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# ASSESSING A POINT COUNT SAMPLING PROTOCOL IN MONTANE MEADOWS

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**We conducted 142 unlimited distance point counts for birds in 15 Sierra Nevada and Cascade Range montane meadows from May to August 2006 to evaluate the effect of protocol variations on estimates of species richness and abundance. Developing a long-term strategy to inventory and monitor montane meadow birds was a priority for the California Department of Fish and Game Resource Assessment Program. Point count and species-specific surveys are widely used to infer avian abundance and species richness. We surveyed each meadow every 7 to 10 days for a total of eight times during the summer. Vocalizations of willow flycatcher (*Empidonax traillii*), Lincoln's sparrow (*Melospiza lincolnii*), and Wilson's warbler (*Wilsonia pusilla*) were broadcast at every point count station to increase their detections. Our results suggest that three point count survey cycles per field season, using point count durations of 10 minutes, optimize the number of species detected and sampling effort expended. Aural stimuli by song tape playback can supplement point counts as a quick and easy method to increase detections of the three focal species.**

Key words: Cascade Range, montane meadow, point count survey, Sierra Nevada, species richness

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## INTRODUCTION

Montane meadow and aspen communities form ecological islands throughout forests in the Sierra Nevada and generally support a rich avifauna (Cicero 1997). However, human management including diverting water, road building, and livestock grazing have threatened biodiversity in montane meadows (Mayer et al. 1999). Long-term monitoring of bird species in Sierra Nevada montane meadow and aspen communities has been recommended to evaluate population trends and assess conservation and management guidelines (Green et al. 2003).

In 2001, the California Department of Fish and Game (CDFG) established a Resource Assessment Program to develop long-term strategic programs to inventory, monitor, and assess the distribution and abundance of priority species, habitats, and natural communities in California. Birds in montane meadow and aspen communities in the Sierra Nevada were one of the program priorities. Our Sierra Nevada inventory and assessment project gathered information to evaluate and guide the development of a long-term monitoring strategy for bird species surveyed by point counts in montane meadow ecosystems. We used multiple-species point count surveys because they are one of the most widely used methods for counting bird populations. Point counts can provide a robust and efficient characterization of the number of different species in a given area (species richness) and changes in abundance for a large number of species over large areas (Ralph et al. 1995, Manley et al. 2004). We gathered sufficient data from the field to examine different sampling effort for point count surveys, and playback supplements, in Sierra Nevada montane meadows upon which to base a long-term survey protocol that will also meet CDFG's objectives.

## METHODS

We conducted our project in 15 wet montane meadows from the north-central Sierra Nevada to the southern Cascade Range including portions of Plumas, Sierra, Alpine, and Siskiyou counties, a linear distance of about 370 km (Table 1). The meadows were unurbanized and most were accessible by unimproved roads. Average daily summer (May to August) temperatures ranged from 8 to 18° C. Summer precipitation averaged 1.4 cm (National Oceanic and Atmospheric Administration 1971–2000). We selected meadows as study sites that met the criteria that they were within the Sierra Nevada and southern Cascade Range, and maintained a significant amount of water from spring through early summer (bordering lakes not included). The riparian shrub communities in these montane meadows were dominated by willow (*Salix spp*.) and alder (*Alnus spp*.), and the herbaceous community was dominated by sedges (*Carex spp*.), grasses (Poaceae), and rushes (*Juncus spp*.). The meadows were surrounded by lodgepole pine (*Pinus contorta*) and quaking aspen (*Populus tremuloides*) forests. Riparian shrubs in the meadows often bordered streams but were also scattered throughout the meadow (Bombay et al. 2003, King and King 2003). We selected meadows of varied size (Table 1), as avian species composition and abundance have been shown to change with habitat patch size (Davis 2004). We used aerial photographs and GIS software, followed by field observations, to identify 15 easily accessible, unurbanized meadows located on public lands that fulfilled the criteria.

