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INTRODUCTION

The influence of logging on breeding-season bird populations has been documented for a variety of forest types in the Western United States: mixed conifer (Franzreb and Ohmart 1978; Mannan and Meslow 1984; Verner and Larson 1989), coastal Douglas-fir (*Pseudotsuga menziesii*) (Hagar 1960; Meslow 1978), interior Douglas-fir (Medin 1985; Medin and Booth 1989), giant sequoia (*Sequoiadendron giganteum*) (Kilgore 1971), lodgepole pine (*Pinus contorta*) (Austin and Perry 1979), and ponderosa pine (*Pinus ponderosa*) (Szaro and Balda 1979).

Medin (1985) provided a summary of bird species' responses to various logging methods based on several of the cited studies. Although general patterns of response were evident for many species, certain species, including yellow-rumped warbler (scientific names of bird species censused in the study area are in the appendix) and hairy woodpecker were reported to increase, decrease, or show no response following clearcutting. This suggests that studies of bird responses to logging may be spatially or temporally specific. Thus, a need exists for other investigations of the effects of logging on birds, especially in unstudied forest types.

Recently we studied the influence of logging on a wide range of birds in the Coram Experimental Forest, located within the western larch (*Larix occidentalis*) forest cover type (Eyre 1980). This report describes 2 years of observed differences in the avian assemblage following logging and site-preparation treatments.

STUDY AREA

This study was located within the southern quarter of the Coram Experimental Forest (CEF),

about 28 miles (45 km) east of Kalispell, MT, on the Flathead National Forest (fig. 1). It includes both the Terrace Hill sale area (THSA) and the adjacent Coram Research Natural Area (CRNA) (fig. 2).

Description

The site occupies a portion of the watershed drained by the South Fork of Abbot Creek. The THSA ranges in elevation from 3,360 to 4,500 ft (1,021 to 1,372 m), lies mostly southwest of Abbot Creek, and is on northeast-facing slopes. The CRNA ranges in elevation from 3,500 to 4,458 ft (1,067 to 1,359 m), lies northeast of Abbot Creek, and is mostly on southwest-facing slopes. Slopes of both areas range from 5 to 35 percent. Annual precipitation averages 34 inches (86 cm). Temperature averages 60 °F (16 °C) from May through August (Hungerford and Schlieter 1984).

The study area represents a seral stage of the subalpine fir/queencup beadlily (*Abies lasiocarpa/Clintonia uniflora*) habitat type classified by Pfister and others (1977). Western larch and Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) are the dominant trees on the CEF. The old-growth larch is composed mostly of 300-year-old trees and occasionally of 500-year-old veterans. Other trees include Engelmann spruce (*Picea engelmannii*), subalpine fir, lodgepole pine (*Pinus contorta*), western white pine (*Pinus monticola*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), and black cottonwood (*Populus trichocarpa*). Dominant shrubs include Rocky Mountain maple (*Acer glabrum*) and fool's huckleberry (*Menziesia ferruginea*). Queencup beadlily and pinegrass (*Calamagrostis rubescens*) are the primary herbs.

①

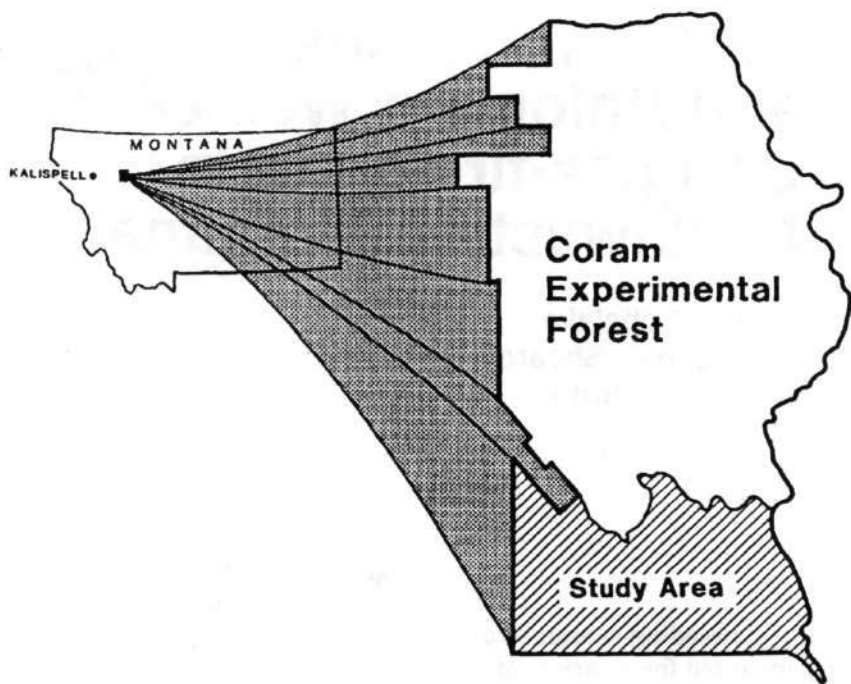


Figure 1—Location of study area within Coram Experimental Forest, northwestern Montana.

