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Small Mammal Populations and Food Selection in Relation to Timber Harvest Practices in the Western Cascade Mountains

Abstract

Small mammals were snap-trapped in a mature conifer forest, unburned clearcuts, and burned clearcut in the western Cascade Mountains in central Washington. The largest populations were in unburned clearcuts, and the smallest overall population was in the forest. *Sorex trowbridgii* was the most abundant insectivore caught. *Clethrionomys gapperi* was the most abundant rodent caught in most clearcuts, and its population was the largest of any species in the study area. Other species caught include *Sorex monticolus, Neurotrichus gibbsii, Eutamias townsendii, Glaucomys sabrinus, Peromyscus maniculatus, Microtus townsendii,* and *Zapus trinotatus.* Vegetation and percent cover were analyzed in the study area, and small mammal stomach contents of all nine animal species were examined. In the forest and burned clearcut, small mammals ate more invertebrates than any other food type. In unburned clearcuts, fungi and epiphytic lichens, especially *Alectoria sarmentosa,* and conifer seeds were the major foods eaten by rodents.

Introduction

In contiguous forests, cover is an important factor limiting small mammal presence and relative abundance (Dice 1931; Getz 1970; Miller and Getz 1972, 1973, 1977; Dragavon 1978). Logging and controlled burns drastically alter vegetation, ground cover, and soil moisture. Small mammal species react differently to habitat alterations depending on their specific shelter, energy, nutrient, and moisture requirements (Bunnell and Eastman 1976).

Most studies relating small mammal species distribution and abundance in forests have shown a decline in forest dwelling small mammals and an increase in small mammals typical of grassland plant communities wherever forests are logged and burned (Gashwiler 1959, 1970; Ahlgren 1966; Miller and Getz 1972, 1973, 1977; Sims and Buckner 1973; Hooven and Black 1976). These studies were conducted in areas with a low percentage of ground cover and ranged over a period of several years after clearcutting. Other studies (Kirtland 1977, Martell and Radvanyi 1977) found that after spruce forests were clearcut, small mammals increased within the first year after logging and then decreased in subsequent years. Ground cover estimates were not given in these studies.

The purpose of this study was to examine the relative abundance of small mammals in a mature western hemlock (*Tsuga heterophylla*) forest, recent clearcuts, and burned

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clearcut. The clearcuts were characterized by a large amount of slash, such that the total amount of ground cover in the clearcuts was greater than in the forest. In addition, small mammal food habits, which were related to vegetation abundance, were compared among species and within a single species in different habitats. Small mammal sampling was conducted only during July and September 1980, approximately three months after the forest was logged and two months after the logged area was burned. Although we realize the intersite variation and seasonal fluctuation known for small mammal abundance and food selection, we believe that this study is of merit because of the direct correlations we found among mammal abundance, food selection, and debris and vegetative cover.

Description

Our study area is located on the west slope of the Cascade mountains in central Washington within the Mt. Baker-Snoqualmie National Forest. Annual precipitation in the general area averages 229 cm.; elevation in the study area ranges from 853 m to 1058 m. The area has a northwest exposure and a 66 percent slope which decreases to 33 percent in the western one-third section. Western redcedar (*Thuja plicata*), western hemlock, Douglas-fir (*Pseudotsuga menziesii*), and silver fir (*Abies amabilis*) are the major tree species. These stands are about 110 years old, with a stocking of about 385 trees per ha (Fig. 1). Part of the forest was logged during fall 1979 and spring 1980 in six clearcut units. Our study area includes part of the remaining mature forest and three clearcuts that are closest to the mature forest. They are 12 ha, 25 ha, and 8.5 ha in size. Strips of mature conifers (61 m-120 m wide) are left between the clearcuts (Fig. 2). A logging road crosses the eastern section of the clearcuts. A commercial mixture of grass and clover was planted in 4 m to 9 m strips on either side of the logging road to minimize erosion. The soil is relatively moist, rocky, and acidic. Ground water seepage and permanent streams occur throughout the study area. The three clearcuts are referred to as Clearcut 1, 2, and 3. Clearcut 2, which was burned in late July 1980, is referred to as burned Clearcut 2.

