

Effects of recreational development on forest-breeding birds in U.S. National Forests

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INTRODUCTION

The purpose of this report is to describe a study of the effects of recreational development on forest-breeding birds on US National Forests, summarize the results of this study, and offer a preliminary set of recommendations regarding recreation on National Forests.

History of Forest Service partnership with Cornell Lab of Ornithology

In 1999, the USDA Forest Service (USFS) entered into a National Challenge Cost Share project with The Cornell Lab of Ornithology (CLO) to promote and implement “Citizen Science” programs on National Forest lands. This project highlighted the mutual benefits of the two organizations working together towards bird conservation efforts on a national scale. The agreement outlined two primary goals: (1) to expand and implement CLO’s *Birds in Forested Landscapes* (BFL) citizen-science project on USFS lands; and (2) to develop a new pilot program to address a question of USFS management concern.

The first goal was achieved; during the 1999 field season, 110 volunteers were recruited to coordinate with 31 national forests to collect BFL data on USFS lands. The BFL project was designed to study the effects of landscape-level habitat fragmentation on forest-breeding birds, both on and off of national forest lands. A similar continent-wide study of breeding tanagers had previously shed new insights into the effects of forest fragmentation (Rosenberg et al. 1999a, Hames et al. 2001) resulting in the publication of *A Land Manager’s Guide to Improving Habitat for Scarlet Tanagers and other Forest-interior Birds* (Rosenberg et al. 1999b). Continuing with this work, the BFL project focused on several species of forest-dwelling thrushes, including Wood Thrush (*Hylocichla mustelina*), Hermit Thrush (*Catharus guttatus*), Veery (*Catharus fuscescens*), Swainson’s Thrush (*Catharus ustulatus*), and Varied Thrush (*Ixoreus naevius*); and two species of accipiters—the Sharp-shinned Hawk (*Accipiter striatus*) and Cooper’s Hawk (*Accipiter cooperii*) (Hames 2001, Hames et al. 2002). With support and participation from USFS, this research resulted in a second publication: *A Land Manager’s Guide to Improving Habitat for Forest Thrushes* (Rosenberg et al. 2003).

Early in 2000, efforts were begun to address the second goal; develop a new pilot project that would address a USFS management concern. The USFS national coordinator worked with staff at CLO, USFS regional Wildlife Program Managers, and a group of USFS Avian Researchers to develop a list of issues of avian conservation concern. One of the highest priority issues generated by this group was understanding the effects of recreational use on avian and wildlife communities.

The group consensus was that recreational development and user days were intensifying on USFS lands and the effects of increased recreation on wildlife, especially avian communities, were largely unknown. Based on this, we decided that the new pilot effort would focus on studying the effects of recreational development on forest-nesting birds. The new study was proposed to run as a pilot the first year, 2000, with two additional years of data collection, 2001, and 2002. Our hope was that research would enable USFS to minimize impacts and develop policies that are compatible with needs of forest birds and other wildlife. The long-term goals of this new program would be to provide a foundation for developing conservation recommendations and habitat management strategies for USFS sensitive, and Partners in Flight (PIF) priority, avian species.

This new study expanded and modified the existing BFL protocol. Building on the existing protocol and sampling network enabled us to incorporate the data that already existed within the BFL dataset. The existing BFL data collected on forests in 1999 could serve as control sites for the new study, with the additional new sites selected according to their proximity to campgrounds or other recreation areas. In spring of 2000, the new pilot study was begun with 76 citizen scientists and 26 forests eager to participate.

Why study effects of recreation on birds?

According to the 2001 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, 39% of U.S. residents participate in some type of outdoor related recreation each year. The USFS, with more than 23,000 recreational facilities, including campgrounds, picnic areas, boat ramps, and visitors centers under its purview, is the largest provider of outdoor recreational opportunities for U.S. citizens. From 1977 to 1999, visits to USFS

lands increased by 76% from 205 to 362 million visitor-days, respectively. According to USFS statistics, there were an estimated 900 million individual visits to USFS lands in 1999. Much of this activity occurs at designated campgrounds, parks, and day-use areas, placing widespread and sometimes intense pressures on bird and other wildlife populations.

Development of recreation sites and associated activities can have both direct and indirect impacts on wildlife (Cole and Landres 1996). For example, clearing or altering of forestland for recreation areas can have direct effects by eliminating habitat and/or decreasing habitat suitability. Food left behind by visitors at recreation areas can have indirect effects on wildlife by attracting and sustaining unusually large numbers of some nest predators, such as red squirrels. For more than a decade, conservation scientists have been focused on studying the direct and indirect impacts of increasing, and sometimes intense, recreational activity on birds and other wildlife. In a discussion of knowledge gaps, regarding recreational impacts, Cole and Landres (1996) wrote: "The preceding review should make it clear that animals are impacted by recreational disturbance of habitat. Two important questions remain, however; how significant are these impacts to wildlife populations and communities, and which habitat disturbances are most damaging to wildlife? Answers to these questions will require research designs radically different than the short-term correlational analyses that characterized research on indirect impacts."

Many researchers have compared wildlife communities in campgrounds to those in nearby undisturbed habitats to determine the effects of campground development and activities on wildlife populations. For example, Guth (1978) found that campgrounds in Wisconsin had a greater density of birds than adjacent non-campground forests. However, a higher percentage of the campground species were common, widespread species compared to the communities found at non-campground sites. In northern Utah, Blakesley and Reese (1988) compared use of riparian habitats by 14 bird species in campground and non-campground sites. They found that the differences in avian communities between campground and non-campground sites could be attributed to available food resources and nesting sites. Of the 14 common species in their study

area, seven were associated with campgrounds and seven with non-campgrounds. Campground species such as American Robins and Warbling Vireos tended to be tree nesters, while ground and shrub nesting species such as Song and Fox sparrows were found in non-campground areas. In a study of corvids responding to human settlement and recreation in western Washington state, Marzluff et al. (2001) found that crows increased their abundance by decreasing their home range size when near human-altered habitats, while Steller's Jays and Common Ravens showed no population level response. Both crows and ravens capitalized on human food, but the response appeared to be opportunistic, as opposed to sustained, for ravens.

These studies, along with others not described here, have provided conservation biologists with the initial clues regarding the response of birds to human recreational sites. Because recreation is almost always coincident with other environmental stressors such as development, building logging roads (Lugo and Gucinski 2000), timber harvesting, and wildfires, it's often difficult to discern the effects of the recreation from other disturbances. The high potential for results to be confounded by extraneous factors dictates a research approach that employs large spatial and numerical scales, and controls for potential confounding factors. We achieved the required scale and control by combining a citizen-science approach with a rigorous, systematic protocol.

Goals of the Recreation Study

Using Citizen Science as a research tool, the aim of our research was to analyze the impacts of recreation at spatial and numeric scales that heretofore have been unexplored.

The primary goals of the research were to: 1) Develop and refine protocols for evaluating the effects of recreational development and activities on forest birds, 2) Compare high-use recreation areas with undisturbed sites in similar habitats, and 3) Develop recommendations for mitigating the impacts of recreational activities on bird populations.

METHODS

USFS Coordination, Recruitment, and Training Efforts

To implement the program on USFS lands the USFS appointed a national coordinator (Barbara Kott) to work with the CLO project managers to recruit and coordinate project participants and collaborators. Two forms of recruitment were necessary to establish the program initially. First, USFS district biologists were recruited to coordinate the effort on individual forests and secondly, those participating biologists needed to recruit local volunteers to collect, record and submit the data. Internal recruitment of Forest Service biologists was carried out by the National Coordinator. Throughout the three years of the project, an average of 29 forests participated annually in the program.

