# Seasonal Diets of Herded Sheep Grazing Douglas-fir Plantations

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### Abstract

Use of livestock for biological weed control in timber plantations is gaining popularity in the United States and elsewhere. Efficient use of livestock to control unwanted brush relies upon knowledge of livestock feeding habits. A study was conducted during 1981 and 1982 to determine seasonal diets of herded sheep grazing cutover Douglas-fir (Pseudotsuga menziesii) forests in the Coast Range of Oregon. Study sites included both 4- to 6-year-old non-grass-seeded and 2-year-old grass-seeded plantations. Sheep grazing was monitored in spring, summer, and late summer. Forage on offer ranged from 764 to 2,459 kg/ha. Vegetational composition of sheep diets varied by year, season, and plantation age class. Averaged over the 2 years of grazing, graminoids and forbs were nearly equal, at approximately 40% each, in sheep diets in older plantations. In contrast, diets of sheep in young grass-seeded plantations averaged 70% graminoids and only 16% forbs. Ferns were a minor component (< 2%) of sheep diets in both plantation age classes. Browse averaged 15 and 12% of sheep diets in old and young plantations, respectively. Douglas-fir was most palatable to sheep in spring soon after bud break. It was generally avoided, however, and never comprised more than 3% of sheep diets. Our data suggest that sheep can be most effectively used for biological control of unwanted brush species during summer and late summer when differences in relative preference indices for target brush species and Douglas-fir are greatest.

# Key Words: biological control, brush control, conifer plantations, forest grazing, forest management, sheep diets

Recent court decisions restricting the use of herbicides on federal land in the United States have prompted foresters to consider alternative approaches to vegetation management. Controlled sheep grazing has been shown to be a useful management tool for controlling competing vegetation in young conifer plantations in the U.S. Pacific Northwest (Sharrow and Leininger 1983, Thomas 1983, Allen 1986); Southwest (Pearson 1923); Southeast (Barnes 1984); and in Australia (McKinnell 1975) and New Zealand (Beveridge and Klomp 1973). Prior to widespread implementation of sheep grazing as a silvicultural tool, data on seasonal diets of sheep grazing young conifer plantations are needed. This information is required by resource managers to assess the nutrient intake of animals (McInnis and Vavra 1986), to aid in the evaluation of potential forage competition among herbivore species (Holechek et al. 1982, Uresk and Paintner 1985), and to predict seasonal differences in the relative preference between tree crop and forage species. Although sheep grazing has been advocated for vegetation control in conifer plantations of the Pacific Northwest for over 50 years (Ingram 1931), data on seasonal diets have never been published.

The objectives of this study were to: (1) determine the amount of forage on offer to sheep in Douglas-fir (Pseudotsuga menziesii) plantations of 2 different age classes; (2) identify the kinds and amounts of forage eaten by sheep; and (3) evaluate seasonal preferences of sheep for different forage species, including Douglas-fir.

### Study Area

The study was conducted in the Coast Range, approximately 15 km west of Alsea, Oregon. Climate of the area is characterized by wet winters, relatively dry summers, and small variation in mean monthly temperatures (Corliss and Dyrness 1965). Evening and morning fog is common, even in summer. Most of the approximately 250 cm of annual precipitation falls as low intensity rain from October through May (Corliss 1973).

Five Douglas-fir plantations in the Alsea District, Siuslaw National Forest, were selected for observation. These 5 plantations represented 2 age classes (i.e., older 4-6-year-old, and younger 2-year-old plantations). Study plantations within each age class were chosen based on similarities in tree size and understory plant composition. Elevations ranged from 170 to 440 m. Soils were slickrock gravelly loams (Pachic Haplumbrept, Corliss 1973). Study plots were restricted to the vine maple-sword fern (Acer circinatum-Polystichum munitum) community type because it represents the most extensive understory vegetation in the Alsea District (Corliss and Dyrness 1965). Based on plantation age in 1981 and month during which sheep grazing occurred, the 5 study plantations will be referred to as follows: (1) a four-year-old plantation grazed in May (0-My), (2) a six-year-old plantation grazed in August (0-Ag), (4) a two-year-old plantation grazed in May (Y-My), and (5) a two-year-old plantation grazed in July (Y-Jy). Both younger plantations (Y-My and Y-Jy) were seeded with a mixture of orchardgrass (Dactylis glomerata) and perennial ryegrass (Lolium perenne) at tree planting.

