Logging Impacts on Bitterbrush in the Lodgepole Pine-Pumice Region of Central Oregon

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Highlight: The effect of logging on factors influencing production of bitterbrush in the lodgepole pine forest of central Oregon was evaluated. Production of bitterbrush in logged areas was approximately the same or greater than in adjacent nonlogged areas even though an average of 43% of the bitterbrush plants were lost during the logging operation. Bitterbrush plants growing in logged areas had leaders 2.5 cm longer than plants in nonlogged areas with 71% of their production in terminal and lateral leaders. Plants in nonlogged areas had only 45% of their production in the developed leaders. Plants taller than 40 cm were more frequently destroyed during logging operations than smaller plants. Plants 20–40 cm in height accounted for the greater production response after logging. Densities of germinated rodent caches of bitterbrush were much lower in logged areas. Percent canopy cover and density of lodgepole pine were highly correlated with cache densities of bitterbrush in logged areas.

Until recently lodgepole pine (*Pinus contorta*) growing in the pumice region of central Oregon was considered marginal for logging. New developments in harvesting and milling technology, together with increased availability of new markets, have created a more favorable economic environment for harvesting of lodgepole pine timber.

Bitterbrush (*Purshia tridentata*) constitutes a major understory dominant over much of the 2.1 million acre pumice region in central Oregon (Volland, 1974). This shrub also has been shown to constitute a large portion of the diets of cattle (*Bos taurus*), sheep (*Ovis aries*), and mule deer (*Odocoileus hemionus hemionus*) which utilize the region for summer range (Stuth, 1975). With increasing harvest of lodgepole pine, a need exists for information relative to the impact of logging on this important forage species.

Edgerton et al. (1975) have reported a 71% reduction in crown cover of bitterbrush following logging of a lodgepole pine/bitterbrush/western needlegrass (*Stipa occidentalis*) community in the pumice region of Oregon. Most of the damage resulted from slash disposal. However, twigs on bitterbrush plants in the logged areas averaged 108% longer than those in adjacent nonlogged areas, indicating a certain degree of compensatory response in production.

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The purpose of the study was to determine the production characteristics of bitterbrush growing in logged and nonlogged situations.

Study Area

The two areas chosen for study were located in the east-central portion of Klamath County, Ore. One area was located 21 miles west of Silver Lake, Ore., in the Fremont National Forest; the other area was located 14 miles east of Chemult, Ore., in the Winema National Forest. Elevation is approximately 1,500 m. The growing season is short and freezing temperatures are common during the summer.

The soil belongs to the Lapine series which is a well drained entisol developed on dacite pumice from Mt. Mazama, Crater Lake (U.S. Bureau of Indian Affairs et al., 1958). Lodgepole pine is considered an edaphic and topographic climax species on many sites in the pumice plateau of south central Oregon. It has an unusually wide ecological amplitude and can be found on wet, poorly drained to extremely droughty sites (Franklin and Dyrness, 1969). Lodgepole pine/bitterbrush/western needlegrass communities as described by the U.S. Forest Service (1972) were selected for this study. Detailed descriptions of the various lodgepole pine communities have been made (Youngberg, 1959; Volland, 1963; Dyrness and Youngberg, 1966; Youngberg and Dahms, 1970; Dealy, 1971; U.S. Forest Service, 1972; Volland, 1974) with the lodgepole pine/bitterbrush/western needlegrass the most widespread community. Important associated species within this community include bottlebrush squirreltail (*Sitanion hystrix*) and Ross sedge (*Carex rossii*).

Methods

The study was conducted in the summers of 1973 and 1974 on two areas in a square mile clearcut block (Fremont National Forest) and in two cutting units (Winema National Forest) which were part of a series of alternating clearcut strips one-half mile long and 60 meters wide with 120-meter uncut strips in between. The square mile block was cut in 1971, and the slash left in place. The strip clearcut areas were logged in 1969 and the slash piled and burned in 1970.