Recruiting local citizens was a collaborative effort between the USFS national coordinator and the local USFS biologists. Various resources were developed to assist the biologists in their recruitment efforts. The strategy required the resident biologist submit a prepared press release, customized to their location, to their neighborhood newspaper. The release invited interested citizens to an upcoming lecture that would highlight opportunities for individuals or families to participate in bird conservation efforts on National Forest lands. The lecture was a prepared PowerPoint presentation that highlighted the project and gave interested citizens an idea of what the program entailed. After the lecture, individuals were encouraged to sign up to participate and were asked to attend a more intensive training session. All the materials for the training session were developed for the local biologist; they revised materials to match their potential study sites and geographical location. At the training session, participants were taught the protocol for the survey, given a forest safety overview, and were asked to select a study site to adopt for the season.

Because there was an average of 29 forests participating in a given year, the session's content and the amount of oversight provided to the volunteers varied. Some coordinators provided the volunteers with a backpack to sign out for their survey period. The backpack contained everything needed to complete the surveys (i.e. maps, compass, flash light, hard hats, gloves, field forms, tape recorder, bird

ID field guide, pencils, and pre-recorded tapes to conduct the playback protocol). Other USFS units required the volunteers to supply their own materials.

Collecting and submitting the final data forms was a critical aspect of the project. In the first year, all of the local USFS coordinators collected the data forms from the volunteers, quality checked them for completeness, and mailed the entire set of forms to CLO. By the second year of the project, CLO had developed and established a process for entering the data online. This made the data entry process far more efficient and provided the opportunity for the volunteers to work at the USFS office entering their own season's data. The local USFS coordinator still maintained the quality control check, but the volunteers now had the opportunity to submit their data and feel they had completed the final step of data collection. The on-line data submittal process proved to be very efficient and effective.

Recruitment of forests as well as local volunteers varied annually depending on the effort put forth by the national coordinator and the local district coordinator (Table 1). In 2001, the USFS developed a partnership effort with the Student Conservation Association (SCA) to provide student interns to forests that wished to host an intern to assist with the project implementation. The SCA is the leader in national resource conservation, providing service opportunities, outdoor skills, and leadership training to thousands of young women and men each year. The interns were sponsored by the forest, provided a place to live, and transportation to and from their home state. The expectation was that they would coordinate the program for the district biologists. The SCA partnership proved to be a very effective way for a forest to implement the program while providing young natural-resource professionals hands-on experience in their career field of choice.

Table 1. Participation by volunteers, National Forest, and SCA volunteers.

Year	Number of volunteers	Number of forests	Number of SCA volunteers
2000	76	26	-
2001	120	29	5
2002	76	33	6

A regional breakdown of participation by national forests in 2001 (Fig. 1) further illustrates the added value of SCA interns in increasing volunteer hours and number of sites; the presence of the USFS national coordinator in Region 6 clearly benefited project participation in that region.



Figure 1. Forest Service participation in 2001 showing the number of sites, volunteers, and volunteer hours by USDA Forest Service region.

Study Design and Protocols

For the purposes of our research, we restricted the study to high-use recreation areas on National Forest lands. These areas included overnight campgrounds and day-use locations such as picnic areas and boat launches. Relatively undisturbed, low impact sites that received minimal use, such as hiking trails and a few dispersed campsites, were not included in the study.

Participants selected three survey points in each recreation study area (Fig. 2). The first survey point (*R*) was in the geographic center of the high-use recreation zone, even if it fell within an unforested area. The high-use recreation zone was defined as the area that was physically modified or disturbed to accommodate recreational activities. This zone included all structures, roads, camping, and picnic sites. There was usually a clear delineation between this zone and the surrounding, undisturbed forest. The second point (*E*) was 500 feet or 150 meters from the edge of the high-use zone, within relatively undisturbed forest. The third point (*C*) was a control point located at least 1,500 feet or 460 meters, but not more than 5 miles or 8 km, from the edge of the high-use recreation zone. In addition, these points were at least 500 feet or 150 meters

from the edge of the forest patch. *C* and *E* points were required to be within the same forest patch and in similar habitats, thus allowing us to control for hydrology, elevation, and forest type. *C* and *E* points were required to meet criteria for standard B F L

points—the points must be in appropriate breeding habitat for the target species and the forest within the patch should be no less than 20 feet or 6 meters tall, whereas the *R* point did not need to meet these criteria. These three survey points were grouped into a study site for comparative analyses. All three survey points were located within the same contiguous forest patch so the between-point effect of fragmentation and other landscape-level changes were minimized.

The BFL study requires visiting each survey point twice and following a simple, standardized survey protocol. Each visit includes one 10-minute Observation Period, a 5-minute Playback Period for each focal species, and a 10-minute Behavior Watch Period. The playback period requires the participant to use the BFL CD to broadcast recorded vocalizations of their study species to elicit a response from local, territorial birds.

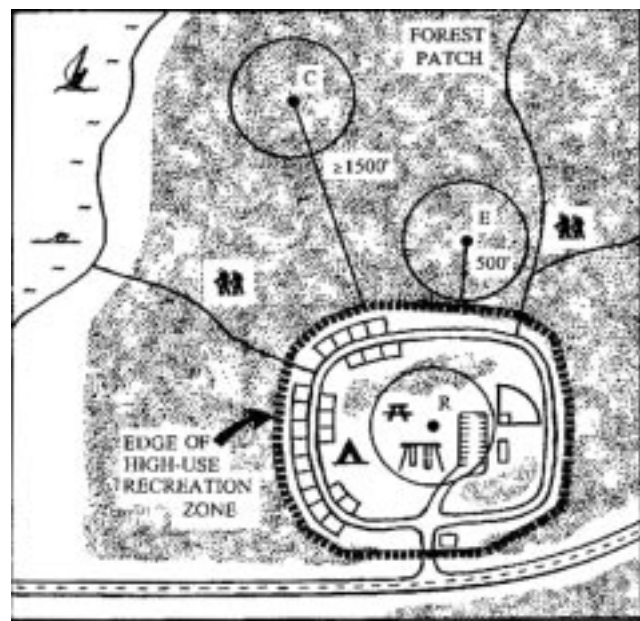


Figure 2. Study design showing the placement of the *R* (campground), *E* (edge), and *C* (control) points in and around a hypothetical campground. The three points, taken together, constituted one study site.

Once a bird has been drawn into view, volunteers use several behavioral cues that indicate its breeding status. (The codes for these behaviors were derived from Breeding Bird Atlas methodology.) This coding system allowed BFL participants to quickly and accurately determine a bird's breeding status and record the appropriate code on the BFL Field Form. The Behavior Watch Period requires the participant to broadcast a recording of chickadee mobbing calls with a calling Eastern Screech-Owl (*Megascops asio*) for the eastern version and a Northern Pygmy-Owl (*Glaucidium gnoma*) for the western version. Broadcasting mobbing calls greatly increases the probability of detecting breeding birds and identifying breeding behavior at or near the study site without having to search for nests (Gunn et al. 2000).

The basic protocol for Visit 1 and Visit 2 during the BFL recreation study was the same as the regular BFL protocol. For the purposes of the BFL recreation study, participants focused their efforts on thrushes only, building on the thrush data set collected by Forest Service teams in past seasons. Groups who were renewing participants were asked to use their same sites, and if time permitted, to consider adding more sites at additional recreation areas. We recommended beginning site visits late enough in the season (late May in most areas) to ensure that recreational activity had begun in each study area and to visit the sites at a relatively quiet time of day, preferably in the early morning. Points were surveyed on the same or consecutive days. If points were visited on consecutive days, participants were asked to go at the same time each day and to survey for all selected study species at a particular survey point on a given day.

In addition to the regular BFL protocol for Visit 1 and 2, participants were asked to record information about the presence and volume of any human-generated noise, and whether such noise interfered with their ability to hear birds. They also recorded whether or not trash containers were provided, the type provided and whether containers were covered or open. In addition, they were asked to rate the amount of trash outside of containers at the site. This information was recorded on the Recreation Field Form during the 10-minute Observation Period.

Data forms and data-entry web site

There were two data forms associated with the BFL recreation study; the *BFL Recreation Field Form*, used to record information about the two visits and to record characteristics of the survey points, study sites, and the surrounding landscape, and the *BFL Recreation Study-Site Coordinator Form* used to record information about the recreation area, which helped to determine the scope and intensity of recreational disturbance at each study site. This form was filled out in conjunction with the area's Forest Service Site Coordinator (see appendix).