Table 1. Location, elevation, area, and number of point count stations in 15 montane meadows in the Sierra Nevada and Cascade Range where point counts were conducted from May to August 2006.

| Latitude | Longitude | Elevation (m) | Area (ha) | # Points |
|---|---|---|---|---|
| 41°13'16"N | -122°00'27"W | 1083 | 84 | 14 |
| 41°13'55"N | -121°48'39"W | 1215 | 209 | 5 |
| 40°25'23"N | -121°20'11"W | 1439 | 45 | 5 |
| 38°40'49"N | -119°57'35"W | 2429 | 22 | 5 |
| 38°46'30"N | -119°55'50"W | 2197 | 432 | 30 |
| 39°29'24"N | -120°21'57"W | 1981 | 99 | 14 |
| 39°29'13"N | -120°22'07"W | 1993 | 23 | 4 |
| 41°15'37"N | -121°54'07"W | 1126 | 71 | 17 |
| 40°25'31"N | -121°20'23"W | 1438 | 38 | 3 |
| 39°28'40"N | -120°22'36"W | 2005 | 160 | 21 |
| 38°42'10"N | -119°58'19"W | 2411 | 8 | 2 |
| 38°41'49"N | -119°58'54"W | 2400 | 4 | 2 |
| 38°43'15"N | -119°57'44"W | 2362 | 16 | 6 |
| 40°24'54"N | -121°19'33"W | 1439 | 21 | 2 |
| 40°24'23"N | -121°19'10"W | 1437 | 121 | 12 |

## Point Count Surveys

We established a total of 142 point count stations systematically throughout our study meadows (Table 1). The location of the first point count station in each meadow was randomly selected from a grid of equally spaced points, 10 m apart, placed within the meadow boundaries using aerial photo overlays. Subsequent point count stations were selected to reduce the potential for double counting individuals by identifying the grid point closest to the prior station within a distance of 250 - 400 m and, when possible, represented a change in vegetation. We stratified the points by the vegetation cover types: riparian deciduous shrub, herbaceous, forest patches within the meadow, and meadow edge. We placed point count stations within each meadow so all vegetation cover types were sampled in proportion to the amount of cover. To optimize survey accuracy and precision in small meadows, where only 2 to 5 points could fit within the study area, the first point count station was selected by determining all possible locations where the most points could fit into the meadow. We then randomly selected a point from the selected potential locations. Point count locations were located in the field using GPS and were marked with PVC pipe and flagging. Points placed in locations with loud noises or where visual detection could be hindered were moved in a random direction and distance within 25 m of the original location when possible. If no suitable location was found within that radius the point was eliminated.

We recorded all individuals of every species seen or heard during three continuous 5-min intervals, totaling 15 min at each station. For each bird detected, distance from the observer was estimated as 0-50 m, 51-100 m, or greater than 100 m. The time interval (1, 2, or 3) during which each individual was detected was also recorded. Individuals detected flying overhead were recorded as such.

We conducted point count surveys at each station every 7 to 10 days from 6 June to 4 August 2006, resulting in each point count station being sampled eight times during the summer. In each meadow, a different field crewmember surveyed during every visit to reduce the potential for observer bias. Point counts were conducted from first light until 10:00. Surveys were not conducted on days with strong winds (>30 km / hour), heavy precipitation, or other conditions that could lead to poor bird detectability. Every meadow was sampled before any meadow was re-sampled during the next round of surveys.

We broadcast recorded vocalizations of Wilson's warbler (*Wilsonia pusilla*), Lincoln's sparrow (*Melospiza lincolnii*), and willow flycatcher (*Empidonax traillii*), regardless of their occurrence during the count period, in an effort to increase detections of those species. The observer broadcast the first vocalization for 15 s while slowly turning in a circle so the call was broadcast in all areas surrounding the point location. The observer then waited for 30 s and tallied any individuals of that species that responded. Observers used an aerial photo to identify the location of each individual detected to avoid double counting individuals. The observer then repeated that process until no additional individuals of that species were detected. The methodology was then repeated for the other two focal species. We randomized the broadcast order to eliminate any order effects.

