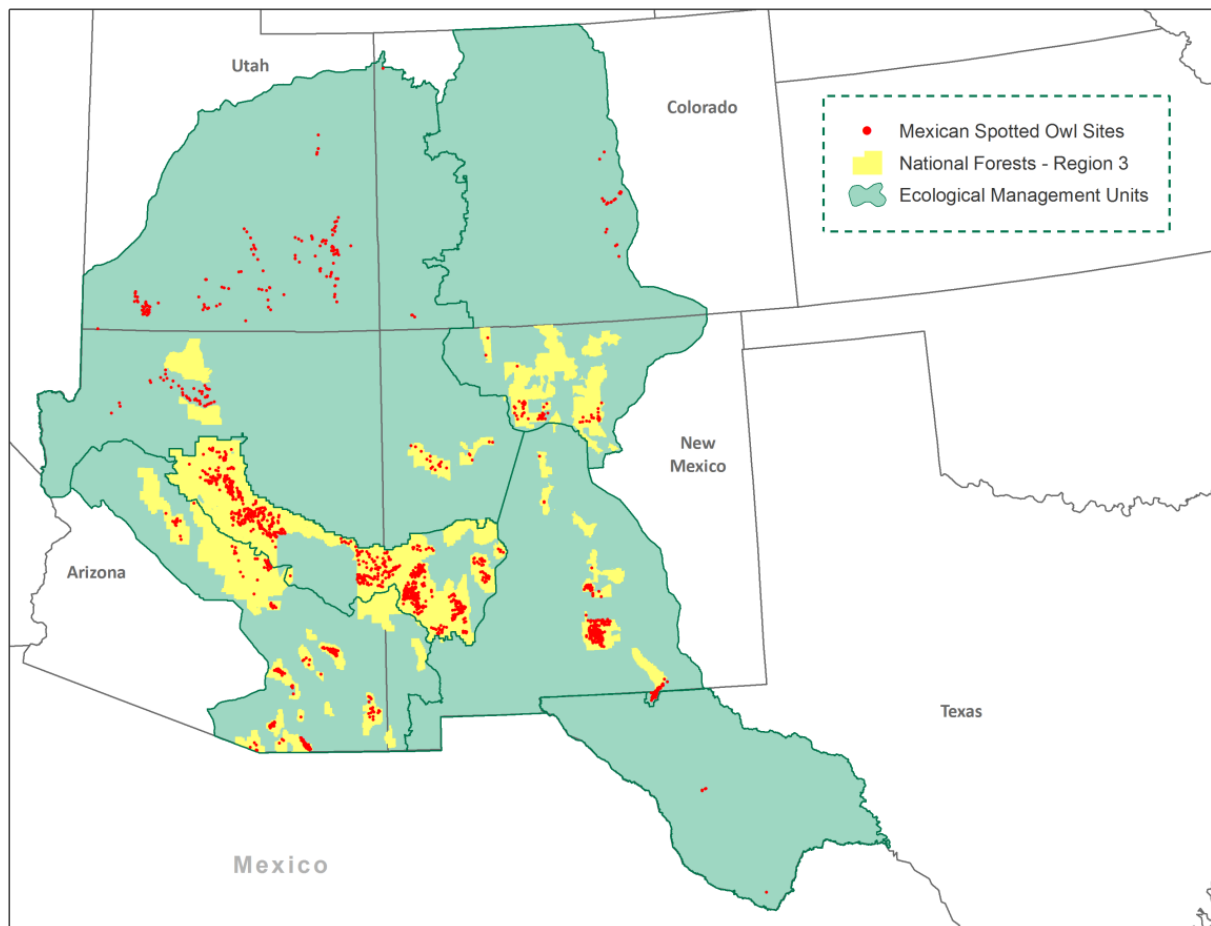


Figure 1. Range of the Mexican Spotted Owl in the United States and extent of US Forest Service lands (excluding National Grasslands) in the Southwestern Region. Mexican Spotted Owl sites are from the Recovery Plan, First Revision (2012).

Table 1. Ecological Response Unit Classes and subclasses (potential vegetation cover types) commonly used by Mexican Spotted Owls (MSO), based on 1074 MSO Protected Activity Centers.

Ecological Response Units
Madrean Encinal Woodland
Madrean Pine-Oak Woodland
Mixed Conifer - Frequent Fire
Mixed Conifer w/ Aspen
Ponderosa Pine - Evergreen Oak
Ponderosa Pine Forest (no subclass)
Ponderosa Pine / Gambel Oak (a subclass of Ponderosa Pine Forest)
Riparian (consists of numerous ERUs, all containing trees or tall shrubs, e.g., cottonwoods, evergreens, alders; not wilow nor desert scrub)
Spruce-fir - Lower
Spruce-fir (no subclass)

