WINTER SURVEYS FOR MEXICAN SPOTTED OWLS WITH AUDIO RECORDERS

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ABSTRACT: Monitoring Mexican Spotted Owls (*Strix occidentalis lucida*) in and near breeding territories during winter has practical value but has not been previously studied by passive techniques, including acoustic recorders. Such information could inform breeding survey strategies as well as identify new breeding pairs. The U.S. Fish and Wildlife Service's standard survey protocol, entailing four nighttime visits to a site and listening for a response to broadcast calls, has limitations in winter, when nonbreeding owls are less likely to respond and multiple visits may not be possible. Instead, I tested the feasibility of using passive sound-recording equipment to detect the owl in winter, deploying audio recorders at two known nesting sites in northern Arizona over 6 months through winter 2014–2015. As a result, I recorded spontaneous calls during each month of the survey. Paired males and females called to each other in winter, and the variation in frequency of calling through the night paralleled the pattern found in previous studies. My data suggest that automated audio detection provides a reliable tool for continuous, high-resolution, long-term, and cost-effective monitoring of the Mexican Spotted Owl, in both winter and summer.

The U.S. Fish and Wildlife Service (USFWS 2012) has issued a protocol to guide the design of surveys for the Mexican Spotted Owl (*Strix occidentalis lucida*) during the breeding season but not for surveys in the nonbreeding season. The protocol, which instructs surveyors to broadcast owl calls in order to elicit a call in response, has several limitations: (1) nesting Spotted Owls might be less likely to respond if Barred Owls (*S. varia*) are present (Crozier et al. 2006), (2) surveys must stop if a Great Horned Owl (*Bubo virginianus*), a potential predator of the Spotted Owl, is present, (3) training personnel to survey effectively is challenging and time-consuming, (4) multiple visits are required for a probability of detection to be estimated and a reliable measure of occupancy to be generated (USFWS 2012), and (5) nighttime surveys in rugged terrain can be dangerous. In addition, broadcast surveys are typically limited to two to four per breeding season, to balance logistics with the need for an adequate sample size and to minimize any potential disturbance of the birds. To ensure a fairly uniform spread of surveys across the breeding season, no more than one survey per site can be completed in March (USFWS 2012). The applicability of the standard survey protocol in winter has been considered limited because of the Spotted Owl's generally lower responsiveness to broadcast calls outside the breeding season (Ganey 1990, Gutiérrez et al. 2020). Finally, the broadcast survey's protocol requires four nighttime visits before the absence of owls at the site is considered confirmed, which in winter may be not achievable because of snow or icy conditions and road closures. In contrast, wildlife surveys based on passive acoustic monitoring circumvent the limitations of the traditional survey method because audio recorders can be deployed and retrieved by day. Such equipment allows unattended and noninvasive data recording of a wide range of animals emitting detectable acoustic signals (Sugai et al. 2019).

The winter habits of the Mexican Spotted Owl have been rather well

studied via radio-telemetry (e.g., Zwank et al. 1994, Ganey et al. 2005, 2014). Radio-tracking of adults in southern Utah during both the breeding and nonbreeding seasons, 1991–1995, demonstrated that the nonbreeding home ranges were on average 49% larger than home ranges during breeding (Willey and van Riper 2007). While many of the tracked owls remained close to their breeding sites year round, some moved to peripheral areas or migrated up to 35 km from the nest area during the nonbreeding season (Willey 1998). Such diverse patterns of winter movements highlight the need for a reliable method of winter surveys that allows for simultaneous monitoring of the owls' vocal behavior at multiple locations, as passive acoustics enable. Winter surveys are necessary if the Mexican Spotted Owl's habitat is to be to protected and its population sustained, especially with climate change (Peery et al. 2012).