A BFL recreation study web site:http://birds.cornell.edu/bfl/recstudy/rec_study_start.html with online data entry was developed specifically for this project (Fig. 3). Participants downloaded instructional materials from this site and entered all their data electronically. An online mapping tool was created that enabled participants to place their study points on a topographic map or aerial photograph and immediately download the latitude and longitude of their survey point into the BFL database. The data entry site was password-protected so a specific participant could only have access to their own data and to historical records associated with each site. There was also an optional email listserve available for participants, giving them the opportunity to interact with one another, share observations, and ask questions about the project.



Figure 3. Screen capture of Data Entry Welcome Page for CLO-USDA-FS web data entry for the Recreation project.

Data analysis

Data entered via the web were converted to SAS datasets (SAS Institute 1989). For predator species we tested for an effect of point type (REC) using mixed-model logistic regression with pre-planned contrasts (Proc Mixed (SAS Institute 1989) using the Glimmix macro (Littell et al. 1996) with a logit link and binomial errors to compare point types. Study site was treated as random, and point type (treatment) was treated as fixed.

For focal thrush species we tested for an effect of point type (REC) using mixed-model logistic regression with pre-planned contrasts, as for the predator species. The dependent variable for the predator regression was the presence or of the predator taxon on one or more visits; for the focal thrush species, the dependent variable was the presence of the focal species on both visits. This equates to “probable” breeding (Anonymous 1986).

We also regressed the presence or absence of potential predators and the focal thrush species at campgrounds (R points) on the two indices of disturbance available to us, the size of the high-disturbance zone and the number of camp-sites within the campground. (For these analyses the sample size is 143 sites, unless otherwise noted. Proc Logistic (SAS Institute 1989) was used for all analyses). We also used Proc Freq (SAS Institute 1996) to conduct contingency-table analyses of the effects of predator presence-absence on the occurrence of the focal thrush species at campgrounds.

RESULTS

Data were collected and returned to CLO from a total of 26 National Forests for the breeding seasons of 2000, 2001, and 2002. Participating forests were located in seven western and two eastern states, and the bulk of the study sites were located in the West, particularly in Oregon (Fig. 4). Two eastern Forest Service regions contributed 23 study sites and 5 sites were in Alaska. The total number of points from which we received data, pooled across all three years, was 525. This includes sites for which one or more of the three point types (i.e., R, E, C) was missing.

Many sites were missing data that were required for pre-planned analyses, even if some data were returned for all three points within a site. For example, information on the method used to calculate user-days, which we ex-

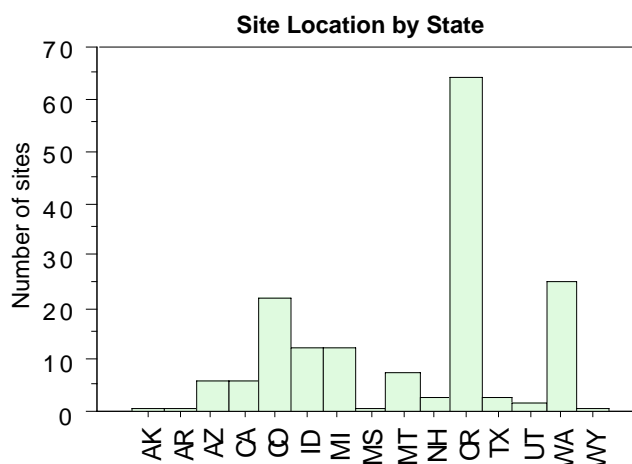


Figure 4. Number of study sites from which data were returned, by state. Figure is based on the number of unique R points, pooled across years, including those for which incomplete data were returned. Total number of sites = 167, not all of which can be included in analyses because of missing data.

pected *a priori* would provide the best index of disturbance due to recreation, was missing from the bulk of points. Where user days were reported, a total of four different metrics were used. The measures were sufficiently different to preclude converting among them.

Reported Site Characteristics

The number of user days was not reported for the bulk of study sites and when it was provided, four different metrics were used (Fig. 5). Therefore, we were not able to use this information in any analysis of effects of recreation on birds. The number of

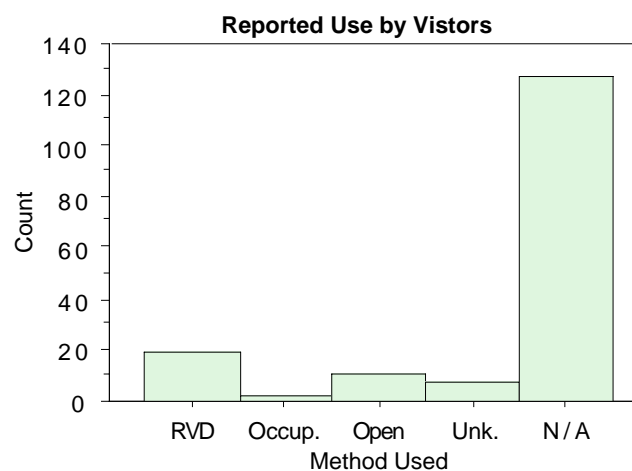


Figure 5. Reported methods used to collect campground usage data in user-days. (RVD = Recreation Visitor Day; Occup = Days Occupied; Open = number of days campground is open; unk = method unknown, but data submitted; N/A data were not submitted.)

campsites at each campground study site varied from 0 to 55; the median number of sites available was 18, and the mean (\pm s.d.) was 29.6 ± 31.5 (Fig. 6). The size of the high-usage, disturbed area at campgrounds varied from less than 0.2 ha (0.4 ac) to 57 ha (140 ac), with a median size of 3 ha (8 ac) and a mean of 5.7 ± 8.6 (14 ± 21.2).

Permanent structures were reported at 125 of 143 study sites (87.4%); at 24 of 167 sites (14.4%) the presence or absence of permanent structures was not reported. Electricity was available at eight of 109 (7.3%) sites reported, and eight sites reported some kind of lighting.

Covered trash containers were reported at 121 sites (72.4%); one site reported an uncovered trash container, and 46 sites (27.5%) did not report arrangements for trash disposal.

A wide range of recreational activities was permitted at the campgrounds (Fig. 7). Hunting was permissible at 43 of 126 sites (34.1%; 41 sites not marked). Horseback riding was permissible at 54 of 120 sites (45%; 48 sites not marked). Mountain biking was allowed at 90

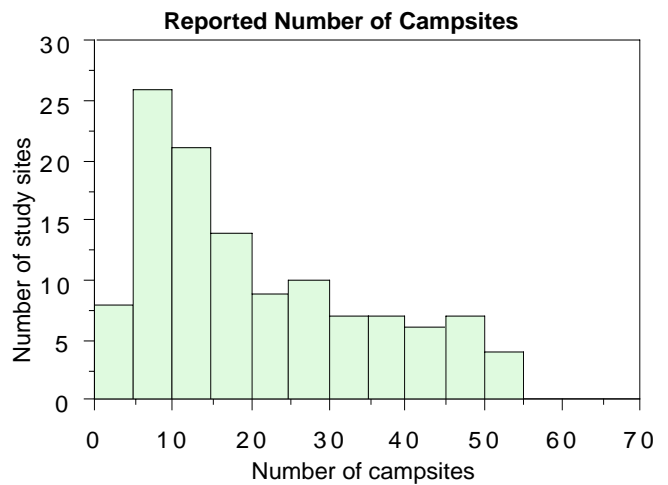


Figure 6. Number of campsites per campground, where reported. Figure is based on the number of unique R points, pooled across years, including those for which incomplete data were returned. Total number of study sites = 167, not all of which can be included in analyses.