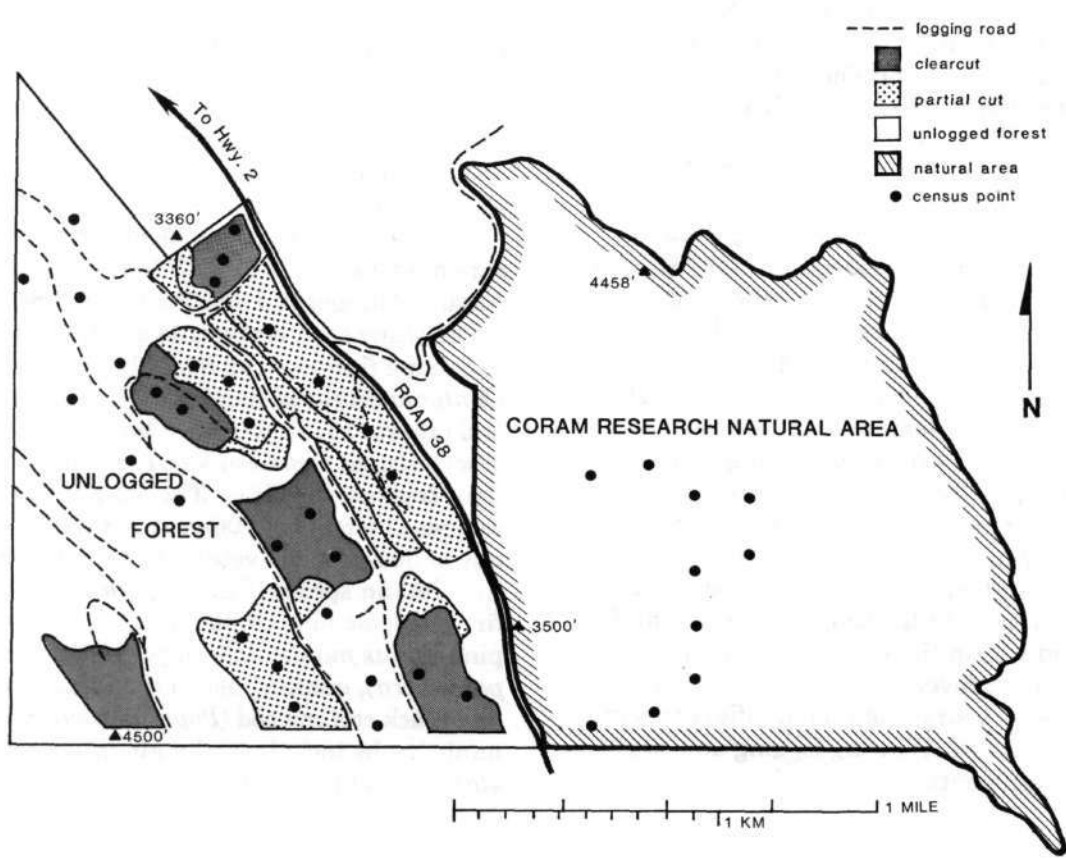


Figure 2—Posttreatment stand conditions and location of bird-count/vegetation sampling points on the Terrace Hill sale area and Coram Research Natural Area, Coram Experimental Forest, 1989 and 1990.

TREATMENTS

The THSA was initially harvested from 1942 to 1944, leaving three to five seed trees over 12 inches (31 cm) d.b.h. per acre (0.4 ha) (Fredeking 1953). The seed trees and trees that were unmerchantable in the 1940's were removed in the winter of 1988-89 within partial-cut units, and more extensive over-story removal occurred in the clearcut units. Based on guidelines for the management of cavity-nesting birds by McClelland and Frissell (1975), snags of all species of trees, along with living paper birch, quaking aspen, and black cottonwood, were retained in the cutting units during the recent harvest (figs. 3 and 4).

The THSA was 650 acres (263 ha) and included clearcut and partially cut units along with unlogged forest (fig. 1). There were five clearcuts ranging from 14 to 35 acres (6 to 14 ha). The largest partial-cut unit was 70 acres (28 ha), and eight others ranged between 5 and 40 acres (2 and 16 ha). Experimental controls were provided by the unlogged forest of 330 acres (134 ha) within the THSA and the adjacent 837-acre (339-ha) CRNA.