The focus of my study is a population of the Mexican Spotted Owl in Walnut Canyon near Flagstaff, Arizona, that has a long history as the subject of research and conservation projects. In Walnut Canyon, two owls radio-tracked in 1986 and 1987 were demonstrated to occupy their home range year round apart from 2–3 weeks in late December and early January, during which they moved ~10 km down canyon (Ganey and Balda 1989). During that study, the owls were radio-tracked for ~1000 hours over 190 nights and were heard calling at distances up to 400 m (Ganey 1990). The frequency of these spontaneous calls increased from March through May, then declined from June through November. No calls were heard from December through February. During the breeding season, owls were heard calling during all hours of the night but were most vocal during the first 2 hours following sunset.

After successful use of passive sound recorders to survey Mexican Spotted Owls during the breeding season in Walnut Canyon for the National Park Service from 2011 to 2013, I tested them from October 2014 to March 2015 at two known nest sites. My objectives were to record the type and frequency of Mexican Spotted Owl calls in winter, determine whether breeding pairs exchanged calls in winter, and establish whether winter surveys for the Mexican Spotted Owl can rely on passive sound monitoring.

METHODS

Study Area

The two nesting sites I monitored in Walnut Canyon lie ~15 km east of Flagstaff. The study area includes a canyon deeply incised between rugged limestone cliffs within a broadly defined mixed ponderosa pine (*Pinus ponderosa*) forest (Schelz et al. 2017). Pinyon pine (*P. edulis*), Utah juniper (*Juniperus osteosperma*), alligator juniper (*J. deppeana*), one-seed juniper (*J. scopulorum*), and ponderosa pine dominate along the rims and upper canyon walls (Menzel and Covington 1997). Along the canyon bottom, the common trees are Arizona walnut (*Juglans major*), box elder (*Acer negundo*), narrowleaf cottonwood (*Populus angustifolia*), quaking aspen (*P. tremuloides*), willows (*Salix lasiolepis* and *S. laevigata*), Gambel oak (*Quercus gambelii*), Douglas fir (*Pseudotsuga menziessii*), and ponderosa pine (Joyce 1976). Mexican Spotted Owls nest and roost within the cooler and shaded areas of the canyon, primarily in Douglas fir trees and vertical rock slots. Great Horned

Owls also inhabit the canyon, nesting close to the canyon rims. The closest road is ~400 m from the recording area but is typically closed in winter.

Sound-Monitoring Equipment

I used Electrohome EAMP100 players with a voice recorder (Electrohome, Cheektowaga, NY). Two RadioShack D-cell battery holders (https://www.radioshack.com, catalog no. 2700403) were soldered in parallel to the AAA battery connectors of each recorder. To extend recording time, the MP3 players were powered by two Duracell MN1300 alkaline manganese D-cell batteries. The recording unit comprising one recorder and two batteries was approximately 88 mm long × 70 mm wide × 55 mm high, weighing ~330 g. These MP3 players are no longer manufactured, but the AudioMoth (https://www.openacousticdevices.info/audiomoth) and Wildlife Acoustics (www.wildlifeacoustics.com) recorders are suitable current alternatives.

Data Collection

Sound monitoring started on 6 October 2014 and finished on 21 March 2015. During this time, daily mean ambient temperatures varied from −10.8 to 13.6 °C, with an average of 4.0 °C (Flagstaff Pulliam Airport, https://www.weather.gov/wrh/Climate?wfo=fgz). One recorder each was deployed ~200–300 m from two known Spotted Owl nests, in rock niches protected from precipitation and animal investigation by a natural overhanging cliff, as depicted in Figure 1. The recorders monitored sound continuously for

FIGURE 1. Sound-monitoring equipment deployed in Walnut Canyon, Arizona, to record the calls of Mexican Spotted Owls.