#### **Materials and Methods**

Phytomass on offer and diets of sheep were determined using the "before and after" technique (Cassady 1941). Current year's growth (CYG) of all plant species, except vine maple on the 3 older plantations and Douglas-fir on all study plantations, was estimated using the plot-harvest method. Prior to grazing, 10 pairs of .45-m<sup>2</sup> quadrats were randomly located in each of three .05-ha replications in each study plantation. The 3 replications were randomly located within each plantation, and sheep were herded to each replication and were allowed to graze on the study plots until they started to consume Douglas-fir. The interval between the before- and after-clippings never exceeded 7 days when plants were growing. Consequently, error associated with growth between clippings was believed to be minimal. Current year's growth was separated within clipped plots by species, then oven-dried at 50° C for 72 hours prior to weighing.

Current year's growth and utilization of vine maple were determined for 10 randomly selected plants within each replication. Four branches from each plant were chosen prior to grazing, and available CYG on 2 randomly selected branches clipped, ovendried, and weighed. The remaining 2 branches were marked and treated similarly following grazing. The total number of branches on each clipped vine maple was counted along with the number of vine maple in each replication. Multiplication of weight/branchlet  $\times$  no. branchlets/shrub  $\times$  no. shrubs/ha allowed an estimation of standing crop on an area basis. Foliage on branches greater than 1.5 m above the soil surface was not sampled, as it was considered to be unavailable to grazing sheep (Ingram 1931).

Tree height and number of lateral branchlets within 1.5 m of the

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Research was funded by the USDA Forest Service, Alsea Ranger District, Siuslaw National Forest and the Oregon Agricultural Experiment Station. This article is submitted as Technical Paper 7333. Oregon Agricultural Experiment

Station, Corvallis.

Manuscript accepted 28 May 1987.

ground were determined for each of 92 Douglas-fir trees. These data were then used to develop a regression equation (Y =.0148 $X^{1.9946}$ ,  $r^2$  = .89) relating the number of branchlets on Douglasfir trees within 1.5 m of the ground to tree height (in centimeters). Trees noticeably affected by previous animal browsing were not included in the analysis. Height of all Douglas-fir trees within study plots was measured prior to sheep grazing. The predicted number of branchlets was then calculated for each tree. Current year's Douglas-fir growth available to sheep was estimated by multiplying the predicted number of branchlets for each tree in the study plot times mean oven-dry weight of 100 branchlets collected at the time of grazing. Percentage of CYG removed by sheep was ocularly estimated for each tree immediately after sheep left the plantation using techniques described by Lawrence et al. (1961). Weight of foliage removed from each study tree was calculated as the product of percentage CYG removed and its predicted biomass.

Sheep preference for individual plant species and forage classes were evaluated with a relative preference index (RPI) (Van Dyne and Heady 1965):

Relative Preference Index (RIP) = <u>% dry weight composition in diets</u> % dry weight composition in plantation

Krueger (1972), Van Dyne and Heady (1965), and others stated values greater than 1 indicate preference for a plant, while values less than 1 indicate avoidance. For these inferences to be statistically valid, however, it is necessary to estimate the error associated with each preference value (Hobbs and Bowden 1982). Thus, 90% confidence intervals were constructed about each preference index, and results were interpreted as follows: (1) plants for which the lower limit of the 90% confidence interval exceeded 1.0 were considered preferred; (2) plants for which the upper limit of the 90% confidence interval was less than 1.0 were considered avoided; and (3) plants for which the 90% confidence interval included 1.0 were considered neutral (McInnis and Vavra 1986).

Seven-hundred Columbia ewes and their lambs and 900 Columbia yearling ewes grazed the forest from May to September in 1981 and 1982, respectively. Both years all sheep were managed as a single flock under the constant supervision of a herder with dogs. A series of small plantations ranging in size from 10 to 40 ha each were grazed. Sheep were moved from plantation to plantation on a predetermined route, spending from 1 to several days in each. Within this schedule, study plantations were grazed once each year, with the exception of Y-My which was grazed once in May and again in August both years. Data from the August grazing were taken in 1982 only. These data are identified as Y-My/Ag.

