BREEDING BIRD POPULATIONS OF BURNED AND UNBURNED CONIFER FOREST IN THE SIERRA NEVADA

CARL E. BOCK[1]

AND

JAMES F. LYNCH

Museum of Vertebrate Zoology
University of California
Berkeley, California 94720

In August 1960 the 39,000-acre Donner Ridge fire passed within several hundred yards of the University of California Sagehen Creek Field Station in Nevada County, California. In 1965 two permanent study plots of 20.9 acres each were established northeast of the station, one in the burn and the other in adjoining unburned forest (figs. 1, 2). Long-term studies were initiated for the purpose of recording floral and faunal changes on the burn as it recovers, using the unburned plot as a control or projection of what the burned area eventually should resemble. This paper presents a comparison between the breeding avifaunas of the two areas based upon censuses taken in 1966, 1967, and 1968, when the burned study plot was still in the early stages of recovery.

STUDY AREAS

The two study plots were established in areas judged to be essentially the same before the 1960 burn. Both lie along the crest of an east-west ridge, at about 7000 ft (2100 m) elevation. The fire came in from the south and burned over the eastern half of the ridge. The plots are situated on the burned and unburned sections, with a buffer zone between them. Neither encompasses springs, major rock outcrops, steep slopes, or other topographic features which might influence their avifaunas.

The vegetation on the unburned study plot (fig. 1) consists of a mixed coniferous overstory of mature Jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*), with some sugar pine (*P. lambertiana*), lodgepole pine (*P. murrayana*), red fir (*A. magnifica*), and incense cedar (*Libocedrus decurrens*). Growing under this broken canopy, in addition to young conifers, is a variety of shrubs and herbs, including tobacco brush (*Ceanothus velutinus*), squaw carpet (*Ceanothus prostratus*), and chinquapin (*Castanopsis sempervirens*).

The Donner Ridge fire, fanned by winds reaching 70 mph, completely razed most of the area encompassed by the burned study plot (fig. 2). It did spare several small pockets, however, and in these a few mature Jeffrey pine and white fir remain. Elsewhere on the plot only post-fire vegetation occurs, the most common species being mule's ear (*Wyethia mollis*), tobacco brush, squaw carpet, golden currant (*Ribes aureum*), greenleaf manzanita (*Arctostaphylos patula*), rabbit-brush (*Haplopappus bloomeri*), and young Jeffrey and lodgepole pines which had germinated after the fire. By the summer of 1968 there had been no significant regeneration of fir or sugar pine.

FIELD METHODS AND TREATMENT OF DATA

The census technique used was the Williams spot-mapping method (Williams 1936; see also Kendeigh 1944), which involves determining the distribution and number of birds on a grid. The Sagehen Creek study plots are rectangular in shape, measuring 1300 × 700 ft. To facilitate censusing, each plot was divided into 91 squares 100 ft on a side, using permanent red and white steel fence posts at every grid point. Each post was marked with a letter (A–H) and number (0–13) designating its relative position along the width and length of the plot.

The usual census technique was to walk slowly along the grid lines, recording the positions and movements of all birds on mimeographed maps of the grids. A system of two-letter abbreviations for the species names was adopted to facilitate rapid recording of data. Solid lines were used to represent movement; wavy lines were drawn between individuals of the same species observed simultaneously. We made a special effort to discover nests and to plot the locations of singing males.

Most of the field work was carried out in the morning, when bird activity was greatest. A total of 113 individual censuses were made during the nesting seasons in May, June, and July, each of 1–3 hr duration. The yearly numbers of censuses of the burned and unburned plots were, respectively: 1966, 20 and 23; 1967, 19 and 13; and 1968, 21 and 15.

After each day's census the data collected were transferred to permanent summary sheets kept for the individual species. Because most birds were territorial, or at least occurred more frequently in the vicinity of their nests, the species summary sheets revealed

[1] Present address: Department of Biology, University of Colorado, Boulder, Colorado 80302.

FIGURE 1. Photograph of the unburned study plot.

FIGURE 2. Photograph of the burned study plot.

clusters of observations on different parts of the grids. From these patterns of occurrence, and from information on the locations of specific nests and the simultaneous singing of two or more males, we estimated the numbers of breeding pairs of each species on the two plots. Raptorial birds with very large home ranges and other species observed only as vagrants were not included in the analysis.