Slash piling and scarification of the units was accomplished with a bulldozer in 1989. Most of the slash piles were burned during the autumn of 1989, and sites with slopes greater than 20 percent were broadcast burned in September 1990.



Figure 3—Evidence of woodpecker foraging surrounds a wildlife tree marker on a western larch snag. The snag was retained for wildlife use within a clearcut on the Terrace Hill sale area.



Figure 4—Clearcut stand on the Terrace Hill sale area, with western larch snags and living paper birch retained for wildlife use.

METHODS

Tobalske collected field data on bird populations and vegetation characteristics for this study. Our statistical analysis was selected to quantify differences among stand conditions in the study area.

Design

During the 1989 and 1990 breeding seasons, bird populations were censused with fixed-point counts 109 yards (100 m) in radius. Species detections were by sight or sound, including birds in flight over the plot. During both years, each point was visited on three evenly spaced days between June 1 and July 7. Counts were done between one-half hour after sunrise and 10 a.m., for a period of 10 minutes each.

Count points were located with a coordinate grid overlay placed on figure 2. After scaling distances between lines on the grid to be 218 yards (200 m) apart on the ground and numbering the points of intersection sequentially, a random-numbers table was read to select 10 points within each of three stand conditions: clearcut, partial-cut, and unlogged forest. Points were selected so that the radius of the plot would not intersect another stand condition. These points defined the census plots on the ground; each was marked at the center with a survey flag.

Because the CRNA (fig. 2) was difficult to map accurately, a different method was used there to select census points. Beginning at the southwest corner of the natural area stand, a random number was generated with a pocket calculator to determine a compass bearing. After following this bearing for

273 yards (250 m), a census plot was centered at the destination. Subsequent plots were selected in the same manner with a new bearing for all 10 points. Bearings that would carry a plot within 109 yards (100 m) of the boundary of the natural area were ignored by returning to the origin and taking a new bearing.

Vegetation was sampled once per year during July 1989 and 1990 at the 10 points in each stand condition that were selected for bird censusing (table 1). Sampling followed the guidelines of the Ocular Method in Hahn and Jensen (1987) using the General Plot Data and Ocular Plant Species Data forms. Each plot had a 37-ft (11-m) radius, with one plot at the center of each bird-count point. Snags were included in all tree measurements. Tree basal area was estimated with a "Relascope" prism, and average dominant tree d.b.h. was determined through diameter-tape measurements of five trees, or the maximum number left standing if fewer than five. Percentage of cover was measured for trees, shrubs, graminoids, and forbs, using horizontal estimates of the vertical projection of each life form. Tree and shrub cover was further sampled at three height categories: pole and larger, sapling, and seedling tree classes, and tall, mid, and low shrub classes.

Analysis

The mean count per point for each bird species censused in 1989 and 1990 was calculated by averaging data for the three yearly visits to each point, giving 10 average counts for each bird

Table 1—Estimates of vegetation components within each of the four stand conditions at the Terrace Hill study area and adjacent Coram Research Natural Area, Coram Experimental Forest, in 1989 and 1990

Vegetation component	Stand condition				Probability ²
	Clear-cut ¹	Partial-cut ¹	Unlogged forest	Natural area	
Tree basal area (ft ² /acre)	8 ^A	35 ^A	104 ^B	112 ^B	0.001
Tree d.b.h. of dominant tree (inches)	4 ^A	7 ^A	14 ^B	15 ^B	.001
Tree total cover (percent)	3 ^A	24 ^B	59 ^C	63 ^C	.001
Pole and larger (percent)	1 ^A	18 ^B	44 ^C	48 ^C	.001
Sapling (percent)	1 ^A	5 ^A	13 ^B	13 ^B	.001
Seedling (percent)	1	2	2	2	1.000
Shrub total cover (percent)	13 ^A	37 ^B	47 ^B	44 ^B	.006
Tall ³ (percent)	1 ^A	9 ^{AB}	10 ^{AB}	13 ^B	.016
Mid ³ (percent)	10	22	25	18	.192
Low ³ (percent)	2 ^A	6 ^{AB}	12 ^B	12 ^B	.016
Graminoid total cover (percent)	9	11	6	4	1.000
Forb total cover (percent)	22	18	35	42	.032

¹Tree snags of all species and living paper birch trees were left standing where possible.

²Low probability values indicate significantly different means among stand conditions, Bonferroni adjusted to control for experimentwise error (SPSS Inc. 1983); superscript letters group similar means for each vegetation component.

³Tall shrub, >10 ft (3 m); midshrub, 2 to 10 ft (0.6 to 3 m); low shrub, <2 ft (0.6 m) (Hahn and Jensen 1987).

species within each stand condition and year. The mean of each of these 10 averages was used to test for differences in relative abundance of bird species among stand conditions and years. Sampling vegetation components at the census points once per year generated 10 sample values for the selected variables within each stand condition. The mean of each set of 10 samples was compared to the means for the other stands during each year.

