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A Rapid, Inexpensive Field Protocol for Assessing the Importance of Montane Meadows to Breeding and Post-Breeding Birds, and a Test of the Late-Season Protocol

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ABSTRACT. In this paper we describe a bird survey protocol for rapidly assessing the importance of individual montane meadows to breeding and post-breeding Sierra birds. In another paper (Siegel et al. 2001) we demonstrated that fairly reliable indices of a site's importance to breeding birds can be generated with a single morning of point counts during the height of the breeding season. Here we test whether a single day of mist-netting is equally successful at characterizing site importance for post-breeding birds, which may be considerably less sedentary than breeding birds. We find that capture rates of species and individual birds at Sierra mist-netting stations are remarkably constant during the post-breeding period, and conclude that rapid assessment is a useful tool for prioritizing conservation efforts at Sierra meadows.

INTRODUCTION

Montane meadows constitute an important habitat element for numerous bird species in the Sierra Nevada, including meadow-obligate breeders such as Little Willow Flycatcher (*Empidonax traillii brewsteri*) and Lincoln's Sparrow (*Melospiza lincolnii*), as well as species like Orange-crowned Warbler (*Vermivora celata*) and Nashville Warbler (*Vermivora ruficapilla*), that breed in other habitats but disperse upslope and aggregate in meadows later in the summer (Siegel and DeSante 1999). The population densities of many forest-inhabiting species, as well, are often highest near meadow edges, even if the birds rarely or never actually venture into the meadows (Siegel and DeSante 1999).

Human activities, most notably livestock grazing, have compromised the quality of bird habitat in meadows throughout the Sierra Nevada (Kattelman and Embury 1996; Menke et al. 1996; Siegel and DeSante 1999). California's endangered species list includes two meadow-dependent bird species, the Willow Flycatcher (only the brewsteri subspecies truly requires meadows, as opposed to riparian areas) and the Great Gray Owl (*Strix nebulosa*), both of which are sensitive to the effects of poorly managed grazing in their meadow habitats (Serena 1982; Harris et al. 1987; Gaines 1992; Harris et al. 1988; Ohmart 1994; Graber 1996). North American Breeding Bird Survey (BBS) data indicate several additional meadow-affiliated species, including Red-breasted Sapsucker (*Sphyrapicus ruber*), American Robin (*Turdus migratorius*), Chipping Sparrow (*Spizella passerina*) and White-crowned Sparrow (*Zonotrichia leucophrys*) are declining in the Sierra (Siegel and DeSante 1999).

Prioritizing meadows for targeted conservation efforts has been identified as an important step in safeguarding populations of meadow-dependent birds throughout the Sierra Nevada (Siegel and DeSante

1999). We therefore surveyed a large number of Sierra meadows, in terms of diversity and abundance of breeding as well as post-breeding birds, and used the survey results to identify the top third of meadows for targeted conservation efforts. To pursue this objective we needed a rapid, inexpensive survey protocol that would allow a small crew to survey a large number of meadows in a summer. The protocol needed to characterize meadows, including meadowforest edges, with respect to two distinct factors: importance to breeding birds, and importance to post-breeding, dispersing birds.

The rapid assessment protocol we summarize below integrates three distinct bird survey techniques, including point counts, area searches, and mistnetting, that met our survey objectives quickly and inexpensively. Each bird survey technique satisfied a slightly different objective. Point counts provided quantitative indices of avian diversity and abundance, and were particularly well suited to breeding season surveys (Ralph et al. 1993; Ralph et al. 1995). We augmented point counts with area searches (Lyon 1986; Slater 1994; Nur et al. 1999), because they allowed rare or secretive species to be deliberately pursued, possibly increasing their detection probability. Lastly, we used mist-netting to survey birds in the post-breeding period, when aural survey methods become much less effective (Faaborg et al. 1996).

