

## Summer Birds of the Upper Subalpine Zone of Mount Adams, Mount Rainier, and Mount St. Helens, Washington

### Abstract

Fifty-five bird species were observed during the summers of 1982 and 1985 using the upper subalpine habitat on three Cascade volcanoes. The vegetation differed somewhat among the study areas, although subalpine fir (*Abies lasiocarpa*) was the dominant tree at all sites. Bird species richness was highest at Mount Adams and Pine Creek on Mount St. Helens, and lowest at Butte Camp on Mount St. Helens. Bird abundance was highest at Butte Camp where there were large numbers of pine siskins. Several species exhibited wide variation in abundance among study areas. Approximately 18 species nested at each study area, but there was variation in species composition. Differences in abundance and species composition were partly attributable to vegetation features of the study areas. Birds feeding on insects on or near the ground, and conifer seed-eaters were numerically dominant. There appeared to be no longterm impact of the 1980 eruption of Mount St. Helens on the subalpine avifaunas except at Pine Creek where the trees were scorched and subsequently died.

### Introduction

The large dominant volcanic peaks, Mount Rainier, Mount Adams, and Mount St. Helens, in the Washington Cascade Range are part of a belt of active volcanoes surrounding the Pacific Ocean (Bullard 1979). The particular species composition and structure of subalpine forest communities on these volcanoes and the bird assemblages that depend on them have been shaped by previous volcanism and geographic location. Although these peaks, particularly Mount Rainier, have been previously studied by botanists, we are unaware of any previously-published studies on bird communities in the upper subalpine zone of the Cascades.

Subalpine bird communities have been investigated in other parts of the United States (e.g., Rabenold 1978, Sabo 1980, Smith 1980, Kendeigh and Fawver 1981, Smith and MacMahon 1981). In general, these studies have shown that high-elevation forest avifaunas show marked differences in some characteristics compared with lower elevation forests.

This study was initiated as part of an interdisciplinary investigation on the effects of the 1980 eruptions of Mount St. Helens on plants, animals, and soils. Since nearly all the subalpine zone of Mount St. Helens was destroyed or disturbed by the 1980 eruptions, we selected undisturbed subalpine sites on Mount Adams to the east and Mount Rainier to the north for comparison. This allowed us a broader perspective of subalpine bird communities in the Cascades.

The specific questions asked were: (1) how do avian species composition and abundance on Mount St. Helens compare with those on Mount Adams and Mount Rainier? and (2) what were the effects of the 1980 eruptions on the summer birds of the upper subalpine zone of Mount St. Helens?

### Study Area

We use the term subalpine to refer to the tree-dominated montane forests that border the upper elevation treeless zones (MacMahon and Andersen 1982). On the western slopes and crest of the Cascade Range, this forest is classified as the Mountain Hemlock Zone (Franklin and Dyrness 1973). This zone has been divided into two major subzones: a lower one that is a nearly closed canopy forest, and an upper one that is a meadow-forest mosaic. Two of our study sites (Sunrise and Butte Camp) were in the upper subzone, one was in the lower subzone (Killen Creek), and one (Pine Creek) incorporated features of both subzones. Even though all study sites were in the subalpine zone, tree species composition, relative abundance (Table 1), and understory vegetation (Table 2) varied among the four areas. We first tested these differences by using one-way ANOVA, followed by Student's t tests for comparisons between individual areas (Colton, 1974).

The Butte Camp site (elevation, 1360 m), at treeline on the southwest flank of Mount St. Helens, was dominated by a mixture of small-sized subalpine fir (*Abies lasiocarpa*) and

TABLE 1. Characteristics of the subalpine forest censused on Mount St. Helens, Mount Adams, and Mount Rainier, Washington.