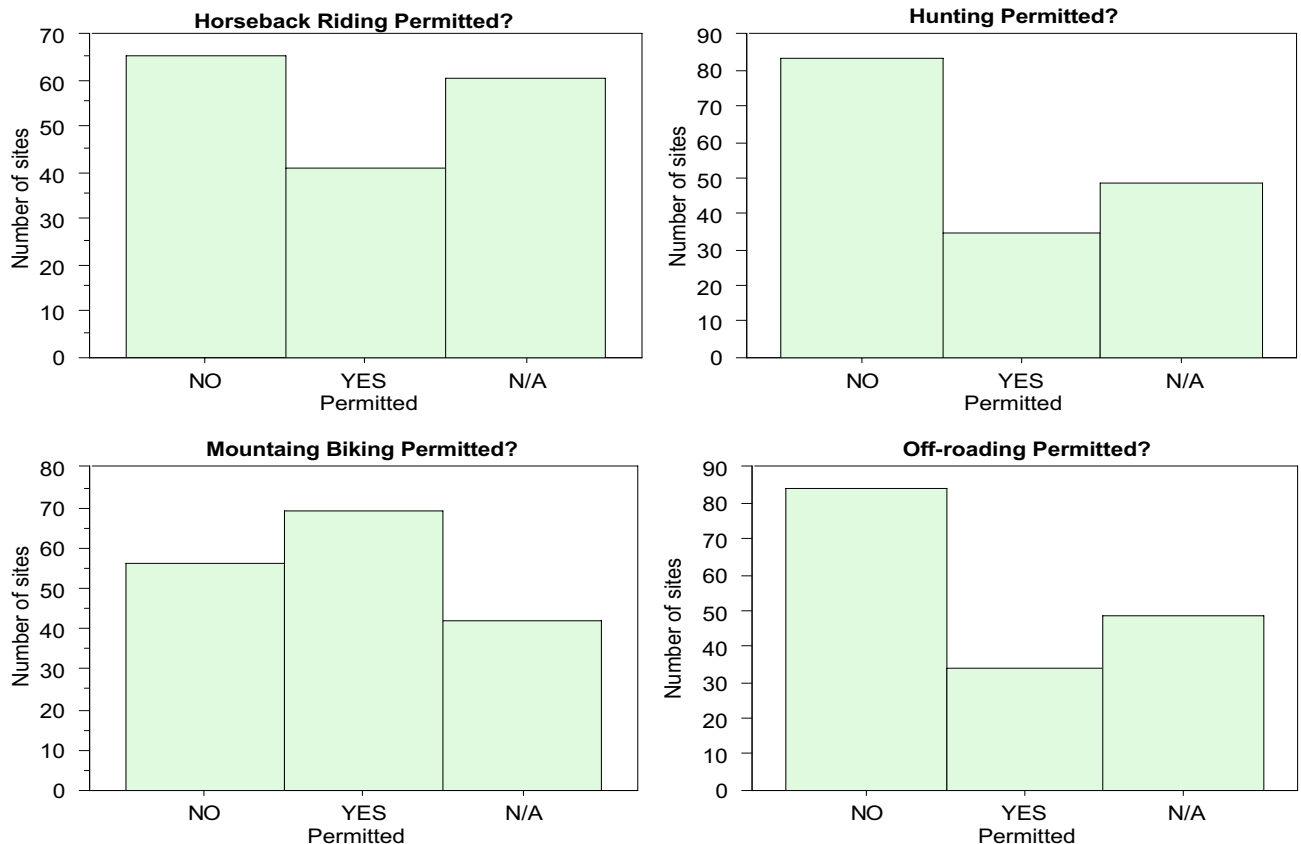


Figure 7. Visitor activities that are allowed at each campground (Yes = activity allowed; No= activity not allowed; N/A = section not marked on Site Coordinator Form.)

of 146 sites (61.6%; 21 (12.6%) not marked) and off-road vehicle use was permitted at 35 of 119 (29.4%; 48 sites (28.7%) not marked). In addition, pets were allowed at 154 of 167 (94%) campgrounds. Although these represent allowable activities at recreation sites, we have no way to assess how much activity or disturbance actually took place in the campgrounds; therefore, we did not test specifically for an effect of these activities on thrushes.

Table 2. Scoring coefficients from principal components analysis of vegetation variables at all campground, edge, and control sites. Factors derived using Varimax rotation; factors as presented are standardized to a mean=0 and Standard Deviation=0.

	Factor 1	Factor 2	Factor 3	Factor 4
Canopy Height	0.34330	0.06989	0.30688	0.10959
Coniferous Canopy	0.53910	0.00776	0.03966	0.05697
Deciduous Canopy	-0.47985	0.06735	0.28301	0.25690
Coniferous Shrubs	-0.02450	-0.05836	-0.15745	0.87246
Deciduous Shrubs	0.06735	0.68356	-0.19016	-0.20563
Saplings	0.00875	-0.03799	0.78014	-0.17685
Total Low Vegetation	-0.00376	0.56652	0.15953	0.13830

Changes in vegetation structure at campgrounds

We examined seven vegetation variables that were measured at all campground, edge, and forested control points using principal components analysis (PCA). This analysis resulted in four factors — gradients of vegetation structure that represented potential changes due to disturbance at campgrounds, compared with undisturbed forest (Table 2). The first factor distin-

guished points with taller canopies dominated by coniferous trees, compared with points with shorter, more open canopy or dominated by deciduous trees. Not surprisingly, campground points were significantly different (shorter more open canopy) from control points along this gradient ($p=0.0434$), with edge points being intermediate and not different from either camp-

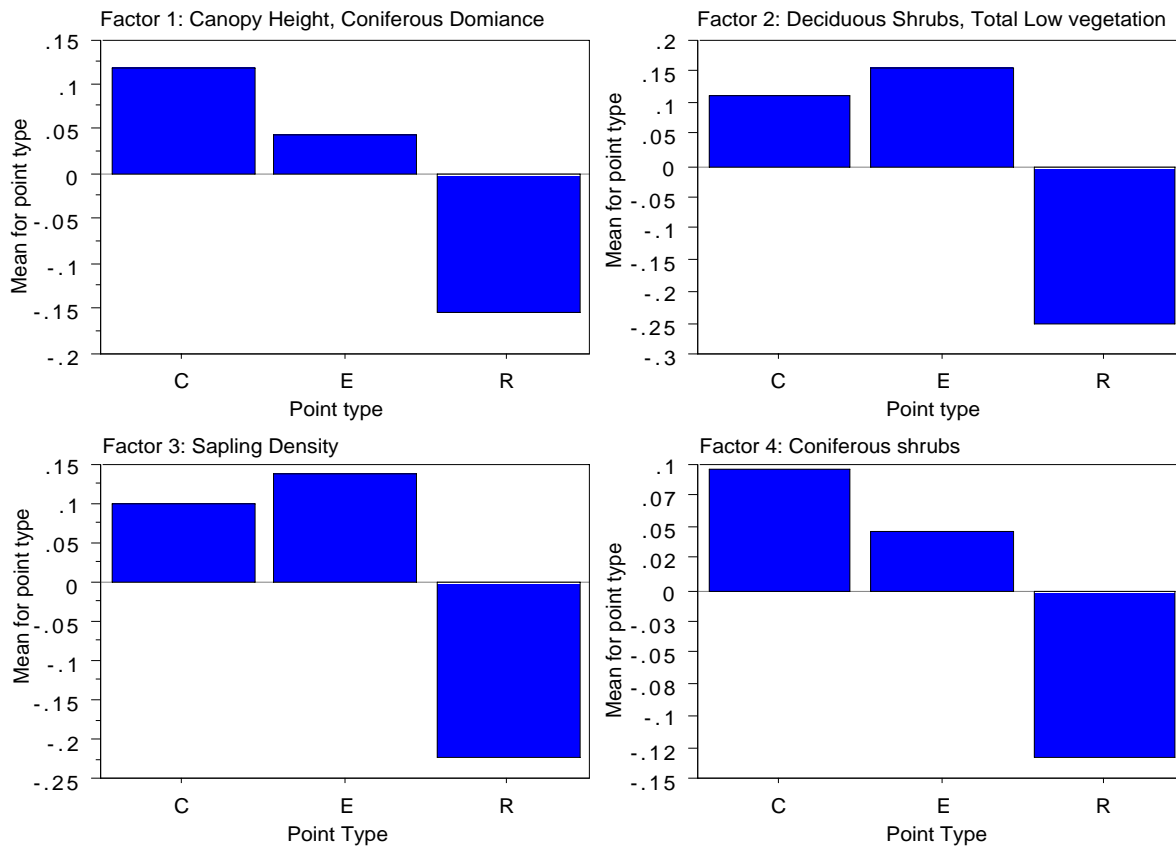


Figure 8. Changes in vegetation structure at campgrounds in National Forests. Point types are recreation (campgrounds)=R, forested control=C, edge of campground=E. Mean values for each point type based on principal components analysis of seven vegetation variables (see Table 2 and text).