It became evident early in the study that many birds occupied territories or home ranges which lay only partially within the 20.9 acre plots. By spending much time collecting data (approximately 226 total field hours) both on and peripheral to the plots we were able to determine about what percentage of a given territory lay on the study area and thus to estimate densities to the nearest quarter pair with considerable accuracy. However, some birds in certain years were recorded often enough to suggest that they were nesting on one of the plots, but with much less than one quarter of their home ranges lying within them. These instances (designated with "+" signs in table 3) were assigned the arbitrary value of 0.05 pairs for purposes of numerical analysis. The influence of these data on the overall estimations of density was slight; using even 0.25 instead of 0.05 increases the computed total number of pairs per 100 acres by only a few per cent.

DENSITY AND DIVERSITY

Table 1 presents a list of all bird species observed, with information concerning their status on the two plots. Table 2 is a summary comparison of the burned and unburned study plots. These tables show that only about half the total species observed occurred in both areas, each plot having a sizeable distinctive element in its avifauna.

An analysis of the regular breeding avifaunas is presented in table 3. Salt (1953, 1957) studied the composition of bird populations in terms of various "feeding categories" which he based upon foraging position and diet (e.g. "Foliage-insect," "Ground-insect," "Ground-seed," "Timber-searching," etc.). In table 3 we have assigned each species to one of a series of categories modified slightly from Salt's scheme. The categories are: Flycatching (F), Tree Foliage-Searching (TFS), Timber-Gleaning (TG), Timber-Drilling (TD), and Ground-Brush Foraging (GBF). A major difference between our classification and Salt's is our distinction between tree and brush foragers. This seemed relevant in light of the vegetational differences between the burned and unburned plots. Also, we did not make the often arbitrary attempt to separate seed-eaters from more exclusively insectivorous species. Salt did this in order to compare primary with secondary consumers, a consideration not immediately relevant to our study. Average densities are expressed as the number of pairs per 100 acres rather than hectares to facilitate comparison with similar studies (Salt 1953, 1957; Dixon 1959; Lawrence 1966; Kilgore 1968).

Although the plots used appear to have been somewhat smaller than would have been best suited to our study, there are two reasons why we feel the results and conclusions are valid. First, the large amount of time spent on and peripheral to the plots during each breeding season appears to have resulted in accurate estimates of density. Note in table 3 that while densities varied from a low in 1967 to a high in 1968, this trend was similarly detected by our censuses in both the burned and unburned areas. That is, our determinations of relative densities on the two plots remained consistent in relation to one another. Second, the major differences in the avifaunas of the burned and unburned areas, those of biomass and of foraging categories occupied, were of such magnitude as to be beyond the realm of probable error.

McIntosh (1967:398) has recently derived the following index of diversity:

$$I_p = \frac{N - \sqrt{\sum_{i=1}^{s} n_i^2}}{N - \sqrt{N}},$$

TABLE 1. Bird species observed on or near the study plots.

