FIRE'S EFFECTS ON A SMALL BIRD POPULATION

L. Jack Lyon and John M. Marzluff

ABSTRACT: Changes in bird populations as a result of a 122 ha forest fire are evaluated. There is little evidence of any drastic effect on numbers of birds, species, or species diversity in the year of the fire or 2 years later.

INTRODUCTION

The influence of fire on small bird populations is most often visualized in the context of the Smokey Bear poster showing a female robin on the nest--and the obvious implication that the bird, and the eggs or young, will be burned to a crisp if someone is careless with matches. A somewhat more pragmatic view suggests that direct mortality, even in large forest fires, is a relatively unusual event (Vogl 1967; Phillips 1965; Stoddard 1963). Nevertheless, modification of important niches in the habitat might be as lethal as fire if the bird is unable to find other, equally suitable, places to feed and nest. Bendell (1974), for example, concluded that bird species that forage on the tree trunk and in the canopy may be eliminated from burned areas but that ground feeders may be attracted and benefited. Overall, his summary of 22 reported studies suggests remarkable stability, although the postfire avifauna might be slightly richer. There is also some possibility of a shift to larger birds (Bock and Lynch 1970; Martin 1960).

STUDY DESCRIPTION

Study Areas

As a part of an exploratory investigation of small bird habitat utilization on the Lolo National Forest in 1979, we selected 21 representative 5-ha study sites in the Lolo Creek drainage. Our locations included habitats varying from ponderosa pine (*Pinus ponderosa*) types at 1 052 m to Engelmann spruce (*Picea engelmannii*)-subalpine fir (*Abies lasiocarpa*) types at 1 628 m. Representative forest communities ranging from clearcuts to old-growth timber stands were selected. Results of the first year of study were reported by Marzluff and Lyon (1981, 1983). Field work was repeated in 1981 on the same areas by Lucia Settimi under a contract with the U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

On July 20, 1979, two of the study areas burned in a forest fire. The burned area was relatively small (122 ha), but the fire was intense, and it appeared to destroy all green vegetation at ground level and many of the tree tops. In this paper, we report the immediate response of birds to this drastic change in the environment and the apparent effect on bird populations 2 years later.

Of the 21 areas on which birds were counted, none were considered directly comparable to the two that burned. The Mill Creek upland site that burned (MCB) was located adjacent to another upland site with fewer trees but in a similar forest community. This area, Mill Creek unburned (MCU), was not disturbed in the fire. The Mill Creek riparian area (MCR), so designated because of its location on the first bench above the creek, was virtually unique; however, we had another area, about 14 km away, near the Lewis and Clark campground (LCC) that was also adjacent to a flowing stream. For comparative purposes in these analyses, we have included both burned and unburned areas, but it should be recognized that the four study sites are only comparable in that all are south of Lolo Creek on generally north aspects, all were unlogged until after the fire, and all are in a similar forest community mostly dominated by Douglas-fir. All areas were classified as Douglas-fir/*Physocarpus malvaceous* habitat types (Pfister and others 1977), although MCR and LCC both had some Engelmann spruce and several species of large shrubs that indicate a slightly more mesic condition than the two upland sites, MCB and MCU.

Field Methods

Bird censuses were taken in both years of study at about 2-week intervals in the period between June 15 and September 15. Working between a half hour before sunrise and noon, observers walked slowly along a transect 500 m in length and recorded all birds seen or heard within a belt approximately 100 m wide. A 3-minute pause at each of 20 permanently marked transect points allowed the observer to carefully scan the area for nonsinging or inactive birds.

Vegetation data were recorded in each of 20 circular plots, 5.6 m in radius (100 m^2), spaced at 25 m intervals along the transect. Data

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L. Jack Lyon is wildlife research biologist, Intermountain Research Station, Forest Service, U.S. Department of Agriculture, Missoula, Mont. John M. Marzluff's current address is Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ 86001.

included categorical classifications for percentage cover (0 = 0%, 1 = <5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, and 5 = >75%) within each of six vertical intervals (0.0-0.5 m; 0.5-1.5 m; 1.5-2.5 m; 2.5-8.0 m; 8-25 m; and >25 m); number of live and dead stems in six diameter classes (0-2 cm, 2-5 cm, 5-10 cm, 10-25 cm, 25-50 cm, and >50 cm); live and dead basal area; counts of dead and down stems; slope; aspect; and elevation. Vegetation sampling was repeated in 1981 to detect any permanent changes in habitat structure. We are indebted to Kenneth Pitt for completing the 1981 sampling under the Volunteers in Service program of the U.S. Department of Agriculture, Forest Service.