	Mount St. Helens								Mount Adams				Mount Rainier			
	Pine Creek				Butte Camp				Killen Cr.				Sunrise			
	N	D*	$\bar{X}$	SD	N	D	$\bar{X}$	SD	N	D	$\bar{X}$	SD	N	D	$\bar{X}$	SD
Subalpine Fir <i>Abies lasiocarpa</i>	110	58	21.0	15.1	76	124	8.4	8.3	80	63	21.7	15.2	147	16	22.2	16.8
Lodgepole Pine <i>Pinus contorta</i>	27	14	13.1	12.7	72	117	6.5	6.1	36	28	11.3	10.3				
W. White Pine <i>P. monticola</i>	2	1	31.9	3.6	4	6	9.3	12.3	15	12	7.3	4.7				
Whitebark Pine <i>P. albicaulis</i>													9	1	24.2	13.8
Mountain Hemlock <i>Tsuga mertensiana</i>									27	21	19.4	11.5	1			
Pacific Silver Fir <i>Abies amabilis</i>	19	10	6.9	2.8												
Noble Fir <i>A. procera</i>					8	13	3.2	0								
Englemann Spruce <i>Picea engelmannii</i>									2	2	26.0	7.1				
TOTAL	158	83			160	260			160	125			157	17		

\*D is density (trees/ha)

TABLE 2. Mean percent cover and height (cm) of understory vegetation at subalpine study sites in the Southern Washington Cascade Mountains. Values in bold and bold italic are not significantly different ( $P > .05$ )

	Mount St. Helens				Mount Adams		Mount Rainier	
	Butte Camp		Pine Creek		Killen Creek		Sunrise	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Percent herb cover	2.5	2.9	<b>12.8</b>	<b>13.1</b>	<b>10.4</b>	<b>8.7</b>	34.1	17.4
Percent woody cover	<b>6.5</b>	<b>12.8</b>	<b>30.3</b>	<b>24.2</b>	<b>30.3</b>	<b>17.5</b>	<b>4.8</b>	<b>13.3</b>
Height of herbs	3.9	2.7	10.1	8.6	<b>16.2</b>	<b>5.2</b>	<b>16.2</b>	<b>7.9</b>
Height of woody plants	<b>26.5</b>	<b>30.8</b>	<b>36.5</b>	<b>21.3</b>	47.2	13.7	8.4	19.8

<sup>a</sup> $P < 0.001$

lodgepole pine (*Pinus contorta*). A few western white pines (*P. monticola*) and noble firs (*A. procera*) were also present. During the 1980 eruptions this area received a layer of airborne tephra as well as two mudflows near the site. The trees showed no obvious effect from the eruptions. The sparse ground vegetation, however, was impacted even though it was under snow when the large eruption occurred in May. There was some reduc-

tion in plant species diversity and ground cover, but by 1982 it had recovered substantially (del Moral 1983).

The Pine Creek site (elevation 1,650 m) was also at treeline on the southeast flank of Mount St. Helens at the edge of the large Pine Creek mudflow. The tree species composition and structure of this area was an ecotone between the upper and lower subzones of mountain hemlock

(*Tsuga heterophylla*). As at Butte Camp, the upper subzone is very narrow in vertical extent there. The study area was a mixture of several conifer species dominated primarily by live and lethally-scorched subalpine firs. Pacific silver fir (*A. amabilis*) was abundant in the understory of the lower subzone and less numerous in the overstory. Lodgepole pine, which thrived on the xeric volcanic soils, was important in the upper subzone. Western white pine and noble fir were frequent in the lower subzone overstory. Tree heights varied more than those at any site: at treeline subalpine firs and lodgepole pines were 2 m tall whereas 300 m downslope trees were 20 m tall. Ground vegetation was lush in the lower subzone, being dominated by lupine (*Lupinus latifolius*) and huckleberry (*Vaccinium membranaceum*).

The Killen Creek site (elevation 1,650 m) was on the north side of Mount Adams in the lower subzone. The dominant trees were subalpine fir and lodgepole pine. The forest is broken by many small openings that are densely choked with *V. membranaceum*, indicating that the stand may be a slowly-developing fire-related seral stage (Franklin and Dyrness 1973). The dominant shrub was *V. membranaceum*. This stand has elements of the Mountain Hemlock Zone of the upper west slope of the Cascades and the Subalpine Fir Zone typical of the eastern upper slope of the Cascades. Tree density was intermediate between the two Mount St. Helens sites.