Species	Status[a] Burned	Unburned
Turkey Vulture (*Cathartes aura*)	V	
Goshawk (*Accipiter gentilis*)	V	
Red-tailed Hawk (*Buteo jamaicensis*)	V	
Sparrow Hawk (*Falco sparverius*)	V	
Mountain Quail (*Oreortyx pictus*)	V	
Mourning Dove (*Zenaidura macroura*)	V	
Great Horned Owl (*Bubo virginianus*)		V
Poor-will (*Phalaenoptilus nuttallii*)	V	
Common Nighthawk (*Chordeiles minor*)	V	V
Vaux Swift (*Chaetura vauxi*)	V	
Rufous Hummingbird (*Selasphorus rufus*)	V	V
Calliope Hummingbird (*Stellula calliope*)	V	V
Pileated Woodpecker (*Dryocopus pileatus*)		V
Red-shafted Flicker (*Colaptes cafer*)	B	B
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	B	B
Williamson Sapsucker (*Sphyrapicus thyroideus*)	B	
Hairy Woodpecker (*Dendrocopos villosus*)	B	B
White-headed Woodpecker (*Dendrocopos albolarvatus*)	B	B
Black-backed Three-toed Woodpecker (*Picoides arcticus*)	B	B
Empidonax sp. (probably *E. oberholseri*)	B	B
Western Wood Pewee (*Contopus sordidulus*)	B	B
Olive-sided Flycatcher (*Nuttallornis borealis*)	B	
Tree Swallow (*Iridoprocne bicolor*)	V	
Cliff Swallow (*Petrochelidon pyrrhonota*)	V	
Steller Jay (*Cyanocitta stelleri*)	V	B
Clark Nutcracker (*Nucifraga columbiana*)	V	
Mountain Chickadee (*Parus gambeli*)	B	B
White-breasted Nuthatch (*Sitta carolinensis*)	B	B
Red-breasted Nuthatch (*Sitta canadensis*)	V	B
Pygmy Nuthatch (*Sitta pygmaea*)	B	V
Brown Creeper (*Certhia familiaris*)	B	B
House Wren (*Troglodytes aedon*)	B	
Robin (*Turdus migratorius*)	B	B
Hermit Thrush (*Hylocichla guttata*)		B
Mountain Bluebird (*Sialia currucoides*)	B	
Townsend Solitaire (*Myadestes townsendi*)	B	B
Golden-crowned Kinglet (*Regulus satrapa*)		B
Ruby-crowned Kinglet (*Regulus calendula*)		V
Solitary Vireo (*Vireo solitarius*)		B
Nashville Warbler (*Vermivora ruficapilla*)		B
Yellow Warbler (*Dendroica petechia*)		V
Audubon Warbler (*Dendroica auduboni*)	B	B
MacGillivray Warbler (*Oporornis tolmiei*)	V	V
Brown-headed Cowbird (*Molothrus ater*)	V	V
Western Tanager (*Piranga ludoviciana*)	B	B
Lazuli Bunting (*Passerina amoena*)	B	
Evening Grosbeak (*Hesperiphona vespertina*)		V
Cassin Finch (*Carpodacus cassinii*)	B	B
Pine Siskin (*Spinus pinus*)	V	V
Green-tailed Towhee (*Chlorura chlorura*)	B	
Oregon Junco (*Junco oreganus*)	B	B
Chipping Sparrow (*Spizella passerina*)	B	
Brewer Sparrow (*Spizella breweri*)	B	
Fox Sparrow (*Passerella iliaca*)	B	B
Summary		
Breeding:	26	23
Vagrant:	19	12
Total:	45	35

[a] B = Breeding, V = rare or vagrant.

TABLE 2. Avifaunal comparison of burned and unburned study plots.

Species	Total	No. species on: both plots	burned only	unburned only
All observed	54	26(48%)	19(35%)	9(17%)
Regular breeding	32	17(54%)	9(28%)	6(19%)

where N = total sample size, s = number of species represented in the sample, n = number of individuals of a particular species in the sample, and I_p = per cent of theoretical maximum diversity for a particular N.

Since the number of pairs per 100 acres for our two plots was virtually identical ($N = 91.2$ for the burned plot and 91.8 for the unburned plot), it was possible to calculate and compare I_p on the two areas. For the burned plot, this index was 78 per cent maximum diversity, and for the unburned plot, 72 per cent.

From these data the breeding avifauna on the burned study plot appears to have been slightly richer and more diverse than that of the unburned forest, although these differences may be negligible within the accuracy of our study. This might at first seem surprising, since the burn appeared to be much less heterogeneous than the living forest with its variety of conifers and understory vegetation. However, the fire spared numbers of mature trees on the burned study plot, so that, in addition to those species living exclusively on the burn, the area also attracted several species which (1) nested in live trees and fed out on the burn (Robin, Audubon Warbler, Cassin Finch), (2) nested in burned stubs but foraged mainly in live timber (both species of sapsuckers, Pygmy and White-breasted Nuthatches, Mountain Chickadee), or (3) were restricted to live trees (Western Tanager). Insofar as our burned plot was a mixture of the original unburned forest and the post-fire vegetation, it might be said to have had some characteristics of an edge or ecotone between two simpler habitats, where an increase in diversity could be expected. Karr (1968) has recently shown a close correlation between avian and vegetational diversity on strip-mined lands in Illinois.