All bird species seen less than eight times during both years' censusing over all points were arbitrarily excluded from species-level statistical analysis (table 2). These species were included in the guild

analysis (table 3). Statistical significance in all tests was $P < 0.05$, employing the Bonferroni adjustment to control for experimentwise error rate (SPSS Inc. 1983). We used two-way analysis of variance to test for significant interaction and main effects for a given species' abundance by stand condition and year (SPSS Inc. 1983). Parametric analysis was justified on the basis of normal probability plots for the common species within the sample. Although count data is heavily right-skewed, the analysis of variance procedure is robust for comparison of samples with similar distributions (Sokal and Rohlf 1981).

Table 2—Mean number of birds counted per census point within the four stand conditions at the Terrace Hill study area and adjacent Coram Research Natural Area, Coram Experimental Forest, in 1989 and 1990

Species ¹	Foraging guild ²	Nesting guild ²	Stand condition				Probability ⁵
			Clear-cut ⁴	Partial-cut ⁴	Unlogged forest	Natural Area	
Killdeer	GF	GR	0.15	0	0	0	0.640
Vaux's swift	FC	SC	.15	.07	0	0	1.000
Red-naped sapsucker	TD	PC	.45	.35	.27	.52	1.000
Hairy woodpecker	TD	PC	.17	.13	.19	.33	1.000
Northern flicker	GF	PC	.22	.13	.07	.18	1.000
Olive-sided flycatcher	FC	CB	.17	.07	.02	0	.224
Western wood-pewee	FC	CB	.07	.03	.05	0	1.000
Tree swallow	FC	SC	.62 ^A	.07 ^B	0 ^B	0 ^B	.016
Steller's jay	FF	CB	.03	.05	.13	.05	1.000
Common raven	GF	CB	.11	.03	.10	.22	1.000
Black-capped chickadee	TG	SC	.30	.27	.40	.57	1.000
Mountain chickadee	TG	SC	.08	.17	.28	.28	1.000
Red-breasted nuthatch	TG	SC	.30	.42	.58	.53	1.000
Brown creeper	TG	SC	0	.03	.02	.12	1.000
Winter wren	GF	GR	0	.13	.08	.17	1.000
Golden-crowned kinglet	FF	CT	0 ^A	.45 ^{AB}	.47 ^{AB}	.73 ^B	.016
Ruby-crowned kinglet	FF	CT	.13 ^A	.52 ^B	.40 ^{AB}	.17 ^A	.016
Mountain bluebird	GF	SC	.13	0	0	.03	1.000
Townsend's solitaire	FF	GR	.13	.25	0	.02	.192
Swainson's thrush	FF	CB	.15 ^A	1.05 ^B	1.05 ^B	1.23 ^B	.002
American robin	GF	BT	.58	.30	.22	.05	.096
Varied thrush	GF	BT	.03 ^A	.05 ^A	.10 ^A	.38 ^B	.016
Solitary vireo	FF	CB	.05	.10	.07	.18	1.000
Warbling vireo	FF	BT	.13	.20	.18	.18	1.000
Yellow-rumped warbler	FF	CT	.28	.35	.28	.25	1.000
Townsend's warbler	FF	CT	.43 ^A	1.00 ^B	1.22 ^{BC}	1.50 ^C	.002
MacGillivray's warbler	FF	BT	.02	.12	.13	.22	.864
Western tanager	FF	CT	.10	.20	.10	0	.896
Chipping sparrow	GF	BT	.68 ^A	.72 ^A	.52 ^{AB}	.17 ^B	.016
Fox sparrow	GF	GR	.18 ^A	.32 ^{AB}	.40 ^{AB}	0 ^A	.016
Dark-eyed junco	GF	GR	1.27 ^A	.80 ^A	.25 ^B	.13 ^B	.002
Pine siskin	FF	CB	.78 ^A	.57 ^{AB}	.17 ^B	.08 ^B	.032
Total No. species	32	32	29	30	28	25	

¹Scientific names of bird species are listed in appendix.

²Foraging guild: FF = foliage forager; FC = flycatcher; TD = tree driller; TG = tree gleaner; GF = ground forager (Diem and Zeveloff 1980).

³Nesting guild: CT = conifer tree; CB = conifer or broadleaf tree; BT = bush or small tree; PC = primary cavity; SC = secondary cavity; GR = ground (Diem and Zeveloff 1980).

⁴Tree snags of all species and living paper birch trees were left standing where possible.

⁵Low probability values indicate significantly different means among stand conditions, Bonferroni adjusted to control for experimentwise error; superscript letters group similar means for each species (SPSS Inc. 1983).