Analyses

The test hypothesis of primary interest was whether numbers of birds or the bird community structure were significantly changed as a response to changes in the habitat. Initial examination of the data, however, revealed substantial changes in species composition during the 2-week observation cycles and a significant decline in numbers of birds observed in the second year of study. Thus, it became necessary to compare all analyses on the burned areas with similar analyses of comparable unburned areas in an attempt to recognize changes unrelated to the fire. Data were compiled and examined with variance analysis in matrixes using combinations of the following categories two at a time:

Season, N=6 (June, July A and B, August A and B, September)
Guild, N=8 (feeding guilds, see footnote, table 3)
Area, N=4 (two burned, two unburned).

In a few instances, it was possible to combine two selected categories with years in a three-way factorial analysis; however, this design was not considered statistically acceptable if it forced us to interpret first- or second-order interactions that were even slightly obscure. Thus, our analyses are broken up into a series of smaller analyses rather than the large factorial: Years X Areas X Seasons X Guilds.

Each variance analysis was replicated to test for differences in numbers of birds recorded, numbers of species recorded, and average weights of birds observed. We also examined changes in species composition of bird populations observed on each area by season and calculated the Shannon/Weiner diversity index (see Krebs 1972:506) for each replication in an Area X Season matrix.

STUDY RESULTS

Changes in Available Habitat

All study transects were evaluated in 1979 and again in 1981 to determine changes related to vegetation regrowth and/or salvage logging. Averages for cover category estimates, stem densities, and basal areas, 1979 and 1981, on four study areas are presented in table 1.

A common perception about the effects of fire in a coniferous forest is that the postfire community will consist of blackened stems with bare branches. In fact, unless a forest fire sweeps through the crowns, it is possible to kill the trees without even removing the needles. For some period after the fire, the ground surface may be blackened and bare, but the cover above ground level, and particularly above 1.5 m may not be perceptibly different than before the fire. As a general rule, needles scorched by ground fires will turn brown in the first 2 weeks, and in some cases the scorched trees may even recover.

Both burned areas in this study retained some cover at all levels following the fire. The most noticeable characteristics of the burned areas in mid-August 1979 were a broad layer of ash 2 to 5 cm deep, and a lack of green vegetation below 2.5 m, but there were small patches of unburned vegetation at ground level and considerable amounts of green canopy interspersed with the brown-needle cover above 2.5 cm. Three sample points on MCB remained unburned, and although the majority of tree boles were scorched on both transects, the crowns of some mature trees were still green 3 weeks after the fire. The immediate habitat change on MCR was somewhat greater than on MCB because the preburn community had an understory component of large shrubs. These lost all their foliage even though many of the stems were still present.

In the 18 months following the fire, the landowner completed a salvage logging operation in which the majority of the larger trees were removed. About the same basal area was removed from both areas, but MCB had fewer stems in the large-diameter classes, and as a result, the remaining forest stand in 1981 was similar to the undisturbed area MCU except for a greater basal area of snags. By contrast, the riparian burned area, MCR, was almost completely salvage logged. The removal of all stems over 15 cm resulted in a substantial loss of both tree cover and basal area. By 1981, however, the shrub understory had resprouted, and cover up to a height of about 1.5 m was only slightly less than that recorded before the fire.

In addition to structural changes in the habitat, we also noticed an immediate postfire increase in apparent numbers of a variety of insects that had not been commonly observed before the fire. Charles F. Tiernan, Forest Service entomologist, conducted a brief survey of the burned area for us, and reported intense insect activity involving at least four species of wood borers (genera *Buprestis, Monochamus, Neoclytus, and Agrilus*); ichneumonid females (parasites of wood borers); and predaceous flies of the families Therevidae and Asilidae. Attraction of insects to either the smoke or heat of forest fires has previously been reported (Evans 1971). On both of the burned study areas, we observed almost frenetic feeding activity among warblers and a few species of woodpeckers.