Table 1 Results of Acoustic Survey for the Mexican Spotted Owl at Two Nest Sites in Walnut Canyon, Arizona, October 2014–March 2015

	Audio detection of Mexican Spotted Owls calls[a]					
Day	October	November	December	January	February	March
1	—	2	—	0	—	2[b]
2	—	1	—	—	1[b]	1
3	—	0	—	—	1	1
4	—	0	—	—	2	1
5	—	0	—	—	1	0
6	2[b]	1	—	0[b]	2	1
7	0	1	—	0	1	2
8	0	0	—	0	2	2
9	0	1	—	1	1	2
10	1	2	—	0	2	2
11	0	1	—	1	1	2
12	1	0	—	2	1	2
13	0	0	—	0	1	2
14	2[b]	0[b]	0[b]	0	1	1
15	0	0	0	1	1	2
16	0	0	1	1	0	2
17	0	0	1	1	0	1
18	1	1	1	2	—	2
19	1	0	1	1	—	2
20	1	1	2	1	—	2
21	1	0	0	0	2[b]	2[b]
22	1	—	0	1	2	—
23	0	—	0	1	2	—
24	2	—	0	1	2	—
25	1	—	0	0	1	—
26	1	—	0	1	2	—
27	2	—	0	1	2	—
28	0	—	0	1	2	—
29	0	—	0	1	na	—
30	0[b]	—	0	0	na	—
31	2	na	0	0	na	—

[a]Dash signifies days when no recorder was deployed at the sites. 0, no calls; 1 single calls (one owl at a time); 2, double calls (two owls at a time).

[b]Day when recorders were deployed, replaced, or retrieved.

~2 weeks (until the memory card filled up), after which I replaced them with a new set with a cleared memory cache and new batteries. Each audio recording began by stating the recording location, date, and time. With no prior knowledge of the performance of the recorders in winter, I visited the locations every 8–30 days, for a total of 10 visits over the 6 months of sound monitoring (Table 1).

Sound-File Analysis

After downloading compressed WAV files from the recorders I decompressed the files with the Poweramp Music Converter (https://www.dbpoweramp.com). I then divided these files into 1-hour fragments with

DAPP (Digital Audio Post-Processor, Far North Aquatics, Fairbanks, AK) and renamed then in the format "Location_YYYYMMDD_HHMMSS" (e.g., SiteA_20150213_170000). Because DAPP has been discontinued, I suggest Raven Pro (https://ravensoundsoftware.com/software/raven-pro/) or Kaleidoscope Pro (https://www.wildlifeacoustics.com/products/kaleidoscope-pro) as suitable current alternative programs. The 1-hour audio files were scanned for the Mexican Spotted Owl calls with a band-limited energy detector built within Raven Pro (https://www.birds.cornell.edu/ccb/raven-pro), according to the manufacturer's instructions. Audio technicians verified potential Spotted Owl calls this detector identified automatically by listening to the audio clip of the detected sound and analyzing its spectrogram.

RESULTS

From October 2014 to March 2015, the devices recorded sound for 18–27 days per month (reflecting presence or absence of the equipment in the field), 137 days total (Table 1). Spotted Owl calls were registered in every month for 5–22 days per month. Such variability may be partially explained by coverage being more thorough in some months than in others (e.g., 27 days in January vs 18 days in December). The total number of days with verified Spotted Owl calls was 86 (63% of all days monitored), on 51 of which only one Spotted Owl called at a time. On the remaining 35 days two owls (male and female) called simultaneously. The proportion of days with such double calls the lowest in January (12.5%) then increased to 50% and 70% in February and March, respectively.

The two sites pooled, the total number of 1-hour recordings with verified Spotted Owl calls was 225. Of these calls, 69% were recorded after sunset between 18:00 and 21:00 or between 04:00 and dawn. By hour, the number of recorded calls peaked at 28 between 18:00 and 19:00, decreased to 9–13 between 22:00 and 03:00, then peaked again at 27 between 05:00 and 06:00. No calls were recorded during the daytime from 07:00 to 16:00. Similar hourly patterns of calling behavior were observed when the data were analyzed for each month separately (data not shown).