## Analyses

### *Influence of Audio Stimulus*

We tested the influence of the attraction of the focal species to call playback on detectability using a goodness-of-fit test (Zar 1999:461). For each point count, individuals of the focal species were tallied either as detected during the point count only, or as detected by either the point count or playback (total detections). We hypothesized the two values for each species to have equal proportions and compared them using the multinomial test Chi-square effect size estimator with *alpha* = 0.05 (Zar 1999:461). All analyses in our study were run using SPSS™ 13 (SPSS, Inc., Chicago, IL) unless otherwise noted.

*Sampling Intensity*

We tested the optimal duration of point counts to assess species abundance by tallying the total number of initial detections during three, 5-min periods: the first 5 min, 6 to 10 min, and 11 to 15 min for each point count. We used a one-way Analysis of Variance (ANOVA; Model III for unbalanced designs) and a Tukey-Kramer multiple comparisons test (Zar 1999:177) to determine if detections among the three time periods differed. The total number of new species detected during the three time periods was also compared using the same approach. Time period was the independent variable and number of initial individual detections and initial species detections, respectively, was the dependent variable.

We generated species accumulation curves for each meadow, and for all meadows combined using a custom software program developed by one of us (Szewczak) based on methods described by Moreno and Halffter (2000). From the species accumulation curves we determined what percent of the asymptote in species richness was met for each meadow. We generated the curves from the raw field data using the exponential and Clench models (Moreno and Halffter 2000) to account for uncertainties in the observational data and to acquire quantitative estimates of species richness and anticipated total species. The exponential model assumes that the number of species detected decreases linearly as sampling effort increases (Moreno and Halffter 2000). The exponential model was developed for populations where the taxa were well known, or where the study area was relatively small and could theoretically reach an asymptote over a finite period of time (Soberon and Llorente 1993). The Clench model assumes that the probability of adding species to the list decreases with the number of species already recorded, but increases over time (Moreno and Halffter 2000). Soberon and Llorente (1993) suggested this model performs better than the exponential model in larger areas, or for taxa where the probability of adding new species would increase as more time is spent in the field. The results from the exponential model and Clench model can be considered the lower and upper limit, respectively, of sampling effort needed for specific species richness goals (Moreno and Halffter 2000). Each curve was smoothed using the regression of 1,024 randomizations of the data from the eight 15-min point surveys conducted at each point count station.

We estimated the number of survey cycles that should be conducted in one season to optimize sampling effort for the number of species detected. For each number of survey cycles, point counts were randomly selected from all samples collected at each point during the field season. Point location was constrained for each randomly selected point count, while successive visits were randomly selected. The process was repeated five times for each number of surveys. A one-way ANOVA was used to determine the significance of the differences between the number of species detected for each number of survey cycles (Zar 1999:177). The differences among means were compared with a Tukey-Kramer multiple comparisons test.

We also created a matrix comparing the number of species detected for different combinations of number of survey cycles and numbers of point counts. Observations for each combination were obtained by randomly selecting from all of the samples collected during the field season. For each randomly selected point count, point location was constrained while successive visits were randomly selected.

We used power analysis to determine the number of meadows that needed to be sampled to detect a 5% and 10% change in regional species richness within 3, 5, and 7 years as examples for planning purposes. Power was determined for annual, every other year, and every three year sampling schemes for an average of 5 and 10 points per meadow using program MONITOR™ 7.0 (Gibbs 1995). Program MONITOR™ 7.0 estimated statistical power relative to the number of meadows monitored, number of counts per meadow, count variance, duration of monitoring, interval of monitoring, magnitude and nature of ongoing population trends, and the significance level associated with trend determination (*alpha* = 0.05). Simulated sets of count data were generated based on monitoring programs and sample counts drawn at random from distributions we defined. The proportion of trials in which the average trends differed from zero was used to estimate power (MONITOR™ Users Manual: www.mbr-pwrc.usgs.gov/software/monitor.html).