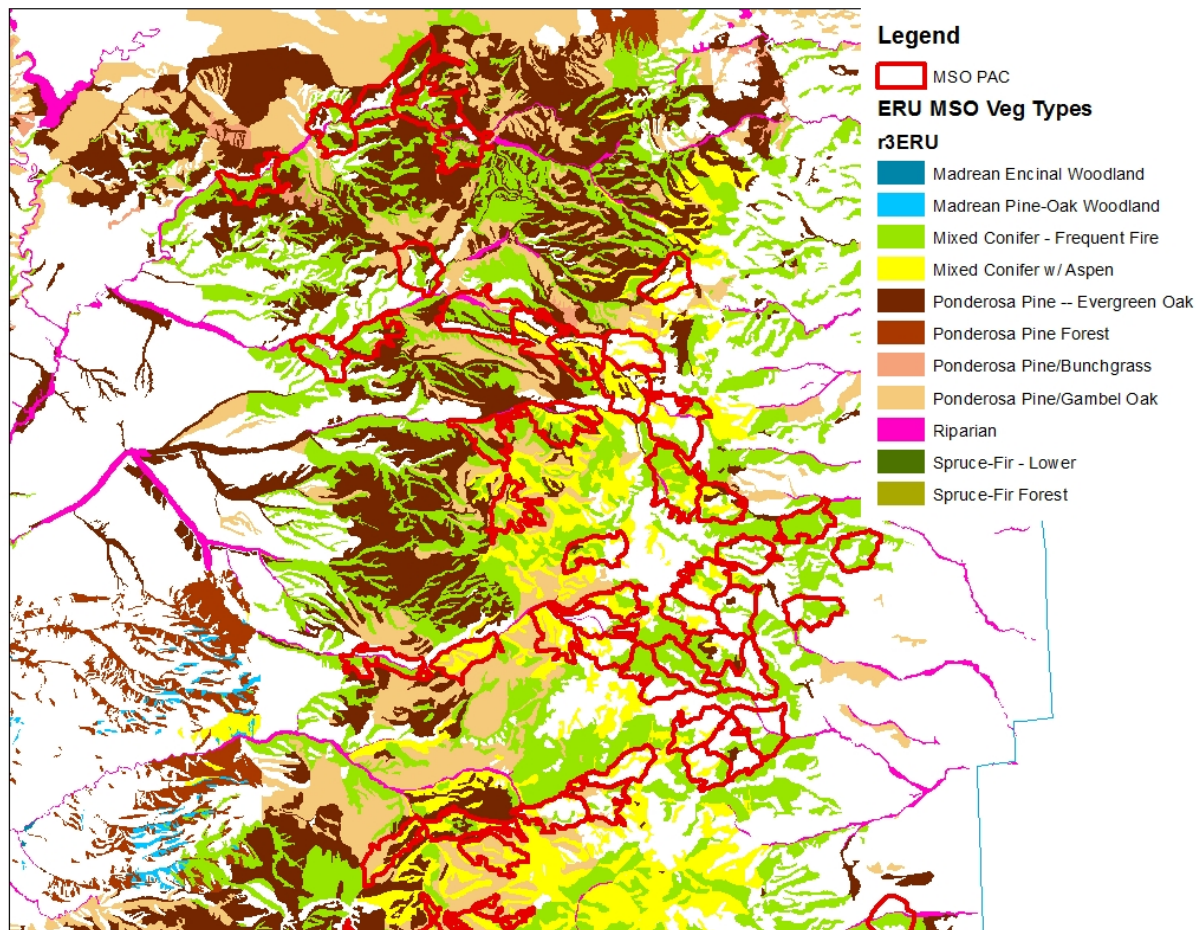


Figure 2. An example of Mexican Spotted Owl Protected Activity Centers (MSO PAC) in relation to potential vegetation cover types.

Johnson (2003) created a geophysical model of potential MSO habitat in the southwestern US. Johnson used 626 owl locations to develop and validate his model. Johnson’s model produces a “Potential Habitat Index” (PHI) value at 30 m² resolution; PHI is scaled from 1 - 250 (Table 2; Figure 3). PHI values ≥ 141 predicted the location of 80% of MSO locations (Johnson 2003). This model appeared to perform well for the 1074 established PACs; 95% of PACs contained one or more potential sampling cells that consist of at least 25% PHI pixels ≥ 141 (recall that PHI values were predicted as 30 m pixels). In contrast, only 24% of cells in the sampling frame were composed of at least 25% PHI pixels ≥ 141.

Table 2. Distribution of Spotted Owl locations among categories of Potential Habitat Indices from Johnson’s (2003) geophysical Spotted Owl habitat model.

	Potential Habitat Index						
	250-210	209-169	168-141	140-114	113-91	90-77	76-1
MSO locations	30%	30%	20%	10%	5%	2%	Not habitat
Cumulative %	30%	60%	80%	90%	95%	97%	Not habitat

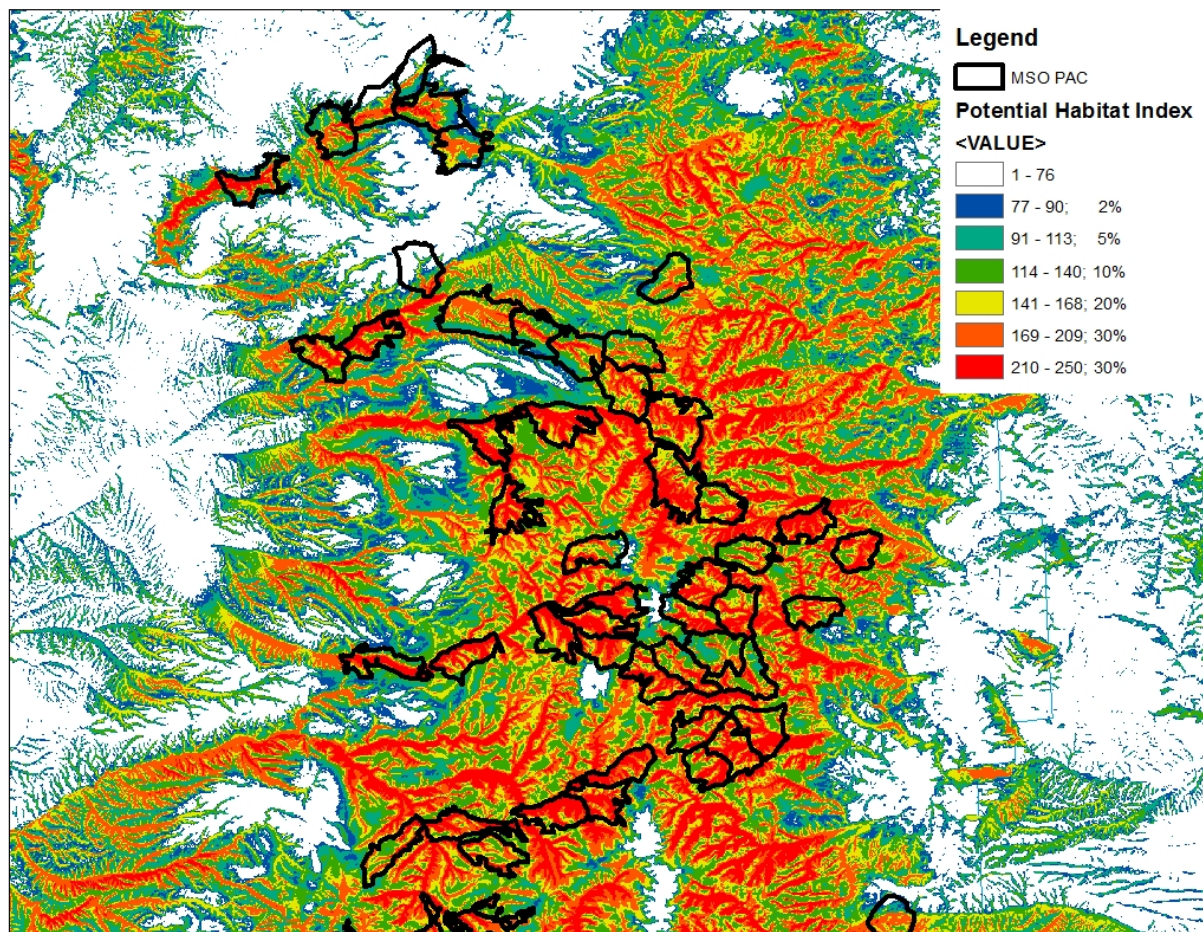


Figure 3. An example of Mexican Spotted Owl Protected Activity Centers (MSO PAC) in relation to a geophysical model of potential Mexican Spotted Owl Habitat.

Sampling Units

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The MSO Recovery Plan, First Revision suggested that sampling units consist of 1-km² areas. I used the US National Grid (1 km²) to define potential sampling units. All spatial data were compiled using ARCGIS 10.x (ESRI 2010). Any grid cell containing at least 50% USFS land was initially included in the sampling frame (88,482 cells).