grounds or controls (Fig. 8). The second factor separated points according to their density of understory vegetation, particularly deciduous shrubs. In this case, campgrounds differed significantly (lower shrub density) from both control points ($p=0.0074$) and edge points ($p=0.0026$); although edge points tended to have the highest understory density, these did not differ significantly from controls (Fig. 8). The third factor represented differences in sapling density among points, in particular young coniferous trees. As with shrubs, campground points differed significantly (lower sapling density) from control points ($p=0.0166$) and edge points ($p=0.0079$), with edge points showing the highest sapling density (Fig. 8). Factor 4 identified points with high evergreen shrub density, again with campground points showing significantly lower density than control points ($p=0.0941$).

Overall, campground points differed significantly with respect to vegetation structure from forested control points, with campgrounds exhibiting lower and more open canopies and lower densities of understory shrubs and saplings. In most cases, edge points did not differ from control points, indicating that the changes in vegetation structure did not extend beyond the edge of the campgrounds. There was a tendency for edge points to show the highest shrub and sapling densities, however.

Characteristics of landscape surrounding the campgrounds

Most campground study sites were situated within large forest patches (Fig. 9), with a median patch size of 4,050 ha (10,000 ac). The proportion of forested land in the landscape surrounding each study site also was high, with a median forest coverage of 85% (Fig. 9). The median distance of the edge point from the recreation point was 116 m (380 ft). The median elevation for study sites was 1,036 m (3,399 ft.) above sea level.

Effects of recreation site on breeding thrushes

Analyzable data were returned on attempted breeding by four focal thrush species. Although participants sampled for Wood Thrush at 64 sites, this species was detected at only nine sites, precluding further analysis.

The Hermit Thrush was the most widespread species in this study, with participants sampling for the Hermit Thrush at 165 study sites (493 REC points); a majority of sample sites for this species were in Oregon (64), Washington (22), and Colorado (22).

Hermit Thrushes were detected at 29% of study points, including 27% of campground points (Fig. 10). Although Hermit Thrushes were equally likely

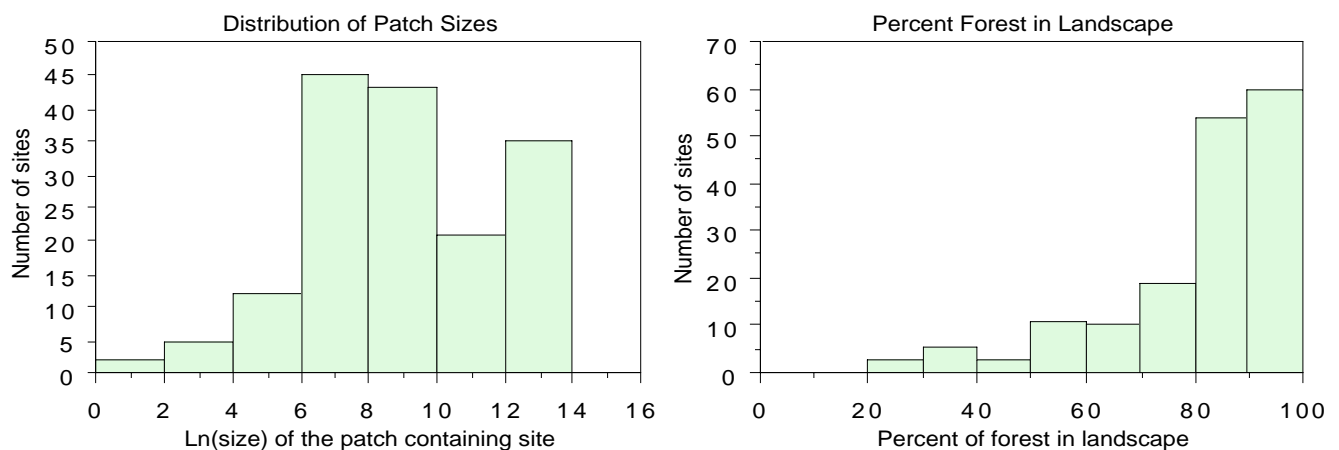


Figure 9. Patches containing study sites were generally large and located in landscapes containing large amounts of forest.

to be present at campground, edge, and control points ($p = 0.3188$), when we considered only points where thrushes were present on both visits (indicating attempted breeding through the season), we found a highly significant effect of point type (Table 3). Hermit Thrushes were significantly more likely to be present through the season at forested control points than at either campground or edge points, and edge points were more likely to have breeding Hermit Thrushes than campground points. We found no effect of either campground size ($p=0.4380$) or number of campsites ($p=0.8489$) on the presence of Hermit Thrush.

We received data on attempted breeding by Swainson's

Table 3. Effects of point type on breeding thrushes. The overall model measures an effect of point type on the probability of detecting a thrush species on both visits to a site, indicating probable breeding (Anonymous 1986). Contrast indicates paired comparisons among point types.

Thrush Species	N	Model p -value	Planned Contrast	p -value
Veery	53	0.0016	Control-Recreation	0.0004
			Control-Edge	0.1856
			Edge- Recreation	0.0167
Swainson's Thrush	158	0.0022	Control- Recreation	0.2058
			Control-Edge	0.0007
			Edge- Recreation	0.0247
Hermit Thrush	165	0.0001	Control- Recreation	0.0001
			Control-Edge	0.0040
			Edge-Recreation	0.0341
Varied Thrush	96	0.2647	Control- Recreation	0.1590
			Control-Edge	0.1513
			Edge- Recreation	0.9765