The Sunrise site (elevation 2,100 m) was on the northeast slope of Mount Rainier in the upper subzone. This subalpine environment differed from the other sites in that it was at a higher elevation, the trees were arranged in widely-spaced clumps, and whitebark pine (*P. albicaulis*) replaced lodgepole pine. The open meadows between tree clumps were dominated by a variety of primarily herbaceous plants.

## Methods

Trees were sampled by using the point-centered quarter method (Mueller-Dombois and Ellenberg 1974). Forty points were spaced along the bird point-count route in each study area. Understory cover was estimated using a 1 m square frame made of PVC tubing. Four quadrats were placed 1 m from the station point marker in the four cardinal directions, making a total of 48 quadrats in each study area.

Originally, we used the variable circular plot technique (Reynolds *et al.* 1980) to estimate bird densities. However, we found this method unsuitable because of logistical constraints, the presence of uncommon species, and relatively large numbers of flocking birds for which no density estimate could be calculated. We therefore estimated relative abundance by a station count method in which we established 11-22 stations spaced 100 m apart, usually along a rectangular route. All birds seen or heard during an eight-minute period at each station were recorded and a mean detection rate was calculated by dividing total number of observations by total number of station counts for six visits. Observer discretion was used to avoid double counting. Preliminary observations were made by Manuwal in 1981. All data reported are for 30 June-30 August 1982 and 8 July-26 August 1985.

Coefficients of species similarity ( $S_s$ ) were calculated with the Sorenson equation (Able and Noon 1976):

$$S_s = 2C / (A + B)$$

where C represented the species common to the two subalpine habitats, and A and B the number of bird species in each habitat. Values higher than 0.50 indicate that the two habitats are more alike than different.

We also evaluated the abundance pattern by using a coefficient of population similarity ( $S_p$ ) (Odum 1950):

$$S_p = 1.0 - \Sigma(P_a - P_b) / P_a + P_b$$

where  $P_a$  is the population of a species in habitat a and  $P_b$  in habitat b, +  $\Sigma P_a$  and  $P_b$  are the total populations (sum of detection rates in Table 3) in the two habitats. Differences in detection rates among the four study areas were tested by using one-way analysis of variance. The birds using our study areas were classified into nine general foraging guilds similar to those described by Smith (1982) and Sabo and Holmes (1983).

## Results

*Vegetation Parameters*—Subalpine fir was the dominant tree species on all study areas (Table 1) and the only species to occur at all study sites. Lodgepole pine was a codominant at Butte Camp and was the second most abundant species at Pine Creek (except in the lower subzone) and Killen Creek. Western white pine also occurred

TABLE 3. Sampling effort, species richness, and abundance of summer birds of subalpine forests of Mount St. Helens, Mount Adams, and Mount Rainier, Washington

Category	Mount St. Helens		Mount Adams	Mount Rainier
	Pine Creek	Butte Camp	Killen Creek	Sunrise
Number of station Counts <sup>a</sup>	184	160	248	224
Total Observations	1278	1354	1845	1427
Total Species	43	35	44	30
Detection Rate <sup>b</sup>	6.92	8.53	7.41	6.44
Mean Detection Rate/Species	0.16	0.24	0.17	0.21
Breeding Species	23	12	18	18
Detection Rate	6.57	7.55	6.64	5.71
Mean Detection Rate/Species	0.27	0.63	0.37	0.32

a Product of the number of stations and the number of visits.

b Mean number of birds detected per station count.

at three of the four sites. Several other conifers were unique to each particular site. Tree density ranged from 260 trees/ha at Butte Camp to 17 trees/ha at Sunrise (Table 1). Mean diameter of trees was smaller ( $t = 2.58$ ,  $P < .001$ ) at Butte Camp than at the other three sites.