Methods

Vegetation was sampled by establishing five random subplots within the forest and each clearcut. Each subplot encompassed an area of 9.37 m. The vascular vegetation within each subplot was recorded and rated as either abundant, common, or occasional. Vegetation was classified into three vertical categories: overstory tree/shrub stratum greater than 4 m, understory tree/shrub stratum less than 4 m, and herbaceus stratum. Percent vegetative cover and down material was recorded. Scientific names of plants follow Hale (1969) and Hitchcock and Cronquist (1973).

Reference plant material was collected in the forest and clearcuts, and permanent plant slides for identification of food items in dietary analysis were prepared (see Baumgartner and Marten 1939).

Five 90 x 100 m trapping grids, each composed of 110 stations (10 x 11 lines) with 10 m spacing between stations, were established in the forest and clearcuts. Grids were located a minimum of 30 m from a road or sample plot edge. Two Museum Special snap traps, baited with peanut butter and rolled wheat, were placed within a

Figure 1. Mature forest in the study area.

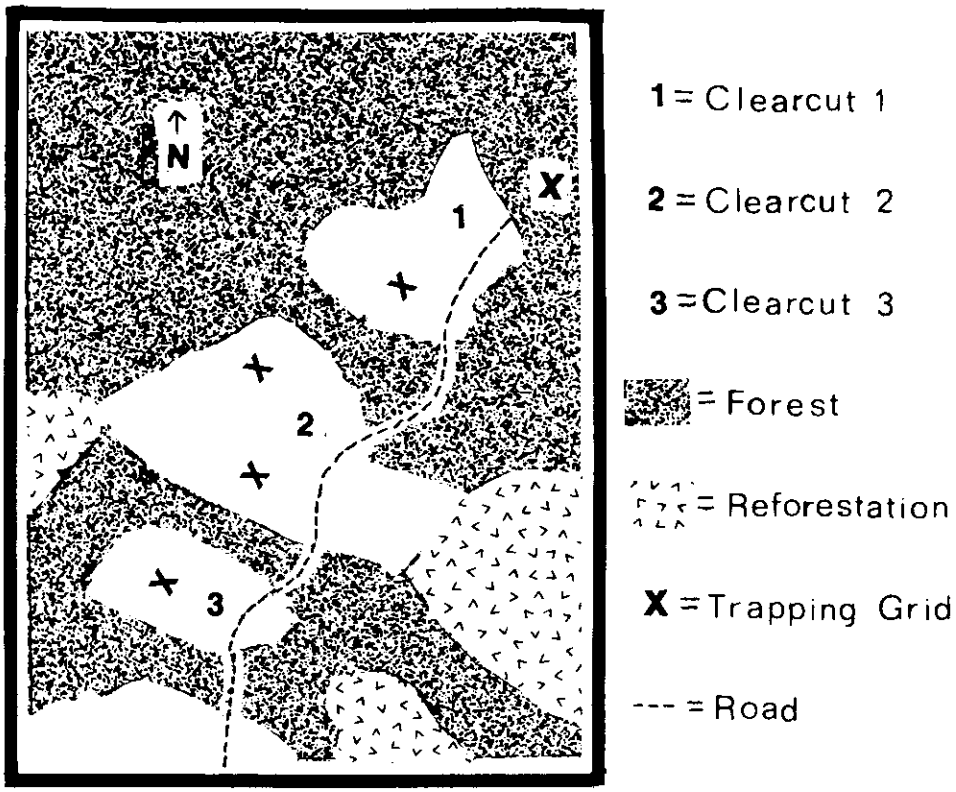

Figure 2. Topographic outline of study area.

one-meter radius of each station. Four similarly baited snap rat traps were placed at intermittent stations within each line (44 traps/grid). Forest traps were additionally baited with apple slices to sample the northern flying squirrel (*Glaucomys sabrinus*) population.

