Mexican Spotted Owl Occupancy

An Exploratory Analysis using Bayesian Statistics

Chad Hockenbary

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INTRODUCTION

In Utah, Mexican spotted owls (*Strix occidentalis lucida*) are widely distributed across the southern and eastern portions of the state (Willey and van Riper 2007). In this region, the spotted owl occupies a variety of habitat types that are included with the Canyonlands geographic subsection of the Colorado Plateau (Baars 1983, Hintze 1988, Block et al. 1995). Mexican spotted owls were listed as "threatened" in 1993 by the U.S. Fish and Wildlife Service (Cully and Austin 1993, Block et al. 1995). Within the Colorado Plateau spotted owl recovery unit (Block et al. 1995), the Mexican spotted owl has been associated with steep sandstone canyon habitats (Kertell 1977, Rinkevich and Gutierrez 1996, Willey 1998).

Of vital interest to biologists are long-term demographics of the owl in Utah's canyonlands (Block et al. 1995). The relationship between habitat quality and owl population parameters, such as occupancy, is poorly understood, yet these relationships are critical to the owl's management. Therefore, the field research described in this report was designed to address the effects of human recreational activities on spotted owl population status and draw inferences about habitat integrity. The research activities described in this progress report were conducted in southern Utah within Zion National Park (NP), Capitol Reef NP, Grand Staircase-Escalante National Monument (GSENM), and on Cedar Mesa near Blanding. Mexican spotted owls are widely distributed across this portion of southern Utah and the owls are known to nest in steep canyon habitat often accessed by humans for recreational activities, including off-road vehicle (ORV) use, hiking, hunting, and canyoneering (Hintze 1988, Rinkevich 1991, Willey 1998 Swarthout and Steidl 2002).

Due to their strong association with steep canyonlands (Rinkevich 1991, Willey 1998), Mexican spotted owls may be vulnerable to human activities that are focused in rocky canyon habitats; for example, by hikers traversing nest areas (Block et al. 1995, Swarthout and Steidl 2002, Bowden 2008). Human-use levels in Zion have increased in recent years, e.g., permits for access through some popular canyons increased 1714% during 1998-2002 (Zion NP, unpublished database, Natural Resources Division). Levels of recreational use differ across southern Utah, e.g., close to 50% of known territories in Zion include canyoneering routes and approach trails, whereas in Capitol Reef NP, popular canyoneering routes receive less than ten visitors per week (Dave Worthington, NPS Wildlife biologist, pers. com.). This environment provided the opportunity to estimate the effects of differing levels of human use on spotted owls.

To assess the 2009 population status of territories in southern Utah, occupancy-based population monitoring was conducted to estimate occupancy rates of historic territories used by spotted owls. To estimate the potential effects of human recreation, owl territories in the field sample spanned a range of human-use levels. Research was designed to estimate occupancy rates and investigate potential effects of human-use on spotted owls. The research objectives will allow estimates of spotted owl detection probabilities and occupancy rates associated with our sample of owl territories (MacKenzie et al. 2006).

METHODS

Occupancy Visits and Analyses

Data Collection

Each identified spotted owl territory (n = 47 historic sites) was surveyed using a standardized procedure (Forsman 1983, USDI 1993) that includes two visits per owl site per year to estimate site occupancy using methods described by MacKenzie et al (2003). Field surveys were conducted from 1 April through 31 August 2009. Each standardized field visit to a owl site began with a 1 hr search period conducted within the nesting core area or primary roost area (Willey 1998, Willey and van Riper 2007) prior to sunset to look for evidence of occupancy, such as: feathers, whitewash, pellets, perched owls, and to listen for spotted owl vocalizations. If no owl was located within the 1 hr search period, a standardized vocal survey was conducted using the human voice to imitate a variety of spotted owl calls. Surveyors established five calling stations each spaced 500 m (i.e., 2- km line transect) centered (i.e., station-3) at known nest sites or at commonly used roost area within each selected owl site. If no owls were detected during the pre-calling search, a surveyor began the survey at station-1 located at the up-canyon end of each transect. Station-1 began ~30 min after sunset and each station initiated with a 5-min listening period. After the first five min period, the surveyors mimicked a variety of spotted owl vocalizations for 20 min, alternating calling and listening. The surveyor then listened for the final 5-min at each station. This procedure was repeated for each survey station until an owl was detected, or all five stations had been visited. If an owl was detected, additional calling may have been used to verify location and the number of owls present, but this was kept to a minimum so as not to alter the owl's normal activities. The type of detection (vocal, visual, or both), estimated distance, time, and sex of the owl was recorded on standard data forms. Surveyors were careful to keep survey effort, e.g., length of search period, calling effort, and speed of each survey visit equal among study sites.

