Table 7--Soil properties at the Mount Hood experimental area [1]

Property	Depth in centimeters [2]		
	0-15	16-30	31-46
PH	5.30	5.70	5.50
Cation exchange capacity (meq/lOO g)	23.39	20.00	26.10
Total nitrogen (percent)	0.16	0.11	0.08
Phosphorus (pm)	4.90	6.00	6.40
Potassium (pm)	75.00	90.00	114.00
Calcium (meq/lOO g)	0.69	0.29	0.38
Magnesium (meq/lOO g)	0.12	0.07	0.07
Sodium (meq/lOO g)	0.13	0.16	0.16
Boron (pm)	0.32	0.30	0.28
Acetate extractable iron (pm)	47.10	18.70	25.90

[1] Average values based upon analyses of 4 samples--l for each of the randomly distributed control plots.

[2] To obtain depth in inches, multiply by 0.394.

EXPERIMENTAL DESIGN

We treated one plot in each of six pairs; the other, randomly located plot was used an an untreated control (fig. 12). Control plots are l/3 acre (0.14 ha); adjacent treated plots are the same size, with an additional 30-ft (9-m) buffer strip that includes a tractor-built fireline.

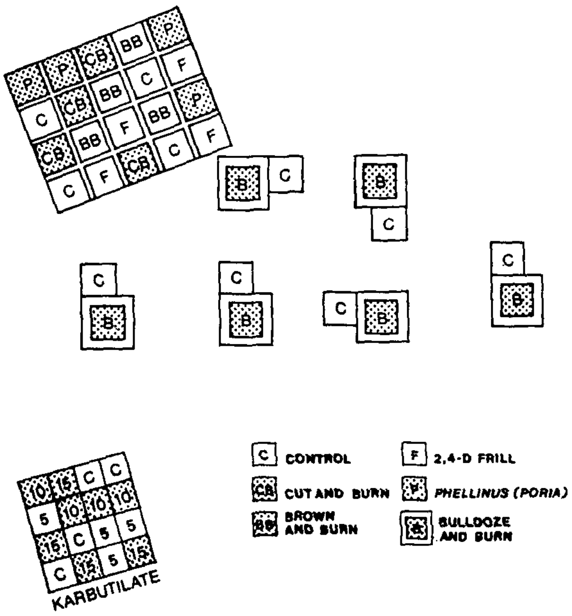


Figure 12.--The Mount Hood experimental area showing the paired-plot bulldoze-and-burn experiment (center), the Karbutilate plots (lower left), and the grid plots (upper left). Karbutilate plot numbers indicate pounds of active ingredient per acre.

TREATMENT

A Caterpillar D6C tractor with 12-ft angle blade was used to push over all trees on each of the six treated plots on October 23 and 24, 1973. Trees larger than 14 in (36 cm) d.b.h. were difficult to uproot or break off. Those smaller than 4 in (10 cm) d.b.h. tended to spring back after the blade went over them. Except where buried by slash or disturbed by uprooted trees, huckleberry shrubs were not damaged by the tractor. After transportation charges were deducted, the bulldozing cost $34 per acre ($84 per ha).

Slash created by the bulldozing was burned the following summer, early in the evening on August 26, 1974. Eight miles (13 km) away and 350 ft (107 m) lower, a weather station recorded a 2:00 p.m. relative humidity of 23 percent, a maximum temperature of 84° F (29° C), northwest winds of 6 mi/h (10 km/h), and a 10-h lag fuel moisture of 7 percent (see footnote 8) for that date. Cooperating personnel from the Zig Zag Ranger District, Mount Hood National Forest, used drip torches to ignite each plot. No contamination with fuel oil occurred. The slash burned well, but the fire did not spread into areas without slash. Small patches (less than 10 percent of the area treated) remained unburned. Most huckleberry shoots were blackened, but not consumed.