Table 1.--Cover category means, number of stems, basal area and snag basal area on four study areas in the Lolo Creek drainage, 1979 and 1981

Area	Mill Creek-Burned 1979	Mill Creek-Burned 1981	Mill Creek-Unburned 1979	Mill Creek-Unburned 1981	Mill Creek-Riparian 1979	Mill Creek-Riparian 1981	Lewis & Clark Campground 1979	Lewis & Clark Campground 1981
Average cover[1]								
25 m+	0.10	0.05	0.05	0.05	0.25	0.00	0.00	0.00
8.0-25 m	0.95	0.75	0.80	0.80	1.35	0.05	1.85	1.85
2.5-8.0 m	2.15	1.40	0.95	0.95	1.80	0.15	2.10	2.10
1.5-2.5 m	1.20	1.25	0.85	1.00	2.25	0.50	1.45	1.45
0.5-1.5 m	1.55	1.50	1.55	1.55	3.15	2.10	1.85	1.85
0.0-0.5 m	4.95	5.00	5.00	5.00	5.00	4.90	4.90	4.90
Numbers of Stems/ 100 m^2								
50 cm+	0.05	0.00	0.05	0.00	0.15	0.00	0.00	0.00
25-50 cm	0.30	0.05	0.20	0.20	1.05	0.00	1.10	1.10
10-25 cm	3.90	0.90	1.25	1.50	2.40	0.10	5.45	5.50
5-10 cm	4.90	1.25	0.90	1.15	1.30	0.15	3.95	3.85
2-5 cm	3.45	0.65	1.00	1.30	0.70	0.10	1.95	1.50
<2 cm	2.85	0.20	2.10	2.15	1.20	0.00	0.65	0.50
Basal area, m^2/ha	3.27	0.48	0.94	1.06	2.94	0.01	4.35	4.27
Snag basal area, m^2/ha	0.29	1.32	0.09	0.14	0.38	0.57	0.46	0.42

[1]Cover categories scaled 0-5: 0 = 0, 1 = < 5%, 2 = 5%-25%, 3 = 25%-50%, 4 = 50%-75%, 5 = > 75%.

Changes in Bird Species and Numbers

In the initial analysis of variance, each study area was examined in a 6 X 8 matrix of Seasons X Guilds. This analysis did not prove to be informative. Almost without exception, there were significant differences among guilds and no differences among seasons. Throughout all observations on all study areas, the two guilds including insect feeders contained more birds and more species than all other guilds combined.

Analysis of the 4 X 6 matrices of Areas X Seasons was more revealing. In 1979, an average replicate produced observations of 36 birds of 10 species (table 2). In 1981, the overall means dropped to 20 birds and 8 species. Seasonal differences were significant only in 1979, but a consistency can be detected in both years. Immediately following the fire, in 1979, there was a significant depression in numbers of birds seen and a concurrent depression in the numbers of species. This depression occurred on both the burned and unburned areas, although it appeared to be slightly more severe in the burn. A similar depression was recorded 2 weeks earlier in 1981, and in both years, the depressed counts were followed by substantially increased counts as immature birds and family groups began to move about and flock before migration. Because the immediate postfire decline was slightly greater on burned areas, the increases also seem larger for the burn, but there is actually nothing in these data to indicate that the burn was anything more or less than a favorable transitory hunting opportunity. In 1981, the four species primarily involved in the apparent increases repeated similar patterns of increased abundance in late August, although actual numbers were somewhat subdued because of an overall decline in insectivorous birds. Numbers of chipping sparrows, yellow-rumped warblers, golden-crowned kinglets, and Townsend's warblers increased dramatically during this period.

Analysis of the 4 X 8 matrices of Areas X Guilds (table 3) confirmed the already-mentioned dominance of insect feeders in these bird populations. Overall, the numbers of birds and numbers of species that feed on insects in the foliage was significantly greater than the numbers and species of insect feeders on the ground, which, in turn, exceeded any other feeding guild.

Further examination of the numbers of birds recorded by guild reveals that, although maintaining numerical superiority, insect feeders suffered a disproportionate share of the decline in numbers of birds recorded between 1979 and 1981. Analysis of variance of the factorial design Years X Areas X Guild demonstrates a significantly greater decline in the two insect feeding guilds than in other guilds. Foliage insect feeders, in particular, declined to only a third of the numbers seen in 1979.