Rapid assessments of species diversity and overall conservation importance of sites often rely on indices of abundance or taxonomic diversity, rather than complete inventories, especially when a) very species-rich taxonomic groups, or b) very large areas or many disparately located sites need to be surveyed (Disney 1986; Abate 1992; Hammond 1994; Olivier and Beattie 1996). In the latter scenario, it is critical that survey methods produce reproducible indices that can be reliably compared across sites (Jones and Eggleton 2000). If substantial temporal variability exists in a) the abundance or diversity of animals

being surveyed, or b) the detectability of animals being surveyed, however, 'rapidness' can compromise the reliability of results.

In a separate paper that tests the reliability of our rapid survey methodology for assessing the importance of montane meadows to breeding birds, Siegel et al. (2001) show that species richness estimates based on point counts conducted during just a single breeding season visit may provide a reliable index for prioritizing conservation efforts. The reliability of our rapid assessment protocol for assessing meadows' importance to post-breeding birds, however, still required testing. The late-summer portion of the protocol relies on mist-netting, which may be prone to chance events influencing capture rates. Many birds that congregate in Sierra meadows in the late summer are upslope dispersers, such as Orange-crowned Warbler, Nashville Warbler, House Wren (*Troglodytes aedon*), or early southbound migrants, such as Rufous Hummingbird (*Selasphorus rufus*) and Wilson's Warbler (*Wilsonia pusilla*), whose habits during this time period are poorly described. If these birds tend to arrive at meadows in large aggregations, and then depart after only a brief stay, then mist-netting during just a single day late in the summer may produce results that depend more on chance events than on habitat quality or true importance to the avifauna. Likewise, if avian abundance or diversity changes systematically within the late-summer period, then again, the value of our survey protocol will be compromised. However, if avian diversity and abundance at individual meadows stays relatively constant throughout the late summer (as it does during the early summer when the birds are breeding), then our protocol should provide an efficient way to rapidly assess the importance of late summer to post-breeding birds.

In this paper we provide a general description of our rapid meadow survey protocol, and then present an analysis of constant-effort mist netting data that tests whether mist-netting during a single day in the late summer can adequately prioritize meadows according to their importance to post-breeding birds.

METHODS

Below we present our protocol for surveying bird communities and describing habitats and overall ecosystem health at montane meadows. The protocol requires two single-day visits to each meadow; an early-season visit (May 15 - June 30, depending on elevation) to quantify the diversity and abundance of breeding birds, and a late-season visit (July 15 - August 31, depending on elevation) to produce indices of the diversity and abundance of dispersing juvenile and post-breeding adult birds using the meadow. The early season visit can be completed by a single observer, whereas the late-season visit

will generally require two observers to ensure that birds can be safely mist-netted and processed.

In addition to conducting bird surveys, at each meadow visit we also produce narrative descriptions of meadow vegetation and of the habitats that surround the meadow. Our methods are suitable for broadly characterizing meadow habitats, but depending on individual survey objectives, observers may wish to develop more quantitative methods of describing habitat characteristics. For the meadow interior, we visually estimate the percent cover of willows and other woody plants, and also describe the species composition and structure of the herbaceous plant community. We also describe the extent to which streams are channelized, note any areas of active erosion, and describe any effects of livestock grazing or other human-use impacts that are evident. For the surrounding habitats, we qualitatively describe the structure and composition of the understory, subcanopy, and canopy, and note the presence of large snags, recently burned areas, talus slopes, or any other habitat features that might influence the compositions of the local bird community. We also produce a rough map of the site that includes major vegetative and hydrologic features, and indicates the location of any species of management concern that were detected. We recommend copying and enlarging sections of 7.5' USGS quads to use as base maps for the hand-drawn maps, in order to increase accuracy.

Meadow Bird Survey Protocol

1. Early-season visit

a) Point count survey

The meadow should be explored prior to the point count survey, so that as many points as possible can be arrayed efficiently in the meadow. Points should be placed 150 m apart, and should be located unambiguously within the meadow interior, rather than in the surrounding forest. We generally require a distance of at least 25 m between each point and the meadow edge, although this can be relaxed slightly for very narrow sections of meadow. Even points that are well over 25 m from the forest edge will still generally allow observers to detect birds utilizing the forest edge as well as the meadow interior. Following these guidelines will generally result in a point density of about one point per 1-1.5 ha, depending on the shape of the meadow. The first point count should begin within 10 minutes of local sunrise, and the last point count must be completed by 3.5 hours after local sunrise.