Understory vegetation varied among study areas (Table 2). Of the study area cover comparisons, all but Pine Creek-Killen Creek differed ( $t = 1.08$ ,  $P = 0.28$ ) in the amount of herbaceous vegetative cover. Furthermore, only Pine Creek-Killen Creek ( $t = 0.005$ ,  $P = 0.99$ ) and Butte Camp-Sunrise ( $t = 0.64$ ,  $P = 0.52$ ) did not differ in woody vegetation cover. All but Sunrise-Killen Creek differed ( $t = 1.53$ ,  $P = 0.99$ ) in herbaceous vegetation height and Butte Camp-Pine Creek differed ( $t = 1.86$ ,  $P = 0.07$ ) in woody vegetation height.

*Avian Communities*—Due to the extreme variation in breeding phenologies of birds in the Cascade Range, two analyses of the data were necessary to better understand summer birds using subalpine habitats. At the time of our study, two major groups of birds were using the upper subalpine. These were (1) birds nesting on our study areas and (2) visitors that had already completed nesting at lower elevations and were dispersing or migrating upslope. It was, of course, difficult to identify the breeding status of individual birds observed. Nevertheless, based on observations of nests, adults feeding young, and literature references, we were able to determine which species were breeding or were most likely to breed on our study areas. Our analyses,

therefore, will first consider all bird observations and then the breeding species.

*All birds observed*—During 1982 and 1985 we observed 55 species on the study areas. Species richness was highest at Killen Creek and Pine Creek and lowest at Sunrise (Table 3). The relatively low diversity of these communities was reflected by avian dominance values (the two most abundant species as a percent of the total). These were 59% for Butte Camp, 45% for Sunrise, 39% for Killen Creek, and 37% for Pine Creek.

There were substantial differences in species composition among the four study areas (Table 4). Coefficients of similarity ( $S_s$ ) were low ( $\bar{X} = 0.35$ ) for the six comparisons. These low coefficients reflect the relatively large number of uncommon species detected at each of the sites. For example, the percentages of all species with detection rates of 0.05 or less were 61% for Killen Creek, 56% for Pine Creek, 54% for Butte Camp, and 30% for Sunrise (Appendix).

Total detection rates differed ( $P < 0.001$ ) among the four study areas. Furthermore, there were large differences in abundance of individual species. For example, Clark's nutcrackers and evening grosbeaks were far more common at Killen Creek and Sunrise than the sites on Mount St. Helens (Appendix). Flocking species such as pine siskin, evening grosbeak, and crossbills showed wide variation in abundance among the four study areas.

Pine siskins and dark-eyed juncos were the most abundant birds, comprising 44% of all bird

TABLE 4. Species richness and similarity coefficients (Sp, Ss) among subalpine bird populations in the southern Washington Cascade Mountains

Locations	Species Common to both areas		Similarity			
	All species	Breeding species	All species		Breeding	
			Sp	Ss	Sp	Ss
Pine Creek-Killen Creek	32	11	0.71	0.26	0.61	0.39
Killen Creek-Sunrise	26	14	0.69	0.39	0.70	0.36
Butte Camp-Sunrise	23	11	0.63	0.37	0.63	0.32
Butte Camp-Killen Creek	27	11	0.62	0.37	0.63	0.34
Pine Creek-Butte Camp	30	12	0.56	0.33	0.55	0.37
Pine Creek-Sunrise	23	12	0.55	0.31	0.45	0.34
X	26.8	11.8	0.63	0.34	0.60	0.35

observations (N = 5904). They were the dominant species in all areas except at Pine Creek in 1982 when white-crowned sparrows were more numerous.

**Breeding birds**—Thirty-two bird species nested on study areas. On average, there were 18 nesting species at each study area (Table 3). The four study areas differed substantially in breeding species composition, having low coefficients of species similarity (Ss) ( $\bar{X} = 0.34$ ) (Table 4). However, when abundance was included in the comparisons, coefficients of population similarity (Sp) were relatively high for all comparisons, indicating that nesting populations were similar in size. The mean breeding species component was about 44% of all birds detected.