DATA COLLECTION AND PROCESSING

Vegetation data were collected on each bulldoze-and-burn plot in 1975 and 1977 by the techniques used at Mount Adams. Huckleberry and total overstory cover were tallied along four 120-ft (37-m) lines established on each plot. Competing understory species were not tallied.

Sixteen 1-milacre (0.0004 ha) subplots were established at equal intervals on each plot. Equal numbers of these subplots were randomly chosen on each plot in 1975 and 1977, and the berries on the chosen subplots were picked and weighed. Picked weights were converted to ripe weights by using the procedure described earlier.

Ripe berry weights, huckleberry cover, and total overstory canopy cover on the treated and control plots were compared by analyses of variance in 1975 and 1977.

RESULTS

The bulldoze-and-burn treatment eliminated dense overstory competition. The huckleberry understory was severely damaged by the burn, however, and huckleberry cover and berry production had not recovered to control levels 3 years after treatment (table 8). Huckleberry shrubs sprouted vigorously (fig. 13), but they produced very few berries.

CONCLUSIONS

Bulldozing provided suitable slash fuel for burning upper elevation huckleberry fields if the slash was allowed to dry for 1 year. It provided this fuel at less cost than tree-cutting with chain saws. The bulldoze-and-burn treatment effectively eliminated competing vegetation, but burning the slash seriously damaged huckleberry shrubs and reduced berry production for at least 3 years. Bulldozed sites look unattractive; bulldozing should not be done in scenic areas or where soil erosion is a problem.

Karbutilate Experiment

OBJECTIVE

Researchers in the Coast Ranges of Oregon and Washington observed that karbutilate killed most plant species, but had little effect on evergreen huckleberry and red huckleberry. Our objective was to determine if it could be used to kill competing plant species in Cascade Range huckleberry fields without affecting big huckleberry.

EXPERIMENTAL DESIGN

Four treatments were replicated four times in a completely random experiment. One-tenth-acre (0.04 ha) plots were used in a four-by-four grid (fig. 12). The following treatments were randomly assigned to these plots: 5 lb karbutilate/acre (5.6 kg/ha); 10 lb karbutilate/acre (11.2 kg/ha); 15 lb karbutilate/acre (16.8 kg/ha); and control (no treatment).

Table 8--Average overstory cover, huckleberry cover, and berry production on the Mount Hood bulldoze-and-burn experimental plot [1]

	1975		1977	
	Control plots	Bulldoze-and-burn plots	Control plots	Bulldoze-and-burn plots
Overstory cover (percent)	45.30	0.20	50.60	0.20
Huckleberry cover (percent)	33.00	6.00	35.20	9.40
Berry production (kg per ha) [2]	94.85	10.14	66.73	7.89

1/ All control vs. bulldoze-and-burn differences are statistically significant ($P<0.05$).

2/ To obtain pounds per acre, multiply by 0.8927.

Figure 13.--Three-year-old huckleberry shoots on a bulldoze-and-burn plot near Mount Hood. They are not producing berries.

TREATMENTS

The active ingredient in Tandex[10] is karbutilate (*m*-(3,3-dimethylureido) phenyl *tert*-butylcarbamate). It is often used as a soil sterilant. Mammalian toxicity is very low. We applied a granular form of the chemical (Tandex 10 G) in late June 1975, by uniformly spreading measured amounts on treated plots as the last snow was melting. We were extremely careful to secure an even distribution of the chemical and expended about 8 man-hours per acre (20 man-hours per ha). Control plots were located and marked, but they received no other treatment.

DATA COLLECTION AND PROCESSING

Overstory and understory cover were recorded in both 1976 and 1977 along three lines established on each of the 16 plots. As in the other huckleberry experiments, the resulting linear measurements were converted to percentage cover for each species. Cover percentages were then subjected to analyses of variance. Where significant differences occurred, Scheffé multiple comparison tests were used to identify the treatments involved. Berry production was observed, but not measured on the treated plots.