Production sampling of bitterbrush and associated species in the logged and nonlogged sites involved random selection of locations until eleven .89-m² (9.6 ft²) circular cages were established with vegetation in them. The number of incidences without vegetation was recorded for later analysis. Dry weight production of current year's growth on the shrubs was obtained by clipping and oven drying at 60°C for 48 hours. Each sample was stratified into three leader classes (1) terminal leaders, those initiating from ends of branches; (2) lateral leaders, those initiating from the sides of last year's or older growth; and (3) spurs, those undeveloped leaders less than 1 cm in length (Fig. 1). Production was determined during the second week of September both years.

Fig. 1. Twig classes of bitterbrush which were used for production and utilization measurement.

Growth rates of the bitterbrush leaders were determined by clipping and measuring the three leader classes on one branch from 20 randomly selected shrubs in a protected area. Measurements were made in mid-June, early July, mid-August, and mid-September.

Density of bitterbrush was determined during the 1974 sampling season for each of the logged and nonlogged sites using eight, 1.15×45.72 m (4.4×150 ft) belt transects (660 ft^2 or 61.3 m^2). Shrubs were classified into three groups based on height and were designated: (1) > 40 cm; (2) 20–40 cm; and (3) < 20 cm.

The density of germinated bitterbrush caches was counted on the same belt transects. Sampling took place in the 1974 season since no significant number of caches germinated in 1973. Differences in cutting patterns as they affected cache germination as well as canopy cover and stems per acre (> 2 inches or 5 cm) were analyzed. A Type C forest densiometer (Lemmon, 1956) was used to measure lodgepole pine canopy cover and the density of lodgepole pine was determined on the established belt transects.

The density of germinated rodent caches of bitterbrush on logged and nonlogged areas was examined with analysis of variance (completely random design) and Duncan's test.

Student's *t*-test was used to evaluate differences in distribution of production on bitterbrush in logged and nonlogged sites. Differences in the density of bitterbrush in logged and nonlogged areas were also evaluated with this statistical test.

Linear regression was used to correlate the density of germinated rodent caches of bitterbrush with various vegetative parameters within each site.

Results and Discussion

Precipitation recorded at the Chemult weather station indicated that the 1972–1973 season (October–September) was 18% below the 30-year average. There was 42% more precipitation at the Chemult station for the 1973–1974 season as compared to the 30-year average. However, no precipitation was recorded in August and September for 1974. This corres-

Fig. 2. Average seasonal growth rates of all bitterbrush leaders on all sites combined for plants growing in logged and nonlogged areas (lodgepole pine/bitterbrush/western needlegrass communities).

ponds to the period of active growth in bitterbrush in this area.

There was an average 10% increase in total production in logged areas during the dry year (1973) (Table 1). However, approximately 2.2 times more total production was recorded for logged areas in the wet year (1974). Herbaceous species accounted for the largest percent increase in production after logging. However, bitterbrush made up well over 85% of the total production in all cases; therefore, the response of bitterbrush to logging warrants closer attention. Although production generally increased in the wet year, it was lower for bitterbrush in the wet year on the nonlogged areas as compared to those shrubs on the logged areas. This area received average minimum temperatures below freezing for nine consecutive days during early August. The data suggest that plants growing under a tree canopy in this region may be more susceptible to cold conditions during active leader development than those bitterbrush plants growing in logged areas. Also, the area experienced only a trace amount of rainfall during August and September in 1974. Cold nightly temperatures coupled with greater daytime transpirational demand by the trees during the late growing season may have been responsible for low production of bitterbrush in nonlogged areas during the wet year.

A depression in growth rates of bitterbrush leaders was also noted on nonlogged areas in August of the wet year (Fig. 2). Depressed growth rates during the active growth period of the

Table 1. Summary of production values (lb/acre) for all areas combined with the corresponding change in productivity after logging (lodgepole pine/bitterbrush/western needlegrass communities).

Vegetation class	1973 unseasonably dry			1974 unseasonably wet		
	Nonlogged	Logged	Degree change	Nonlogged	Logged	Degree change
Grasses	8.9	47.6	5.3 x	11.4	110.4	9.7 x
Grasslikes	2.6	5.8	2.2 x	5.1	9.9	1.9 x
Forbs	0.7	4.5	6.4 x	1.4	5.5	3.9 x
Total herbaceous	12.2	57.9	4.7 x	17.9	125.8	7.1 x
Total shrub	297.0	282.0	-0.9 x	223.0	396.6	1.8 x
Total	309.2	339.9	1.1 x	240.8	522.4	2.2 x

leaders resulted in lower production. The values noted here produced questions concerning the possibility of at least partial cold hardness in actively growing plants. Since both production and leader growth rate data showed similar results, the unexpected values were not felt to be related to sampling error. A complete answer lies beyond the scope of this study.