Available phytomass on offer, composition of sheep diets, and RPI's were evaluated using analysis of variance techniques. Data were analyzed as a split, split plot with plantations as main plots and forage classes and years as subplots in a completely randomized design. Where appropriate, means were separated with Tukey's w procedure (Steel and Torrie 1980). Because we have considered our three .05-ha plots within each plantation as "replications" (rather than subsamples), site effects are confounded with treatment effects and a strict statistical interpretation of our results would be limited to only the plantations we studied. This limits the generality of our conclusions, but in a descriptive study such as ours, helps to elucidate our results most clearly.

## **Results and Discussion**

Vegetational composition of sheep diets differed ( $P \le .01$ ) between the 2 years of study (Table 1). Graminoids averaged 42% of sheep diets in 1981 compared to 61% in 1982. Both the amount of forbs on offer to sheep (Table 2) and the percentage of forbs in their diets (Table 1) decreased ( $P \le .05$ ) from 1981 to 1982. The preference shown for forbs by sheep (Table 3), however, did not differ (P > .10) between years. Modest reductions in both amount of browse on offer and preference for browse from 1981 to 1982 resulted in a substantial decrease ( $P \le .01$ ) in the amount of browse consumed in 1982. Browse made up 18% of sheep diets in 1981 compared to only 11% in 1982. The available CYG of Douglas-fir more than doubled from 1981 to 1982. However, there was only a small increase ( $P \le .01$ ) of Douglas-fir in sheep diets from .9% in 1981 to 1.6% in 1982. Sheep generally avoided consuming Douglas-fir both years (Table 3).

Sheep diets also varied ( $P \le .01$ ) between plantations grazed in spring (O-My and Y-My) and those grazed in summer (O-Jy and Y-Jy). Averaged over the 2 years of the study, available graminoids averaged 1,075 kg/ha in spring-grazed plantations compared to 937 kg/ha in summer-grazed plantations. Reduction in available graminoids was reflected in a decline ( $P \leq .01$ ) of graminoids in sheep diets from 63% in spring to 49% in summer. The relative preference indices for graminoids did not differ (P > .10) between seasons. Forb consumption increased ( $P \leq .05$ ) from 26% of the diet in spring to 31% in summer. Both amount of forbs on offer and preference displayed for them by sheep increased ( $P \leq .10$ ) as the grazing season advanced. Skiles (1984) reviewed the available literature on sheep diets and concluded that they consume nearly equal proportions of graminoids and forbs. The great consumption of graminoids in our study may reflect the high availability, especially in the 2 young grass-seeded plantations. Vavra and Sneva (1978) found that sheep will readily consume diets composed largely of grass when grazing ranges where grass is the dominant forage class.

Consumption of browse was lower  $(P \le .01)$  in spring than in summer. This was particularly evident in 1982 when sheep diets contained only 2% browse in both spring-grazed plantations (Table 1). Above-average precipitation, coupled with below-aver-

Table 1.	Veg	etational com	position of shee	p diets from 5 Dou	glas-fir	plantations.	1981 and 1982	. Data are mean	percenta	ge ± standard error.
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<u></u>	Plantation											
Forage class	O-My <sup>1</sup>	O-Jy	O-Ag	Y-My	Y-Jy	Y-My/Ag	Average <sup>2</sup>					
1981												
Graminoids	$37 \pm 3$	$22 \pm 2$	$29 \pm 6$	66 ± 4	$56 \pm 10$		42					
Forbs	$43 \pm 8$	56 ± 5	<b>44</b> ± 7	$18 \pm 1$	19 ± 4		36					
Ferns	0	<1 ± <1	6 ± 3	$1 \pm < 1$	6 ± 4		3					
Browse	$18\pm 6$	$20 \pm 4$	$20 \pm 2$	$14 \pm 2$	$20 \pm 8$		18					
Douglas-fir	$2 \pm 1$	$1 \pm 1$	<1 ± <1	$1 \pm < 1$	<1 ± <1		1					
1982												
Graminoids	58 ± 7	50 ± 12	36 ± 5	<b>90</b> ± 1	69 ± 7	$63 \pm 11$	61					
Forbs	$36 \pm 8$	$28 \pm 10$	$39 \pm 6$	$8 \pm 1$	$20 \pm 3$	$15 \pm 8$	26					
Ferns	$1 \pm 1$	$2 \pm < 1$	<1 ± <1	<1 ± <1	<1 ± <1	0	1					
Browse	$2 \pm 1$	$19 \pm 3$	$21 \pm 4$	$2 \pm 1$	$11 \pm 7$	19 ± 4	11					
Douglas-fir	$3 \pm 1$	1 ± <1	$3\pm 2$	<1 ± <1	<1 ± <1	$3 \pm 1$	2					

<sup>1</sup>Abbreviations are for plantation age class (older—4-6-year-old, and younger—2-year-old) and month of grazing (May, July, and August). <sup>2</sup>Does not include Y-My/Ag.