RESULTS

The karbutilate applications produced no immediate results, but huckleberry leaves began to turn brown 1 month later. By late autumn 1975, a few of the overstory trees also began to show herbicide damage. One year later, effects of the herbicide were evident (fig. 14). The two heaviest applications

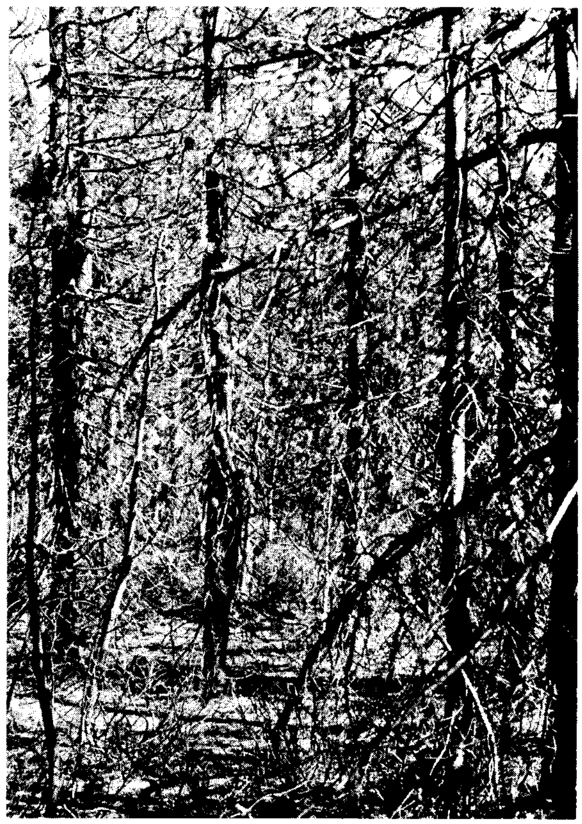


Figure 14.--A karbutilate plot 15 months after treatment with 15 lb of karbutilate per acre (16.8 kg/ha). The trees and huckleberry shoots are dead. September 1976.

[10]Mention of companies or products does not constitute an endorsement by the U.S. Department of Agriculture.

Table 9—Average vegetative cover in percent on plots treated with karbutilate[1]

Year and treatment	Overstory[2]				Understory[2]						
	Lodgepole pine	Douglas fir	Noble fir	All species	Big huckleberry	Beargrass	Dwarf bramble	Pearly everlasting	Violet	Lodgepole pine	Total huckleberry competition
1976:											
Control	53.5	3.6	2.6	61.1	22.6	10.5	4.7	1.9	0.4	1.6	24.0
5 lb/acre (5.6 kg/ha)	34.6	7.2	1.9	46.1	9.8	8.1	4.3	0.7	0.9	1.0	18.8
10 lb/acre (11.2 kg/ha)	7.3	4.4	1.4	12.0	2.1	8.0	2.4	0.1	0.2	0.6	11.9
15 lb/acre (16.8 kg/ha)	3.9	3.6	3.3	9.0	2.4	9.5	1.0	0.1	0.4	0.5	13.0
1977:											
Control	49.4	4.0	2.9	58.4	30.2	7.6	6.6	2.2	0.5	3.3	23.6
5 lbs/acre (5.6 kg/ha)	28.8	5.6	3.5	38.5	22.5	5.7	4.9	0.8	1.0	1.4	17.8
10 lb/acre (11.2 kg/ha)	2.3	5.6	0	8.6	8.7	7.5	5.3	0.3	0.4	0.7	15.8
15 lb/acre (16.8 kg/ha)	1.5	3.9	0.2	5.6	5.1	8.6	2.7	0.1	0.9	0.2	13.5

1/ Each average represents 4 treatment plots. Averages within a common bracket are not significantly different (Scheffé tests were not significant at P<0.05).

2/ Only major species are listed individually, but all are included in the "all species" and "total huckleberry competition" columns.

could be identified on the ground by amount of vegetation damaged. Indeed, most plants (including huckleberry shoots) were dead. The 5-lb/acre (5.6-kg/ha) treatment produced significantly less damage (table 9); many of the overstory trees and huckleberry shoots were not killed.