## RESULTS

### Influence of Audio Stimulus

Playback did not significantly increase the detection rate of the three focal species ($X^2$, $P \geq 0.1$ for all species, Table 2). Even though the total number of detections did not increase significantly for any of the species, all three species were detected in some meadows during playback where they were not detected during point counts. During point counts, we detected Lincoln's sparrow in 10 meadows, willow flycatcher in 9 meadows, and Wilson's warbler in 14 meadows. Each of the species was detected in one additional meadow using playback. For specific locations of detections of each species see Tegeler-Amones (2008).

### Sampling Intensity

Most initial detections of an individual of any species occurred within the first 10 min of the point counts. On average, 7.2 individuals were initially detected during the first 5 min (SD = 5.51, range = 0 to 102), 7.0 were initially detected during 6 to 10 min (SD = 4.68, range = 0 to 59), and 4.3 were initially detected during 11 to 15 min at each point count (SD = 4.00,

Table 2. Comparison of the number of individuals of each focal species detected during point counts and during a combination of point counts and playback (total detections) in 15 Sierra Nevada and Cascade Range montane meadows from May to August 2006 using a multinomial Chi-square test.

| | Detections | | | |
|---|---|---|---|---|
| Species | Point count | Total | $X^2$ | $P$ |
| Lincoln's sparrow | 234 | 271 | 2.71 | 0.10 |
| Willow flycatcher | 351 | 358 | 0.07 | 0.79 |
| Wilson's warbler | 251 | 285 | 2.16 | 0.14 |

range = 0 to 55). Of the initial detections, 39% occurred within the first 5 min and 78% occurred within the first 10 min of the 15-min counts. The numbers of initial detections between the first and second time periods were not significantly different. However, initial detections during the last 5 min time period were significantly less than either of the other two time periods ($F = 132.02$, df = 2, $P < 0.001$).

Most initial detections of each species were within the first 5 min of the point counts. On average, 6.8 species were initially detected during the first 5 min at each point count (SD = 2.85, range = 0 to 24). On average, during the 6 to 10 min time period two new species were detected (SD = 1.42, range = 0 to 9) and during the 11 to 15 min time period only one additional species was detected (SD = 1.30, range = 0 to 8). Of all the species detected, 64% were initially detected within the first 5 min and 84% were initially detected within the first 10 min of the 15-min counts. The number of new species detected during the three time periods all were significantly different ($F = 2272.01$, df = 2, $P < 0.001$).

We detected 113 species during the field season. The exponential model estimated an asymptote of 105 species and the Clench model estimated an asymptote of 112 species for all study meadows combined. According to the exponential model at least 100% of the asymptote in species richness was reached for each meadow. The Clench model estimated that at least 90% of the asymptote in species richness was reached in seven of the 15 study meadows. Between 80% and 90% of the asymptote was reached in seven meadows, and 70% to 80% of the asymptote was reached in one meadow. When we combined all the meadows, the exponential model estimated 109% of an asymptote in species richness was reached, and the Clench model estimated 102% of the asymptote was achieved. For additional details, see Tegeler-Amones (2008).

We detected most species during the first three survey cycles (Figure 1). We detected 85 species when only one survey was completed, and 94 and 101 species when two and three surveys, respectively, were completed. Despite non-overlapping error bars, the number of species detected did not differ significantly between three and four surveys, and was not significant for any additional surveys ($F = 64.83$, df = 7, $P > 0.5$). We detected 104 species when four surveys were completed and 107, 108, 111, and 113 species, respectively, when five through eight surveys were completed (Figure 1).