Table 3—Mean number of birds, by guilds, counted per census point within the four stand conditions at the Terrace Hill study area and adjacent Coram Research Natural Area, Coram Experimental Forest, in 1989 and 1990

Guild ¹	Number of species	Stand condition				Probability ³
		Clear-cut ²	Partial-cut ²	Unlogged forest	Natural area	
Foraging						
Foliage forager	23	2.4 ^A	5.0 ^B	4.5 ^B	4.7 ^B	0.001
Flycatcher	5	1.0 ^A	.3 ^B	.1 ^B	0 ^B	.001
Tree driller	4	.7	.5	.5	.9	.544
Tree gleaner	5	.7 ^A	.9 ^{AB}	1.3 ^{BC}	1.5 ^C	.003
Ground forager	14	3.4 ^A	2.7 ^{AB}	1.8 ^{BC}	1.4 ^C	.001
Total	51					
Nesting						
Conifer tree	8	1.0 ^A	2.6 ^B	2.5 ^B	2.7 ^B	.001
Conifer or broadleaf tree	10	1.4	2.0	1.6	1.8	1.000
Bush or small tree	10	1.5	1.6	1.2	1.0	1.000
Primary cavity	5	.9	.6	.6	1.1	.416
Secondary cavity	9	1.6	1.0	1.3	1.6	1.000
Ground	9	1.7 ^A	1.5 ^{AB}	.9 ^{BC}	.3 ^C	.001
Total	51	16.2		16.3		

¹Guilds adapted from Diem and Zeveloff (1980).

²Tree snags of all species and living paper birch left standing where possible.

³Low probability values indicate significantly different means among stand conditions, Bonferroni adjusted to control for experimentwise error; superscript letters group similar means for each guild (SPSS Inc. 1983).

The same statistical analysis was used on guild populations (table 3) and vegetation structure (table 1).

RESULTS

The differences among the stand conditions in the study area are described for bird populations and vegetation components.

Birds

Tobalske observed 51 bird species during censusing of the study area (appendix), but only 32 species were sufficiently abundant to include in the statistical analysis (table 2). Pine siskins and varied thrushes exhibited a significant interaction effect between stand condition and year. Significant differences in abundance occurred among stand conditions for 10 species of birds. Tree swallows were frequently detected in clearcuts, but virtually absent elsewhere. Species that were less abundant in clearcut or partial-cut areas were golden-crowned kinglet, Swainson's thrush, varied thrush, and Townsend's warbler. Conversely, dark-eyed juncos and pine siskins were more abundant in harvested habitat than elsewhere. Ruby-crowned kinglets and fox sparrows were least abundant in clearcuts and

in the CRNA, while chipping sparrows were common in all areas except the CRNA.

Several other species did not exhibit significant differences in abundance, but were less abundant in clearcuts than elsewhere. These include brown creeper, winter wren, and MacGillivray's warbler (table 2). Likewise, species that were more abundant in harvested stands but did not exhibit significant differences include olive-sided flycatcher, Townsend's solitaire, and American robin. Interestingly, robins were least abundant in the CRNA and relatively common in the unlogged forest between harvest units on the THSA.

When species were grouped into foraging guilds, following Diem and Zeveloff (1980), foliage foragers were least abundant in clearcuts. Similarly, tree gleaners were less abundant in clearcuts and partial cuts than in unharvested areas. In contrast, flycatchers and ground foragers were more abundant in harvested habitat, particularly clearcuts. Among the nesting guilds, conifer tree nesters were least abundant in clearcuts and ground nesters were most abundant in cutover sites. Ground nesters and ground foragers had a significant interaction effect between stand conditions and years because of a marked increase in abundance in harvested areas in 1990.

Vegetation

Some components of the vegetation varied by stand condition while others did not (table 1). Obviously the cutover areas had significantly less tree basal area and d.b.h. than the uncut controls. The clearcuts had some tree basal area and d.b.h. because, where possible, snags of all species and live paper birch were left for use by birds and animals. Percentage of total tree cover (made up of seedlings, saplings, and pole-size and larger trees) significantly increased from clearcut through partial cut to uncut units. Although the pole-size and larger trees followed this pattern, sapling-size trees were not significantly different between the cutover areas. Seedling cover was not significantly different among stand conditions.

Following timber harvest, total shrub cover (percent) on partial-cut and uncut stands was significantly greater than on clearcuts (table 1). The tall-shrub and mid-shrub components were decreased substantially on clearcuts compared to partial cuts or the uncut controls. Low shrub cover on clearcuts was significantly less than on the uncut stands, and was intermediate (but not significantly different) on partial cuttings.