Table 2. Above-ground phytomass within 1.5 m of ground (mean ± SE) and percentage species composition in 5 Douglas-fir plantations, 1981 and 1982.

	Plantation													
Forage	O-My <sup>1</sup>		O-Jy		O-Ag		Y-My		Y-Jy		Y-My/Ag		Average <sup>2</sup>	
class	kg/ha %	6	kg/ha %		kg/ha %		kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
1981											·······			
Graminoids	408 ± 42	32	361 ± 41 1'	7	867 ± 190 3	1	1497 ± 381	65	$1290 \pm 236$	64			885	42
Forbs	458 ± 76	36	787 ± 79 3	7	770 ± 100 2	.7	498 ± 29	22	$256 \pm 53$	13			554	26
Ferns	$20 \pm 10$	2	115 ± 67	5	$255 \pm 129$	9	$31 \pm 7$	1	$156 \pm 15$	8			115	5
Browse	$262 \pm 25$	21	295 ± 100 14	4	409 ± 52 1	4	$238 \pm 20$	10	274 ± 81	13			296	14
Total forage	$1148 \pm 32$	90	$1558 \pm 246$ 72	2	2301 ± 258 8	1	$2263 \pm 389$	99	1976 ± 292	97			1850	87
Douglas-fir	$129 \pm 9$	10	598 ± 89 24	8	$529 \pm 59$ 1	9	$34 \pm 1$	1	55 ± 3	3			269	13
Total Phytomass	$1277 \pm 26$ 10	00	$2156 \pm 206 \ 100$	0	$2830 \pm 151 \ 10$	0	2298 ± 390	100	2031 ± 291	100			2119	100
1982														
Graminoids	359 ± 90	42	829 ± 215 2	9	764 ± 55 2	26	2035 ± 78	82	$1269 \pm 200$	58	$1276 \pm 183$	62	1051	46
Forbs	$218 \pm 18$	26	$544 \pm 40$ 19	9	486 ± 80 1	7	$336 \pm 57$	14	$408 \pm 79$	19	$428 \pm 117$	21	398	18
Ferns	$10 \pm 3$	1	43 ± 9	1	$31 \pm 24$	1	5 ± 4	<1	$26 \pm 7$	1	2 ± 2	<1	23	1
Browse	177 ± 25	21	298 ± 75 10	0	314 ± 97 1	1	83 ± 20	3	$370 \pm 100$	17	$245 \pm 56$	12	248	11
Total forage	$764 \pm 104$	90	1715 ± 137 59	9	1596 ± 47 5	54	$2459 \pm 26$	100	$2073 \pm 158$	94	1951 ± 125	94	1720	76
Douglas-fir	87 ± 3	10	$1174 \pm 168 4$	1	$1341 \pm 66  4$	6	$10 \pm 1$	<1	$130 \pm 3$	6	$118 \pm 11$	6	548	24
Total Phytomass	850 ± 102 1	00	$2888 \pm 253 100$	0	2937 ± 112 10	0	2469 ± 27	100	$2203\pm161$	100	2069 ± 161	100	2268	100

<sup>1</sup>Abbreviations are for plantation age class (older—4-6-year-old, and younger—2-year-old) and month of grazing (May, July, and August). <sup>2</sup>Does not include Y-My/Ag.

Table 3. Relative preference indices for different forage classes in 5 Douglas-fir plantations grazed by sheep, 1981 and 1982. Data are mean ± standard error.