In terms of abundance, low understory and ground insectivores (LUGI) and tree-seed eaters (TS) were the largest guilds using these subalpine areas (Fig. 1). These foraging guilds were dominant at all sites except Pine Creek where the TS guild was depauperate. At Pine Creek few trees were available for foraging due to the destructive force of the 1980 eruption. Pine Creek had the highest percentage (62) of birds in the LUGI guild, dominated by dark-eyed juncos and white-crowned sparrows. This guild was about 50% smaller at the other three sites.

## Discussion

The particular assemblages of species at each site were probably the result of habitat structure, tree-seed production, and climate. The harsh weather conditions typical of the upper subalpine zone shape the structural features of subalpine forests

(Arno and Hammerly 1984). Structural attributes of subalpine and other forests have been linked with avian niche development (Holmes *et al.* 1979, Sabo 1980, Maurer and Whitmore 1981). The large differences in vegetative features could account for the relatively low coefficients of similarity among the four areas. Conversely, Pine Creek and Killen Creek were most similar in vegetative attributes and breeding avifauna.

Despite the dominance of subalpine fir at all study sites, the presence of other tree species undoubtedly affected bird abundance as well as guild development. The presence of pines, particularly whitebark pine and other seed-bearing conifers support the TS guild. For example, the Clark's nutcracker is a specialized seedeater that utilizes large seeds of pines (Mewaldt 1956, Tomback 1977). Nutcrackers nested only at Mount Rainier and Mount Adams where whitebark pine occurred on the study area. The large number of crossbills and possibly pine siskins were most likely linked with the abundance of seed-bearing trees. In our study and others (Smith 1980) pine siskins were a common element of western subalpine forests. Wiens (1975) and Smith (1980) found that seed-eating species were the dominant avian groups foraging in subalpine trees.

The adverse climate and the reduced resources associated with the relatively small trees typical of upper subalpine areas in the Cascades apparently affect the number of birds that search for insects in tree foliage. There is a paucity of warblers, flycatchers, and woodpeckers in these subalpine forests. The typical warbler of the subalpine was the yellow-rumped,