FORAGING CATEGORIES

The occurrence of birds belonging to different foraging categories (table 3) was closely correlated with the nature of the vegetation on the burned and unburned study plots (fig. 3). Those species specialized for foraging amongst the needles and twigs of living conifers (TFS) were much more common on the unburned plot. These included: Mountain Chickadee, Golden-crowned Kinglet, Nashville Warbler, and Western Tanager. Species characteristic of low brush and relatively open ground predominated on the burned plot (fig. 3). Ground-brush foragers (GBF) nesting only on the burn were the House Wren, Mountain Bluebird, Lazuli Bunting, Green-tailed Towhee, Chipping Sparrow, and Brewer Sparrow. In addition Red-shafted Flickers, Robins, Cassin Finches, and Fox Sparrows were more common in the burned area. Of species placed in the ground-brush category, only the Hermit Thrush was restricted to the unburned forest, and was characteristic of only the most shaded and concealed areas of forest floor. The Oregon Junco was common on both plots and comprised over half the ground-brush component in the unburned forest.

Although timber-drillers formed a greater percentage of the burn's avifauna due to the regular occurrence of one pair each of three-toed woodpeckers and Hairy Woodpeckers (table 3), woodpeckers did not comprise a large precentage of the avifauna of either plot. Soon after a forest fire, dead trees become infested with woodboring insects, and woodpeckers may be common at this stage. Blackford (1955) found three-toed and Hairy Woodpeckers extremely abundant in November 1945 in a Montana coniferous forest which had burned the previous July, but found no woodpeckers at all the following March. Field observers at Sagehen Creek noticed that woodpeckers were abundant on the Donner Ridge burn in the first few years following 1960. By the time our study was initiated, however, the burned trees were thoroughly decayed, apparently supporting few woodboring insects.

Joseph Grinnell (1928) pointed out that birds, because of their mobility, readily respond to changes in habitat or food availability. Our data support this observation, as have studies by other workers. For example, Lawrence (1966) found that, following a fire in chaparral of the Sierra Nevada foothills, the avifauna quickly shifted from one dominated by species characteristic of dense brush to one with large numbers of grassland species. Less

TABLE 3. Analysis of the breeding avifauna of the study plots.