Neither the graminoid nor the forb cover was significantly different among the stand conditions after the cutting treatments (table 1), but twice as much average graminoid cover occurred on cutover than on uncut areas. Conversely, forb cover within the cutover stands was about half that of the uncut areas.

DISCUSSION

For the bird species and guilds that exhibited significantly different means among stand conditions, abundance patterns seem biologically reasonable in light of their habitat requirements. For example, tree swallows were most abundant in clearcuts with some snags and birch trees reserved (fig. 4). For these members of the flycatching and secondary-cavity nesting guilds, open, meadowlike habitat with nest-tree resources is probably ideal habitat. Likewise, dark-eyed juncos, as ground foragers and ground nesters, were most abundant in clearcuts and partial-cut units. In contrast, the members of the conifer tree nesting guild, with species like golden-crowned kinglet and Townsend's warbler, were less abundant in clearcuts than elsewhere (tables 2 and 3).

Ruby-crowned kinglets and fox sparrows were most abundant in partial-cut stands and unlogged forests interspersed between the cutting units. Perhaps an increase in edge habitat is beneficial to these species; males of both species were frequently

heard singing from conifers adjacent to clearings. Chipping sparrow and American robin were least abundant in the CRNA and relatively abundant in the unlogged forest on the THSA, pointing out that they may favor edge habitat in conjunction with open stands.

The pine siskin, a foliage-foraging and conifer- or broadleaf-tree nesting species showed a significant interaction between habitat and year for abundance, but this was due to a dramatic increase in abundance during 1990 in all habitat categories of the study. This species is known for sporadic, large changes in abundance and irruptive foraging behavior. Abundance of pine siskins within harvested habitat is the result of retaining living birch trees and the small size of the cutting units. These two factors may also have increased the abundance of other members of the conifer/broadleaf tree nesting guild (table 3).

Varied thrushes showed a significant habitat and year interaction for abundance. No varied thrushes were detected while censusing during 1990 even though these birds were relatively common in 1989. Censusing during 1991 may help to clarify which year was unusual for this species on the study area. Varied thrush is the only species among those that were most abundant in unharvested areas to have a significant difference in numbers between the unlogged forest and the natural area (table 2). This may illustrate a qualitative difference for this species between contiguous and fragmented old-growth forest.

A habitat and year interaction for abundance was also significant for ground-foraging and ground-nesting guilds. The number of ground foragers increased from 1989 to 1990 in clearcut, partial cut, and unlogged forest, but decreased in the CRNA. Numbers of ground nesters also increased more in partially cut areas than elsewhere. These patterns are shifts away from contiguous forest toward harvested and fragmented forest. A time-lag effect following logging, as described for these guilds, seems reasonable in light of the possibility of site tenacity by breeding birds (Atwood and Massey 1988). Adults may be predisposed to return to the same site to breed following migration, and they may not have time immediately upon arrival to search for other potential territories. If this is true, they may correct the situation in late summer when they have time to search for a new site.

Because more than half of the species included in the statistical analysis did not show significant differences in abundance among stand conditions, it is possible that factors related to logging may not affect the majority of species if reserving snags and live trees, and if small harvest units surrounded by

unlogged forest function as mitigating influences. Other alternatives, however, merit consideration.

A factor that may have contributed to overlooking biologically important differences in abundance was the small sample consisting of 10 replicates within each stand condition. This reduced the power, or the ability to detect differences in means, for our statistical tests. The relative scarcity of many species contributed to this problem. Nineteen species were detected less than eight times during censusing; these were not included in the species-level analysis. Nonetheless, among the species included, zero counts at census points were commonplace, and this property of census data, in combination with the small sample size, served to inflate variance and render different sample means statistically indistinguishable.

An example of the conservative nature of our statistical tests is the killdeer, which was detected only at two points in clearcut habitat during both years. As a ground-nesting and ground-foraging species, probably more killdeer will use cleared than uncut habitat, but large variance (mean number counted per point in clearcuts = 0.15, standard error = 0.08) caused a failure to reject the null hypothesis of equal means. The power for this analysis of variance model was 44 percent, which was rather low. We grouped species into guilds (table 3) to partially circumvent the problem of uncommon species' counts and, as shown in table 3, ground foragers and ground nesters showed a highly significant difference in abundance between habitats. They were especially common in clearcut and partially cut areas.

Even if population sizes do not vary among stand conditions, it is conceivable that the abundance of a species may not be a valid indicator of habitat suitability (Van Horne 1983). A given habitat may act as an ecological sink where individuals experience low reproductive success or high mortality in comparison to more favorable habitats (Wiens and Rotenberry 1981). For example, birds may be abundant in cleared areas but raise fewer offspring per nest than conspecifics in contiguous forest. The resupply of individuals to inadequate habitat from optimal areas could be behaviorally mediated.