Bitterbrush leaders grew at differential rates on plants in logged and nonlogged areas (Fig. 2). Plants in logged areas initiated leader growth approximately one week earlier. However, they were soon surpassed by the more rapid leader growth of plants under a tree canopy. By late July and early August the leaders on plants in logged areas exceeded those in nonlogged areas. At the end of the growing season leaders averaged 2.5 cm longer on plants in logged areas. Edgerton et al. (1975) reported average annual twig length to be 3.8 cm longer on bitterbrush plants in logged areas of similar communities.

Leader growth followed similar trends both years except for the depression of growth for the nonlogged areas during the wet year. Leader development was less in the Fremont study area than in the Winema study area (Table 2). The ridgeline which separates the two main study areas could have had a slight rainshadow effect on major storm patterns creating drier conditions in the Fremont study area.

Table 2. Average leader length (cm) of bitterbrush at the end of the growing season (Sept. 11) in the Fremont and Winema study areas as affected by logging and yearly precipitation.

Forest and leader class	Average leader length (cm)			
	Nonlogged areas		Logged areas	
	1973 (dry)	1974 (wet)	1973 (dry)	1974 (wet)
Winema				
Terminal	6.7	5.8	8.8	10.6
Lateral	5.7	5.2	7.8	8.7
Fremont				
Terminal	5.3	5.2	5.4	6.7
Lateral	5.3	5.1	5.9	6.4

Plants in logged and nonlogged areas not only differed in total production and growth rates, but also differed morphologically. Plants growing in nonlogged areas had a fine, lacy appearance, while those in logged areas were more compact. Plants growing in logged areas had approximately 71% of their production accounted for by developed leaders (Table 3). Over one-half of the production on bitterbrush plants growing in nonlogged areas was in the spurs. Stuth (1975) indicated that spurs were seldom utilized by cattle, sheep, and mule deer using the area; therefore, plants growing in logged areas also had more desirable production on a per plant basis.

There was an average 42% loss of bitterbrush plants during the logging operation (Table 4). The > 40 cm height class was more susceptible to damage during the logging operation.

Table 3. Production (%) of the various bitterbrush classes in logged and nonlogged areas.

Leader class	Logged areas	Nonlogged areas
Terminal	17.5	23.5
Lateral	53.5* ¹	21.5
Total developed leaders	71.0*	45.0
Spurs	29.0*	55.0

¹Indicates significant difference at the 95% level between logged and nonlogged areas.

Table 4. Average density and percent loss of the various bitterbrush height classes as affected by logging.

Height class	Average density				Percent loss
	Nonlogged area		Logged area		
	No./acre	No./ha	No./acre	No./ha	
>40 cm	1044	2580	380	939	63.6* ¹
20–40 cm	503	1243	425	1050	15.5 n.s. ²
<20 cm	823	2034	563	1391	31.6*
Total	2370	5856	1368	3380	42.3*

¹Indicates a significant difference between nonlogged and logged areas at the 95% level.

²Indicates no significant difference between nonlogged and logged areas at the 95% level.

Although there was a large reduction in the density of bitterbrush as a result of logging, no substantial change in productivity was generally noted. Correlation of the various height class densities with production revealed that the 20-40-cm group accounted for approximately 62% of the variation in production. This was based on only four paired observations; therefore, significance could not be demonstrated. However, a strong indication of the important role of the 20-40-cm height groups in providing compensatory response after logging is suggested. Branches on bitterbrush plants in this height class are generally more flexible and the plants have better developed root systems than the <20-cm group. These two features were likely responsible for the higher survival rate of plants in the group. Plants in the >40-cm group also did not appear to respond well to the new conditions created by logging. However, the >40-cm group provided the bulk of seeds needed for regeneration of bitterbrush. Therefore, the potential exists for a serious reduction in seeds available for caching and subsequent regeneration if this age class is lost from the stand. Plants in the <20-cm groups were physically too small for immediate response; however, they can provide a substantial portion of the production in the future.

