Presence/Absence as a Metric for Monitoring Vertebrate Populations

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Abstract—Developing cost effective methods for monitoring vertebrate populations is a persistent problem in wildlife biology. Population demographic data is too costly and time intensive to acquire, so researchers have begun investigating presence/absence sampling as a means for monitoring wildlife populations. We examined three important assumptions regarding the probability of detection (POD) requisite to implementing presence/absence sampling for wildlife monitoring: constant POD within species among sampling visits, among years, and among habitats. POD was constant for all small mammals examined between habitats and for most small mammals among visits and between years. Presence/absence may eventually serve as an effective means of monitoring some wildlife populations for demographic changes over time, but additional research will be necessary to further test these and other assumptions.

One of the greatest challenges facing wildlife managers is that of monitoring wildlife populations. Estimates of relative abundance and density are often successfully employed in comparing wildlife populations between habitats within the same time period. However, populations can exhibit dramatic natural year-to-year variation that renders population monitoring over time infeasible for most species of concern because of excessive cost and effort necessary to detect biologically significant changes in populations (Verner 1983). More recent work has been directed toward using data on a species presence or absence as a means of monitoring for trends in wildlife populations (Azuma and others 1990). However, presence/absence methods, though easier and cheaper to implement, still do not overcome the problem of excessive effort and cost (Zielinski and Stauffer 1996).

An alternative approach to using presence/absence data for monitoring population trends is the use of these data for monitoring changes in the distribution of a species over time. For example, if an area is gridded and grid cells are monitored for the presence or absence of a species, a reduction in the number of grid cells where the species is detected could effectively indicate a population decline. Monitoring for distributional changes of this sort is less demanding than monitoring population trends.

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Additionally, low cost, low effort presence/absence techniques allow for geographically extensive sampling. Extensive presence/absence information is particularly appealing from a conservation standpoint because such data provide not only information about changing distributions, but also allow biologists to determine the aerial extent and connectivity or isolation of wildlife populations on the landscape (e.g., Zielinski and others 1995). Although hundreds of distribution maps can be found in field guides for birds and mammals, more refined maps indicating where wildlife populations actually occur within the broad-brush species ranges are virtually non-existent.

However, in order for presence/absence sampling to be successful, the effort necessary to obtain reliable presence/absence estimates must be minimal such that extensive areas can effectively be sampled. In addition to this criterion, several critical assumptions must be met that are common to all population indices. The probability of detection (POD) must not vary in space or time (Thompson and others 1998), and the POD must be constant for repeated visits to correct for detection errors using the binomial distribution (Zielinski and Stauffer 1996). Thompson and others (1998) also suggested that POD must be linearly correlated with density.

In the current study we attempted to determine the following: (1) proportion of the small mammal communities in ponderosa pine (*Pinus ponderosa*) and western larch (*Larix occidentalis*) cover types that is effectively sampled for varying sampling effort in time, (2) species detection rates or probabilities of detection (POD) and how they differ between habitats and years for each species, and (3) consistency of the POD among visits within and among species.

Methods

The study area consisted of nine sites located throughout west-central Montana. Five sites were dominated by old-growth ponderosa pine, and four sites were dominated by mature western larch. Three transects and three grids of 25 Sherman live traps were placed within each of the nine sites by randomly selecting starting points and randomly orienting the grid or transect to a cardinal direction. Trap spacing was 10 m for transects and grids, resulting in 50-m by 50-m grids and 250-m transects. Squirrel-size Tomahawk wire-mesh live traps were placed at the four corners of each grid (40-m interval) and at 40-m intervals along transects, beginning with trap station one and extending for 120 m (four Tomahawk traps). Due to limited numbers of Tomahawk traps, only the first two grids and transects on each site included Tomahawks. All traps were baited with a mixture of peanut butter and whole oats and run for eight consecutive days. Tomahawk traps were also baited with strawberry jam to increase the likelihood of capturing northern flying squirrels (*Glaucomys sabrinus*). Traps were checked each morning and small mammals were ear tagged, identified to species, aged, weighed, sexed, their reproductive condition was determined, and they were released at the trap station. Stands were trapped in 1997 and 1998, beginning in May and ending in July.

We calculated latency to detection (LTD) to assess members of the communities that were likely to be detected by different sample periods. LTD was defined as the number of days until an individual was first detected at a sampling unit (each transect and grid is a sample unit). Probability of detection was defined as POD = D_{ij}/D_{i8}; where D is the number of sample units detecting species i by day j, and D_{i8} is the occurrence of species i by day 8. Because we defined a species occurrence as its detection on a site by day eight, POD may be biased for some organisms. The assumption of constant POD was tested for each species by visually assessing goodness of fit of the POD data for D_{i2}/D_{i8} against a model for constant POD based on the binomial distribution: $D(1\text{-}D)^{k-1}$; where k = the number of sampling visits. We tested for differences in POD_{i2} between habitats and years for the five most abundant species using hierarchical logistic regression with an index of abundance (the number of individuals captured by day 8 at a sample unit) entered in the first step and cover type and year entered simultaneously in the second step. The hierarchical approach was taken to control for abundance in order to assess the influence of habitat and year independent of the effect of abundance, since abundance is known to affect POD (Thompson and others 1998; Hayek and Buzas 1997).