Factors that ultimately determine habitat selection include food and cover availability, but Hildén (1965) suggested that vegetation structure is the proximate cue birds use to select territories. Birds arriving during spring in northern latitudes must select nesting territories based on structural features of the habitat rather than a direct assessment of food availability. If we manipulate habitat to provide appropriate cues for these species, we could see birds within the habitat even though it is not suitable. Thus some human-altered environments

may function as ecological sinks (Gates and Gysel 1978).

Consider woodpeckers, for example. We detected no difference in abundance between stand conditions for red-naped sapsuckers, hairy woodpeckers, and northern flickers (table 2). A proximate cue that may influence a woodpecker settling into a nesting territory could be the previous year's nest tree. Lawrence (1967), studying yellow-bellied sapsuckers (*Sphyrapicus varius*) in Ontario, suggested that pair bonds were reestablished through site rather than mate recognition, and females in particular cued in on the former nest tree. Thus, by reserving snags and deciduous timber during the harvest and site preparation treatments on the THSA, adult woodpeckers returning in the spring may have been motivated to establish territories within inadequate habitat. A detailed study that evaluates habitat quality through measures of reproductive success among red-naped sapsuckers is in progress (Tobalske and others 1990).

Wiens and others (1986) suggested that interpretation of a species' response to habitat alteration may depend on the spatial scale of the manipulation. The largest clearcut on the THSA was 35 acres (14 ha) (fig. 2), but commercial clearcuts may cover areas much larger (Dickson and others 1983). Extrapolating the results of a small-scale study to that of a large-scale system is ignoring biological reality. Moreover, landscape-level changes on a very large scale, such as a portion of a State or country, may significantly affect bird species yet be impossible to address without regional data.

MANAGEMENT RECOMMENDATIONS

The variation in abundance within the community of breeding bird species relative to logged or unlogged stand conditions indicates that management for any particular species or guild will probably fail to provide for the integrity of the entire system. In short, diversity of habitat will likely promote diverse bird assemblages. During timber harvest, tree-dependent bird species are losing access to an important resource, and it is generally this portion of the bird community for which managers seek to mitigate adverse effects.

The most striking feature of the clearcuts on Terrace Hill is the large number of standing larch snags and live paper birch trees (fig. 4). It is feasible that the snags and living trees, along with the small size of the cutting units in relation to interspersed unlogged forest, mitigated the effect of the timber harvest for tree-dependent bird species, ranging from cavity nesters, such as red-naped sapsucker and red-breasted nuthatch, to foliage

foragers, such as yellow-rumped warbler and western tanager. Therefore, we reiterate the recommendation of McClelland and Frissell (1975) to leave, wherever possible, all snags and nonmerchantable timber including paper birch, quaking aspen, and black cottonwood within cutting units.

Additionally, we have observed a variety of species of birds, including winter wren, Townsend's solitaire, and dark-eyed junco, using unburned slash piles as perches, food sources, or nest sites (figs. 5 and 6). These piles may contribute substantially to the quality of postharvest habitat for certain bird and small mammal species. Further study is required to establish the importance of this potential resource; nonetheless, measures should be taken to retain some slash piles during and after site treatments.

It is beyond the scope and intention of this study to provide quantitative recommendations regarding the optimum number of snags, trees, or slash piles to maintain the integrity of western larch/Douglas-fir bird communities when harvesting timber. Research in progress (Tobalske and others 1990) suggests that harvests that mimic naturally occurring habitat, such as an open, wooded meadow, may be appropriate models.



Figure 5—Juvenile winter wrens perched on a branch within a slash pile on the Terrace Hill sale area. Slash piles may provide important cover for several bird species in clearcut and partial-cut stands.



Figure 6—Slash piles such as this were frequently used as perching and foraging sites by several bird species censused within clearcut and partial-cut stands on the Terrace Hill sale area.