Forage class	O-My <sup>1</sup>	O-Jy	O-Ag	Y-My	Y-Jy	Y-My/Ag
1981		······································				
Graminoids	$1.17 \pm .06^{n2}$	$1.34 \pm .08^{P}$	$.98 \pm .06^{n}$	$1.04 \pm .03^{n}$	$.88 \pm .11^{n}$	
Forbs	$1.19 \pm .06^{9}$	$1.54 \pm .12^{p}$	$1.60 \pm .04^{P}$	$.75 \pm .13^{n}$	$1.49 \pm .20^{n}$	
Ferns	0*	$.36 \pm .36^{n}$	$.79 \pm .48^{n}$	$.84 \pm .43^{n}$	$.51 \pm .37^{n}$	
Browse	$.85 \pm .22^{n}$	$1.54 \pm .08^{p}$	$1.47 \pm .25^{n}$	$1.28 \pm .08^{P}$	$1.34 \pm .29^{n}$	
Douglas-fir	$.17 \pm .08^{a}$	.04 ± .03ª	.02 ± .01 <sup>a</sup>	$.60 \pm .10^{a}$	$.03 \pm .01^{a}$	
1982						
Graminoids	$1.41 \pm .07^{p}$	$1.76 \pm .10^{p}$	$1.41 \pm .28^{n}$	1.09 ± .02 <sup>₽</sup>	$1.21 \pm .01^{P}$	$1.01 \pm .12^{n}$
Forbs	$1.35 \pm .05^{p}$	$1.47 \pm .42^{n}$	$2.38 \pm .26^{P}$	.63 ± .12ª	$1.07 \pm .08^{n}$	$.72 \pm .31^{n}$
Ferns	$1.23 \pm .15^{n}$	$1.60 \pm .68^{n}$	$2.04 \pm 1.49^{n}$	$.88 \pm .88^{n}$	$.43 \pm .32^{n}$	0ª
Browse	$.09 \pm .04^{*}$	$1.97 \pm .37^{n}$	$2.18 \pm .39^{p}$	$.55 \pm .20^{n}$	$.52 \pm .17^{n}$	$1.64 \pm .08^{p}$
Douglas-fir	.27 ± .06 <sup>a</sup>	$.02 \pm .01^{a}$	.08 ± .03*	$1.08 \pm .04^{n}$	.04 ± .01ª	$.57 \pm .26^{n}$

<sup>1</sup>Abbreviations are for plantation age class (older—4-6-year-old, and younger—2-year-old) and month of grazing (May, July, and August). <sup>2</sup>n, p, and a are neutral, preferred, and avoided, respectively ( $p \le .10$ ).

age temperatures in April (NOAA 1982), delayed the phenological development of most browse by approximately 2 weeks in 1982 relative to 1981. This resulted in less ( $P \le .01$ ) browse on offer to sheep in plantations grazed in May 1982 compared to May 1981 (Table 2). Sheep also exhibited less ( $P \le .05$ ) preference for browse in spring 1982 than spring 1981 (Table 3). The lower preference for browse in spring 192 could reflect lower biomass or a lower palatability of the less phenologically developed shrub growth, or possibly a higher palatability of the other forage classes in the 2 study plantations grazed in May 1982. Also, a younger band of sheep grazed in the forest the second year of the study. It has been shown that both age (McKinnell 1975, Gillingham et al. 1976) and pasture grazing experience of sheep (Knowles et al. 1973, Stoddart et al. 1975, Gillingham et al. 1976, Arnold and Maller 1977, Mathews and Kilgour 1979) influence forage selection.

An increase ( $P \le .05$ ) in available browse in July was accompanied by higher ( $P \le .01$ ) RPI's for browse at that time. Because large standard errors were associated with the preference estimates for browse in O-Ag in 1981 and O-Jy in 1982, RPI's for browse were statistically neutral in both plantations in spite of relatively high numerical values (Table 3). Observations of the grazing sheep indicated that browse was a preferred food in these plantations. The percentage of browse in diets of sheep was higher ( $P \le .01$ ) in summer than spring. For example, sheep diets contained nearly 10 times the percentage of browse in August 1982 when they regrazed plantation O-My than they contained in May (Table 1). Other studies have also reported a shift towards browse in diets of sheep grazing forests as summer progressed (Ingram 1931, Cook and Harris 1968, Harshman 1979, Vavra 1981).