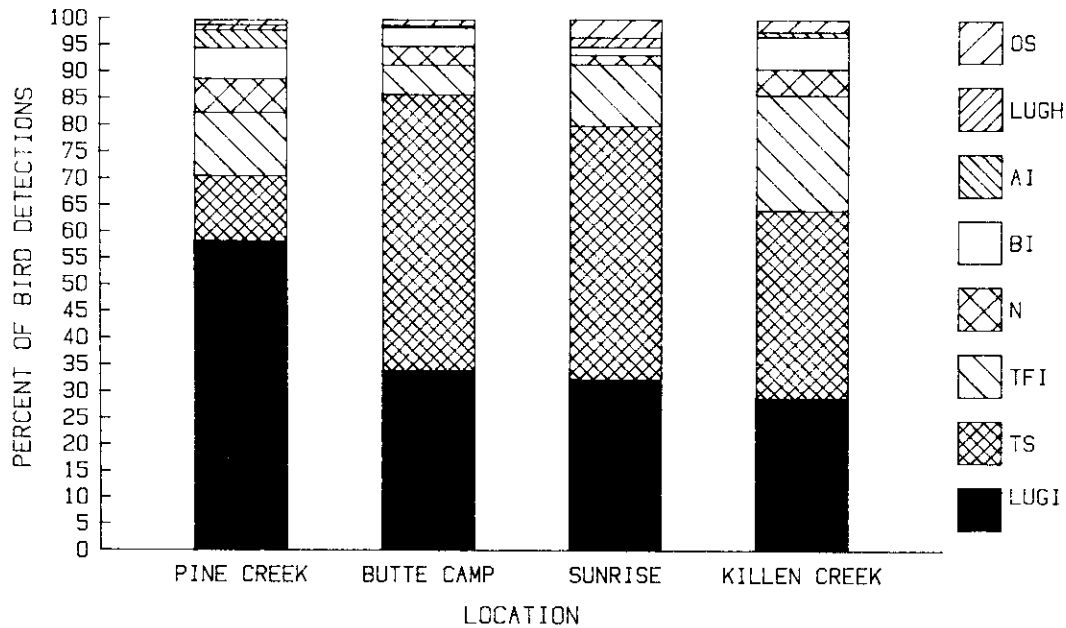


Figure 1. Histograms showing proportion of birds in each of nine feeding guilds at four subalpine sites in the Washington Cascades. Guilds are as follows: OS = omnivore-scavenger, LUGH = low understory and ground herbivore, AI = aerial insectivore, BI = bark insectivore, N = nectivore, TFI = tree foliage insectivore, TS = tree-seed eater, LUGI = low understory and ground insectivore.

which was observed consistently in all study areas. Townsend's and the yellow-rumped are the common warblers dwelling in the tree canopy of the higher elevations on the east slope of the Cascades.

Although flycatchers were present, they were rare, olive-sided being the most common. Apparently the lack of flycatchers reflects either an inadequate supply of flying insects or some unfavorable structural features of the forests. Flycatchers were also uncommon in northeastern subalpine forests (Sabo 1980, Sabo and Holmes 1983) and in the Rocky Mountain subalpine forests (Smith 1980, Smith and MacMahon 1981).

Low numbers of woodpeckers are probably due to small tree and snag size and high wood density of the slow-growing subalpine conifers. Although we did not sample bark insects, the small woodpecker populations may have been limited by lack of wood-boring insects. Red-breasted nuthatches, which nested in the study areas, forage on the trunk and on branches and needle clusters where they presumably exploit a different group of insects than woodpeckers. This

may explain why this species was the most common member of the bark insectivore (BI) guild in our study areas.

Data on understory cover and height did not explain differences in abundance and guild development. The LUGI guild was well-developed in all areas despite wide variation in cover and height values. Furthermore, understory characteristics of Pine Creek and Killen Creek were similar, yet there were substantial differences in abundance and species composition within the LUGI guild. Why white-crowned sparrows were common breeders at Pine Creek and not at Killen Creek; and why fox sparrows were nesting at Killen Creek but not at Pine Creek remains unexplained. Other habitat features such as plant species composition or dispersion of conifers may have affected birds using the ground or understory vegetation.

An interesting distributional pattern was evident with the purple finch, typical of the lower elevation coniferous forests on the west slope of the Cascades, and the Cassin's finch, more typical of the east slope of the Cascades. We observed

Cassin's finches breeding in all study areas, including Mount St. Helens which is west of the Cascade Crest. Purple finches did not occur in numbers until August, after the lowland breeding season. This pattern suggests that the Cassin's finch is the more typical upper subalpine red finch of either slope.

Only one species appeared to be strongly characteristic of one subzone or the other. The chipping sparrow was much more numerous in the upper subzone than the lower and nested only in the upper subzone. The species may be responding to the mosaic of meadows and tree clumps. This structural feature is also present in other Washington state habitats such as the ponderosa pine forests of eastern Washington, where chipping sparrows are common.

Finally, the effect of the 18 May 1980 eruption of Mount St. Helens on the bird populations varied according to the amount of devastation. Butte Camp, which received only a light tephra fall, and where the birds probably dispersed for a short time (Butcher 1981), had a bird community with foraging guilds similar to Killen Creek on Mount Adams, even though the physical appearances of the stands differ.

Pine Creek, although out of the area of high devastation, was nonetheless dramatically impacted by the hot gas eruption of July 1980 that scorched the forest. Some birds were probably killed outright, but the greatest impact occurred because the vegetation was destroyed. This resulted in the loss of the tree foliage insectivore (TFI) and TS foraging guild substrates and the dramatic reductions of birds using these guilds in comparison with the other sites. The few birds in these guilds were in the lower vertical strata that escaped the scorching. The avifauna occupying the scorched forest area two and five years after the eruption was dominated by birds using the ground and understory vegetation, for exam-

ple, dark-eyed juncos, white-crowned sparrows, and rufous hummingbirds.