In some cases, especially at higher elevations, a meadow may freeze over in the early morning just before it is hit by the sun. This will often slow or completely stop bird activity within the meadow. In these cases, if cold temperatures appear to be

dampening bird activity, points counts may be suspended for up to 30 minutes. It is important to begin point counts on time, however, even if a cold-induced suspension must be taken after one or more points have been conducted. Cold-induced suspensions may sometimes be avoided by starting point counts in a portion of the meadow that is receiving direct sun, and then moving toward the colder, shaded areas later in the survey. Freezing conditions in the meadow generally affect the activity level of meadow birds much more strongly than birds in the surrounding forest. Therefore, even when a meadow is entirely shaded, one or more points should always be conducted at sunrise, to ensure a relatively consistent sampling of early-singing forest birds.

We recommend five-minute point counts, conducted in accordance with standard protocols (e.g. Ralph et al. 1993). In addition to recording whether each bird is within 50 m, outside a 50 m radius, or a 'flyover' that isn't actually using the local habitat at all, observers should also record whether the bird was within or outside the boundaries of the meadow. It is extremely important not to double count birds; in most circumstances, if birds are detected that have already been recorded at a previous point, they should not be recorded again. The only exception is when a bird is recorded as being outside of the 50 meter circle on one point count but inside of the 50 meter circle of a later point count. In this instance, record the bird again and then place an 'X' in the field where the birds was previously counted.

b) Area search

Area searches are employed in conjunction with point counts to identify species that may be present but missed during the point counts. Area searches are conducted immediately after the last point count is completed, and are usually completed by the individual who conducted the point counts. The length of time spent conducting point counts is proportional to the size of the meadow. Ten minutes of area search effort are allotted for every point count completed, with a cap of 90 minutes (i.e., a meadow which was large enough to contain six point count stations would then be surveyed with a 60 minute area search). Area searches are carried out by slowly walking ("birding") throughout the meadow and counting all birds detected. Paying particular attention to "birdy" areas is important as is taking the time to cover all areas of the meadow thoroughly. Observers should not venture far into the forest beyond the meadow edge, but should record birds that are heard from the surrounding forest. Birds observed in the meadow should be recorded separately from those detected in the surrounding forest.

2. Late-season visit

a) Mist-net survey

Post-breeding and juvenile birds are ineffectively

surveyed with point counts, which depend largely on aural detections. This protocol therefore employs a single late-season morning of mist-netting. Observers should arrive at a meadow the afternoon before the survey in order to establish net lanes. We have found that six 12 m mist nets (and associated poles, stakes, etc.) is about the maximum number that a two-person crew can realistically carry to remote, backcountry locations; using more nets may be possible in meadows that are easily accessible, and, indeed, may be preferable for large meadows, or meadows. When establishing nets in a meadow, place three nets adjacent to willows, two nets on the meadow/forest edge and one net 10-15 m into the adjacent forest. In meadows where willows are absent or very sparse, place more nets on the meadow/forest edge. In general we recommend looking for 'natural' net lanes—areas that birds frequently use to travel between willow stands and between willows and the surrounding forest. Nets erected in the interior of a meadow, more than about ten meters from any shrubs or trees, rarely catch many birds. Net locations should be indicated on copies of the maps produced during the early-season survey. Nets should be opened within ten minutes of local sunrise, and operated for six hours, weather conditions permitting. All birds captured should be banded, aged, and sexed, according to established methods (Pyle 1997; DeSante et al. 2000).