Traps were set on four consecutive nights, totaling 1056 trap night in each sample plot. Clearcuts 1 and 2 were sampled during 11-14 July, the forest sampled 15-18 September, and Clearcut 3 and burned Clearcut 2 sampled 22-25 September 1980. The two grids in Clearcut 2 were placed in opposite corners of the plot (Fig. 2) and were sampled at different dates. Small mammal specimens were collected daily and subsequently prepared as study specimens and deposited at the Washington State Museum, University of Washington, Seattle. Scientific names follow Hall and Kelson (1959) and Hennings and Hoffman (1977).

Standard weights and measurements as well as sex and reproductive status were obtained from all specimens. Stomach contents were preserved in 12 percent formalin. Stomach content fragments were identified using 100 power compound microscopes. Cellular characteristics of the stomach plant fragments were compared to plant reference slides. Invertebrates were noted and tallied but were not identified as to species. Identified plant and animal fragments from stomachs were divided into six categories: 1) fungi and lichen, 2) conifer seed parts, 3) shrub, herbaceous leaf and reproductive parts, 4) grass leaves and seed parts, 5) invertebrate parts, and 6) other matter.

Frequency of occurrence of fragments in these categories was determined by examining 20 randomly selected microscopic fields within each stomach's contents and identifying the fragment closest to the microscope pointer. This information was pooled across animals to obtain relative frequency estimates for each habitat.

Results and Discussion

Vegetation

The major plant species and their relative abundance within each vertical stratum in the forest, clearcuts, and burned Clearcut 2 are listed in Table 1. Dominant shrubs in the forest and clearcuts were salal (*Gaultheria shallon*) and huckleberry (*Vaccinium ovalifolium*). The most aboundant herbaceous plant in the forest was twinflower (*Linnaea borealis*). The percent overstory canopy cover and understory ground cover is listed in Table 2. Total ground cover in thhe clearcuts ranged from 83 to 90 percent (Fig. 3),

TABLE 1. Relative abundance of major plant species.

Species	Forest	Clearcut 1	Clearcut 2	Burned Clearcut 2	Clearcut 3
Overstory tree stratum					
Abies amabalis	O[1]	O		O	O
Pseudotsuga menziesii	C[2]	O	O	O	O
Thuja plicata	A[3]	O	O	O	O
Tsuga heterophylla	A	O	O		O
Understory tree/shrub stratum					
Abies amabilis	O		O		O
Berberis nervosa	O	C	C	O	C
Gaultheria shallon	A	A	A	O	A
Holodiscus discolor		O	O		
Meziesia ferrugina	C	C	C	O	A
Oplopanax horridum		O	O	O	
Pseudotsuga menziesii	O	O			O
Rosa gymnocarpa	O				
Thuja plicata	O	O			O
Tsuga heterophylla	C	O	O		O
Vaccinium ovalifolium	A	A	A	C	C
Herbaceous stratum					
Blechnum spicant	O		C	C	C
Caltha biflora	O	O	O	O	O
Chimaphila menziesii	C	O	O		O
Clintonia uniflora	O	C	O	O	O
Corallorhiza mertensiana	C				
Cornus canadensis	C	C	C	C	C
Galium trifidum			O		O
Gymnocarpium dryopteris	O				
Linnaea borealis	A				
Montia sibirica			O		
Pyrola secunda	O	O	O		O
Streptopus roseus		O	O		
Tiarella trifoliata	O	O	C	O	C
Festuca sp.	O				
Commercial mix of grass and clover (Agrostis, Bromus, Festuca, Phleum, Trifolium)		O	O	O	O

[1]O = Occasional

[2]C = Common

[3]A = Abundant

TABLE 2. Percent overstory canopy cover and understory ground cover on the sample plots. T = Trace.

	Forest	Clearcut 1	Clearcut 2	Burned Clearcut 2	Clearcut 3
Overstory canopy cover	65	T	T	T	T
Understory herb and shrub cover	40	21	22	8	30
Dead and down material	10	62	64	45	60
Total ground cover	50	83	86	53	90

Figure 3. Slash and vegetation remaining on clearcuts after logging.

and the forest averaged 50 percent. The amount of down material left on the clearcuts ranged from 252-296 tons per ha.

