EFFECTS OF JET AIRCRAFT NOISE ON MEXICAN SPOTTED OWLS

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Introduction A team of personnel from the United States (U.S.) Air Force, Geo-Marine, Inc., Hubbs-Sea World Research Institute, and Wyle Laboratories is currently conducting the fourth field season of a study of the effects of military jet aircraft overflights on the Mexican Spotted Owl. The Mexican Spotted Owl is designated as a threatened species, protected from harm by the Endangered Species Act of 1973.

The goal of the study is to determine whether exposure to noise produced by military jet aircraft affects owl territory occupancy or reproductive success and to establish a “safe” level of exposure, below which no detrimental impact to owls is expected. To accomplish this, acoustical monitoring, surveys for owls, and monitoring of owl behaviors, are conducted. Additionally, habitat variables that may contribute to owl success are measured.

Methods

Study Area The study is being conducted in approximately 580 km^2 of the Gila National Forest in western New Mexico. The area was selected because it has historically supported a large concentration of Mexican Spotted Owls, it lies beneath low-level military training airspace, and agreements with the Gila National Forest ensure long-term access to the area.

The area is characterized by steep-walled canyons in the southwest that level off to hills in the north, east, and southeast. Elevations range from 1945 m to 3035 m. Mixed conifer forests dominate the higher elevations and pinyon-juniper forests characterize the less steep, lower-elevation areas. Because the study area is remote, a base camp is established to provide housing, a communications facility, work space, equipment, vehicles, and other supplies. This camp supports 30 researchers and logistics personnel who live and work there during the April through July field season.

Acoustic Monitoring

Logistics Sound is monitored at 39 stations located within owl territories. An effort is made to distribute monitoring stations at approximately equidistant intervals beneath the paths most frequently used by military jets. The stations are deployed between mid-April and mid-May as weather conditions allow. Accumulations of snow at high elevation sites prevent access along the many unimproved roads in the study area. Each sound monitoring station is equipped with a Larson Davis (LD) 820 or 824 sound level meter (SLM), a Bruel & Kjaer prepolarized microphone (model 4176 that is a 1.3 cm prepolarized condenser microphone), preamplifier, windscreen, and bird spikes atop a 10-foot stand.

Tornado and F-16 aircraft use the airspace above the study area to train. During the dry New Mexico summers, firefighting aircraft, both fixed-wing and helicopters, are often present due to the proximity of a fire-fighting base camp. Other sound sources in the study area are thunder, wind, bird calls, high-altitude commercial jet aircraft, vehicular traffic, and, during the hunting season, gunshots and all terrain vehicle noise.

Before the beginning of each field season, the airspace schedulers and pilots who use the airspace above the study area are interviewed and briefed by the study team. Details of their training requirements were incorporated into the study’s design. Each year, operators are

asked to follow a designated flight path above the study area. This path is changed annually to ensure that different owls are exposed to jet overflights in each year.

Noise Data Collection and Processing Both the LD 820 and 824 SLMs have a dynamic range of approximately 110 decibels (dB). For this study, the upper limit of the range is set at 130 dB, a level expected to exceed that of any recorded noise event. Sound levels in the study area frequently drop below the noise floor, which varies slightly from instrument to instrument around 20 dB. Continuous two-second A-weighted equivalent sound level (^{L}eq) measurements are recorded by the SLMs. Each two-second value is calculated from 64 samples collected at a rate of 32 per second. A-weighting (dBA) rather than C-weighting was chosen as a conservative estimator of the hearing of birds.
Continuous time history data is collected at each of the 40 SLMs, resulting in approximately 67,000 hours of data per season. These data are examined and recognizable events (noise floor, bird calls, wind, thunder, military jet aircraft, high elevation jet aircraft…) are labeled so that noise attributed to a particular source may be easily partitioned from the remaining data. Noise from a single source (i.e. military jet aircraft) can be examined alone and noise from multiple sources can be grouped into broader categories for analysis (i.e. ambient noise).
Because it is not possible to monitor all occupied owl territories in the study area throughout the field season, an interpolation model is used to estimate noise levels at locations where it is not measured with an SLM. NoiseMap Simulation model (NMSIM) was developed by Wyle Laboratories for the U.S. Air Force. NMSIM uses aircraft sound characteristics, flight trajectory and terrain to estimate the propagation of jet aircraft noise taking into account the effects of topography. Flight trajectory is derived from radar tracking data or is estimated based on the best-fit to recorded data (Ikelheimer et al., 2001).
The following event-related metrics are calculated for segments of the noise data that originated from recognizable sources:

- Duration (sec) — time from event start to end;
- Maximum 2-s ^{L}eq (dBA) — highest 2-s ^{L}eq value within an identified event;
- SEL (dBA) — A-weighted sound exposure level; used as a measure of the total energy of an event; and
- Onset Rate (dB/sec) — the rise time of the beginning of an event to maximum ^{L}eq.

Additional metrics are collected to characterize cumulative exposure on various time scales (hour, week, season for events from a recognized source). These include:

- Duration (sec) — time from event start to end;
- Cumulative ^{L}eq (dBA) — measure of average noise level in selected time period;
- Maximum 2-s ^{L}eq (dBA) — as above, in the selected time period;
- Minimum 2-s ^{L}eq (dBA) — lowest 2-s ^{L}eq value in the selected time period;
- Percentiles (L1, L10, L50, L90, L99) — levels exceeded by 1%, 10%, 50%, 90%, and 99% of collected data; and
- Time above 60 dB (sec) — total time that levels in excess of 60 dB are collected within a selected time periods.

Identifying and Monitoring Owls

Surveys for Owls A team of surveyors identifies locations of Mexican Spotted Owls in the study area. To avoid introducing bias into the data, owl surveys are conducted at established points along a grid rather than in what is believed to be suitable habitat.

Mexican Spotted Owl vocalizations are broadcast at these points to elicit responses from territorial owls. The location of responding owls are estimated and follow-up surveys are conducted in the area on the following day. During daytime follow-ups, surveyors search for roosting owls or nests. When an owl is located, it is offered live mice, which it often feeds to its mate or young at the nest or roost. The following data are collected for each identified territory: presence and number of adult owls, presence of nest, presence and number of young, whether young has fledged. Territory boundaries are estimated based on several factors including: average territory size, topographic features, number of owls present, number and location of detections. These territories are re-visited throughout the study period in attempt to identify the often-cryptic nests and to follow the fate of nests and young present.

Behavioral monitoring Once nest or roost locations are identified during daytime follow-up surveys, teams of behavior specialists or remote video-monitoring units are used to record owl activities (Ambrose et al. 2000). Observations are made during scheduled jet overflight events to record owl responses. In addition, owl behaviors are monitored during thunderstorms, to put jet noise reactions in context with naturally occurring sound; and under normal ambient sound conditions, to quantify the baseline behaviors against which to measure response. When possible, observers record behaviors for at least one hour prior to and one hour following noise events. In addition, behaviors are categorized along an intensity scale (flight is categorized as a high intensity response).

Environmental Variables

A number of other factors likely affect owl presence and success. In order to accurately assess the impacts of military jet-generated noise on owls, it is necessary to apportion its effects from those of other factors. The following variables, believed important to owl success, are measured and used as predictors in this study:

- Measures of topography (elevation, slope, aspect, curvature);
- Distance from nearest river drainage;
- Habitat type;
- Canopy cover;
- Distance to burned areas;
- Percentage of territory previously burned;
- Rainfall (as a surrogate for small mammal abundance);
- Distance from roads;
- Index of study related activities; and
- Index of predator density.

Data Analyses

Effects of Noise on Occupancy The study is designed to determine the relationship between exposure to military jet aircraft noise and owl territory occupancy and nest success with sensitivity sufficient to detect effects sizes in the range of 5% to-15%. Specifically, the analyses will determine whether or not survey points where owls are located are distinguishable from those where owls are absent with respect to cumulative exposure to military jet aircraft noise and other predictors. Non-parametric multiple logistic regression analysis will be used to determine these relationships.