Results

We captured 2,007 individuals of 16 species over the course of the study. We treat here only the 15 species detected at ≥3 sampling units. Most species (60 percent) appeared to exhibit a constant POD over time when compared to expectation (fig. 1). However, three species appeared to exhibit negative deviations from the constant POD model, and we could not assess three other species that had high initial POD because they rapidly achieved POD of one. Latency to detection estimates indicated that on average 46 percent of the species could be sampled in <3 days. Relative abundance produced significant logistic regression models for predicting POD_2 for deer mice (*Peromyscus maniculatus*) (c^2 = 19.67, df = 1, P < 0.001), yellow-pine chipmunks (*Tamias amoenus*) (c^2 = 5.94, df = 1, P = 0.015), and red-backed voles (*Clethrionomys gapperi*) (c^2 = 18.55, df = 1, P < 0.001), but not for golden-mantled ground squirrels (*Spermophilus lateralis*) and red-tailed chipmunks (*T. ruficaudus*). However, the logistic regression model predicting POD_2 for golden-mantled ground squirrels was nearly significant, so we ran the regression again for POD_3 and found the model for abundance was significant (c^2 = 6.34, df = 1, P = 0.012) for this sampling interval. Probability of detection did not differ by cover type after controlling for abundance for any of the five species examined, and year differed only for the red-tailed chipmunk (Wald = 6.95, df = 1, P = 0.008).

Discussion

For presence/absence sampling to be an effective tool to assess wildlife habitat relationships at landscape scales, or to monitor for changes in distributions of wildlife populations, these methods must be efficient, that is, they must quickly and effectively sample the target species with minimal effort. Additionally, detection success must be high or error corrections must be applied to adjust for false negatives (i.e., concluding a species is absent when it is present), and POD must not vary by habitat, year, or visit or more intensive sampling will be necessary to develop complex corrections.

We found that only 46 percent of the small mammals observed in western larch and ponderosa pine communities in west-central Montana were detected in less than three days. Furthermore, for sites where species were known to be present, most species (80 percent) exhibited low detection rates of <25 percent or <50 percent for the first and second visits respectively. Such high detection error would greatly diminish the efficacy of sampling of these species unless a correction for detection error could be applied. Methods for adjusting for detection errors based on understandings of the binomial distribution have been developed by Azuma and others (1990) and applied by Zielinski and Stauffer (1996), but these methods are based on the assumption of a constant POD for repeated visits to a site. If the POD for an organism is not constant over time, error adjustments based on the binomial distribution cannot be applied.

Although our sample sizes are not large enough to statistically test for constant POD for most species, a visual comparison of distributions suggests that most species (60 percent) appeared to exhibit a constant POD. The three species that exhibited high detection rates, deer mice, red-backed voles, and bushy-tailed woodrats (*Neotoma cinerea*), converged on a POD of one too rapidly to assess the assumption of constant POD. Three other species, the red squirrel (*Tamiasciurus hudsonicus*), the long-tailed vole (*Microtus longicaudus*), and the columbian ground squirrel (*S. columbianus*), went undetected for the first three to four days, then rapidly achieved high detection rates soon after. These data are quite interesting in that they establish the importance of deviations from the constant probability model. Although we could not assess the assumption of constant POD for the species with high detection rates, these species are not problematic in that, although they may not conform to error estimates based on the binomial distribution, error corrections are unnecessary because errors are insignificant. However, deviations from the constant POD model that result in high LTD times or very low POD followed by rapidly increasing POD are problematic. Such species defy early detection and so will rarely be sampled in spite of their presence. For such species, correcting for detection error is particularly important. However, error adjustments based on the binomial distribution can not be applied because the assumption of constant POD is not met. Intensive sampling would be necessary to develop species-dependent models to apply corrections to POD for these species.

In general, the constant POD model can be thought of as a null model for behavioral responses to detection methods because deviations from this model indicate behavioral