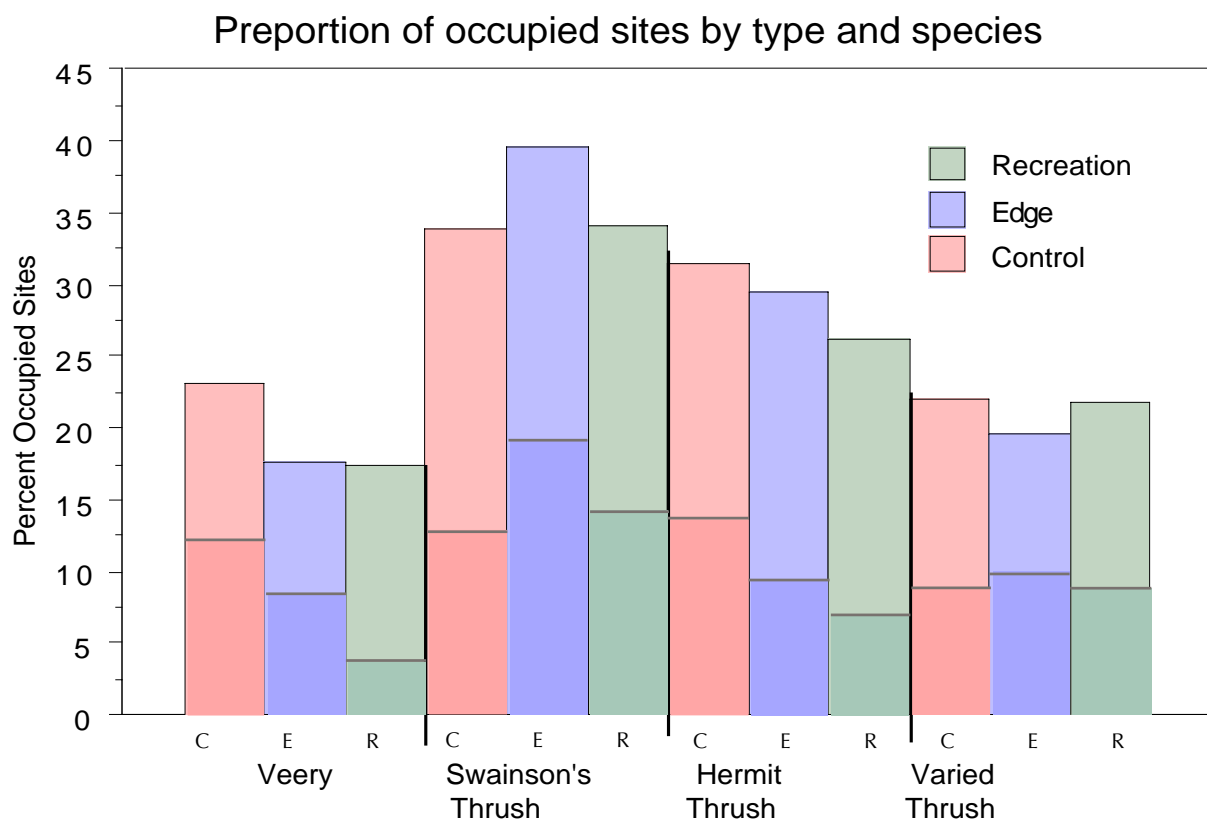


Figure 10. Proportion of each point type sampled that was occupied by the focal species. In Veery, Hermit, and Varied Thrush there was no effect of point type on thrush presence on at least one visit; for the Swainson's Thrush probability of occupation of the point was significantly predicted by point type ($p=0.0393$). A stronger measure of reproductive success (the probability that thrushes were present on both visits, indicating attempted breeding through the season) indicated a significant reduction at campground sites for Hermit Thrush and Veery (see Table 3).

Thrushes at 161 study sites (471 REC points). As with the Hermit Thrush, most sample sites were from Oregon (64), Washington (25), and Colorado (22). Swainson's Thrushes were present at 36% of these sites, including 345 campground points (Fig. 10). There was a significant effect of point type ($p=0.0393$) on their presence; however, there was no significant difference in probability of presence between control and recreation points ($p= 0.9845$). Swainson's Thrush was more likely to be found in edge points than either campground points ($p=0.0278$) or control points ($p=0.0279$). A similar pattern was evident when we considered only points where Swainson's Thrush was present on both visits, with a significantly greater probability of finding breeding thrushes at edge points than either campground or control points (Table 3). Within campgrounds, we found a weak effect of the size of the disturbed zone (fewer thrushes at larger campgrounds; $p=0.0646$), but no effect of number of campsites on Swainson's Thrush presence ($p=0.7520$).

Participants sampled for Varied Thrush at 96 study sites (279 REC points), primarily in Oregon and Washington. While this thrush was found at 21% of points (Fig. 10), there was no significant effect of point type on their presence ($p= 0.4678$), nor on the probability of Varied Thrushes remaining through the season to attempt breeding (Table 3). The presence of Varied Thrush at campground points, however, was significantly related to the size of the disturbance zone (fewer thrushes at larger campgrounds; $p=0.0516$). Presence was not related to number of campsites ($p=0.1306$).

For the Veery, data were returned from 53 study sites (155 REC points). A majority of

sample points for Veery were located in Washington, Michigan, and Montana. Overall, Veeries were detected at 19% of sites, including 17% of campground points (Fig. 10). Veeries were equally likely to be present at campground, edge, and forested control points ($p= 0.402$). When we considered only points where Veeries were present on both visits, however, the effect of campgrounds became significant. Veeries were more likely to stay through the breeding season (indicating attempted breeding) at control and edge sites than at campground sites (Table 3). The presence of Veeries at campground sites was not related to either the size of the disturbance zone ($p=0.6771$) or the number of campsites ($p=0.7671$).

Overall, our results indicate a significant negative effect of campgrounds on breeding thrushes, with reduced probability of breeding by Hermit Thrushes and Veeries at campgrounds and a reduced presence of Varied Thrushes at larger campground sites (Table 4).

Predators at campgrounds

The protocol called for participants to report the presence and abundance of potential nest predators at each point, as well as possible competitors of the focal species. The following predators and competitors were not reported at any points: domestic cats, grackles, European Starlings, and House Sparrows. Raccoons were reported during one visit to a campground, and a bear was reported on two visits. Pets were reported on 19 visits to campgrounds; 18 reports were of one pet on one visit, and one report was of >1 pets.

Table 4. Summary of effects of campgrounds on breeding thrushes in National Forests. Presence is defined as the focal species detected on at least one visit; probable breeding is defined as the species detected on both visits.

Thrush species	Effect on presence?	Effect on probable breeding?	Effect of campground size?	Effect of number of campsites?
Hermit Thrush	NO	YES	NO	NO
Swainson's Thrush	YES	YES	NO	NO
Varied Thrush	NO	NO	YES	NO
Veery	NO	YES	NO	NO

At least one mammalian nest predator was reported at 95 of 167 points (56.8%). Chipmunks were the most frequently reported mammalian predator, being present at 69 of 167 (41.3%) points, with up to eight chipmunks counted per campground (Fig. 11). Red or Douglas squirrels were reported at 51 of 167 (31%), although usually only a single squirrel was reported (Fig.

11). Jays of various species were reported at 41 of 167 points (25.5%), with up to 5 individual jays per campground (Fig. 11). Crows or ravens were reported at 72 of 167 points (43.1%), with up to 4 individuals reported (Fig. 11). Overall, at least one avian predator was reported at 92 of 167 points (55%) with 58 points reporting more than one individual (Fig. 12).