Data Analysis

For my analysis of occupancy rate, Ψ will be defined as the number (*x*) of owl sites (n = 41 surveyed by 2-km transects) occupied by owls divided by the total number of sites visited (*s=41*), thus the proportion of sites occupied is $\Psi = x / s$. Because it is likely that owls will not always be detected at every site, *x* cannot be directly measured; instead, it must be estimate ($\hat{x}$) by determining the probability of detecting an owl at a site if the site is occupied. The detection probability can be estimated by visiting sites multiple times during a primary survey period, T (MacKenzie et al. 2002, 2003, 2006, MacKenzie and Royle 2005). A minimum of two visits is required to estimate detection probability within a primary survey period, thus the probability of observing the detection history $h_i = 01$ given p_j is the probability of detecting the species at each survey (j), if the site is occupied is: $\Pr(h_i = 01) = \psi(1-p_1)p_2$. A detection history $h_i = 00$ could be a result of missing the species twice given the site was occupied $[\psi \prod_{j=1}^{2}(1-p_j)]$ or the site was unoccupied $[(1-\psi)]$, thus the probability statement for the history is:

$$\Pr(h_i = 00) = \psi \prod_{j=1}^{2}\left(1-p_j\right) + (1-\psi).$$

After all the probability statements for each site are formed, the model likelihood for the observed data can be constructed:

$$L(\psi, p | h_1, h_2, \ldots, h_s) = \left[\psi^{s_D} \prod_{j=1}^{K} p_j^{s_j} (1-p_j)^{s_D - s_j}\right]\left[\psi \prod_{j=1}^{K}(1-p_j + (1-\psi)\right]^{s-s_D}$$

where s_D is the number of sites where the species was detected at least once and s_j is the number of sites where the species was detected during the jth survey. All owl sites received two occupancy surveys during the 2009 field season to estimate detection probability.

A logit model was defined to relate Ψ to two covariates:

$$logit(\Psi) = \beta_0 + \beta_1 mid.rec + \beta_2 high.rec$$

Covariate definitions are as follows: mid.rec is sites that are defined as having medium recreation, and high.rec is sites that are defined as having high recreation. Therefore, β_0

represents low recreation sites.

A logit model was also defined to relate p to two covariates:

$$logit(p_j) = \alpha_0 + \alpha_1 temp_j + \alpha_2 day_j$$

Covariate definitions are as follows: temp is the temperature for a given visit rescaled around zero by taking the average temperature and subtracting it from observed temperatures ($temp = Y_i - \frac{\sum_{i=1}^{n} Y_i}{n}$), and day was the day of the year for a given visit rescaled the same as above. Therefore, α_0 represents the detection probability given an average temperature and average day of the year.

<u>Recreation Level</u>

Recreation level varies as a site-specific model covariate (MacKenzie et al. 2002). Therefore, recreation level was considered a predictive variable for occupancy probability. Site level recreation effects were assigned to three categorical levels: high, medium, and low level of hiker presence for each spotted owl site. These categorical covariate levels were identified for each study site using trail cameras, permit records, and expert opinion from local area biologists. Recreational use of many canyons in the study unit is well understood by the biologists that work in these areas. Thus, expert opinions on the levels of use were considered in assigning a categorical use level of disturbance for each site. Zion and Capitol Reef require backcountry permits to access numerous canyons, and are documented each year. To confirm levels of use, trail cameras were used to count the number of individuals using the canyons on a daily basis.

<u>Day of Year</u>

Detection probability could be time specific (MacKenzie et al. 2002). Day of year was considered a continuous predictive variable for detection probability. Investigating nocturnal social behavior in Arizona, Ganey (1990) observed calling activity occurred most frequently from March through May, and declined from June through November. I expect detection probability to be negatively associated with time of year. Detection will decrease as day of year increases.

<u>Temperature</u>

Detection probability could be temperature specific. Visit specific average temperature was considered a continuous predictive variable for detection probability. Spotted owls are known to avoid relatively high daytime temperatures (Barrows 1981, Ganey et al. 1993, Rinkevich and Gutiérrez 1996, Willey 1998, Willey and van Riper 2007). Therefore, I expect detection to decrease as temperature increases.