I used GIS to find the most parsimonious criteria for minimizing the sampling frame as much as possible without eliminating > 5% of PACs from the sampling frame, using a combination of potential vegetation and geophysical data. Some PACs had a high proportion of important MSO vegetation types and a moderate proportion of area with high PHI values whereas other PACs had very little MSO vegetation and high proportion area with high PHI values. Consequently, 1 km² cells included in the sampling frame met at least one of 2 sets of criteria:

- A. At least 50% of the cell must contain PHI values > 141 AND at least some portion of the cell is classified as MSO vegetation type (Figure 4);
- B. At least 50% of the cell must contain MSO vegetation type AND at least 20% of the cell must contain PHI values > 141 (Figure 5).

17,903 1-km² cells met these criteria (Figure 6A).

Sample Selection

I used generalized random-tessellation stratification (GRTS), a spatially balanced sampling algorithm, to select sample units (Stevens and Olsen 2004). In the GRTS design all sample units in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially well-balanced sample (Stevens and Olsen 2004; Figure 6B).

I drew a sample of 1000 cells, anticipating that 350 cells would be surveyed in 2014, and allowing for more cells to be sampled in the future (Figure 7). The MSO Recovery Plan (2012) recommended that sampling units be at least 5 km apart so that any territorial Spotted Owl would be unlikely to be detected from more than one sampling unit. Therefore, I excluded cells that fell within 5 km of any other cell with a lower GRTS sample number. I named the resulting sample units using a 3 letter abbreviation for the National Forest in which they fell and the GRTS sample number. For example, the site named "COC0189" represents the 189th sampling unit, which happened to fall in the Coconino National Forest. Use the National Forest as part of the label was for logistical purposes. Use of the Forest name in the label must not be construed to indicate that individual Forests represented strata.

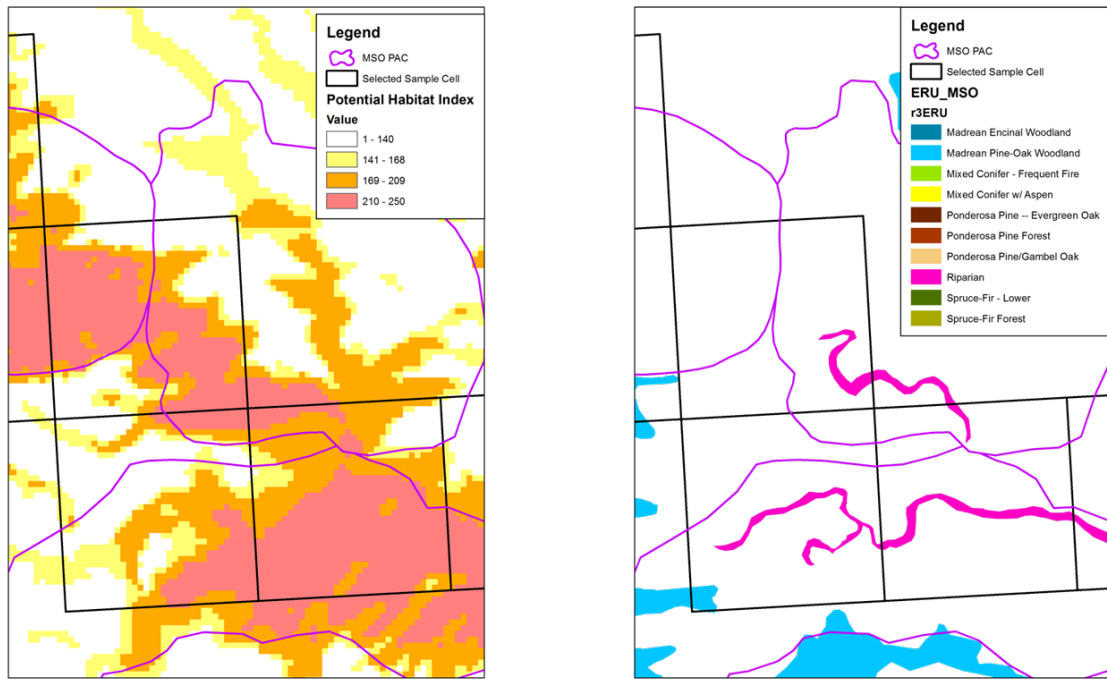


Figure 4. An example of sampling units with high values of potential habitat based on the geophysical model, and a low amount of potentially suitable vegetation cover types.

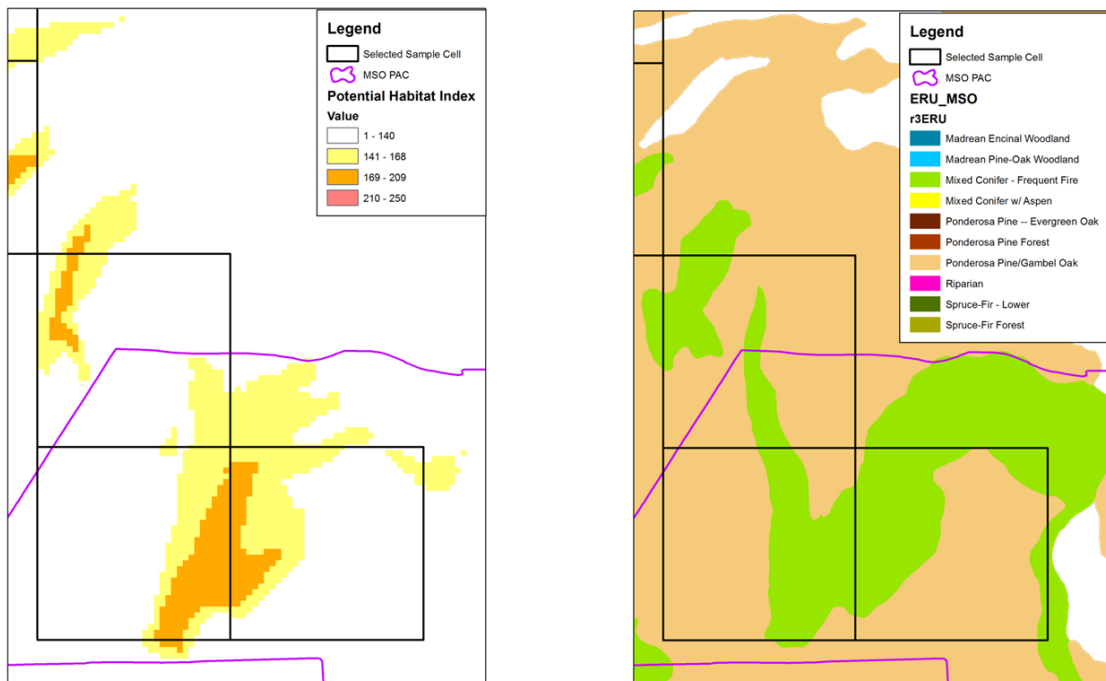


Figure 5. An example of sampling units with low values of potential habitat based on the geophysical model, and a high amount of potentially suitable vegetation cover types.