The relative preference index of Douglas-fir was highest ( $P \le .05$ ) in spring, especially in 1982 in plantation Y-My where it had an RPI of 1.08 (Table 3). New growth on lateral shoots of Douglas-fir averaged approximately 4 cm when sheep were released in Maygrazed plantations in 1982. Browsing was confined to this new growth. Douglas-fir was avoided by sheep during July and August (Table 3). An exception to this was in Y-My/Ag. Grazing in this plantation coincided with a flush of Douglas-fir growth from secondary buds which produced phenological conditions similar to those encountered in spring. These findings are consistent with Hall et al. (1959), who reported that sheep avoided Douglas-fir except during the periods of bud burst and rapid growth of new shoots. Sheep diets in our study never contained more than 3% Douglas-fir (Table 1).

Sheep diets differed ( $P \le .01$ ) between the 2 plantation age classes. Graminoids made up 70% of sheep diets in the 2 younger grass-seeded plantations compared with only 42% in the 2 older

plantations grazed during the same time period. Availability of the preferred graminoids appeared to be an important factor in determining diet composition. Y-My and Y-Jy averaged 311% more graminoids on offer to sheep than were available in O-My and O-Jy. Sheep diets averaged 69 and 32% orchardgrass in plantations Y-My and Y-Jy, respectively. Velvet grass (*Holcus lanatus*), spike bentgrass (*Agrostis exarata*), and colonial bentgrass (*A. tenuis*) were principal foods in older plantations.

Overall, forbs made up 41% of sheep diets in plantations O-My and O-Jy compared to only 16% in Y-My and Y-Jy. Although forb biomass averaged approximately 500 kg/ha in both plantation age classes, the preference shown by sheep for forbs in older plantations was higher ( $P \leq .10$ ). Common pearly everlasting (Anaphalis margaritacea), big lotus (Lotus crassifolius), and tansy ragwort (Senecio jacobaea) were dominant herbaceous species in older plantations, as well as preferred foods of sheep. In contrast, California figwort (Scrophularia californica) and bull thistle (Cirsium vulgare) were dominant forbs in younger plantations, especially Y-My, but had low preference values. Ingram (1931) noted that early seral species which inhabited young plantations were generally less palatable to sheep than species found in older plantations.

Sheep diets averaged 15% browse for the 2 older plantations grazed in May and July compared to 12% for the 2 younger ones grazed during the same time period. Vine maple was the most common browse on offer and in the diets of sheep grazing older plantations. In all study plantations and seasons, bitter cherry (*Prunus emarginata*), elder (*Sambucus spp.*), and red whortleberry (*Vaccinium parvifolium*) were preferred foods of sheep. Douglasfir was represented at low levels in diets of sheep from both older and younger plantations.

#### Summary and Management Implications

Sheep diets generally reflected forage available to them at the time of grazing. The greater availability of graminoids in spring was reflected in their higher percentage in sheep diets during this season. As the season progressed, the relative preference displayed by sheep for forbs and browse increased. In contrast, the preference exhibited by sheep for Douglas-fir was highest in spring soon after bud break, then declined to very low levels as the new foliage matured in early summer. Moreover, Douglas-fir was never a preferred forage; it only contributed from 1 to 3% of sheep diets throughout the grazing season. This pattern of diet selection illustrates the intermediate food habits of sheep described by Hanley (1982) and Hanley and Hanley (1982). As pointed out by these authors, sheep have the time and ability to be highly selective foragers as well as being physically able to exploit high cellulose graminoid diets. Consequently, sheep are well matched to the forage resource found in the Coast Range and have the potential to be an effective biological tool for control of unwanted brush in conifer plantations.

Approximately 600 ha of Douglas-fir plantations were grazed by sheep each summer. Daily observations of the sheep, coupled with data reported in this paper, suggest that sheep grazing can be most effective for the control of unwanted brush during the summer and late summer periods when palatability of target browse species is relatively high and palatability of the conifer tree crop is at its seasonal low.

The most troublesome brush species for reforestation in much of the coast range include red alder (Alnus rubra), salmonberry (Rubus spectabilis), and vine maple. Sheep prefer all of these brush species during summer and late summer (Leininger 1984). Rhodes (1984), working in the same plantations as this study, found that the standing crop of salmonberry and vine maple was significantly reduced after 2 summers of sheep grazing. Although utilization of red alder leaves and young twigs by sheep was high, the extremely rapid growth of this species prevented sheep from controlling its growth.

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