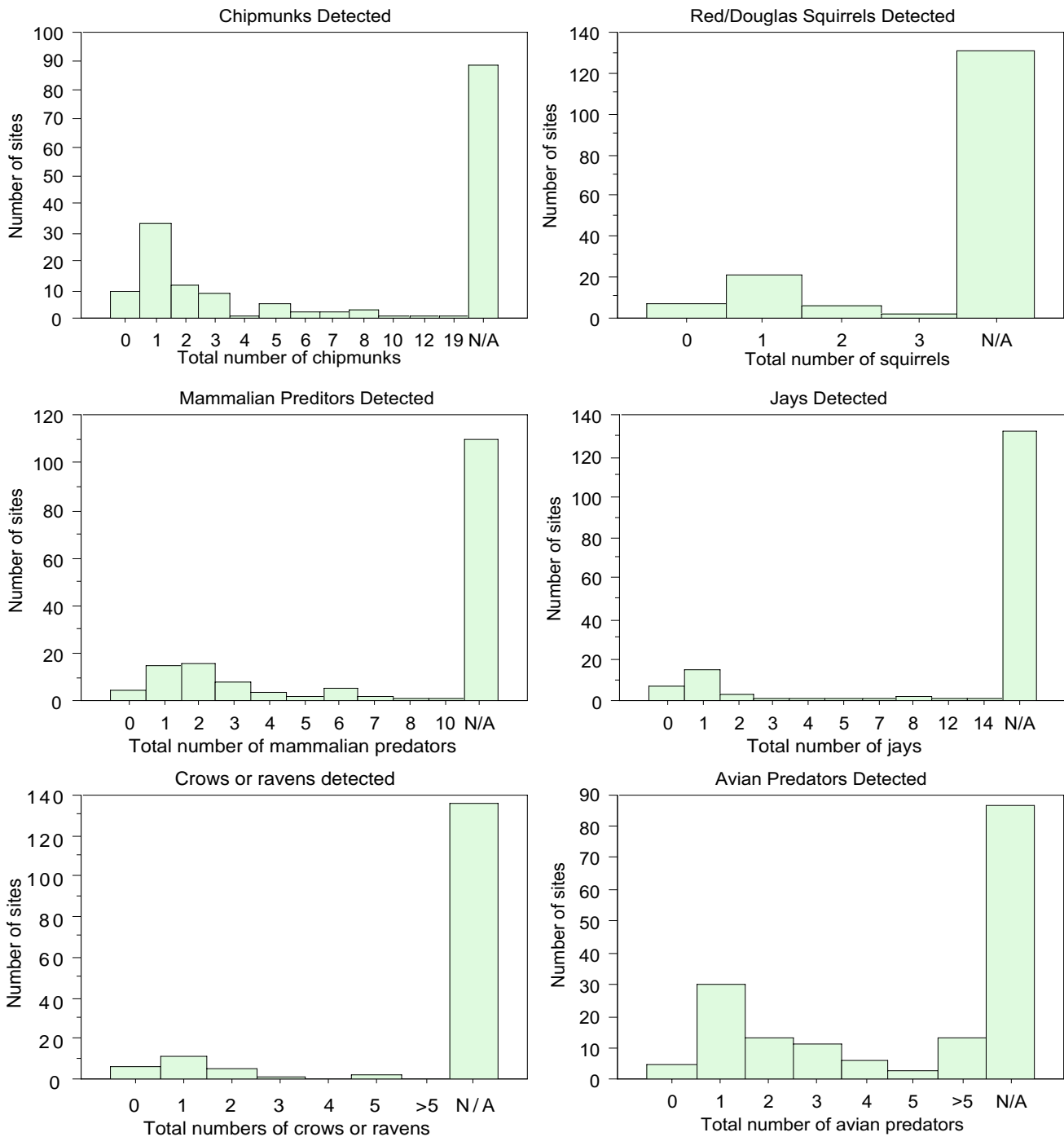


Figure 11. Number of mammalian and avian nest predators detected at each R or campground site. (N/A means that the Field Form was not marked for this category of predator.)

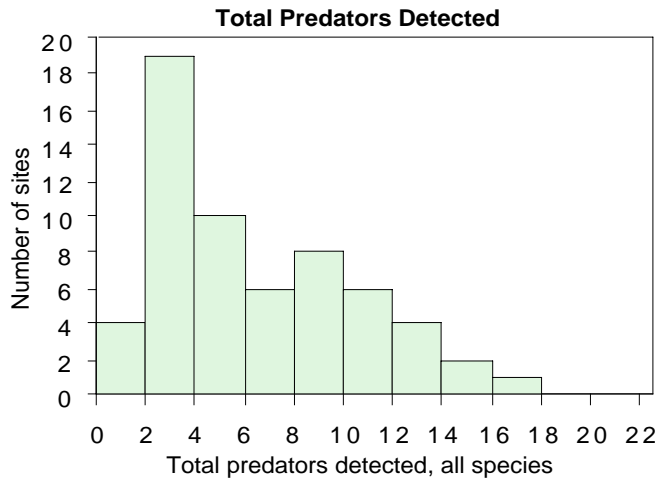


Figure 12. Distribution of the total number of predators detected, including all predator species. Sites that did not report presence or absence of predators are excluded from this figure.

Effects of point type on predator presence or absence

In general, predators were more likely to be detected at campgrounds and less likely to be found at either edge or control points. In most cases, control and edge points did not differ significantly in the probability of occurrence of the focal predator species, but occurrence was usually significantly higher at campgrounds than either of the other point types (Fig. 13 and Table 5).

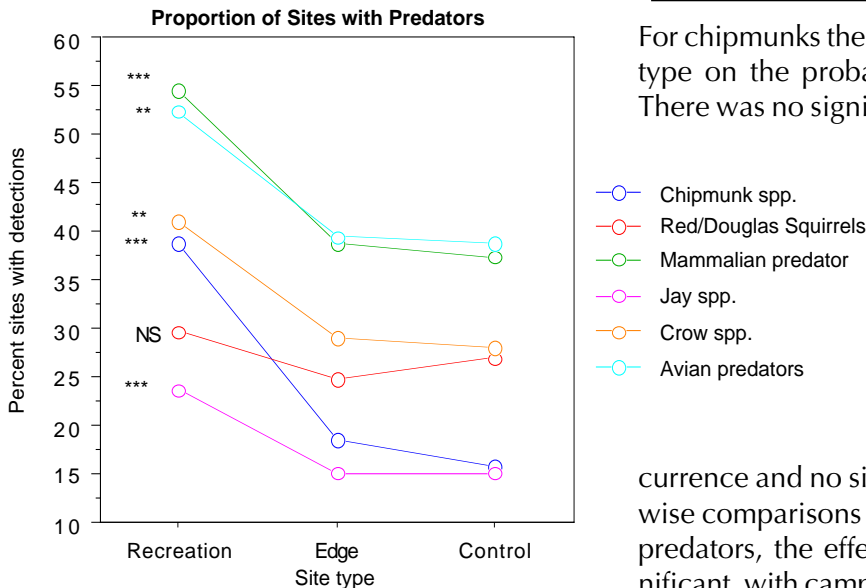


Figure 13. Proportion of each point type at which a predator was detected. *P*-values are the result of mixed-model logistic regression (*= $p=0.05$; **= $p=0.001$; ***= $p=0.0001$; NS=not significant). See Table 5 for paired contrasts between point types.

Table 5. Effects of point type on predator presence. The overall model measures an effect of point type on the probability of detecting a predator on either visit to a site. Contrast indicates paired comparisons among point types.

Predator type	N	Model <i>p</i> -value	Planned contrast	<i>p</i> -value
Chipmunks	175	0.0001	Control-Recreation	0.0001
			Control-Edge	0.2872
			Edge-Recreation	0.0001
Red/Douglas squirrels	175	0.2086	Control-Recreation	0.2286
			Control-Edge	0.6067
			Edge-Recreation	0.0863
All mammalian predators	175	0.0001	Control-Recreation	0.0001
			Control-Edge	0.6644
			Edge-Recreation	0.0003
Jays	175	0.0001	Control-Recreation	0.0001
			Control-Edge	0.8438
			Edge-Recreation	0.0001
Crows or ravens	175	0.0002	Control-Recreation	0.0002
			Control-Edge	0.6651
			Edge-Recreation	0.0010
All avian predators	175	0.0008	Control-Recreation	0.0006
			Control-Edge	0.7330
			Edge-Recreation	0.0019

For chipmunks there was a significant effect of point type on the probability of occurrence (Table 5). There was no significant difference in the probability of occurrence between control and edge points, but chipmunks were significantly more likely to be found at campgrounds than either control or edge points.

For red and Douglas squirrels, there was no effect of point type on the probability of occurrence and no significant differences in any pairwise comparisons (Table 5). Across all mammalian predators, the effect of point-type was highly significant, with campgrounds significantly more likely to have at least one mammalian predator than either edge or control points.

Among the avian nest predators, there was a highly significant effect of point type on the occurrence of

jays, with campground sites more likely to have jays present than either edge or control points (Table 5). Presence of crows or ravens also showed a highly significant effect of point type, with campgrounds showing a greater probability of encountering crows than either edge or control points.

Considering all avian nest predators, there was a highly significant effect of point type on the probability of occurrence. While there was no significant difference in the probability of detecting an avian predator at an edge as opposed to a control point, campgrounds had a much greater probability of supporting an avian predator than either edge or control points (Table 5).

Predator presence in relation to campground characteristics

To further examine possible effects of campground development, we tested for an effect of either the size of the high-disturbance zone (N = 143 sites reporting) or the number of campsites (N = 122) on occurrence of predators at campground points. For chipmunks, there was no significant effect of either high-disturbance zone size ($\chi^2 = 2.347$, $df=1$, $p=0.1256$) or of the number of campsites ($\chi^2 = 0.634$, $df=1$, $p=0.4258$) on the probability of occurrence.