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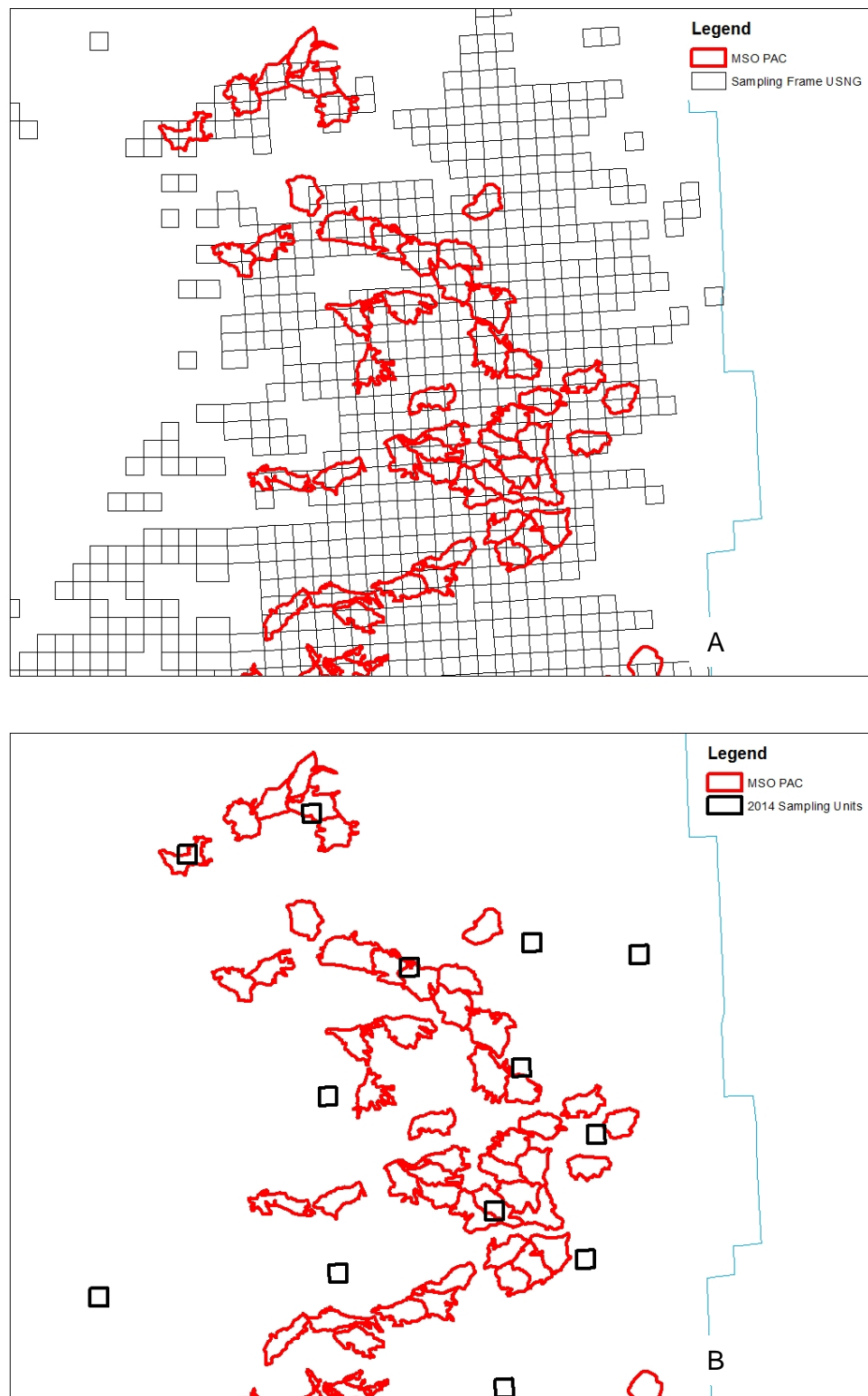


Figure 6. An example of Mexican Spotted Owl Protected Activity Centers (MSO PAC) superimposed on (A) the sampling frame, and (B) some of the 350 cells selected for sampling in 2014.