Lodgepole pine was damaged more than noble fir by the herbicide, and noble fir was damaged more than Douglas-fir. We noted that karbutilate killed all of the conifer species from the bottom up. (When affected by 2,4-D, they die from the top down). Huckleberry shrubs appear to be slowly recovering from the treatments. Some of the damaged shoots bear a few green leaves, and some rhizomes are sprouting. Nevertheless, treated plots produced few berries in 1977, and many brown, curled leaves or bare huckleberry branches remained.

CONCLUSIONS

Karbutilate nearly eliminated competing vegetation in a huckleberry field when applied at 10-15 lb/acre (11.2-16.8 kg/ha). Unfortunately, it also nearly eliminated huckleberry. Lesser quantities of karbutilate were less effective in reducing competition and less damaging to huckleberry.

Five-Treatment Grid

OBJECTIVE

Like the 1972 experiment at Mount Adams, this Mount Hood experiment had as its objective the development of a method of controlling vegetation that could be used against competing species without reducing huckleberry growth or berry production. A successful method should increase berry production.

EXPERIMENTAL DESIGN

We duplicated the completely random experimental design used in the 1972 experiment at Mount Adams for this five-treatment, four replication grid, but applied different treatments (fig. 12): cut and burn; brown and burn; 2,4-D frill; *phellinus (Poria)* inoculation; and control (no treatment). As at Mount Adams, each grid plot is 120-ft (37-m) square, occupying an area of l/3 acre (0.14 ha).

TREATMENTS

Cut and Burn

With chain saws, we cut all of the overstory trees on the four cut-and-burn plots in September 1973. The operation required about 18 man-hours per acre (44 man-hours per ha). The resulting slash was left in place, and firelines were built around each plot.

The 11-month-old slash was burned by Zig Zag Ranger District personnel late in the afternoon on August 26, 1974. Meteorological conditions for that date are recorded elsewhere (see bulldoze-and-burn experiment). Relative humidity was 30 percent and the temperature was 76° F (24° C) when burning commenced 4:00 p.m. Although the slash burned readily after being ignited with drip torches, several small areas without slash (less than 10 percent of the area treated) did not burn at all. Most huckleberry shoots were blackened, but not consumed by the fire,

Brown and Burn

Firelines were constructed around the four brown-and-burn plots in October 1973. These plots were treated with a low volatile ester of 2,4-D on July 23, 24, 25, and 26, 1974. We mixed three lb (1.36 kg) 2,4-D with 3 gal (11.4 1) of diesel oil and 97 gal (367.2 1) of water, then sprayed the resulting emulsion on all vegetation. The vegetation was dense, and we used about 190 gal of emulsion per acre (1 777 l/ha). Most of the foliage below 10 ft (3 m) turned brown during the following month.

Burning was attempted at the same time that adjacent cut-and-burn plots were successfully ignited, but here it failed. Dry fireline slash along the plot edges burned, but the other vegetation--even the brown pine needles and herbicide-damaged huckleberry shrubs--would not carry a fire. Thus, the brown-and-burn treatment was browned, but not burned. It became a test of broadcast spraying with low volatile 2,4-D ester.

2, 4-D Frill

A one-to-one mixture of 2,4-D amine and water was applied to individual trees on the 2,4-D frill plots. We used a hatchet to cut frills 1.5 in (3.8 cm) apart around every tree larger than 2 in (5 cm) d.b.h. and squirted the 2,4-D solution into the frills with a plastic squeeze bottle (fig. 15). This operation is sometimes referred to as the "hack-squirt" technique. Frill plots were treated on July 8-11, 1974, when remnants of the heavy winter snow pack remained as drifts and huckleberry shrubs were just beginning to produce leaves. The large number of overstory trees (3,200/acre or 8,000/ha) made this treatment very time consuming. It required about 21 man-hours/acre (52 man-hours/ha).