Several other high and low numbers in table 3 seem worthy of examination, although in no case were

Table 2.--Numbers of birds and numbers of species, Area X Season for 1979 and 1981

Area	Season June	July A	July B	Aug. A	Aug. B	Sept.	Area sum
1979			Numbers of Birds				
Mill Creek-Burned	36	33	42	14	61	29	215
Mill Creek-Unburned	34	31	51	23	81	43	263
Mill Creek-Riparian	28	45	46	9	62	29	219
Lewis & Clark Campground	23	28	26	18	56	16	167
Season sum	121	137	165	64	260	117	Mean=36
1981							
Mill Creek-Burned	30	30	24	26	17	18	145
Mill Creek-Unburned	27	29	18	43	16	5	138
Mill Creek-Riparian	19	15	10	31	2	18	95
Lewis & Clark Campground	16	23	6	11	33	9	98
Season sum	92	97	58	111	68	50	Mean=20
1979			Numbers of Species				
Mill Creek-Burned	9	9	9	6	10	7	50
Mill Creek-Unburned	14	9	15	11	13	14	76
Mill Creek-Riparian	14	14	12	3	13	10	66
Lewis & Clark Campground	7	9	9	7	9	6	47
Season Sum	44	41	45	27	45	37	Mean=10
1981							
Mill Creek-Burned	6	12	8	7	5	7	45
Mill Creek-Unburned	14	13	11	15	7	4	64
Mill Creek-Riparian	10	8	3	11	2	6	40
Lewis & Clark Campground	6	8	4	6	9	6	39
Season sum	36	41	26	39	23	23	Mean=8

Table 3.--Numbers of birds recorded, Year X Area X Guild[1]

Area	Feeding guild GS	FS	GI	FI	AI	TD	TG	AO	Area sums
1979									
Mill Creek-Burned	6	23	83	78	3	7	15	0	215
Mill Creek-Unburned	14	29	59	108	6	7	38	2	263
Mill Creek-Riparian	8	33	37	115	17	3	6	0	219
Lewis & Clark Camp	5	6	28	112	4	0	12	0	167
Sums	33	91	207	413	30	17	71	2	864
1981									
Mill Creek-Burned	26	22	56	14	12	5	3	7	145
Mill Creek-Unburned	4	19	39	34	16	4	18	4	138
Mill Creek-Riparian	9	10	21	34	11	1	3	6	95
Lewis & Clark Camp	1	18	3	52	2	1	15	6	98
Sums	40	69	119	134	41	11	39	23	476
Guild Totals	73	160	326	547	71	28	110	25	

[1]	Guild	(representative species)
GS	Ground seed feeders	(dark-eyed junco)
FS	Foliage seed feeders	(pine siskin)
GI	Ground insect feeders	(chipping sparrow)
FI	Foliage insect feeders	(yellow-rumped warbler)
AI	Aerial insect feeders	(flycatchers)
TD	Timber drillers	(hairy woodpecker)
TG	Timber gleaners	(red-breasted nuthatch)
AO	All others	

the relationships found to be statistically significant. The high count for insect feeders on the ground (GI) on MCB in 1979, for example, traces to flocks of chipping sparrows seen both before and after the fire. The high count for timber gleaners on MCU traces to two flocks of mountain chickadees. These birds were recorded after the fire burned through the adjacent forest, and the observations might be interpreted to indicate that chickadees were attracted to the general area of the burn. It also seemed meaningful to us that the decline in numbers of timber gleaners from 1979 to 1981 seems to have been disproportionately larger on the two areas that were burned and that numbers of seed feeders on the ground (GS) on MCB was quite high in 1981. These observations appear to confirm Bendell's (1974) conclusion that species which forage on the tree trunk may be eliminated whereas ground feeders may be benefited. On the other hand, Bendell's conclusion that fire will eliminate bird species which forage in the canopy was not confirmed.

Changes in Average Weights of Birds

Analyses examining average weights of birds observed proved to be confusing and not particularly informative. With only one exception, there were no differences among areas or seasons, whereas differences among feeding guilds were always extremely high. These differences among guilds, however, were not consistent. In almost every analysis we found that significant differences were associated with the observation of a single bird. A ruffed grouse or a large hawk would produce statistical significance in any category, and even when these species were removed from the data, a single mourning dove, Steller's jay, or northern flicker would raise the average weight of birds in a guild to a significant level.