Testing the Reliability of the Late-Season Survey Protocol

We used data from 13 MAPS (Monitoring Avian Productivity and Survivorship) stations (DeSante et al. 1998; DeSante et al. 2000) located at varying elevations in the Sierra Nevada to test whether a single day of mist-netting, as described in the meadow survey protocol above, can produce reliable, site-specific indices of late-summer avian abundance and diversity.

The MAPS program is a continent-wide network of over 500 constant-effort mist netting and bird banding stations operated during the North American breeding season every year. All of the MAPS stations in this study were situated at least partially in coniferous forest, with ten stations dominated by meadows or riparian-forest edges. MAPS protocol entails operating an array of about ten permanently located mist nets for six morning hours per day, once during every ten-day period throughout the breeding season. Because we sought to test the reliability of our meadow survey protocol for surveying postbreeding bird communities in the late summer, we restricted data for this analysis to mist netting effort conducted between July 15 and August 31, 1999. The 13 Sierra stations were operated an average of 3.5 days each (minimum = 2 days; maximum = 5 days) within this time interval.

A RAPID, INEXPENSIVE FIELD PROTOCOL FOR ASSESSING THE IMPORTANCE OF MONTANE MEADOWS TO BREEDING
AND POST-BREEDING BIRDS, AND A TEST OF THE LATE-SEASON PROTOCOL

TABLE 1. Average capture rates during mist-netting at 13 Monitoring Avian Productivity and Survivorship (MAPS) stations in the Sierra Nevada. "No. Ind. Visits in Top Third" indicates the number of visits at which more than 0.72 individuals/net-hour were captured.

Station	Average captures/net-hr	Total No. Visits	No. Ind. Visits in Top Third
<i>Top third</i>			
11907	2.86	3	3
11980	1.46	5	4
11107	1.34	5	5
11132	0.98	4	3
<i>Lower two thirds</i>			
11131	0.72	3	1
11130	0.71	3	1
11111	0.60	4	1
11905	0.52	3	0
11936	0.40	3	1
11112	0.38	4	0
11935	0.36	2	0
11929	0.33	2	0
11904	0.20	4	0

Data analysis. We grouped surveys into ten-day periods, in order to produce categorical data for tests of the effect of date on capture rates. We then used 2-way ANOVA to test for effects of individual mistnetting station and survey date on the number of individuals captured (standardized for effort by dividing each day's total captures by the number of net-hours operated that day) and on species richness (again standardized for effort). Statistical tests were performed using SYSTAT (SPSS 1997), and are two-tailed. Results were considered statistically significant at $p < 0.05$.

RESULTS

We tallied the number of species and the number of individual birds captured during each day of

operation at each mist-net survey station, and then averaged the number of individual birds captured per net hour at each station (Table 1) and the number of species captured, divided by the log of the number of net-hours at each station (Table 2).

Two-way analysis of variance revealed that the number of individuals captured per net hour varied highly significantly with station ($F = 4.35$, $df = 12$, $p = 0.001$), but not with date ($F = 0.45$, $df = 6$, $p = 0.220$), indicating that there is no systematic change in capture rates during the time period in which we conduct late-season visits.

To test for stochastic variation in capture rates that would undermine priority rankings based on our

TABLE 2. Number of species captured (standardized by effort) during mist-netting at 13 MAPS stations in the Sierra Nevada. "No. Ind. Visits in Top Third" indicates the number of visits at which more than 0.28 species/net-hour were captured.

Station	Average Species Richness	Total No. Visits	No. Ind. Visits in Top Third
<i>Top third</i>			
11107	0.55	5	5
11907	0.39	3	3
11980	0.31	5	4
11905	0.31	3	1
<i>Lower two thirds</i>			
11131	0.28	3	2
11132	0.25	4	1
11111	0.25	4	1
11130	0.22	3	0
11929	0.21	2	0
11935	0.18	2	0
11936	0.16	3	0
11112	0.15	4	0
11904	0.14	4	0