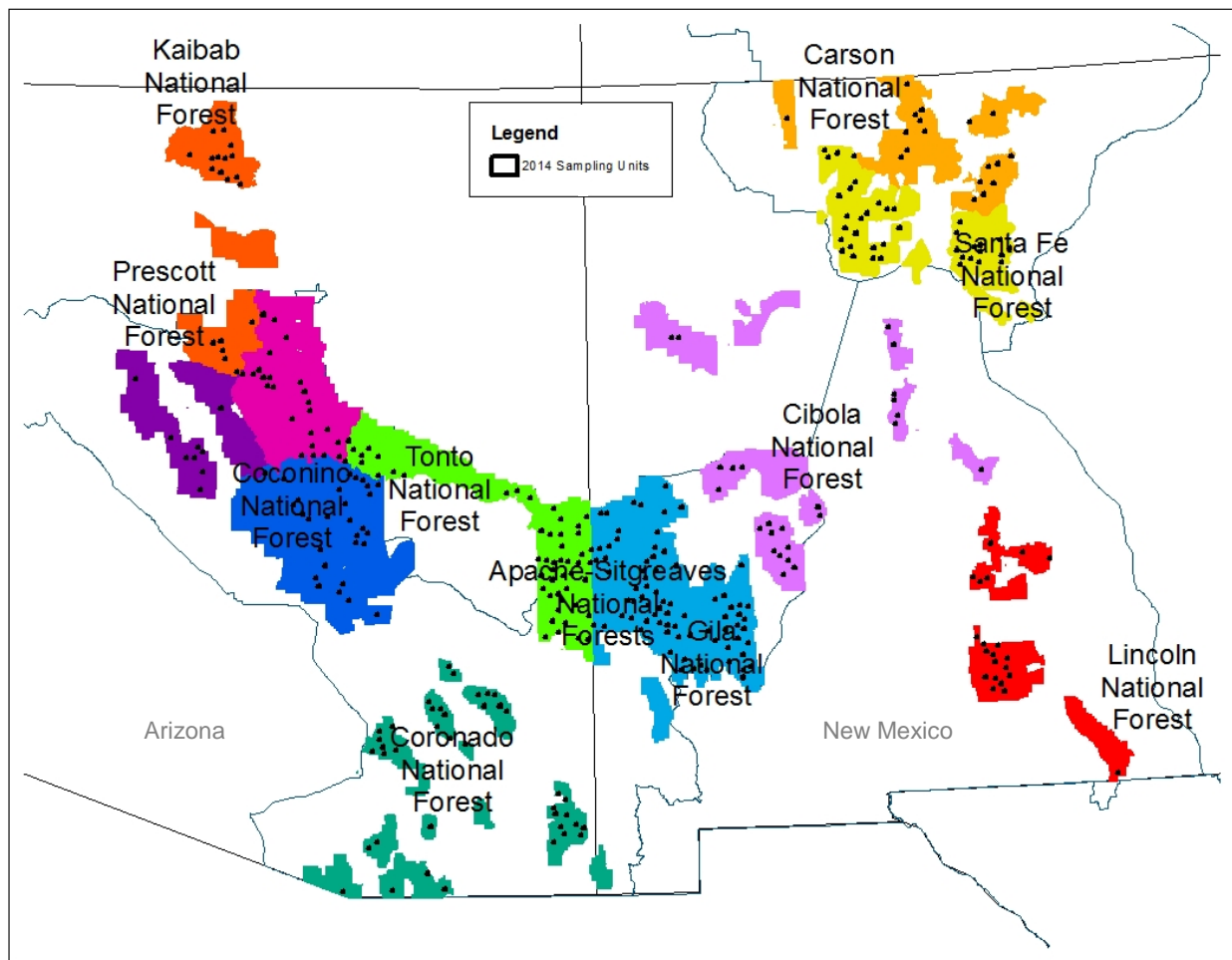


Figure 7. The distribution of sampling units ($n = 350$) targeted for Mexican Spotted Owl occupancy surveys in 2014 in the US Forest Southwestern Region.

Sampling Methods

Methods for conducting Spotted Owl surveys are well-established (Forsman 1983). Spotted Owls are territorial and readily respond to vocalizations of other Spotted Owls, whether they are actual owls calling, recordings of owl calls, or human imitations of owl calls. We broadcast a variety of Spotted Owl calls using FoxPro NX4® broadcast devices. The devices contained various recordings of male and female Spotted Owl calls, with approximately 20 seconds of calls followed by 20 seconds of silence, for 10 minutes. After the 10 minutes of calls, the survey continued with 5 minutes of silence (no broadcasting). Technicians were instructed to listen for and document Spotted Owl responses throughout the survey period (see Appendix A for the complete broadcast survey protocol and Appendix B for the broadcast survey form.)

Within each sampling unit we attempted to survey at each of 5 evenly-spaced survey points (Figure 8). Field technicians were allowed to use their discretion to move survey points to take advantage of local topography and to avoid unsafe terrain; for example, to call from a ridge rather than the side of a slope. Technicians generally surveyed each sampling unit alone unless the survey required an overnight stay in the backcountry or the sampling unit contained especially rugged topography.

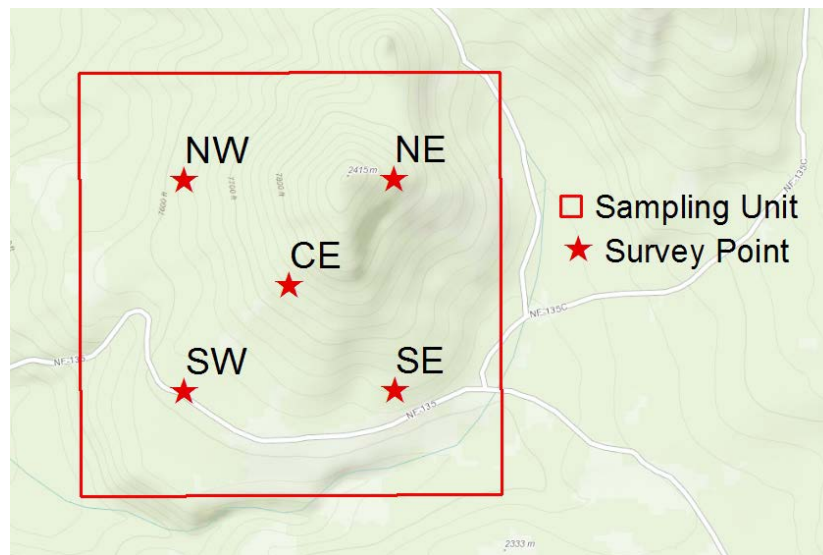


Figure 8. 1-km² square sample site containing 5 survey points.

We conducted reproduction surveys at a subset of sampling units within which we detected Spotted Owls. Reproductive surveys consisted of offering live mice to the owls and following the owls until they took each mouse to their offspring, ate the mouse or cached the mouse (Forsman 1983). We conducted reproductive surveys during the daytime (early morning or late evening). See Appendix C for the complete reproduction survey protocol and Appendix D for the reproduction survey form. We did not conduct reproduction surveys at any site until two broadcast surveys had been completed at the site, in order to avoid biasing the broadcast surveys.

Data Analysis

I conducted site occupancy analyses using Program MARK (White and Burnham 1999). Because there was only a single year of data, the number of models I considered was very small. I modeled the effects of date, sampling occasion, and the location of a sampling unit with respect to roadless areas on detection probability. I used Akaike's Information Criterion, corrected for small sample size (AICc) and an information-theoretic approach to model selection to make inferences about the modeling results (Burnham and Anderson 2002).

Simulation Modeling

Applying the empirical estimates from the data analysis, I used Program MARK's simulation package (Cooch and White 2014) to estimate the number of samples needed to monitor Mexican Spotted Owl site occupancy rates with the precision required by the Recovery Plan (USDI FWS 2012). I used the following initial values for simulations: detection probability = 0.70 and occupancy rate = 0.35.

RESULTS

Of the 350 sampling units (sites) targeted for sampling in 2014, we successfully surveyed 139 sites on two occasions and 137 sites on one occasion from 4 April to 15 July 2014. An additional 13 sites were surveyed from only 1-2 survey points each, and were excluded from analyses. We dropped 51 sites from the sampling frame because they were inaccessible or unsafe to survey due to terrain (35 sites), surrounding private property (13 sites) or issues on

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the US/Mexico border (3 sites). Ten additional sites were not dropped from the sampling frame but were not surveyed because we ran out of time in the field season (9 sites) or were unable to access the site due to a nearby wildfire (1 site).

We attempted to conduct reproduction surveys at 36 sites from 17 June to 21 July 2014 but were only successful in determining owl reproductive status at 12 sites (9 sites with fledglings; 3 sites at which the owls ate mice). At the remaining sites, we were either unable to locate the owls in the daytime (19 sites) or the owls refused to take any mice (5 sites). Even at the 9 sites in which we observed fledgling owls, the parent owls at 4 sites refused to take any mice. I did not include reproduction data in any analyses.

The most parsimonious (lowest AICc) model of detection probability did not include any effects of survey date, sampling occasion (first visit vs second visit) nor location of a sampling unit with respect to roadless areas (the “constant” model; Table 3). However, the second lowest AICc model accounted for nearly as much weight as the “constant” model, and included a positive effect of survey date, indicating that detection probability increased during our field season (β [Date] = 0.009, SE = 0.007).

Table 3. Models of detection probability and site occupancy by Mexican Spotted Owls on USFS land in Arizona and New Mexico, 2014 ($n = 276$ sampling units).