DISCUSSION

Documenting Mexican Spotted Owls in their winter territories is important for protection of their habitat and for planning the breeding surveys, as many pairs winter near where they later nest (Gutiérrez et al. 2020). The detection of multiple Spotted Owl calls (Table 1) in areas of Walnut Canyon where no such calls were detected by traditional survey methods (Ganey 1990) shows the potential of passive sound-recording technology to document the owls' presence and vocal behavior in winter. Continuous sound monitoring over weeks greatly increases the chance of detection, while the few-hour visits by a human surveyor may coincide with the owls' absence from the breeding territory. A comparison of the probability of detection of a Mexican Spotted Owl by the passive acoustic monitoring and by traditional survey methods is still needed. Reassuringly, the hourly distribution of calls obtained by acoustic survey (Figure 2) is consistent with the pattern

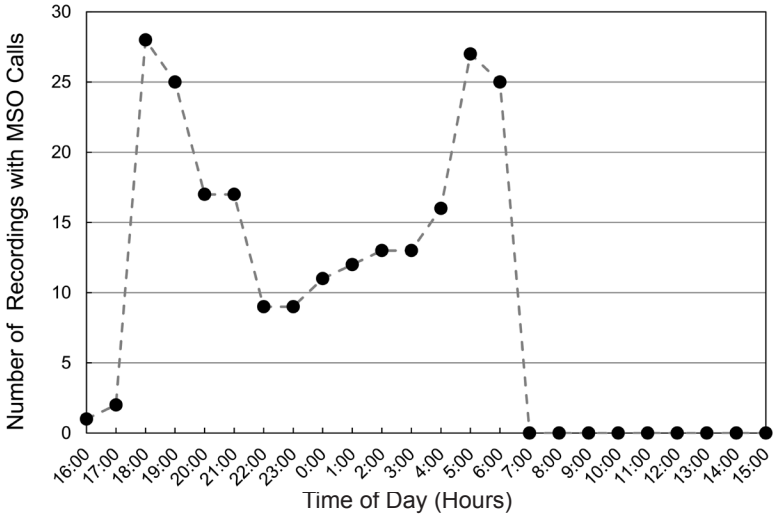

FIGURE 2. Hourly distribution of calls of the Mexican Spotted Owl recorded at two nest sites in Walnut Canyon, Arizona, October 2014–March 2015.

reported by Ganey (1990), with call frequency highest after sunset. Another important advantage of the sound-monitoring equipment was its capacity to record data even during the coldest or windiest of nights, when the sites were not easily accessible.

The communication between pairs of the Mexican Spotted Owl during the nonbreeding season has not been well documented. The acoustic survey yielded dual calls (likely to represent interaction between the female and male) during all 6 months of sound monitoring (Table 1). The increasing proportion of the double calls from January (12.5%) to March (70%) was consistent with the beginning of the breeding season, during which the vocal communication between the female and male is greatest (Ganey 1990, USFWS 2012).

Even during the breeding season acoustic surveys for the Mexican Spotted Owl may have important advantages over the traditional broadcast surveys. Passive recording methods do not elicit unnecessary calling or movements that could expose the owls to increased predation, disrupt their hunting or mating, or reduce their internal energy stores. Recorders require on average two daytime visits (to be deployed and retrieved) for ~2 weeks of continuous sound monitoring rather than four nighttime visits (to broadcast calls) per nest site. The frequency of my visits reflected the exploratory nature of my study rather than necessity. Also, passive sound monitoring is not limited by poor weather or the presence of predators such as the Great Horned Owl. Finally, the daytime visits to deploy and retrieve recorders allow the surveyor to search the habitat for pellets, fecal deposits, and roosting owls.

Passive acoustic monitoring is rapidly gaining use in wildlife research and surveys, following global trends toward automated data collection and analy-

sis of large data sets (Sugai et al. 2019). This technique is now shown to be a reliable tool for continuous, high-resolution, long-term, and cost-effective monitoring of the Mexican Spotted Owl, in both winter and summer.

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LITERATURE CITED

Crozier, M. L., Seamans, M. E., Gutiérrez, R. J., Loschl, P. J., Horn, R. B., Sovern, S. G., and Forsman, E. D. 2006. Does the presence of Barred Owls suppress the calling behavior of Spotted Owls? Condor 108:760–769; doi.org/10.1093/condor/108.4.760.