On 20 July 1980, Clearcut 2 was burned to remove excess slash. The moderately intense slash burn fire on Clearcut 2 consumed 42 percent of the total slash volume. The fire removed small slash and most of the ground cover. Large logs and stumps were only charred by the fire. The average fuel depth was reduced from 76 cm before the burn to 46 cm. After the fire about 108 tons/ha of down material remained. Live vegetation following the burn was composed primarily of deerfern (*Blechnum spicant*), bunchberry (*Cornus canadensis*), and huckleberry (Fig. 4).

Small Mammal Abundance

The total number of small mammals caught in the mature forest, clearcuts, and burned Clearcut 2 are listed in Table 3. The forest and burned clearcuts had fewer small mammals than unburned clearcuts. The most frequently caught small mammals in the forest—Trowbridge shrews (*Sorex trowbridgii*), deer mice (*Peromyscus maniculatus*), and

Figure 4. Remaining slash and vegetation following a prescribed burn on Clearcut 2.

TABLE 3. Number of small mammals caught in the study area.

Species	Forest	Clearcut 1	Clearcut 2	Burned Clearcut 2	Clearcut 3	Total
Sorex monticolus	4	10	8	4		26
Sorex trowbridgii	6	4	21	15	30	76
Neurotrichus gibbsii		1	3	3	1	8
Eutamias townsendii	1	2	6	2		11
Glaucomys sabrinus	1					1
Peromyscus maniculatus	7	22	24	1	17	71
Clethrionomys gapperi	6	33	23	7	45	114
Microtus townsendii				3	4	7
Zaus trinotatus			3			3
Total	25	72	88	35	97	317

red-backed voles (*Clethrionomys gapperi*)—were also the most abundant small mammals in the clearcuts. Two species which are typical of grassland plant communities, Townsend voles (*Microtus townsendii*) and Pacific jumping mice (*Zapus trinotatus*), were not found in the forest but were present in clearcuts.

In the forest no one small mammal species predominated. In most clearcuts the red-backed vole was the most abundant species, and its total population was the largest in the study area. Townsend voles were caught in Clearcut 3 and burned Clearcut 2 only in September. The three jumping mice caught in Clearcut 2 during July were caught in the same trap on different trap nights. In burned Clearcut 2, there were at least twice as many Trowbridge shrews caught than any other small mammal species. Only

one deer mouse was caught in burned Clearcut 2, compared to 17 caught in Clearcut 3, which was also sampled during September.

As the red-backed vole catch increased in two clearcuts, fewer deer mice were caught. Clearcut 3 had fewer deer mice and more red-backed voles than any other clearcut. On the basis of reproductive condition, total length, and body weight, we found that 61 percent of the deer mice and 33 percent of the red-back voles caught in July were immatures. In Clearcut 3, trapped in September, we found that 13 percent of the deer mice and 71 percent of the red-backed voles were immatures. The increase in voles and lack of increase in deer mice in September may be explained by the number of immatures of each species entering the population.

Small Mammal Stomach Contents

Fungi and lichens were the major foods eaten by most rodents, particularly red-backed voles, in clearcuts (Table 4). Epiphytic lichens, hair moss (*Alectoria sarmentosa*), and *Usnea* sps. were abundant on the trunks and branches of fallen conifers in the clearcuts. Most small mammals ate more invertebrates and fewer conifer seeds in the clearcuts during September than during July. In late summer many insects enter pupal and larval stages within the soil and are more accessible to small mammals (Borror *et al.* 1976). In late summer conifer seeds disseminate and become more abundant on the ground (Fowells 1965). The results of our study indicate that small mammals prefer invertebrates over conifer seeds. Most small mammals ate more invertebrates in burned Clearcut 2 than in the forest and unburned clearcuts.