Species	Foraging category[a]	Pairs/plot[b] 1966	1967	1968	No. pairs/ 100 acres	Mean wt./ bird (g)[c]	Standing crop (g/100 acres)	Consuming biomass (g/100 acres)[d]
Burned plot								
Red-shafted Flicker	GBF	0.75	0.50	0.75	3.2	145	928.0	208.0
Yellow-bellied Sapsucker	TD	+[e]	0.25	0	0.5	45	45.0	14.4
Williamson Sapsucker	TD	+	+	0.50	1.0	50	100.0	30.8
Three-toed Woodpecker	TD	0.75	0.50	0.75	3.2	73	467.2	128.6
Hairy Woodpecker	TD	0.25	0.25	0.25	1.2	70	168.0	46.8
White-headed Woodpecker	TD	+	0	0.25	0.5	58	58.0	13.3
Empidonax sp. (*oberholseri*?)	F	0.50	0.25	2.25	4.8	12	115.2	54.7
Western Wood Pewee	F	0.25	0.75	0.75	2.8	14	78.4	35.6
Olive-sided Flycatcher	F	0.25	0.25	+	0.9	32	57.6	20.3
Pygmy Nuthatch	TG	1.00	0.25	1.00	3.6	10	72.0	36.1
White-breasted Nuthatch	TG	0.50	0.50	0.50	2.4	18	86.4	36.4
Brown Creeper	TG	0.50	+	0.50	1.7	8	27.2	15.0
Mountain Chickadee	TFS	1.50	0.75	1.00	5.2	12	124.8	59.3
Robin	GBF	0.50	0.50	1.50	4.0	88	704.0	185.6
Mountain Bluebird	GBF	3.25	3.00	3.25	15.2	27	820.8	304.0
Townsend Solitaire	GBF	0.50	+	0.25	1.3	53	137.8	41.8
House Wren	GBF	+	0.75	1.00	2.9	10	58.0	30.2
Audubon Warbler	TFS	0	0.50	0.75	2.0	13	52.0	24.0
Western Tanager	TFS	0.25	0.25	0	0.8	29	46.4	17.0
Lazuli Bunting	GBF	+	+	0	0.2	15	6.0	2.7
Cassin Finch	GBF	0.50	0.75	1.50	4.4	28	246.4	90.6
Green-tailed Towhee	GBF	+	0	0.50	0.9	27	48.6	18.0
Oregon Junco	GBF	4.00	4.00	3.50	18.4	18	662.4	279.7
Fox Sparrow	GBF	0	0.25	0.50	1.2	31	74.4	26.6
Brewer Sparrow	GBF	0.50	1.00	0.75	3.6	11	79.2	38.6
Chipping Sparrow	GBF	2.00	0.75	0.75	5.6	12	134.4	63.8
TOTALS		18.05	16.20	22.80	91.5		5398.2	1821.9
Unburned plot								
Red-shafted Flicker	GBF	+	+	+	0.2	145	58.0	13.0
Yellow-bellied Sapsucker	TD	0.25	0.25	0.25	1.2	45	108.0	34.6
White-headed Woodpecker	TD	+	0	0	0.1	58	11.6	2.7
Hairy Woodpecker	TD	+	+	0.25	0.6	70	84.0	23.4
Three-toed Woodpecker	TD	0	+	0.25	0.5	73	73.0	20.1
Empidonax sp. (*oberholseri*?)	F	1.25	1.00	3.00	8.4	12	201.6	95.7
Western Wood Pewee	F	0	0.25	0	0.4	14	11.2	5.1
Steller Jay	TFS	0.25	+	+	0.6	88	105.6	27.8
Mountain Chickadee	TFS	3.75	3.25	2.75	15.6	12	374.4	177.8
White-breasted Nuthatch	TS	0.25	+	+	0.6	18	21.6	9.1
Red-breasted Nuthatch	TS	1.25	1.00	1.00	5.2	10	104.0	52.2
Brown Creeper	TS	0.75	0.50	1.00	3.6	8	57.6	31.7
Robin	GBF	0.25	+	+	0.6	88	105.6	27.8
Hermit Thrush	GBF	0.50	0.50	0.50	2.4	26	124.8	45.9
Townsend Solitaire	GBF	0.50	0.50	0.25	2.0	53	212.0	64.4
Golden-crowned Kinglet	TFS	4.00	3.00	4.00	17.6	5	176.0	109.1
Solitary Vireo	TFS	0	+	0.25	0.5	30	30.0	10.8
Nashville Warbler	TFS	0.50	+	0.75	2.0	11	44.0	21.4
Audubon Warbler	TFS	0	0.25	1.25	2.4	13	62.4	28.8
Western Tanager	TFS	1.50	0.75	1.25	5.6	29	324.8	118.7
Cassin Finch	GBF	0	0.25	1.75	3.2	28	179.2	65.9
Fox Sparrow	GBF	0	+	0.50	0.9	31	55.8	20.0
Oregon Junco	GBF	3.50	3.50	4.00	17.6	18	633.6	267.5
TOTALS		18.50	15.0	23.25	91.8		3158.8	1273.5

[a] F = flycatching; TFS = tree foliage-searching; TG = timber-gleaning; TD = timber-drilling; GBF = ground-brush foraging.
[b] Each plot was 20.9 acres.
[c] From Salt (1957) and Kilgore (1968).
[d] Calculated using 0.7 exponent of body weight.
[e] Recorded frequently enough to suggest nesting on the plot, but with less than one-quarter of home range lying within the plot.