Figure 15.--2,4-D amine being applied to frills cut in an overstory tree. Note hatchet, squeeze bottle, and snowdrift in background. July 1974.

Phellinus (*Poria*) Inoculation

Phellinus weirii (Murr.) Gilbertson (a native, root-rotting fungus that attacks conifers) spreads slowly, but remains in the soil for long periods after it becomes established. Establishment by inoculation could result in continuous, long-term overstory thinning in the huckleberry fields.

Pathologists Earl E. Nelson [11] and Allen W. Todd [12] inoculated 25 well-spaced trees on each of the four *Phellinus* plots. At each tree, two lateral roots were excavated and scarred by removing a strip of phloem and cambium. *Phellinus weirii* inoculum (alder-block cultures) was then placed in contact with the exposed root xylem, wrapped in plastic, and buried. Tree species and diameter, root size, root direction, and the inoculation point on each root were recorded. Azimuths and distances between inoculated trees on each plot were also recorded, and the inoculated trees were labeled with metal tags.

Control

Four control plots were located and permanently marked in the field. No treatments were applied, and the control plots were undisturbed except for periodic measurements of vegetation and berry production.

DATA COLLECTION AND PROCESSING

Vegetation data were collected in 1975 and 1977 on the five-treatment grid by methods used in the bulldoze-and-burn experiment. Only huckleberry cover was recorded below the four 120-ft (36.6-m) lines established on each of the 20 plots. Overstory cover was recorded by species on the grid plots, however, and both total overstory and overstory cover by species were obtained.

Berry production was measured in 1975 and 1977 by picking and weighing all the berries on 16 systematically spaced l-milacre (0.0004-ha) subplots on each of the 20 plots. Picked weights were converted to ripe weights by using the procedure described on page 13.

Ripe berry weights, huckleberry cover, and overstory cover were subjected to analyses of variance in 1975 and 1977.

RESULTS

Overstory Vegetation

Overstory vegetation was significantly reduced by the herbicide spray in the brown-and-burn treatment, which affected lodgepole pine more than the other tree species (table 10). The 2,4-D frill treatment was much more effective, however; it killed all but 8.7 percent of the overstory cover (fig. 16). Only the frilled trees were affected by 2,4-D. *Phellinus weirii inoculations* showed no visible results in 1977, and *Phellinus* plot overstories did not differ significantly from the controls (fig. 17).

[11] USDA Forestry Sciences Laboratory. Corvallis, Oregon.

[12] Oregon State University, Corvallis, Oregon.

Table 10—Average berry production, huckleberry cover, and overstory cover on the Mount Hood 5-treatment plot grid[1]

Year and treatment	Berry production	Huckleberry cover	OVERSTORY COVER										
			Lodgepole pine	Noble fir	Douglas-fir	Mountain hemlock	Subalpine fir	Engelmann spruce	Western white pine	Grand fir	Western hemlock	Western redcedar	Total all species
	kg/ha[2/]	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	Percent	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -
1975:													
2,4-D frill	72.43	46.1	2.0	4.3	1.5	0.7	0	0	0	0	0	0	8.5
Phellinus	173.94	42.9	41.3	4.6	5.3	0.7	2.4	0	0.5	0	0	0	54.8
Control	107.14	44.0	46.0	3.7	1.7	0.8	0	0	0.2	0.5	0.1	0	53.0
Brown and burn	0	5.9	22.4	3.1	4.3	1.5	0	2.1	0.1	0	0.2	0	33.7
Cut and burn	2.70	7.1	0	0	0	0	0	0	0	0	0	0	0
1977:													
2,4-D frill	192.90	49.1	3.1	2.8	1.8	0.9	0	0	0	0	0	0.1	8.7
Phellinus	105.56	45.0	43.9	5.4	5.9	0.9	0.7	0	0.8	0	0.2	0	57.8
Control	73.55	45.2	52.1	4.2	2.5	1.0	0	0	0.3	0.5	0.1	0	60.7
Brown and burn	16.18	28.0	28.3	3.9	5.8	2.0	0	0.6	0.1	0	0.4	0	41.1
Cut and burn	2.36	17.0	0	0	0	0	0	0	0	0	0	0	0