Approximately half the upper subalpine forests of Mount St. Helens were destroyed in the 18 May 1980 eruption. This eruption instantly killed the majority of birds present in these areas. Those birds included permanent residents, winter residents, and early migrants. This area will probably be re-colonized as the vegetation becomes re-established. Presumably, birds using ground vegetation and aerial insects will colonize first (e.g., white-crowned sparrow, dark-eyed junco, mountain bluebird, common nighthawk, (*Chordeiles minor*). This process is already beginning but re-colonization of birds in all foraging guilds, in proportion to the other sites, will probably take many years.

The subalpine forests of the Washington Cascade volcanoes vary in tree species composition, structure, and elevational limits. Bird species composition and abundance patterns show predictable patterns relative to geographical location, general forest structure, and amount of volcanic disturbance. More research is justified to further delineate patterns of distribution and resource use and partitioning in the upper subalpine forest.

### Acknowledgments

We thank the U.S. Forest Service, Randle District, Gifford Pinchot National Forest, and the National Park Service, Mount Rainier National Park, particularly S. Schlegel, for permission to visit the areas under their jurisdiction. We thank the National Science Foundation for the grant to L. C. Bliss, Department of Botany, University of Washington for financial support. We are indebted to N. J. Manuwal, C. Braun and K. Smith and two anonymous reviewers for their editorial comments on the manuscript.

Appendix. Detection rates (mean number detected per station count) of summer birds of subalpine forests of Mount St. Helens, Mount Adams and Mount Rainier, Washington.

Guild and species	Mount St. Helens		Mount Adams	Mount Rainier
	Pine Creek	Butte Camp	Killen Creek	Sunrise
Aerial Insectivores (AI)				
Olive-sided Flycatcher	0.14**	0.01	0.04	
<i>Contopus borealis</i>				

## Appendix continued

Guild and species	Mount St. Helens		Mount Adams	Mount Rainier
	Pine Creek	Butte Camp	Killen Creek	Sunrise
Western Wood-Pewee <i>C. sordidulus</i>	0.01			
Willow Flycatcher <i>Empidonax traillii</i>	0.01			
Western Flycatcher <i>E. difficilis</i>	0.08**	0.01	0.02	
<i>Empidonax sp.</i>		0.02		
Rough-winged Swallow <i>Stelgidropteryx serripennis</i>	0.01			
Tree Foliage Insectivores (TFI)				
Mountain Chickadee <i>Parus gambeli</i>		0.01	0.48**	0.29**
Chestnut-backed Chickadee <i>P. rufescens</i>	0.03**		0.01	
Golden-crowned Kinglet <i>Regulus satrapa</i>	0.33**	0.21**	0.20**	0.07
Ruby-crowned Kinglet <i>R. calendula</i>			0.02**	
Solitary Vireo <i>Vireo solitarius</i>			0.01	
Warbling Vireo <i>V. gilvus</i>	0.01**		+***	
Orange-crowned Warbler <i>Vermivora celata</i>	0.06		0.04	0.01
Nashville Warbler <i>V. ruficapilla</i>	0.01		0.21	
Yellow-rumped Warbler <i>Dendroica coronata</i>	0.25**	0.20**	0.58**	0.32**
Townsend's Warbler <i>D. townsendi</i>	0.01		0.05	0.01
Hermit Warbler <i>D. occidentalis</i>	0.03**	0.01	0.02	
Hermit or Townsend's Warbler	0.03	0.01	0.02	0.01
Western Tanager <i>Piranga ludoviciana</i>	0.06**	0.03	+	0.01
Black-headed Grosbeak <i>Pheucticus melanocephalus</i>		0.01		
Tree-seed Eaters (TS)				
Clark's Nutcracker <i>Nucifraga columbiana</i>		0.01	0.53**	0.39**
Red Crossbill <i>Loxia curvirostra</i>	0.03	0.39	0.16**	0.11
White-winged Crossbill <i>L. leucoptera</i>	0.02	0.11	0.18	0.15
Pine Siskin <i>Carduelis pinus</i>	0.66**	3.41**	1.30**	1.83**