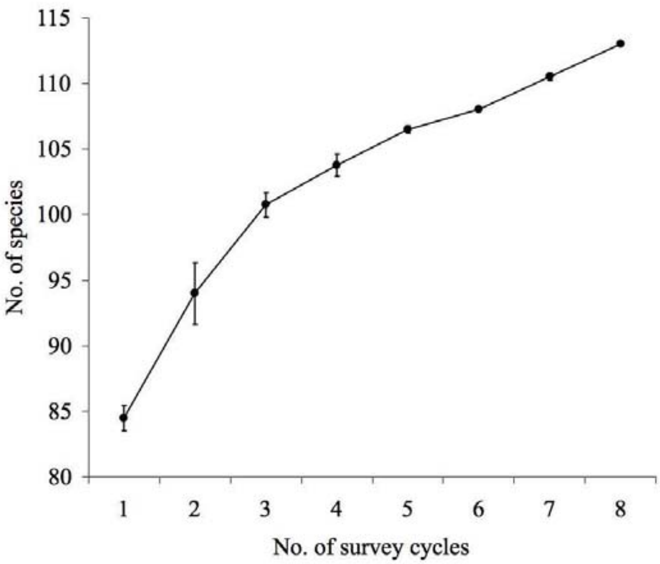

Figure 1. The total number of species detected in 15 Sierra Nevada and Cascade Range montane meadows from May to August 2006 during different numbers of point count survey cycles, with error bars.

The number of species detected increased as the number of point count stations sampled increased and as the number of survey cycles increased (Figure 2). There was a tradeoff between the number of point count stations sampled and the number of survey cycles. Conducting 20 point counts for eight cycles detected approximately the same number of species as conducting 140 point count stations for one cycle (88 and 86 species, respectively). However, increasing the number of point count stations tended to be more efficient for increasing the number of species than increasing the number of survey cycles. To detect at least 90% of the species in this study required surveying 60 point count stations for seven cycles, but for every additional 20 point count stations added, one less survey cycle was necessary.

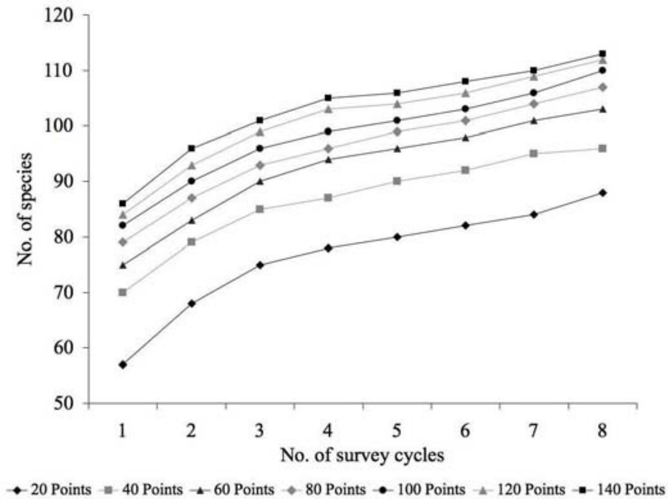


Figure 2. The number of species detected during different numbers of point count stations and number of point count survey cycles in 15 Sierra Nevada and Cascade Range montane meadows from May to August 2006.

The number of meadows and point counts needed to detect a 5% and 10% change in species richness varied depending on how often survey cycles were conducted (Table 3). As the time interval between the first and last survey cycle increased (3, 5, or 7 years), the number of meadows needed to detect a 5% and 10% change in species richness decreased. With five point count stations per meadow, at least 100 meadows need to be sampled annually for 3 years to detect a 5% change in species richness, compared to 25 meadows needed if sampling is conducted annually for 7 years. To detect a 10% change in species richness with five point count stations per meadow, 50 meadows need to be sampled annually for 3 years, compared to 10 meadows if sampling is conducted annually for 7 years. The time interval of survey cycles between the first and last survey (every year, every other year, or every 3 years) appeared to have less of an impact on the number of meadows that needed to be sampled. When five point count stations per meadow were sampled every other year over a 7 year period, 25 meadows need to be sampled to detect a 5% change in species richness, and 10 meadows to detect a 10% change. The same numbers of meadows and point count stations were needed to detect a 5% and 10% change in species richness when sampling every 3 years for a 7 year period. However, to detect a 10% change in species richness in 5 years, sampling every other year required fewer meadows sampled than every year for 5 years. Fewer meadows also needed to be sampled if there were 10 point count stations per meadow compared to five stations per meadow for each sampling scheme.