For red or Douglas squirrels, there was no significant effect of high-disturbance zone size ($\chi^2 = 0.898$, $df=1$, $p=0.3433$), but squirrel occurrence showed significant increases with increasing number of campsites at campground points ($\chi^2 = 3.934$, $df=1$, $p=0.0473$, con-

correlation=0.55). Across all mammalian predators with sufficient sample for analysis (chipmunks and red/Douglas squirrels) there was no significant effect of the size of the high-disturbance zone ($\chi^2 = 2.297$, $df=1$, $p=0.1296$, but the probability of occurrence increased strongly with increasing number of campsites ($\chi^2 = 6.793$, $df=1$, $p=0.0092$, correlation=0.613).

For jays, there was no significant effect of either the size of the high-disturbance zone ($\chi^2 = 0.676$, $df=1$, $p=0.4109$) or number of campsites ($\chi^2 = 0.237$, $df=1$, $p=0.6262$) on occurrence. Similarly, neither disturbance zone size ($\chi^2 = 0.018$, $df=1$, $p=0.8928$) nor number of campsites ($\chi^2 = 1.624$, $df=1$, $p=0.2024$), had a significant effect on the occurrence of crows or ravens. There was also no effect of either zone size ($\chi^2 = 0.040$, $df=1$, $p=0.8423$) or number of campsites on the probability of occurrence for all avian predator species combined.

Summary of effects on potential nest predators

Overall, the presence of campgrounds significantly increased the occurrence of potential nest predators, compared with nearby forested sites on National Forests (Table 6). This was true for both mammalian and avian predators. The presence of predators was not related to the size of the disturbed zone at campgrounds, but the probability of finding mammalian predators, particularly red or Douglas squirrels, was positively related to the number of campsites present.

Table 6. Summary of effects of campgrounds on nest predators in National Forests.

Predator type	More at campgrounds?	Effect of campground size?	Effect of number of campsites?
Chipmunks	YES	NO	NO
Red/Douglas squirrels	NO	NO	YES
All mammalian predators	YES	NO	YES
Jays	YES	NO	NO
Crows or ravens	YES	NO	NO
All avian predators	YES	NO	NO

CONCLUSIONS AND RECOMMENDATIONS

Effects of recreation on forest birds and potential nest predators

Overall, this study documented significant effects of campground development and activities on breeding thrushes in extensively forested national forest lands. Apparently, the relatively low-level, local disturbance and small openings created by campgrounds in large contiguous forests did not inhibit the occurrence of thrushes during the breeding season. The effects we documented, however, indicate that thrushes at campgrounds have a significantly reduced tendency to remain through the breeding season. These results strongly suggest that either fewer thrushes attempt breeding at campground sites, or that breeding success is reduced, thus causing birds to abandon territories in campgrounds. For the species with largest samples, the Hermit Thrush, the negative effect on attempted breeding extended to the edge of the campgrounds.

Negative impacts on breeding thrushes could be due to structural changes in vegetation documented at campgrounds (lower understory densities), or to increases in predation pressure (see below), or to some combination of these factors. In fact, the mere presence of human hikers, particularly if they are accompanied by dogs, may disturb nesting birds (Fernandez-Juricic et al. 2004) and cause them to flush (Miller et al. 2001, Swarthout and Steidl 2001, 2003). Further, approaches by humans who are not on established paths may increase the risk of flushing and, in turn, may lead to increased energetic demands, lower rates of food intake (Swarthout and Steidl 2001), or increased risk of predation on the adults or nests. This pattern has been shown not only in grassland birds, owls and diurnal raptors (Swarthout and Steidl 2001), but also in the American Robin (Miller et al. 2001), a forest-nesting bird that is closely related to the thrush species in this study.

Because of the potential for decreased reproductive success, it is possible that campgrounds with suitable nesting habitat for thrushes may serve as ecological traps by attracting birds to areas with abnormally high densities of nest predators. Extensive forest surrounding campgrounds may serve as a buffer, with a pool of individuals continually available to fill any breeding vacancies, even if thrushes were not reproducing successfully in and

around campgrounds. This could explain why we found no effect of campgrounds on the presence of thrushes, but did find a reduced probability of thrushes remaining there throughout the breeding season. More intensive research that includes nest searching and monitoring may shed light on the impact of recreation on reproductive performance.

Our research clearly demonstrated significant increases in potential nest predators at campgrounds. This finding is consistent with other studies that found increased numbers of small mammals (Clevenger and Workman 1977) and American Crows (Marzluff et al. 2001) in campgrounds and other recreation areas. The primary reason cited for the increased predator densities in these other studies was supplemental food left behind by campers. Specifically, in our study, the number of red/Douglas squirrels increased with the number of campsites, but not overall campground size. It seems reasonable that the number of campsites provides an index to the amount of artificial food available; i.e., more campers equals more food waste.

All of the potential nest predators we detected are common elements of the forested ecosystem surrounding the recreational sites. Although abundance of these predators increased at campgrounds, these disturbed sites did not attract new species of non-forest predators. Similarly, the occurrence of Brown-headed Cowbirds, a nest parasite, at campgrounds was negligible, consistent with other studies of small-scale disturbance in extensively forested landscapes.

Thrushes were selected for this study because, as ground and shrub-nesters, they were hypothesized to be sensitive to both disturbance of vegetation around campgrounds and an increase in ground-based nest predators. This study did not address, however, potential impacts on other forest-breeding species and more sensitive environments, such as riparian corridors or habitats with considerable forest fragmentation. Effects on canopy-breeding birds may be less likely to occur, and more difficult to detect, given the levels of disturbance we measured.

Success of citizen-science approach on national forests: USDA-FS perspective

(Barb Kott) This partnership offered the Forest Service (USFS) an opportunity to work with local community volunteers on a science-based conservation program at a national scale. Projects of this geographic scope are generally difficult to coordinate on such a scale. From a USFS perspective, the opportunities afforded by this program, (i.e. the ability to participate on a science-based project with Cornell's Lab of Ornithology, the potential to involve local citizens in the data collection, and the opportunity to recommend management options applicable to the Forest Service) were highly advantageous and determined by USFS participants to be well worth the investment.

Valuable lessons were learned throughout the four-year term of the project. The positive aspects include the opportunity this program provided the Forest Service to collaborate with Cornell's Lab of Ornithology and local

citizens throughout the country. Working with forest visitors, stewards, and or advocates in this effort built a rapport and positive support network of individuals to assist with the data collection. Members of communities surrounding the study sites on the various National Forest throughout the country stepped forward to collaborate and help carry out this win-win project. This effort could not have been completed without the assistance of the numerous local citizen scientists; their enthusiasm and dedication made the project a success in more ways than one.

This effort also provided the Forest Service with a forum to educate participants on the issues surrounding bird conservation locally and globally. Many of the citizen scientists have continued to assist and stay involved with other avian monitoring efforts occurring on public lands. This has helped to close the knowledge gaps that impede avian conservation efforts and has served to continue the lasting partnerships begun under this Challenge Cost-share Agreement.

Recommendations for Campground Management

Based on the results of this study of breeding thrushes at campgrounds, as well as additional studies in the literature, we offer the following recommendations for management of campgrounds on National Forests:

- Minimize disturbance to natural vegetation in and around campgrounds, especially understory shrubs and saplings that provide shelter and nest sites for forest birds. This could include restrictions on gathering small branches and downed woody materials for firewood.
- Retain islands of protective vegetative cover within larger campgrounds; disperse campsites to create a mosaic of suitable and disturbed habitats.
- Restrict the availability of food to predators. This could be done by asking campers to keep food in sealed containers and making sure that refuse containers are sealed and emptied frequently. Educational materials aimed at preventing campers from willingly feeding camp visitors, such as chipmunks or jays, may also be warranted.
- Where predator densities are artificially high and impacts on birds and other wildlife are measurable, local and limited control may be warranted.
- Minimize or manage human traffic to and from campgrounds and campsites; restrict traffic to trails, and keep dogs on leash.
- Restrict high-disturbance activities (e.g. ballfields, pavilions) to core areas of campgrounds to minimize disturbance effects close to the forest edge.
- Avoid placement of campgrounds in rare or sensitive habitats, where a buffering effect of surrounding vegetation on bird populations may not exist.

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