Prior to the final multiple regression analysis, predictor variables are screened to determine whether each will be included in the final analysis. First, predictor variables are examined for independence and those that are not independent (i.e. slope and aspect since flat slopes have no aspect), are transformed. Predictor variables are then screened for correlation. Pearson product-moment correlation coefficients are calculated among all possible paired combination of predictors. A predictor variable found to be highly correlated with other predictor variables is eliminated from the final analysis. Finally, relationships between each individual predictor variable and the probability of owl detection are determined using selection ratios and single predictor logistic regression analysis. Variables with high selection ratios and significant relationships to owl presence are included in the final analysis. The predictor of interest, cumulative exposure to military jet aircraft noise, is included in all models regardless of its relationship with owl detection.

A set of models based on these screened predictor variables and cumulative military jet aircraft noise is developed using the final set of predictor variables. The predictive power and fit of each of the models is examined using the Akaike Information Criterion and the Hosmer and Lemeshow lack-of-fit test. The final predictive model will be the one with the best predictive power and the fewest predictor variables.

Discussion

Effects of Noise on Nest Success Though larger-than-expected densities of owls have been recorded during the last three field seasons, nesting rates among owls in the study area and throughout their range have been exceptionally low. As a result, only 15 nests have been identified and followed to date. It is unlikely that a sample of nests sufficient to draw statistically powerful results will be obtained.

Effects of Noise on Behavior Frequency of individual owl behaviors, expressed as the number per minute and number per hour, are compared for periods one hour prior to, during and immediately after, and up to one hour after a noise event. The relationship between owl behavior and military jet aircraft noise is examined in two ways. Correlation analysis is used to examine the relationship between noise level and the difference in the rates of behaviors observed before and after a military jet aircraft event. The relationship between noise level and intensity of response are compared.

Owl Occupancy Not enough data have been collected to draw statistically valid conclusions about the effects of military jet aircraft noise on Mexican Spotted Owl occupancy and reproductive success. The study design relies on relating the probability of detecting owls to exposure to military jet aircraft noise and other environmental variables. In the densely populated study area (approximately 70 owl territories), probability of detecting owls at most survey points is high.

Preliminary statistical models tested during the first three years of the study have found that topographic variables (e.g. slope and aspect), rainfall, and habitat type are important predictors of owl occupancy. Such variables will be included in the final multiple logistic regression model. In addition to these variables, seasonal exposure to military jet aircraft noise will be included in the final model in order to determine “safe” seasonal noise exposure. From this

decibel level, slant range and vertical distances of aircraft flights can be extrapolated. 2003 is the fourth of the expected five field seasons needed to collect sufficient data to determine whether owls are impacted by noise generated by low-level military training flights.

Owl Behavior Additional behavior data are also required. Between 40 and 142 military jet aircraft flights over the study area have occurred in each of the last three study seasons. Though times and approximate locations of overflights are coordinated between airspace schedulers and the study team, precise locations of aircraft above the study area are not available in advance. Pilots use the airspace above the study area to train in terrain masking techniques, often flying below ridgelines. Therefore, the propagation of noise is limited within and between canyons. As a result, overflights are often not detectable to observers monitoring owls. As with occupancy, the additional two field seasons planned are expected to produce the data needed.

Results of overflight observations in 2001 and 2002 have shown that Mexican Spotted Owls do not exhibit escape flights from roost groves or nests after exposure to military jet aircraft. Therefore, the risk of accidental collisions with aircraft and exposure of eggs and young resulting from a parent leaving the nest, are minimal. The closest approach within owl habitat while observations were being made was estimated at 100 meters.

Keywords: Aircraft noise, Mexican Spotted Owl, interpolation, NMSIM, Larson Davis 820, Larson Davis 824, Gila National Forest, Tornado, F-16, logistic regression analysis, correlation analysis.

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