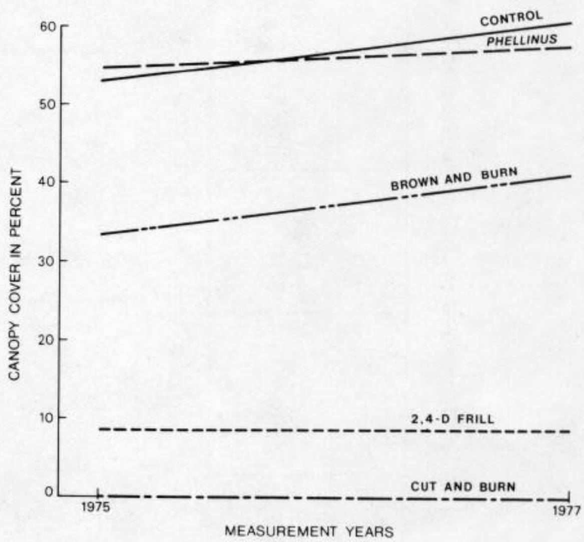
1/ Each average represents 4 treatment plots. Averages within a common bracket are not significantly different (Scheffé tests were not significant at $P<0.05$).

2/ To obtain pounds per acre, multiply by 0.8922.

3/ Absence on most treatment replications made statistical analyses impractical.

Figure 16.--A 2,4-D frill plot 3 years after treatment. Note dead overstory trees. Huckleberry shrubs comprise the understory. September 1977.

Figure 17.--Average overstory canopy on the Mount Hood grid plots. Treatments were applied in 1974.



Overstory species reacted differently to the 2,4-D frill treatment. Lodgepole pine was most susceptible, followed by noble fir, which was more susceptible than Douglas-fir. Mountain hemlock was most resistant. All trees affected by the 2,4-D frill treatment died from the top down, not (as in the karbutilate treatments) from the bottom up.

Huckleberry Cover

Although burned shrubs sprouted vigorously, burning significantly reduced the huckleberry cover measured on cut-and-burn plots in 1975, 1 year after treatment. This reduction was still significant 3 years after treatment, in 1977 (table 10). The brown-and-burn plots were never successfully burned, but they also experienced a significant reduction in huckleberry cover in 1975, a reduction caused by the 2,4-D spray used for browning. Herbicide damage seems to have affected the huckleberry plants less severely than fire damage, however, for by 1977 the average huckleberry cover on brown-and-burn plots, though still much less than that of the controls, appeared to be increasing faster than on the cut-and-burn plots.

Huckleberry cover on the 2,4-D frill, *Phellinus,* and control plots all increased slightly from 1975 to 1977. No significant differences occurred among these three treatments.

Berry Production

As it did in the Mount Adams experiment, the cut-and-burn treatment at Mount Hood essentially eliminated huckleberry production 1 year after treatment (table 10). The few berries picked in 1975 came from shrubs that were not burned. Three years after treatment, in 1977, berries were still limited to those few shrubs, and no increase in production occurred. Burned shrubs sprouted vigorously during the 1st year after treatment, but produced no berries 3 years after burning (fig. 18).

Berry production was also eliminated on the brown-and-burn plots 1 year after treatment. Huckleberries sprayed with 2,4-D bore a few berries again during following years, however, and in 1977 the brown-and-burn plots produced much more than the cut-and-burn plots (table 10). Nevertheless, berry production on brown-and-burn plots was far below the production attained on control, *Phellinus,* or 2,4-D frill plots.

Although berry production on the *Phellinus* plots was higher than that on control plots in both 1975 and 1977, the difference was not statistically significant in either year. Production was appreciably lower for both treatments in 1977 than it was in 1975 (table 10). *Phellinus weirii* inoculations did not affect berry production.