Detection Probability	AICc	Δ AICc	AICc Weights	Model Likelihood	Number of Parameters	Deviance
Constant	465.08	0.00	0.35	1.00	2	461.04
Date	465.50	0.42	0.28	0.81	3	459.42
Roaded vs Unroaded	467.01	1.92	0.13	0.38	3	460.92
Occasion	467.01	1.92	0.13	0.38	3	460.92
Date + Occasion	467.49	2.41	0.10	0.30	4	459.35

Estimated detection probability from the constant model was 72.5% and estimated rate of site occupancy was 37.8% (Table 4). The standard error of both estimates was low (Coefficient of Variation $\leq 10\%$ (Table 4). Inference from the model of detection probability as a function of date indicates that estimated detection probability was approximately 71% on 4 May and 78% on 21 June, for example (Table 5).

Table 4. Parameter estimates from the most parsimonious (lowest AICc) model of detection probability (p) and site occupancy (Ψ) by Mexican Spotted Owls on USFS land in Arizona and New Mexico, 2014.

Parameter	Estimate	SE	95% Confidence Interval		%CV
			Lower	Upper	
p	0.725	0.053	0.610	0.816	7
Ψ	0.378	0.038	0.307	0.454	10

Table 5. Parameter estimates from the second lowest AICc model of detection probability (p) and site occupancy (Psi) by Mexican Spotted Owls on USFS land in Arizona and New Mexico, 2014.

Parameter	Estimate	SE	95% Confidence Interval		%CV
			Lower	Upper	
p ₁ *	0.705	0.055	0.587	0.801	8
p ₂ *	0.783	0.065	0.631	0.884	8
Psi	0.378	0.037	0.309	0.453	10

*Estimates based on unstandardized individual covariate values:

Variable	Value	
DATE1	126.360	(04 May)
DATE2	172.190	(21 June)

Simulation results indicated that surveying 150 sampling units twice each year would be sufficient for detecting a 3% annual decline in the MSO population within the US Forest Service Southwestern Region (Table 6).

Table 6. Simulation results to determine whether various rates of decline in the Mexican Spotted Owl population on US Forest Service lands in AZ and NM would be statistically significant with a variety of sample sizes. Results were based on 1000 simulations each in Program MARK.

	Annual Rate of Decline:	3.0%	2.5%	2.0%	1.5%	1.0%
	Total 10 Year Decline:	24%	20%	17%	13%	9%
Sample Size	100	No	No	No	No	No
	150	Yes	No	No	No	No
	200	Yes	Yes	No	No	No
	250	Yes	Yes	Yes	No	No
	300	Yes	Yes	Yes	No	No
	350	Yes	Yes	Yes	No	No
	400	Yes	Yes	Yes	No	No
	450	Yes	Yes	Yes	No	No
	500	Yes	Yes	Yes	Yes	No

DISCUSSION

Monitoring the population trend of the Mexican Spotted Owl is required by the MSO Recovery Plan (2012). Estimating MSO site occupancy rates through time will be achievable on US Forest Service Lands in Arizona and New Mexico using the sampling frame and survey methods we employed in 2014.

In the future we may be able to conduct more sophisticated data analyses using habitat or climate covariates to improve the precision of MSO occupancy estimates and to increase our understanding of MSO ecology. I believe that an annual, regional estimate of MSO reproductive rates may help to explain annual variation in both detection probability and occupancy rates.

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Unfortunately the reproductive surveys we conducted in 2014 were of little value because they were conducted too late in the breeding season. We may be able to incorporate reproductive data collected by individual National Forest Districts in analyses. After we have collected several years' occupancy data, we may also be able to conduct occupancy analyses that incorporate information about local (site-level) extinction and colonization rates.

Simulation results based on a single year of data suggest that surveying 150 sampling units two times each year would be sufficient for monitoring the MSO population trend. Because we do not yet know the annual variation in detection probability nor site occupancy rates, I recommend that the US Forest Service survey 200 sampling units two times each year until we can evaluate more sophisticated simulation models that include annual variation.

In summary the sampling frame and survey methods used in 2014 provided the framework needed to continue to monitor site occupancy by Mexican Spotted Owls in the Southwestern Region of the US Forest Service. This framework may be expanded or adapted for monitoring Mexican Spotted Owls in additional areas of their range.

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APPENDICES

Appendix A. Mexican Spotted Owl Broadcast Survey Protocol 2014; Rocky Mountain Bird Observatory

Rocky Mountain Bird Observatory is conducting broadcast surveys for the purpose of estimating occupancy rates and monitoring trends in occupancy rates of the Mexican Spotted Owl on all National Forests in Arizona and New Mexico (USFS Region 3). This project is required under the Mexican Spotted Owl Recovery Plan, First Revision (2012).

The sampling locations were selected using a spatially-balanced sampling algorithm (Generalized Random-Tessellation Stratification), and were essentially a random sample of locations within a sampling frame of potentially suitable Mexican Spotted Owl habitat. It is essential to the validity of the monitoring program that all selected sites are surveyed unless they are unsafe to survey.

Sampling locations (sites) consist of 1-km² areas. Each site contains 5 survey points, with one point in the center of the site and one point in the center of each quarter of the site, named according to their location (Figure 1).

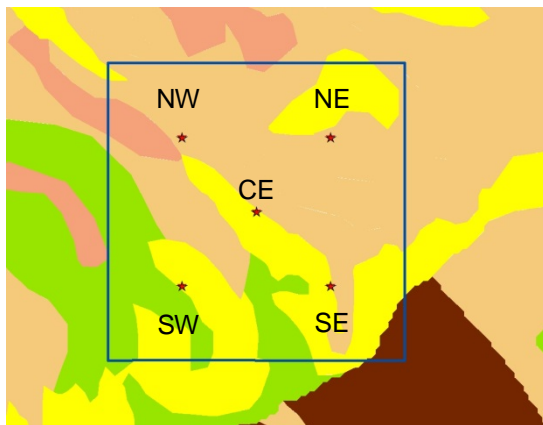


Figure 1. 1-km² square sample site containing 5 survey points.

Field technicians will have topographic maps and UTM coordinates of each survey point in their GPS units. Field technicians may use their discretion to move survey points to take advantage of local topography and to avoid unsafe terrain; for example, to call from a ridge rather than the side of a slope. In general, call points should not be moved more than 100 meters. Field technicians must record the UTM coordinates of the actual location from which they surveyed (see Broadcast Survey Form; Appendix A).

Each field technician will have a FoxPro NX4 broadcast device to use during surveys. The units contain various recordings of male and female spotted owl calls, with approximately 20 seconds of calls followed by 20 seconds of silence, for 10 minutes. Technicians are to listen for spotted owl responses throughout the survey period. Following the 10 minutes of intermittent calls, the technician will listen for owl responses for 5 additional minutes; the entire time spent at each survey point is 15 minutes (unless a spotted owl responds; see below).