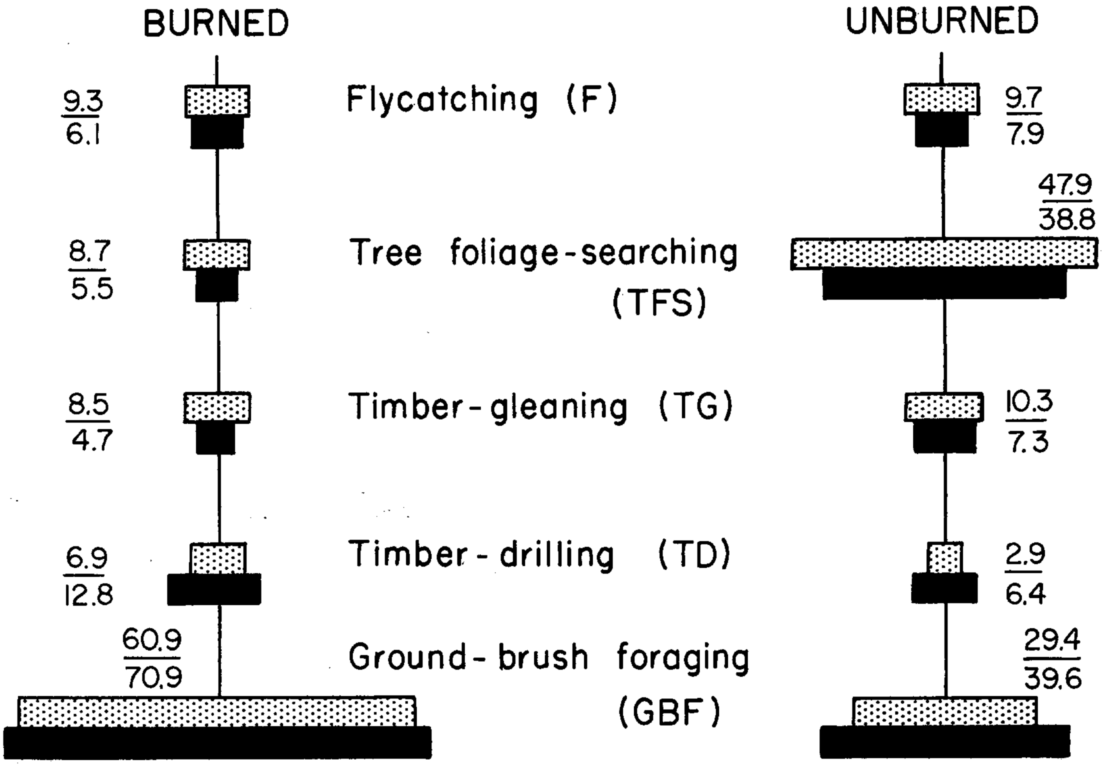

FIGURE 3. Percentage distribution of breeding birds according to foraging type in burned and unburned areas. Solid bars = distribution by consuming biomass; shaded bars = numbers of individuals. Numbers are actual percentages.

striking alterations of habitat will also effect changes in breeding bird populations. Kilgore (1968) made a detailed study of the avifaunas of cut-over stands of *Sequoia gigantea.* On some plots the dense understory of small white fir and incense cedar was artificially removed. This relatively subtle opening of the forest (in comparison with a fire) resulted in elimination of certain brush-dependent species, such as the Rufous-sided Towhee (*Pipilo erythrophthalmus*), while species typical of open habitat, such as flycatchers and Robins, became more abundant.

Because birds do concentrate in areas where food is available to them, because their diets and habitat preferences are relatively well known, and because birds as a group are easy to observe, avifaunal analysis may provide a convenient and meaningful index to the distribution of energy in ecosystems.

BIOMASS CONSIDERATIONS

Salt (1957) pointed out the value of biomass figures, rather than numbers of individuals, as an index of the abundance or productivity of different species; furthermore, he noted that simple standing crop figures do not give a valid estimate of energy flow in a fauna. "Consuming biomass" (table 3), calculated from the 0.7 exponent of body weight, gives a better comparative index of energy flow because it compensates for the fact that larger species have relatively lower metabolic rates per gram of body weight (Salt 1957:376–377; Karr 1968). The ratio of consuming biomass to standing crop biomass is a reflection of the efficiency of a particular species in food utilization; larger birds show a greater discrepancy between consuming and standing crop biomasses and are more efficient because they require less energy per gram of body weight to sustain themselves.

Salt (op. cit.: 392) analyzed breeding avifaunas in three coniferous forest types in Wyoming and concluded that "in the coniferous forest avifaunas an increase has been found in standing crop biomass and in efficiency, as measured by [decrease in] the ratio of consuming biomass to standing crop biomass, as succession proceeds toward the climax. Similar relationships have been found in the avifaunas of three successions of the eastern United States reported in the literature: oak-hickory of Georgia, beech-maplehemlock of New York, and beech-maple-pine in Michigan." In other words, later successional stages were found to support a greater biomass consisting of birds which utilized available energy more efficiently because of larger body sizes. Karr (1968) has shown similar relationships for successional stages on strip-mined areas in Illinois.