## Appendix continued

Guild and species	Mount St. Helens		Mount Adams	Mount Rainier
	Pine Creek	Butte Camp	Killen Creek	Sunrise
Pine Grosbeak <i>Pinicola enucleator</i>			+	
Purple Finch <i>Carpodacus purpureus</i>	0.03	0.05	0.01	+
Cassin's Finch <i>C. cassinii</i>	0.02**	0.31**	0.18**	0.09**
Purple or Cassin's Finch	0.02	0.02	0.03	
Evening Grosbeak <i>Coccothraustes vespertinus</i>	0.08	0.09	0.19**	0.51**
Bark Insectivores (BI)				
Hairy Woodpecker <i>Picoides villosus</i>	0.02		0.02**	
Williamson's Sapsucker <i>Sphyrapicus thyroideus</i>	.01			
Red-breasted Nuthatch <i>Sitta canadensis</i>	0.39**	0.29**	0.43**	0.09**
Low Understory and Ground Insectivores (LUGI)				
Northern Flicker <i>Colaptes auratus</i>	0.23**	0.07	0.08	0.06**
House Wren <i>Troglodytes aedon</i>			0.01	
Winter Wren <i>T. troglodytes</i>	0.30**	0.01	+	0.05
Mountain Bluebird <i>Sialia currucoides</i>	0.08**	0.04		
Hermit Thrush <i>Catharus guttatus</i>	0.18**	0.08**	0.10**	0.05**
American Robin <i>Turdus migratorius</i>	0.37**	0.57**	0.33**	0.21**
Varied Thrush <i>Ixoreus naevius</i>	0.26**	0.31**	0.03**	0.04**
Townsend's Solitaire <i>Myadestes townsendi</i>		0.01		
Wilson's Warbler <i>Wilsonia pusilla</i>	0.01	0.03	0.02	
MacGillivray's Warbler <i>Oporornis tolmei</i>	0.04		+	
Chipping Sparrow <i>Spizella passerina</i>	0.04**	0.38**	0.04	0.37**
Fox Sparrow <i>Passerella iliaca</i>			0.05**	0.10**
White-crowned Sparrow <i>Zonotrichia leucophrys</i>	0.72**	0.01		

## Appendix continued

Guild and species	Mount St. Helens		Mount Adams	Mount Rainier
	Pine Creek	Butte Camp	Killen Creek	Sunrise
Dark-eyed Junco <i>Junco hyemalis</i>	1.83**	1.40**	1.59**	1.06**
Low Understory and Ground Herbivores (LUGH)				
Blue Grouse <i>Dendragapus obscurus</i>	0.07**	0.01		0.12**
Nectivores (N)				
Black-chinned Hummingbird <i>Archilochus alexandri</i>	0.01			
Calliope Hummingbird <i>Stellula calliope</i>				+**
Rufous Hummingbird <i>Selasphorus rufus</i>	0.43**	0.31**	0.35**	0.11**
Omnivore-Scavengers (OS)				
Gray Jay <i>Perisoreus canadensis</i>	0.05**	0.08**	0.10**	0.07**
Steller's Jay <i>Cyanocitta stelleri</i>			0.05	
Common Raven <i>Corvus corax</i>	0.02	0.01	0.01	0.17
Carnivores (C)				
Sharp-shinned Hawk <i>Accipiter striatus</i>				+
Unidentified accipiter	0.01			0.01
Northern Goshawk <i>A. gentilis</i>		0.01		
Red-tailed Hawk <i>Buteo jamaicensis</i>			+	
Golden Eagle <i>Aquila chrysaetos</i>			+	
American Kestrel <i>Falco sparverius</i>	0.01			0.01
Northern Pygmy Owl <i>Glaucidium gnoma</i>	0.01			

\*\*Nested in the study area.

\*\*\*Detection rate was less than &lt;0.01.

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*Received 21 March 1986*

*Accepted for publication 3 October 1986*