Objectives are to **survey every point until both a male and female spotted owl are detected within the 1-km² site, or until all 5 points are surveyed**. If a spotted owl is detected outside of the site, the survey will continue at the remaining survey points. If only one sex of owl is detected from a survey point, the technician will continue the survey at the point, but switch from the recording of both sexes of owls (channel zero) to a recording of the opposite sex of owl. For

example, if a male owl is detected, switch to the recording of female calls (channel one); if a female owl is detected, switch to the recording of male calls (channel two). The purpose of this procedure is to avoid excess disturbance to spotted owls detected.

Record the compass bearing from the survey point to the initial location of all owls detected. Plot the bearing on the paper map of the survey site. Use local topography and common sense to estimate the location of the owl (plot on the map) and record the estimate the distance from the call point to the owl.

When two technicians are surveying separate points at the same site: Do **NOT** conduct broadcast surveys at more than one point at a time, including the 5 minute listening period. Use walkie-talkies to communicate with your field partner to ensure that you do not survey within the same 15-minute period. The purpose of broadcasting spotted owl calls is to entice any spotted owls present to respond because they perceive you as an intruder in their territory. If an owl perceives that there are two intruders in their territory, they may remain silent.

Survey conditions: Do not survey during rainfall more than a light drizzle. Do not survey if wind conditions would prevent you from detecting a calling spotted owl within 250 meters of your survey point (generally greater than 18 mph; see Beaufort wind scale on survey form). Although ridges can be good points from which to survey when winds are not strong, it may be better during windy conditions to survey downslope from ridge tops.

Safety: Except in very gentle terrain, technicians should arrive at their survey sites during daylight hours to view the landscape and plan how they are going to navigate between survey sites. Technicians will check in with their crew leaders at least once a day, either in person, by cell phone, or via their DeLorme inReach satellite communication device. The crew leader may request twice-per-day check-in. The crew leader will designate one crew member with whom they will check in daily.

Survey Form details:

SUMMARY INFORMATION (BLUE PORTION OF THE SURVEY FORM)

Site: Each site name contains 3 letters and 4 digits. The letters indicate the National Forest of the site; the numbers indicate the order of the site in the GRTS random sample.

Date: Follow the example format: 2 digit day, 3 letter month.

Visit number: Each site will be visited 2 times within the season.

Observers 1 and 2: Use 3 initials (or 2 initials if you don't have a middle name).

If two people are surveying separate points within a unit, each person should fill out a form in the field, but after the survey is over, the data from one technician should be copied onto the other technician's form so that only one survey form is turned in for the survey.

Pairs, # Single males, # Single females, # Juveniles: This section should be filled out at the end of the survey, after all points are surveyed for the night. Enter zeros rather than leaving fields blank.

Survey Complete? See the codes on the survey form. If a survey is incomplete, an additional visit to the site will be required.

Why survey incomplete? Enter a very short explanation, following the examples given on the form.

SURVEY INFORMATION (BLACK PORTION OF THE SURVEY FORM)

Point: See Figure 1. Use 2 letter codes. **If you detect an owl while walking between survey points**, stop, record your location as Point 99, enter the UTM's of your location and all other information as you would from an established survey point. Enter the "Minutes to detect" as Zero.

Wind: See codes.

Noise: Use this field for non-wind noise, such as a creek or traffic. Enter the type of noise in the "Notes" box of the survey form.

Survey time: Fill this out after you enter Start Time and End Time. If you do not detect any owls, this will usually be 15 minutes. If you detect a male and female owl, it may be less than 15 minutes. If you need extra time to confirm a detection (or location of a detection), it is ok to spend more than 15 minutes at a point.

Start time: The time you start broadcasting, or the time you heard an owl if you are walking between points or hear the owl before you start broadcasting from a point. Record as 24-hour time; For example, 8:15 PM = 2015. Exact midnight = 2400. 15 minutes after midnight = 0015, NOT 2415.

End time: The time you stop listening for owls.

UTME and UTMN: Use your GPS unit.

DETECTION INFORMATION (RED PORTION OF THE SURVEY FORM)

Only fill out this section if owls are detected.

Most of these fields are obvious and/or have codes on the form.

Unique Bird ID: This field is used to keep track of the same owl heard detected from multiple points. Use the same code to indicate a spotted owl detected from more than one point. Start with M1, F1, U1. For example, if you hear the same male owl from NE and NW points, record its location on one line for each point from which it was detected, and enter the letter M1. If you then hear a second male owl from the SE point, record its location and enter M2. If only one owl of each sex is detected, there is no need to use the Unique Bird ID field.

Inside/Outside: Enter I or O to indicate whether the owl is inside or outside of the 1-km² survey site.

Appendix B. Mexican Spotted Owl Broadcast Data Form 2014; Rocky Mountain Bird Observatory

SPOTTED OWL BROADCAST SURVEY FORM Page ___ of ___

Site: _____ Date: ___/___/2014 Visit #: _____ Observer 1: _____ Observer 2: _____
e.g., SFE0005 e.g., 01 / APR / 2014

MSO Summary:
 # Pairs _____ # Single Males _____ # Single Females _____ # Juveniles _____

Survey Information:

Point	Wind <small>(see codes)</small>	Noise <small>(see codes)</small>	Survey Minutes	Start Time	End Time	UTME	UTMN

Wind codes

Beaufort	mph	Description
0	0	smoke rises vertically
1	1-3	smoke drifts
2	4-7	wind felt on face
3	8-12	leaves in constant motion
4	13-18	raises dust; branches sway
5	18-24	small trees sway

Noise codes

0 – no noise

1 – some noise, but can hear very well

2 – moderate noise; can still hear to 200 meters

3 – loud noise; affecting ability to detect owls

4 – very loud stream or other noise (move!)

Detection Information:

Point	Species <small>(see codes)</small>	Sex <small>(M,F,U)</small>	How Detected	Min. to Detect	Time Detected	UTME	UTMN	Bearing <small>(degrees)</small>	Distance <small>(meters)</small>	Unique Bird ID	Inside/ Outside*

Notes:

Species codes

BDOW Barred Owl
 BNOW Barn Owl
 ELOW Elf Owl
 FEPO Ferruginous Pygmy-Owl
 FLOW Flammulated Owl
 GHOW Great Horned Owl
 LEOW Long-eared Owl
 NOPO Northern Pygmy-Owl
 NSWOW Northern Saw-whet Owl
 SPOW Spotted Owl
 WESO Western Screech-Owl
 WHSO Whiskered Screech-Owl

How detected codes

HO Heard Only
 HS Heard, then Seen
 SO Seen Only
 SH Seen, then Heard

*Inside (I) or Outside (O) sampling unit

3/28/2014

IF FOUND, PLEASE RETURN TO: Rocky Mountain Bird Observatory; 230 Cherry Street; Fort Collins, CO 80521

Appendix C. Mexican Spotted Owl Reproduction Survey Protocol 2014; Rocky Mountain Bird Observatory

Rocky Mountain Bird Observatory (RMBO) is conducting surveys to determine the reproductive output of Mexican Spotted Owls in conjunction with broadcast surveys conducted for the purpose of estimating occupancy rates and monitoring trends in occupancy rates of the Mexican Spotted Owl. Reproduction surveys will occur at a random subset of sites at which we detect one or more Spotted Owls during broadcast surveys.