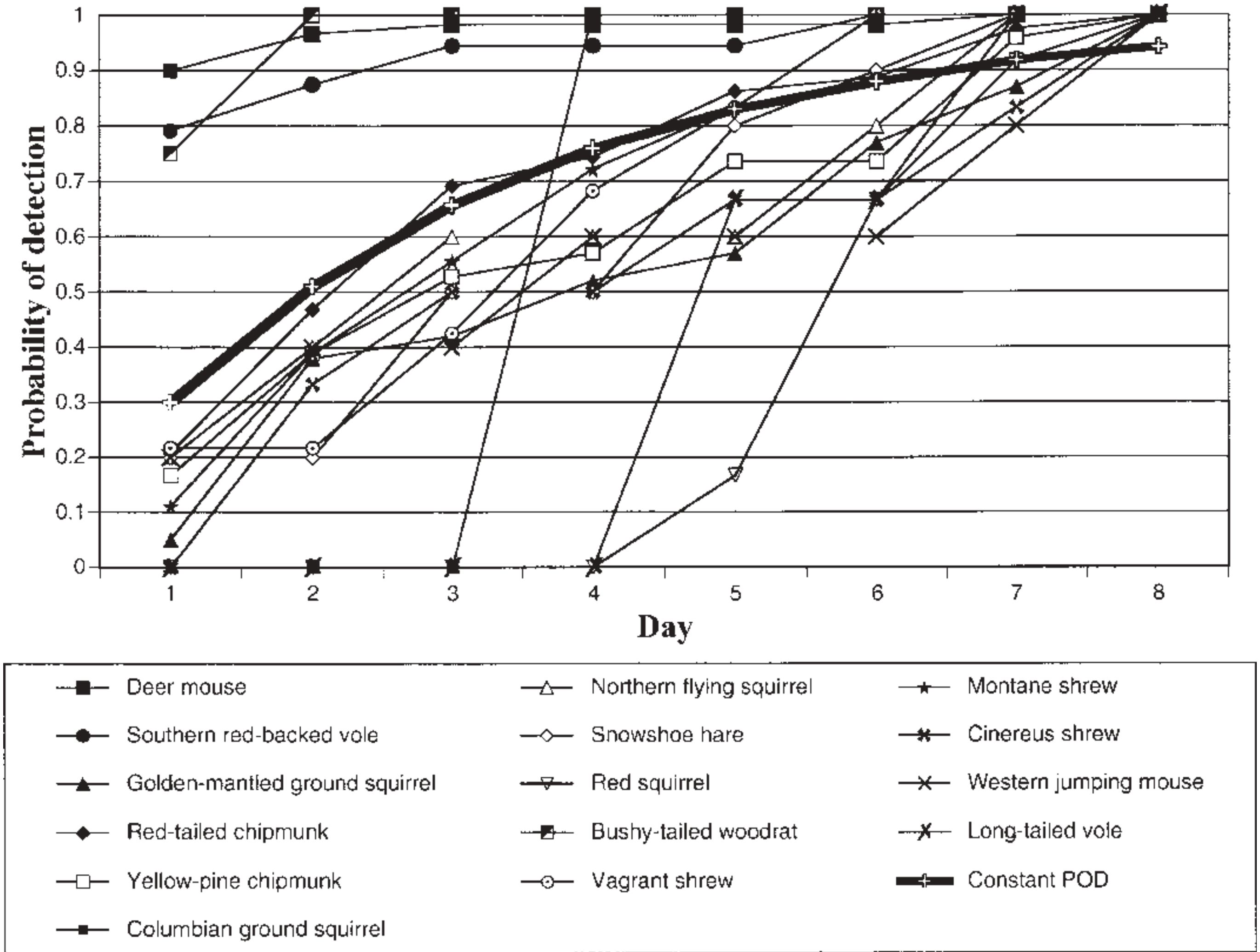

Figure 1—Cumulative probability of detection (POD) for 15 species of small mammals captured in ponderosa pine and western larch habitats of west-central Montana. The distributions in the middle of the chart generally follow expectation as can be seen by comparing their shapes to the expected constant POD. Species with an initial POD of zero and high latency to detection appeared to deviate from the constant POD model due to trap-negative behavioral responses.

responses. For instance, positive deviation from this model suggests "trap-positive" species or species that exhibit an affinity for traps, whereas negative deviations from this model indicate "trap-negative" species or species that initially avoid traps, and then rapidly habituate to them. Understanding these behavioral responses can provide a working model for identifying species that lend themselves to presence/absence sampling versus those that are likely to defy this sampling approach. For example, northern bog lemmings (*Synaptomys borealis*) are associated with rare bog and fen habitats and are classified as sensitive species on several National Forests in Region 1 (Pearson 1999). Although this animal could serve as a good indicator species to monitor for the health of these habitats, it is not readily live trapped and, therefore, does not lend itself well to presence/absence sampling using standard live trapping methods. However, other methods such as tracking stations or fecal tracking boards may produce higher POD for species that exhibit initial trap avoidance, thereby increasing the proportion of the community sampled within the first or second sampling day and decreasing the detection errors for those species with low POD.

Additional assumptions necessary to use POD to determine habitat associations and monitor distributional changes in species over time include the assumptions of constant POD among habitats and among years. For the five species of small mammals for which we had sufficient data to test these hypotheses, we found that after accounting for differences between years and habitats due to relative abundance, POD did not differ between habitats, and POD differed between years only for the red-tailed chipmunk. Therefore, we conclude that within this study POD was relatively constant between habitats and between years. However, we caution that for some species POD may differ among years, as it did for the red-tailed chipmunk, and that testing for constant POD among habitats should be repeated for other habitats and other species before it is assumed to be constant among habitats in general.

As POD appears to be essentially an index of abundance (relative abundance was a significant variable in logistic regression analyses for four of five species) that is robust to variation among years and habitats, it may eventually prove to be an effective monitoring tool. However, a good deal more work must be done to test the assumptions underlying the use of POD before implementing presence/absence sampling for monitoring wildlife populations. In particular, a better understanding of the relationship between POD and abundance will be critical to the application of presence/absence techniques for monitoring (see discussions in Thompson and others 1998; and Hayek and Buzas 1997).

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