Although the burned study plot at Sagehen Creek supported virtually the same number of birds as the unburned plot, the standing crop and consuming biomass figures were 1.7 and 1.4 times greater, respectively, than in the unburned forest (table 3). Furthermore, the ratio of consuming to standing crop biomass was lower (0.34 to 0.40) and thus efficiency was higher on the burned area. The numbers of birds were the same, but individuals were, on the average, heavier on the burned plot. In short, our data seem to contradict the observations of Salt and Karr on plant succession and bird energetics.

There are two factors which may explain the greater biomass and efficiencies observed on the burned study plot. Salt (1957) pointed out that selection favors large body size in birds because of the advantages gained in food storage. However, large body size may prejudice effective foraging. As shown in figure 3, most birds breeding on the burned study plot foraged for seeds and insects on the ground and in low brush. The species involved were relatively heavy bodied, especially the flicker, Robin, and Mountain Bluebird. In contrast, much of the food on the unburned plot consisted of insects living in the foliage of live conifers. This energy was available only to smaller birds, particularly the Mountain Chickadee and Golden-crowned Kinglet (table 3), which are capable of foraging in that type of niche but which are relatively inefficient utilizers of energy because of their small body size.

A second point is that consuming biomass figures reflect basal rather than active metabolic rates. Although we have no quantitative data, qualitative observations suggested that chickadees and kinglets were much more active than birds such as fringillids, and may have consumed much more energy than a ground-brush forager of equal biomass. With these considerations in mind, we suggest that, in addition to the fact that the number of individuals on each plot was virtually the same, aggregate energy flow probably was not very different in the avifaunas of the burned and unburned forest. It simply flowed through different channels.

SUMMARY

The breeding avifaunas of burned and unburned coniferous forest in the Sierra Nevada were censused over a three-year period using two permanent grids. Of 32 regularly breeding species 28 per cent were unique to the burned plot, while 19 per cent occurred only in the unburned forest.

In addition to post-fire vegetation, the burned plot contained small pockets of mature conifers spared by the fire. Perhaps as a result of this heterogeneity, the breeding avifauna of the burned area was slightly richer (26 species vs. 23) and more diverse than in the unburned forest.

The types of birds present closely paralleled the nature of the vegetation in the two areas. Species adapted to forage among the needles of living conifers were much more common on the unburned plot while species characteristic of low brush and open ground predominated on the burn.

Although the number of birds breeding on each plot was nearly the same, the biomass was much greater on the burned study plot. The burn supported birds which were heavier on the average, and which, because of larger body size, presumably utilized available energy more efficiently. Salt (1957) has suggested that communities approaching "climax" conditions are characterized by larger and more efficient avifaunas. However, forest fires are considered to reverse rather than advance succession. It seems likely that the burn supported heavier birds than the mature forest simply because of the different problems of foraging in the two areas. The aggregate energy flow was probably quite comparable in the forest and in the burn.

ACKNOWLEDGMENTS

We wish to thank A. S. Leopold and V. M. Hawthorne for surveying and marking the study plots and for making available the facilities of the Sagehen Creek Field Station. W. D. Arvey and L. F. Baptista participated in the censuses of 1966 and 1967, respectively.

LITERATURE CITED

BLACKFORD, J. 1955. Woodpecker concentration in a burned forest. Condor 57:28–30.

DIXON, K. L. 1959. Ecological and distributional relations of desert scrub birds. Condor 61:397–409.

GRINNELL, J. 1928. Presence and absence of animals. Univ. California Chron. 30:429–450.

KARR, J. R. 1968. Habitat and avian diversity on strip-mined land in east-central Illinois. Condor 70:348–357.

KENDEIGH, S. C. 1944. Measurement of bird populations. Ecol. Monogr. 14:67–106.

Kilgore, B. M. 1968. Breeding bird populations in managed and unmanaged stands of *Sequoia gigantea*. Ph.D. thesis, Univ. California, Berkeley.

Lawrence, G. E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology 47:278–291.

McIntosh, R. P. 1967. An index of diversity and the relation of certain concepts to diversity. Ecology 48:392–404.

Salt, G. W. 1953. An ecological analysis of three California avifaunas. Condor 55:258–273.

Salt, G. W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor 59:373–393.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6:317–408.

Accepted for publication 11 March 1969.