Reproduction surveys will follow the general methods used for decades in the study of Northern, California and Mexican Spotted Owls, including the methods described in the 2012 Mexican Spotted Owl Recovery Plan, First Revision (see box, below). As is common in most demographic studies of Spotted Owls, we will require two successful reproduction visits to any site at which the first reproductive visit indicates no juvenile owls are present. This is necessary for estimating the probability of detecting juvenile spotted owls when juvenile owls are present.

The rationale for determining reproductive status of Spotted Owls by feeding live mice to the owls is that subadult and adult owls with an active nest (a nest containing nestlings or a female owl incubating eggs) or with fledged young will deliver the mice to the nest or to the fledged young. Occasionally, the subadult or adult owl will eat a mouse or two before delivering mice to the nest or young. Consequently, protocols for determining Spotted Owl reproduction (“mousing protocols”) generally require that at least four mice be offered to the subadult or adult owls. ***For the MSO occupancy study, we will attempt to offer four mice to a single individual subadult or adult owl when a pair of owls is present. This is a deviation from the MSO Recovery Plan protocol, in which a reproduction survey may be concluded after a pair of owls is offered four mice.*** Consequently, field biologists should carry 7 or 8 mice with them during reproduction surveys. The reason for requiring four mice be offered to single owl is to avoid a case in which, for example, the male owl eats 2 mice and the female owl eats 2 mice, when a third mouse given to either owl would have been delivered to the nest or young.

When a mouse is first delivered to fledged young, the field biologist(s) should immediately offer an additional mouse to the parent owl to determine whether there are more fledglings present, because it will take a few minutes for the first fledgling to consume the mouse, and a sibling fledgling will be more likely to receive a subsequent mouse. When 3 fledglings are observed, the survey is finished. When four mice are delivered to one or two young, the survey is finished. If the adult owl(s) ate one mouse before delivering the second mouse to the young, offer three additional mice (5 total); if the adult owl(s) ate two mice before delivering the third mouse to the young, offer three additional mice (6 total); etc.

For the MSO occupancy study, if the fate of any mouse taken by an owl is unknown, we may not conclude that no juveniles are present. This is a deviation from the MSO Recovery Plan protocol. However, if the fate of any mouse is unknown, continue to offer mice to the owl(s) until the fates of four mice are known. This will allow for comparisons between conclusions of the Recovery Plan protocol and the Occupancy Monitoring protocol.

The occupancy monitoring protocol uses more “mouse fate” codes than the Recovery Plan protocol (see survey form, below), but the occupancy monitoring codes can be combined to make direct comparisons among protocols.

Mexican Spotted Owl Recovery Plan, First Revision (2012)

APPENDIX D - MEXICAN SPOTTED OWL SURVEY PROTOCOL

6. Methods If Mexican Spotted Owls Are Located on a Daytime Follow-up Visit

Mousing is the primary tool to locate an owl's mate, young, and/or nest. Mousing entails feeding live mice to adult/subadult owl(s) and observing the owl's subsequent behavior. Surveyors should be prepared to offer four mice (one at a time) to at least one member of the pair or to a single owl located on the daytime follow-up visit. For surveyors to draw conclusions about reproductive status, the owl must take at least two mice before refusing them. A mouse is considered "refused" if, after 30 minutes, it has not been taken by an owl.

If an owl takes a mouse and flies away, the surveyor should follow it as closely as possible to determine where it takes the mouse. If the surveyor is unable to follow the owl, and doesn't know if it took the mouse to a mate, nest, or fledged young, then the fate of that mouse cannot be counted toward the four-mouse minimum described above. Surveyors should be ready to rapidly pursue owls that take mice, as owls sometimes fly several hundred meters with mice to reach their nests or young. It is not necessary to complete the four mice minimum after a mouse has unequivocally been taken to a nest.

Owl pairs are determined to be non-nesting if a single owl eats and/or caches all four mice or eats and/or caches two mice and refuses to take a third. A mouse is cached when the owl puts the mouse in a tree or on the ground and then leaves the mouse or the owl perches with the mouse for at least one hour and gives no sign of further activity. Do not feed any more mice than necessary to determine pair status, nest location, and/or reproductive status (i.e., if all observed juveniles have received a mouse then number of young produced is determined and there is no need to continue mousing). Dropped mice or mice whose fates are unknown do not count toward the total of four mice needed to complete the protocol.

Ancillary notes on an owl's behavior during the mousing attempts are also very important to record. These observations can help clarify situations in which incomplete information was collected. For example, if a male is given a mouse and begins to make single-note contact calls while looking in a specific direction in April-June, that is often a good clue that a mate, nest, and/or young may be present. Sometimes observers are too close to other owls or the nest for the "true" mouse fate to be observed. Such observations should trigger another daytime follow-up to secure the location of a mate, nest, or young of the year. For these types of additional follow-up surveys, nighttime calling is usually not necessary.

Appendix D. Mexican Spotted Owl Reproduction Data Form 2014; Rocky Mountain Bird Observatory

SPOTTED OWL REPRODUCTION ("MOUSING") SURVEY FORM

Site: _____ Date: ____ / ____ / 2014 **Repro Visit #:** ____ **Observer 1:** _____ **Observer 2:** _____
e.g., SFE0005 e.g., 01 / APR / 2014

Survey time: _____ - _____ **Total Survey Minutes:** _____ **REPRODUCTION Summary:** _____
start stop

REPRODUCTION SUMMARY CODES

UN = unknown NC = nesting, based on female seen on nest 1F = 1 fledged
 NO = not nesting based on mousing protocol NY = nesting, with young detected in nest 2F = 2 fledged
 NT = nesting, no young detected, based on mousing NF = nesting, with young in nest and young fledged 3F = 3 fledged

Owl / Nest Information:

Owl #	Sex (M, F, U)	Age class (see codes)	Time Detected	# Mice Offered	Mouse Fates, in order (see codes)	UTME	UTMN	Inside/ Outside
1								
2								
3								
4								
5								
Nest								

MOUSE FATE CODES

U = unknown
 E = eaten by the owl that took the mouse
 C = cached (or just perched with mouse for 1 hr)
 X = either eaten or cached, but not unknown
 R = refused (mouse in view >30 min & owl watching)
 I = ignored (doesn't meet R)

F = male gave to female & female ate it
 G = male gave to female & female cached it
 Z = male gave to female, fate unknown
 N = taken to nest
 Y = taken to first juvenile
 S = taken to second juvenile
 T = taken to third juvenile

AGE CLASS CODES

A = Adult
 S = Subadult
 S1 = 1st yr Subadult
 S2 = 2nd yr Subadult
 J = Juvenile
 U = Unknown

Notes: e.g., If an owl is banded note the leg color-banded, band color, tab color, etc., referencing the owl number, above; If a nest is found, describe the nest.

6/15/2014