Ganey, J. L. 1990. Calling behavior of Spotted Owls in northern Arizona. Condor 92: 484–490; doi.org/10.2307/1368245.

Ganey, J. L., and Balda, R. P. 1989. Home-range characteristics of Spotted Owls in northern Arizona. J. Wildlife Mgmt. 53:1159–1165; doi.org/10.2307/3809627.

Ganey, J. L., Block, W. M., Ward, J. P., and Strohmeyer, B. E. 2005. Home range, habitat use, survival, and fecundity of Mexican Spotted Owls in the Sacramento Mountains, New Mexico. Southwest. Nat. 50:323–333; doi.org/10.1894/0038-4909(2005)050[0323:HRHUSA]2.0.CO;2.

Ganey, J. L., Kyle, S. C., Rawlinson, T. A., Apprill, D. L., and Ward J. P. Jr. 2014. Relative abundance of small mammals in nest core areas and burned wintering areas of Mexican Spotted Owls in the Sacramento Mountains, New Mexico. Wilson J. Ornithol. 126:47–52; doi.org/10.1676/13-117.1.

Gutiérrez, R. J., Franklin, A. B., and LaHaye, W. S. 2020. Spotted Owl (*Strix occidentalis*), *in* Birds of the World (A. F. Poole, and F. B. Gill, eds.). Cornell Lab Ornithol., Ithaca, NY; doi.org/10.2173/bow.spoowl.01.

Joyce, J. F. 1976. Vegetation analysis of Walnut Canyon, Arizona. J. Ariz. Acad. Sci. 11:127–133; doi.org/10.2307/40026062.

Menzel, J. P., and Covington, W. W. 1997. Changes from 1876 to 1994 in a forest ecosystem near Walnut Canyon, northern Arizona, *in* Proceedings of the Third Biennial Conference of Research on the Colorado Plateau (C. van Riper and E. Deshler, eds.), p. 151–172. U.S. Dept. Interior, Natl. Park Service, Washington, DC.

Peery, M. Z., Gutiérrez, R. J., Kirby, R., Ledee, O. E., and LaHaye, W. 2012. Climate change and Spotted Owls: Potentially contrasting responses in the Southwestern United States. Glob. Change Biol. 18:865–880; doi.org/10.1111/j.1365-2486.2011.02564.x.

Schelz, C. D., Scher, D. A., Vegh, T., and Abella, S. R. 2017. How many Arizona walnut trees inhabit Walnut Canyon National Monument? Southwest. Nat. 62:157–161; doi.org/10.1894/0038-4909-62.2.157.

Sugai, L. S. M., Silva, T. S. F., Ribeiro, J. W., and Llusia, D. 2019. Terrestrial passive acoustic monitoring: Review and perspectives. BioScience 69:15–25; doi.org/10.1093/biosci/biy147.

U.S. Fish and Wildlife Service. 2012. Mexican Spotted Owl survey protocol (updated 15 March 2022); https://www.fws.gov/media/appendix-d-mexican-spotted-owl-survey-protocol-us-fish-and-wildlife-service-2012-updated.

Willey, D. W. 1998. Movements and habitat characteristics of Mexican Spotted

Owls in the canyonlands of southern Utah. Ph.D. dissertation, N. Ariz. Univ., Flagstaff.

Willey, D. W., and van Riper, C. III, 2007. Home range characteristics of Mexican Spotted Owls in the canyonlands of Utah. J. Raptor Res. 41:10–15; doi.org/10.3356/0892-1016(2007)41[10:HRCOMS]2.0.CO;2.

Zwank, P. J., Kroel, K. W., Levin, D. M., Southward, G. M., and Romme, R. C. 1994. Habitat characteristics of Mexican Spotted Owls in southern New Mexico. J. Field Ornithol. 65:324–334.

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