Salal was the only major vascular plant species, other than conifer seeds, eaten by small mammals in more than small amounts. Salal was abundant in the forest and clearcuts. Grass was not a major component of any small mammal species diet. Native grasses were only occasionally seen in the forest.

The diet of dusky (or montane) shrews (*Sorex monticolus*) was composed of invertebrates, conifer seeds, fungi, and lichens (Table 4). Conifer seeds were an important component in the dusky shrew's diet. The Trowbridge shrew diet was 69-95 percent invertebrates in the forest and clearcuts. These results are similar to those reported by Whitaker and Maser (1976), who found 96 percent insects in Trowbridge shrew stomachs. Shrew mole (*Neurotrichus gibbsii*) diet was 75-88 percent invertebrates during September but mostly conifer seeds (36 percent) and lichens (32 percent) and fewer invertebrates (18 percent) during July.

Fungi and lichens were the major foods eaten by three Townsend's chipmunks (*Eutamias townsendii*) in the forest and burned Clearcut 2 during September (Table 4). Of the eight chipmunk stomachs examined in July, no food preference was found. The "other matter" in their stomachs was pollen. Tevis (1952) also remarked that in conifer forests 99 percent of Townsend's chipmunk stomach content volume is fungi.

The stomach of the one northern flying squirrel caught was entirely of fungal spores. McKeever (1960) found fungi to be the only food of six flying squirrels trapped in summer.

Deer mice ate primarily invertebrates in the forest, conifer seeds in the clearcuts during July, and did not show a preference for any one food in the clearcut during September (Table 4). The stomach of the one deer mouse trapped in the burned Clearcut 2 contained only invertebrates.

TABLE 4. Percent relative frequency of small mammal species stomach fragments in the forest (F), unburned clearcut trapped in July (CJ), unburned clearcut trapped in Sept. (CS), and unburned clearcut (B). T=Trace.

Food stuff	*Sorex monticolus*			*Sorex trowbridgii*				*Neurotrichus gibbsii*			*Eutamias townsendii*			*Glaucomys sabrinus*	*Peromyscus maniculatus*				*Clethrionomys gapperi*				*Microtus townsendii*		*Zapus trinotatus*
	F	CJ	B	F	CJ	CS	B	CJ	CS	B	F	CJ	B	F	F	CJ	CS	B	F	CJ	CS	B	CS	B	CJ
Fungi, lichen	9	12	1	3	13	1	3	32	15		65	27	68	100	9	22	16		91	55	81	79	100	17	60
Conifer seed pt.	35	26	25	15	9	3	3	36	10			37	18		21	45	27		4	29	15	9			22
Shrub, herb. lf., repro pt.	1	T		1	1	T		2		12	35	5	2		9	1	28			1	2	9		73	10
Grass lf., seed pt.	1	4			1	T									1	3	1		5	4				7	3
Invertebrate pt.	54	51	74	78	69	95	90	18	75	88			12		59	23	27	100		3	2	4			3
Other		6		3	7		4	11				30				5	1			7	T			2	2
Total	100	99	100	100	100	99	100	99	100	100	100	99	100	100	99	99	100	100	100	99	100	101	100	99	100
No. stomachs examined	4	17	4	5	25	30	15	4	1	2	1	8	2	1	7	43	16	1	6	56	45	6	4	2	3

Major food of red-backed voles was lichens in all study plots sampled in July and September (Table 4). The six Townsend voles sampled ate lichens in the clearcut and mostly berries and leaves of bunchberry in burned Clearcut 2. The three jumping mice consumed more fungi (60 percent) and conifer seeds (22 percent), and fewer herbs (10 percent) and grasses (30 percent) than jumping mice collected by Whitaker and Maser (1978) in Mason Co., Washington. They found jumping mice stomach volume as fungi (23 percent), seeds (5 percent), herbs (35 percent) and grasses (34 percent).