rapid assessment protocol, we then ranked the stations from 1 to 13 based on the average number of individual birds captured per net-hour. To be ranked in the top third, stations needed an average capture rate greater than 0.72 individuals/net-hour (Table 1). We then counted how many of the *individual* one-day visits to each station garnered a capture rate higher than 0.72 birds per net-hour (Table 1). We confirmed that there was a high degree of intraseason consistency in capture rates (Table 1). The top four sites were surveyed a total of 17 times; capture rates were high enough to rank within the top third of sites (capture rate > 0.72 individuals/net-hour) during 15 (88%) of those 17 one-day surveys. The sites making up the bottom two thirds of the rankings in Table 1 were visited a total of 28 times. Capture rates were too low to rank within the top third of sites during 24 (85.7%) of those 28 one-day visits.

Two-way analysis of variance also revealed that species richness (the number of species captured divided by the net-hours of effort) varied highly significantly with station ($F = 8.84$, $df = 12$, $p < 0.001$), but again, not with date ($F = 0.35$, $df = 1$, $p = 0.557$). There is consequently no systematic change in species richness during the time period in which we conduct late-season visits. To test for stochastic variation in the number of species captured that would undermine site rankings based on our rapid assessment protocol, we also ranked the stations based on species richness indices. To be ranked in the top third, stations needed an average capture rate greater than 0.28 species/net-hour (Table 2). As with intra-season consistency in species richness at each station. The top four sites ranked by species richness were surveyed a total of 16 times; capture rates were high enough to rank within the top third of sites during 13 (81.3%) of these 16 single-day visits. The sites making up the bottom two thirds of Table 2 were surveyed a total of 29 times. Capture rates were too low to rank within the top third of sites during 25 (86.2%) of those 29 one-day visits.

DISCUSSION

The importance of maintaining high-quality breeding habitat to safeguard bird populations is widely recognized, but less well understood is that high-quality post-breeding habitat may be just as critically important for many species (Pagen et al. 2000). Adult birds of many species use the time between breeding and migration to undergo a complete prebasic molt, and hatching-year birds of most species undergo a partial prebasic molt that includes virtually all of the contour feathers and many wing and tail coverts as well (Pyle 1997). Moreover, adult as well as hatching-year migratory birds must also use this time to build up fat reserves in preparation for migration (Moore et al. 1993). Although data addressing habitat needs of postbreeding birds are sparse, evidence suggests that several

Neo-tropical migrant species exhibit substantial habitat shifts during this period (Rappole and Ballard 1987; Anders et al. 1998; Pagen et al. 2000). This may mean that meadows in the Sierra Nevada that are particularly important for meadow-dependent breeding birds are not necessarily the same meadows that are most important for postbreeding birds.

The finding that capture rates of species and individual birds at Sierra mist-netting stations do not change systematically within the late-summer sampling period indicates that a single day of mistnetting effort may provide fairly reliable indices of a meadow's importance to post-breeding birds. This is only true, however, provided that results are not overly prone to distortion by chance single-day surveys with very high or very low capture rates that are not representative of results across multiple days of mist-netting. Fortunately, our finding that 80-90% of single-day surveys at top ranked sites have capture rates (of individual birds and of species) high enough to rank those sites within the top third suggests that results are remarkably constant within the late-season sampling period, and site-ranking errors due to chance events should be fairly rare.

Our results, along with those described in Siegel et al. (2001) confirm the utility of rapid assessment surveys for characterizing the avifauna of meadows throughout the montane west. The loss of reliability inherent in rapid assessment can be kept to an acceptably small level, though it remains important to test for and be aware of potential sources of variability.

Preliminary analysis of data collected using our meadow survey protocol suggest that in some cases there is a surprising discordance between meadows that are particularly important for breeding birds, and meadows that are particularly important for dispersing birds (Wilkinson and Siegel 2002). The habitat needs of post-breeding birds may be just as important as breeding habitat, and require not only further study, but also much greater consideration in conservation planning. Because our survey protocol examines both of these important time periods, it will produce the information necessary to focus conservation efforts in the Sierra Nevada on meadows that are of particular importance to breeding birds, as well as on meadows that are crucial to post-breeding birds.

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