Since this report is based on a single year of data, Single-species, Single-season Occupancy Modeling using a Bayesian approach was used to determine occupancy and detection. The model was run in WinBUGS using vague priors on all the parameters.

RESULTS

A total of 41 sites were visited each twice during the 2009 field season totaling 82 visits. 44 of 82 (0.54) visits had detections of spotted owls. 24 of the sites had confirmed occupancy based on spotted owl detections, thus the naïve estimate of occupancy across all 42 sites was 0.57 (24/42). Recreational use was not well balanced across all 42 sites: 29 sites were considered low use, 9 sites were medium use, and 3 sites were high use. 15 of the low recreation sites had detections of owls, a naïve estimate of occupancy for low recreation site as 0.52 (15/29). The naïve estimate of occupancy for medium recreation was 0.78 (7/9) and for high recreation sites was 1.0 (3/3).

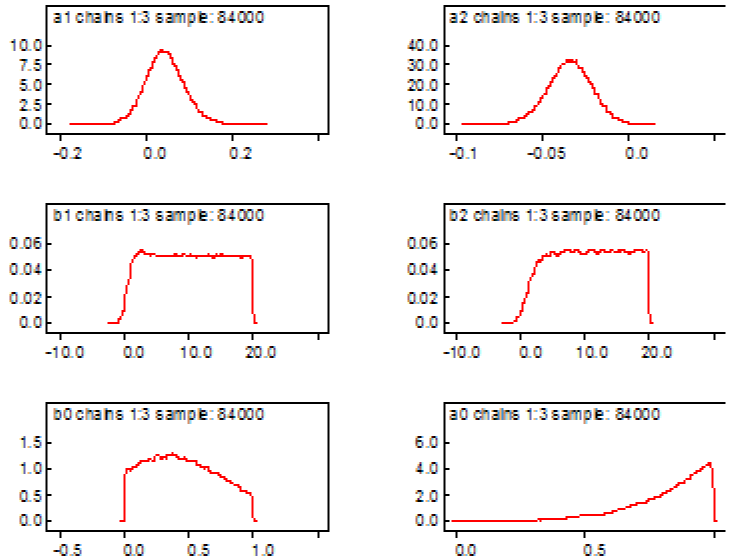
After running the model in WinBUGS, the following estimates were obtained:

	mean	sd	2.5%	25%	50%	75%	97.5%	Rhat	n.eff
p0	0.7	0.0	0.6	0.7	0.7	0.7	0.7	1	7900
psi0	0.6	0.1	0.5	0.6	0.6	0.7	0.7	1	38000
b0	0.5	0.3	0.0	0.2	0.4	0.7	1.0	1	55000
b1	10.1	5.7	0.8	5.2	10.1	15.1	19.5	1	84000
b2	10.6	5.5	1.2	6.0	10.7	15.4	19.5	1	70000
a0	0.8	0.2	0.4	0.7	0.9	0.9	1.0	1	8400
a1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1	84000
a2	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	1	84000
deviance	59.5	7.0	47.9	54.5	58.9	63.9	74.8	1	16000

Note the equations used in the analysis: $logit(\Psi) = \beta_0 + \beta_1 mid.rec + \beta_2 high.rec$ and $logit(p_j) = \alpha_0 + \alpha_1 temp_j + \alpha_2 day_j$. The estimate of occupancy for low recreation sites was estimated to be 0.6 (*s*=0.1). Medium recreation and high recreation were both estimated to have a positive influence on site specific occupancy. Both estimates had high mean beta estimates, but their associated creditable intervals are very large, reaching the upper limit of the vague prior. Figure 1 illustrates the marginals for each estimate. The marginals for parameters associated with occupancy (i.e., β_0, β_1, and β_2) illustrate the uncertainty of the estimates. The estimates for α_1 and

α_2 are both zero, indicating little to no influence on detection probability.

Figure 1.



DISCUSSION

The results above are from an exploratory analysis of Mexican spotted owl occupancy data collected in 2009. The focus of the research is on recreational effects of occupancy. The results suggest recreation has a possible positive effect on occupancy of sites by spotted owls. Interpreting a positive effect of humans using spotted owl territories is virtually impossible; there is obviously more factors that were not analyzed that could be influencing spotted owl occupancy. In the future, I will analyze the effects of additional covariates including vegetation types, annual precipitation, and annual temperature.

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