The only analysis in which weight differences could be interpreted in a meaningful context involved the seasonal movement of Clark's nutcrackers from higher elevations to the general elevation of Mill Creek in September. Arrival of the nutcrackers made average weights of birds in September significantly higher than in previous observation periods.

Changes in Bird Species Diversity

Shannon/Weiner diversity for 6 replications of field counts on 4 study areas ranged from $H = 1.2$ to 3.6 (mean = 2.7) in 1979 and from $H = 1.0$ to 3.6 (mean = 2.5) in 1981 (table 4). Analysis of variance revealed no significant differences among areas or seasons in either year of study, and we could detect no certain influence of the fire on bird species diversity. Examination of individual observation means, however, reveals that one or more H were outside the $P < 0.01$ confidence interval for the overall mean in both years. In 1979, $2.3 < H < 3.1$, and in 1981, $2.1 < H < 2.9$. Of the H outside these ranges, the most interesting is probably the low index for MCR in the first observation period after the burn. Only 9 birds of 3 species were observed, whereas 2 weeks later, the same area produced 62 birds of 13 species. Because this decline in diversity was not duplicated on the adjacent burned area, MCB, we can only speculate about the consistency of the influence of fire. These data supply no indication that burned areas had higher or lower diversities than unburned areas, but there is a strong implication for population instability on recently burned areas. In 1981, despite the passage of two growing seasons in which there was some vegetation recovery, the average change in H from one observation period to the next was more than twice as great on burned areas as on areas that remained unburned.

Table 4.--Shannon/Weiner diversity indices (H) for six replications on four study areas, 1979 and 1981

Area	June	July A	July B	Aug. A	Aug. B	Sept.
1979						
Mill Creek-Burned	2.82	2.33	2.51	2.41	2.64	2.36
Mill Creek-Unburned	3.28	2.45	3.43	3.05	2.97	3.18
Mill Creek-Riparian	3.61	3.40	3.06	1.22	3.13	2.25
Lewis & Clark Campground	2.49	2.92	2.82	2.44	2.49	1.62
1981						
Mill Creek-Burned	1.87	3.12	2.65	2.47	1.89	2.68
Mill Creek-Unburned	3.63	3.37	3.09	3.44	2.42	1.92
Mill Creek-Riparian	2.97	2.87	1.16	3.09	1.00	1.97
Lewis & Clark Campground	2.31	2.49	1.79	2.37	2.77	2.42

This observation prompted us to develop an expression of the relative turnover rate in bird populations from one observation period to the next. The proportions presented in table 5 are calculated as the ratio of the number of species seen in one or the other of two observation periods, but not both, to the total number of species seen both observation periods. We were surprised to find that a turnover rate in excess of 50 percent was not unusual. On all four areas, in an average 2-week period, more than half of the species identified were replaced by other species. Despite this already existing high replacement, we found that turnover increased substantially following the fire in 1979, and it appears that the habitat changes on MCR were great enough to continue this high turnover rate into 1981. During the course of this study MCR was modified far more than MCB, and it appears that the removal of most of the cover above 1.5 m produced a less desirable small bird habitat.

Table 5.--Relative turnover rates in species composition from one observation period (season) to the next

Area	June	July		August	
		A	B	A	B
1979					
Mill Creek					
-Burned	0.800	0.615	0.636	0.667	0.786
-Unburned	0.722	0.588	0.471	0.400	0.773
-Riparian	0.444	0.471	0.846	0.857	0.722
Lewis & Clark					
Campground	0.667	0.364	0.364	0.545	0.750
1981					
Mill Creek					
-Burned	0.733	0.824	0.636	0.667	0.800
-Unburned	0.773	0.588	0.700	0.778	0.778
-Riparian	0.800	0.900	0.883	0.818	1.000
Lewis & Clark					
Campground	0.833	0.800	0.750	0.636	0.750

Observations and Field Notes

Throughout the compilation of these statistical tests we held in abeyance the recognition that some observations simply cannot be tested. The almost total dominance of these bird populations by insect feeders tends to obscure the fact that changes in some of the less abundant guilds or individual species may have been ecologically important even though the available data provide no potential for demonstrating statistical significance.