Density of germinated rodent caches of bitterbrush were lower in the logged areas compared to the nonlogged areas (Table 5). Edgerton et al. (1975) found bitterbrush seedling density in logged areas was slightly greater than in adjacent nonlogged areas. Photos provided in their journal article indicated a high tree canopy cover in the logged areas, which could have had a favorable effect on germination and survival of bitterbrush seedlings in these sites.

The striplogged areas had higher density values than did the large clearcut block area. Cache densities in the nonlogged strips were unexpectedly lower than areas in the large nonlogged block.

Several vegetative characteristics were measured in each of the stands in hope of isolating possible site factors affecting cache germination. Soil factors were ruled out since no difference in depth and sequence of horizons could be found between study areas. Linear regression analysis revealed that a significant correlation existed between the density of the caches and percent cover and/or stems per acre of lodgepole pine in the

Table 5. Mean densities* of germinated rodent caches (number/acre) of bitterbrush as affected by logging and logging patterns.

Rep.	Strips		Blocks	
	Logged	Nonlogged	Logged	Nonlogged
1	25	83 ^a	1 ^c	462 ^b
2	91 ^a	363 ^b	2 ^c	1493
Mean	59 ^a	223 ^b	2 ^c	978

*Means with the same letter exhibited no significant differences at the 95% level.

Table 6. Linear relationships between bitterbrush cache density (dependent variable) and various vegetational influences (independent variables) in logged and nonlogged areas.

Independent variables	r^2 values	
	Nonlogged areas	Logged areas
Percent cover lodgepole pine	0.0400	0.9800*
Lodgepole pine stems/acre	0.1370	0.9220*
Bitterbrush density >40 cm ht	0.2700	0.6080
Bitterbrush density 20-40 cm ht	0.0060	0.0580
Bitterbrush density <20 cm ht	0.0004	0.3250
Total bitterbrush density	0.1370	0.3360

*Denotes significance at the 95% level.

logged areas (Table 6). Cochran's (1969) findings which revealed beneficial environmental influences of a tree canopy cover on natural regeneration of lodgepole pine following logging may also have some applicability to germination and growth of bitterbrush caches. Correlation between vegetational influences and the occurrence of bitterbrush caches was poor for the nonlogged areas.

There appear to be three possible factors influencing densities of germinated rodent caches of bitterbrush.

(1) The status of the rodent population within the site, especially the golden mantled ground squirrel (*Citellus lateralis*) and Townsend ground squirrel (*Citellus townsendi*).

(2) The micro-macro environmental conditions associated with the germination phase of the cached seeds and the bloom stage of seed producing plants the previous year.

(3) The quantity of seed producing plants occupying the site.

It appears likely that rodent population status would be the most important factor in the nonlogged areas. The environmental conditions associated with seed germination and production may be the most important influencing factor in logged areas especially in light of the findings presented in Table 6. The quantity of seed producing plants would likely be of intermediate influence since, on a long-term basis, amount of seed produced is generally not a limiting factor to reproduction of most species.

Conclusions

Yearly precipitation and minimum temperature during the growing season were found to influence differences in production of bitterbrush in logged and nonlogged areas. Apparently, a certain degree of preconditioning must take place to allow plants growing in logged areas to tolerate the much lower nightly temperatures (<0°C) found in these areas. Cochran et al. (1967) indicated that clearcuts in this area lose much of the radiation received during the day because of the lack of reradiation afforded by tree canopy at night.

Although approximately one-half of the shrubs were lost during the logging operation, it appears that bitterbrush growing in logged areas can compensate for this loss by producing longer leaders, increasing the number of leaders produced, and withstanding minimal losses on those age classes which have the greatest potential for responding to the new conditions created by logging. These findings suggest that a density of 1,400 bitterbrush plants per acre (3,450 per hectare) or 3 per 100 ft² (32 per 100 m²) would give an adequate compensatory response to overcome loss of plants during the logging operation. Special efforts should be made to minimize losses of the 20-40-cm height group and to maintain a good distribution of the >40-cm height group for seed production. Special attention also should be given to site conditions which affect the natural regeneration of bitterbrush if the land manager wants to insure replacement of those individuals lost during the logging operation.

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