Cover, Abundance, and Food Correlations

Dusky and Trowbridge Shrews. Dusky and Trowbridge shrews comprised 8 percent and 24 percent, respectively, of the total catch. Of the total Trowbridge shrews caught in September, 10 percent were in the forest, 60 percent were in Clearcut 3, and 30 percent were in burned Clearcut 2. In contrast, Hooven and Black (1976) found 48 percent of Trowbridge shrew catch in a mature forest, 32 percent in an unburned clearcut, and 20 percent in a burned clearcut. Gashwiler (1970) reported similar results. Both Hooven and Black's and Gashwiler's studies were of longer term (six and ten years, respectively) than ours, and percent ground cover in the clearcuts was lower than in our study. With an 83-90 percent total ground cover in the clearcuts of our study area, we believe shrew microhabitat was improved following logging because shrews were shielded from predators and insects on slash were vulnerable to predation.

Dusky shrews ate more conifer seeds, fungi and lichens, and less invertebrates than did Trowbridge shrews. Both shrews were caught in similar numbers in the forest (Table 3). In Clearcut 1, more dusky shrews were caught than Trowbridge shrews. Dusky shrews, Trowbridge shrews, and deer mice ate fewer invertebrates in this clearcut than those trapped in Clearcut 2 on the same date. The southwest half of Clearcut 2, where our trapping grid was placed, was logged during fall 1979. Timber was not removed until spring 1980. Clearcut 3 was logged with timber removed spring 1980. Insects had a longer opportunity to invade the bark and down wood of southwest Clearcut 2. Insect populations would be expected to be larger in southwest Clearcut 2 than in Clearcut 1. Possibly the Trowbridge shrew population was limited by lack of accessible insects in Clearcut 1.

In the unburned and burned Clearcut 2, and in Clearcut 3, more Trowbridge shrews were caught than dusky shrews. When the largest Trowbridge shrew population was sampled at 30 individuals in Clearcut 3 during September, no dusky shrews were caught. As mentioned earlier, insects are more accessible to shrews in September than in July. We believe that Clearcut 1, which had the largest dusky shrew population, had fewer accessible insects than any other trapped clearcut as a result of logging and trapping dates. Although our study was limited to a specific area and we collected small mammals within a limited time span, we suggest that dusky shrews may be more abundant than Trowbridge shrews in areas of low insect populations because of their ability to alter their diet to utilize other food types. In areas of high insect populations, Trowbridge shrews may outnumber dusky shrews.

Shrew Mole. Shrew moles are burrowing insectivores inhabiting areas of moist soil with dense underbrush and little grass (Dalquest 1948). In our study, as well as in Hooven and Black's (1976) study, few shrew moles were caught. We believe that the immediate

ground cover and soil moisture within the vicinity of a trap, rather than sample plot treatment, was the best indicator of shrew mole presence.

Townsend's Chipmunk. Townsend's chipmunks are the only western chipmunk which live in mature forests. Their numbers increase after forests are logged, and herbaceous and shrubby vegetation becomes abundant (Tevis 1956). We suspect that the lack of Townsend's chipmunks in Clearcut 3 was a result of the large number trapped in the southeast corner of Clearcut 2 (Table 3). Otherwise, our results suggest an increase in chipmunks following logging and burning.

Deer Mouse. Deer mice comprised 22 percent of the catch in the study area. Its populations were largest in unburned clearcuts and lowest in burned Clearcut 2 (Table 3). Ahlgren (1966), Gashwiler (1970), Hooven (1973), Sims and Buckner (1973), and Hooven and Black (1976) reported dramatic increases of deer mice following slash burning. Ahlgren believed that burned clearcuts create habitat and food conditions favorable to increases in populations of seed eating rodents. Williams (1959) found that seeds comprised 66 percent of stomach content of deer mice caught in spruce forests. Deer mice ate more seeds than any other mammal in our study area (Table 4), but the one deer mouse trapped in burned Clearcut 2 ate insects exclusively. Tevis (1956) also found that deer mice ate primarily caterpillars on a recently burned area. We suspect that immediately after a burn, deer mice eat what is available, usually insects. When conifer seeds are planted, or when grassland plant species become established in a clearcut, deer mice alter their diet to consume the most prevalent food, which is then seeds.