We were able to demonstrate that the number of birds observed increased significantly after the middle of August 1979 and further, that these large increases primarily involved insect feeders. We were unable to show that some species of insect feeders, notably MacGillivray's warbler, Swainson's thrush, and the warbling vireo, disappeared from the burned areas immediately after the fire.

The Swainson's thrush was not seen in either burned area in 1981, and we have presumed this to be an indication that too much canopy was removed to leave a desirable habitat. MacGillivray's warbler, on the other hand, returned to the same areas occupied in 1981 and repeated an identical disappearance pattern in late August. In 2 years, including data from all the other study areas in the Lolo Creek drainage, only one MacGillivray's warbler was recorded after the middle of August at an elevation below 1 250 m.

Observations made of the warbling vireo were inadequate to demonstrate whether the species responded to habitat change, is an early migrant, or simply reacted to a short-term, locally favorable feeding situation caused by the fire. In 1979, the number of vireos recorded on MCU increased after the fire. Numbers of several other species also increased on MCU at this time, and our initial impression was that MCU was receiving some spillover of birds displaced from the nearby burned areas. Too few vireos were observed in 1981 to determine whether the burned areas continued to be less acceptable than the adjacent unburned area, but we did determine that the vireos observed in 1979 were the only warbling vireos recorded after mid-August on any area in the Lolo Creek drainage in either year of study. This suggests a possibility that the specific foraging opportunity available in MCU following the fire enabled vireos to remain in the area longer than is usual for this species.

In a number of ways, the data describing small bird use of area MCU seem somewhat unusual. There is a general impression in our data of a very favorable small bird habitat. For both years of study, MCU averaged more birds, more species, and a higher ranking of the diversity index in comparisons with the other study areas. It is our impression, however, that this attraction for birds is somewhat greater than might normally have been expected in a plant community of this structure. The location of MCU, immediately adjacent to the two burned areas, has created a relatively unique combination of habitat diversity and edges that make this specific site and the surrounding area appear far more attractive and productive than it really is.

Our final observation from our field notes involves the several species of woodpeckers recorded during the study. Birds classed as timber drillers in 1979 increased from 5 before the fire to 12 after the fire. This difference, since it involved such a small number, was not significant even though 10 of 12 woodpeckers were recorded in the burned areas. In addition, it seemed important to us that these observations included the only northern three-toed woodpeckers seen in 1979 and that this species was seen only on a burned area in 1981.

SUMMARY AND CONCLUSIONS

In the data presented here, there was surprisingly little evidence that the Mill Creek fire of 1979 had any drastic effect on numbers of birds, numbers of species, or species diversity--either during the year of the fire or 2 years later. Considering only the data from the burned areas, it might have been concluded that an immediate postfire depression in bird numbers and a subsequent substantial increase were fire-associated phenomena. A majority of the bird species recorded were insect feeders, and one of the immediate changes in the burned area was a sudden increase in insects attacking the burned trees. Apparently, however, an increase in numbers of birds observed after the end of July is a predictable annual occurrence related to movement by family groups and flocking before migration.

One immediate physical effect of the fire was removal of much of the cover below 2.5 m and thinning of the canopy above that height. Salvage logging further reduced the canopy, especially above 2.5 m. These changes were potentially significant for a few species, but for small bird populations as a faunal group, the influence of the burn was relatively subtle and appeared to cause modifications in patterns of habitat use rather than any strong attraction or avoidance of the modified habitat. The Mill Creek fire, because it was small, and possibly because it was not a completely destructive burn, may actually have increased habitat diversity for the larger area including the unburned forest immediately adjacent to the burn. At the same time, this increased habitat diversity was accompanied by an increase in species turnover from one biweekly observation period to the next.

One of the more significant observations presented in this paper has little to do with the influence of fire. During the summer of 1980, western Montana was subjected to a fine-grain ash fall following the eruption of Mount St. Helens. There was some conjecture at the time about the influence this ash fall might have on insect populations and, potentially, on other fauna dependent on insect foods. We believe the available data indicate a very substantial influence of ash fall on nesting success by insect-eating small birds. We cannot report with certainty that 1980 was a poor year for nesting success by insectivorous birds in western Montana, but such an event would explain the decline in numbers of birds observed in 1981. Data from 19 unburned study areas represent a much larger evaluation base than the four study areas examined here, and we are evaluating those data for presentation in the future.

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