Table 3. The number of montane meadows in the Sierra Nevada and Cascade Range that must be surveyed to detect a 5% and 10% change in species richness with various sampling schemes ranging between 3 and 7 years with an average of 5 and 10 point count stations per meadow, May to August 2006.

| # Stations / meadow | 5 Point count stations | | 10 Point count stations | |
|---|---|---|---|---|
| % Change | 5 % | 10 % | 5 % | 10 % |
| Years surveyed | # Meadows | | | |
| 1,2,3 | > 100 | 50 | 80 | 25 |
| 1,2,3,4,5 | 40 | 25 | 20 | 15 |
| 1,3,5 | 45 | 20 | 25 | 10 |
| 1,3,5,7 | 25 | 10 | 15 | 10 |
| 1,4,7 | 25 | 10 | 15 | 10 |
| 1,2,3,4,5,6,7 | 20 | 10 | 10 | 5 |

## DISCUSSION

Point count duration, number of point count stations, number of survey cycles, and aural stimuli can all affect detection probabilities of avian species. Our results suggest that after 5 min, significantly fewer species were detected than during the initial 5 min in Sierra Nevada montane meadows. The initial detection rate of any individual of any species did not drop off until after the second 5 min period; 78% of the initial detections occurred in the first 10 minutes. An increase in count duration decreases the number of counts conducted per hour. In areas where travel time between points is greater than 10 min, Buskirk and McDonald (1995) and Lynch (1995) reported that point count durations of 10 min optimized survey time. Travel time between points was, on average, 15 to 20 min for our study because observers frequently had to travel through dense vegetation, cross rivers, or wade through standing water, and travel time between meadows sometimes limited the number of points conducted in a morning. To increase detectability and efficiency of time in the field, we found point counts conducted in Sierra Nevada and Cascade Range montane meadows should be at least 10 min long, but our results suggest there are no additional benefits for point count durations of 15 min, particularly when that time could be devoted to surveying an additional point.

Visiting more points, or multiple visits to single points, can reduce variability and increase accuracy of bird abundance and species richness estimates. Regionally, we reached greater than 100% of the asymptote in species richness when all eight surveys were included in the analysis, a total of 113 species. The exponential model estimated an asymptote of 105 species and the Clench model estimated 112 species. However, 101 species were detected during three survey cycles per point count station and our results suggest that optimizes survey effort for the number of species detected. Although species richness continued to increase with increased number of survey cycles, the number of species detected did not significantly increase after the third survey cycle. However, different sampling regimes, such as sampling in different habitat types or differences in desired levels of accuracy, precision, and power, will require alternate numbers of points and numbers of survey cycles. Typically, increasing the number of point count stations will be more efficient at detecting new species than increasing the number of visits (Smith et al. 1995). Hence, large meadows with many point count stations may require fewer survey cycles, whereas small meadows with few points will require more survey cycles to reach the desired level of precision and accuracy. If a project goal is to assess regional trends in bird populations, then to reach the desired analytical power the tradeoff between increasing sampling effort within a meadow and increasing the number of meadows sampled should also be considered.

Lynch (1995) suggested that adding an aural stimulus (playback) would provide a greater benefit for detecting rare species than increases in point count duration or the number of points sampled. While not a significant difference, all focal species in our study were detected in at least one meadow during playback where they were not detected during any point count surveys. To increase detections and accuracy of occupancy determinations of willow flycatcher, Lincoln’s sparrow, and Wilson’s warbler, we recommend supplementing point count surveys with playback for these species in Sierra Nevada and Cascade Range montane meadows. In our study, we took the time to conduct playback regardless of whether the species was detected during the point count. Conducting playback only following a negative detection for a focal species at a survey point would, however, reduce the time at point count stations and optimize survey efficiency. If the unit of interest is the meadow, then no playback would be required anywhere in the meadow after the focal species was detected at one point location.

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