Red-backed Vole. Red-backed voles chiefly inhabit the cool, damp forests of western Washington. They burrow under forest litter and nest in hollow logs or under tree roots (Taylor and Shaw 1927, Dalquest 1948). Tevis (1956) considered log cover to be the limiting factor for these voles. Hooven and Black (1976) stated that removal of timber and reduction of vegetative cover on clearcuts reduce the red-backed vole population. Gashwiler (1959 and 1970), Ahlgren (1966), Miller and Getz (1972, 1973, and 1977), and Sims and Buckner (1973) reported a decline in red-backed vole populations following logging. The presence of red-backed voles in clearcuts within the first year after logging spruce forests was noted by Kirkland (1977), Martell and Radvanyi (1977), and West *et al.* (1980). By the third year after logging, Martell and Radvanyi observed that red-backed voles decreased and were rare. With a 65-75 percent overall ground cover from slash and live vegetation in unburned clearcuts, and an abundant food supply of lichens on fallen trees, the red-backed vole population in our study area would be expected to be larger than the population in the forest where there was 55 percent ground cover and fewer accessible lichens. Perhaps when lichens are completely eaten or die in clearcuts, red-backed voles will seek food and shelter elsewhere.

Townsend Vole. Townsend voles are marsh dwellers, often associated with dense grasses and sedges, regardless of elevation. These voles penetrate forest lands wherever the lands are cleared for agricultural purposes (Goertz 1964). Townsend voles are grass and forb feeders (Cook 1959). Grant (1975) stated that *Microtus* have the ability to eat a wide variety of plants which may not occur in grassland habitats. There were few native grasses in our study area, which may explain why Townsend voles ate pri-

marily lichens and bunchberry (Table 4). We believe that Townsend voles are relatively uncommon or rare in the few exposed areas of the forest and then increase in open areas where grasses or lichens are available.

Summary

More small mammals were caught in unburned clearcuts than in the mature forest or burned clearcut. Slash and down material in the unburned clearcuts provided cover and abundant foods—epiphytic lichens, conifer seeds, and insects. Lichens were the principal food eaten by red-backed voles, which were the most abundant small mammal species in clearcuts. Invertebrates were the main food of most small mammals in the forest. No one small mammal species was predominant in the forest.

We caught more dusky shrews than Trowbridge shrews in the clearcut, where we believed the accessible insect population was lowest. We caught more Trowbridge shrews than dusky shrews in the other clearcuts. Only one deer mouse was caught in the burned clearcut, compared to 17 caught in the unburned clearcut trapped on the same dates. This single deer mouse's stomach content was entirely invertebrates. In the forest and unburned clearcuts deer mice did not consume any one particular food type. Townsend's voles and jumping mice were found in low numbers in clearcuts. Both species ate more fungi and lichen and fewer grasses than past studies have indicated. Grasses were uncommon in the study area.

Small mammals ate a higher percentage of invertebrates in clearcuts trapped in September than in July. As invertebrate consumption increased, fewer conifer seeds were eaten. Insects are more accessible to small mammals in September, and conifer seeds are more abundant in late summer. We suggest that small mammals, especially Trowbridge shrews, shrew moles, and deer mice, prefer insects over conifer seeds if both food types are abundant.

Acknowledgments

This study was financially supported by the U.S. Forest Service, Skykomish Ranger District, through James Bartelme, Resource Assistant, and Gordon Rhinehart, District Ranger. Sievert Rohwer, Washington State Museum at University of Washington provided traps, laboratory space, and equipment. Laboratory space and equipment was also provided by Huxley College at Western Washington University. Stephen West and John Dragavon assisted in initial planning of the study and editing of the manuscript. This manuscript also benefited from suggestions by Douglas Wechsler, Thomas Juelson, Robert Gara, and Ralph Schreiber. We thank the above-mentioned; without their continuous support this study would not have been possible.

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Received April 2, 1981
Accepted for publication July 17, 1981