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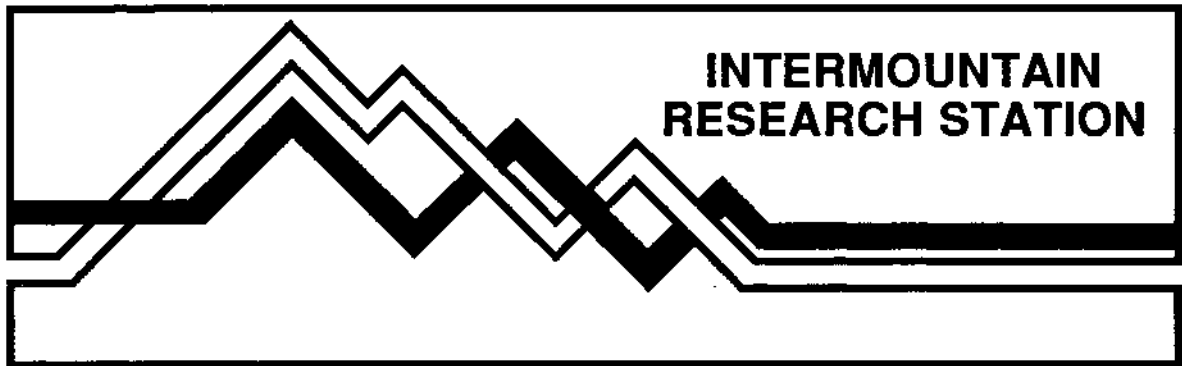
**APPENDIX: COMMON AND SCIENTIFIC NAMES OF BIRD SPECIES CENSUSED
IN THIS STUDY**

Red-tailed hawk	<i>Buteo jamaicensis</i>
Ruffed grouse	<i>Bonasa umbellus</i>
Killdeer	<i>Charadrius vociferus</i>
Barred owl	<i>Strix varia</i>
Vaux's swift	<i>Chaetura vauxi</i>
Rufous hummingbird	<i>Selasphorus rufus</i>
Red-naped sapsucker	<i>Sphyrapicus nuchalis</i>
Hairy woodpecker	<i>Picoides villosus</i>
Three-toed woodpecker	<i>Picoides tridactylus</i>
Northern flicker	<i>Colaptes auratus</i>
Pileated woodpecker	<i>Dryocopus pileatus</i>
Olive-sided flycatcher	<i>Contopus borealis</i>
Western wood-pewee	<i>Contopus sordidulus</i>
Dusky/Hammond's flycatcher	<i>Empidonax</i> spp.
Tree swallow	<i>Tachycineta bicolor</i>
Gray jay	<i>Perisoreus canadensis</i>
Steller's jay	<i>Cyanocitta stelleri</i>
Clark's nutcracker	<i>Nucifraga columbiana</i>
Common raven	<i>Corvus corax</i>
Black-capped chickadee	<i>Parus atricapillus</i>
Mountain chickadee	<i>Parus gambeli</i>
Chestnut-backed chickadee	<i>Parus rufescens</i>
Red-breasted nuthatch	<i>Sitta canadensis</i>
Brown creeper	<i>Certhia americana</i>
Winter wren	<i>Troglodytes troglodytes</i>
Golden-crowned kinglet	<i>Regulus satrapa</i>
Ruby-crowned kinglet	<i>Regulus calendula</i>
Mountain bluebird	<i>Sialia currucoides</i>
Townsend's solitaire	<i>Myadestes townsendi</i>
Swainson's thrush	<i>Catharus ustulatus</i>
American robin	<i>Turdus migratorius</i>
Varied thrush	<i>Ixoreus naevius</i>
Solitary vireo	<i>Vireo solitarius</i>
Warbling vireo	<i>Vireo gilvus</i>
Orange-crowned warbler	<i>Vermivora celata</i>
Yellow warbler	<i>Dendroica petechia</i>
Yellow-rumped warbler	<i>Dendroica coronata</i>
Townsend's warbler	<i>Dendroica townsendi</i>
American redstart	<i>Setophaga ruticilla</i>
Northern waterthrush	<i>Seirus noveboracensis</i>
MacGillivray's warbler	<i>Oporornis tolmiei</i>
Wilson's warbler	<i>Wilsonia pusilla</i>
Western tanager	<i>Piranga ludoviciana</i>
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>
Chipping sparrow	<i>Spizella passerina</i>
Fox sparrow	<i>Passerella iliaca</i>
Dark-eyed junco	<i>Junco hyemalis</i>
Brown-headed cowbird	<i>Molothrus ater</i>
Northern oriole	<i>Icterus galbula</i>
Cassin's finch	<i>Carpodacus casinii</i>
Pine siskin	<i>Carduelis pinus</i>

Tobalske, Bret W.; Shearer, Raymond C.; Hutto, Richard L. 1991. Bird populations in logged and unlogged western larch/Douglas-fir forest in northwestern Montana. Res. Pap. INT-442. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 12 p.

Of 32 species of abundant breeding birds, populations of 10 species differed significantly between small cutting units and adjacent uncut forest. Foliage foragers and tree gleaners were less abundant in cutting units, while flycatching species and ground foragers were more common there. Of nesting guilds, conifer tree nesters were least abundant in cutting units, and ground nesters were more common there. Results suggest that bird management should consider diverse community-level habitat needs and that if maintenance of tree-dependent species is important, broadleaf trees and snags of all species should be retained.

KEYWORDS: breeding birds, bird habitat, wildlife management, timber harvesting



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