Figure 18.--Huckleberry shrub on a Mount Hood cut-and-burn plot, 3 years after burning. Note vigorous young shoots and absence of berries. September 1977.

Fewer berries were produced on the 2,4-D frill plots than on the control plots in 1975, but the difference was not statistically significant. Three years after treatment, in 1977, the frill plots produced more than twice as many berries as the controls, and the difference was significant. Furthermore, although production declined on all other plots but those recovering from herbicide spraying between 1975 and 1977, it increased during the same period on 2,4-D frill plots (fig. 19). Huckleberries were abundant on the frilled plots in 1977 (fig. 20).

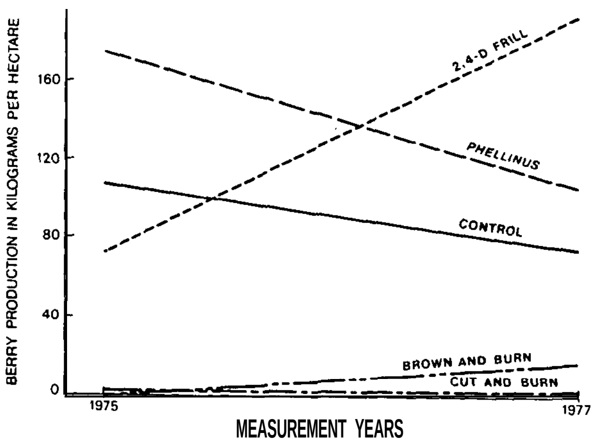


Figure 19.--Average berry production on the Mount Hood grid plots. Treatments were applied in 1974.

CONCLUSIONS

Although the Mount Hood experiment was not contaminated with diesel oil, the cut-and-burn treatment was no more successful there than it was near Mount Adams. Huckleberry shrubs burned in the summer or autumn sprout during the following summer, but do not produce berries for at least 3 years after the fire.

One-year-old slash carries fire satisfactorily, and flame-thrower burning is not necessary if this slash is burned during warm dry weather. Warm dry weather probably will not be sufficient for a satisfactory burn in high elevation huckleberry areas where dry slash is absent, however. Success in burning may require that it be done during high-hazard conditions, which are infrequent. Low fuel densities, frequent fogs, and heavy dews seem to be responsible for unsatisfactory burning. Herbicide browning of the foliage does not provide enough dry fuel to carry a fire on slash-free sites. *Phellinus wierii* inoculations might thin the overstory canopy without the need for either fire or slash, but *Phellinus* has had no visible effect on our plots. We can only conclude that benefits of inoculation, if any, will be slow in appearing.

Figure 20.--Huckleberry shrub on a 2,4-D frill plot, 3 years after treatment. Note abundant berries. September 1977.

Application of 2,4-D amine in frills had little effect on berry production during the first year after treatment, but it greatly reduced the overstory canopy. This reduction in overstory canopy was accomplished without damaging the huckleberry understory. It created favorable conditions for berry production.

LABORATORY RESEARCH

Considerable time and effort were spent in culturing huckleberry in laboratory growthchambers and greenhouses. Our initial attempts were rooting trials. Two thousand stem cuttings were collected from dormant shoots in June 1972. These cuttings were placed in a peat-sand mixture under intermittent mist. All broke buds. None rooted. In late July, another 2,000 stem cuttings were collected from growing shoots. They were soaked in an indolebutyric acid solution (25 mg IBA/l water) overnight, then rinsed before being placed in the peat-sand mixture under intermittent mist. Again, none of the stem cuttings rooted. Rhizome cuttings grew vigorously, even when collected in midsummer and potted without further treatment.

As our attempts to root stem cuttings failed, and as uniform plants are difficult to obtain from rhizome cuttings, we cultured *Vaccinium* plants from seed. *V. membranaceum, V. globulare,* and *V. deliciosum* all grew equally well under the conditions described.

Ripe berries were pulped in a blender with water and a small amount of detergent added to wet the seeds and prevent them from floating away with the pulp. The resulting slurry was placed in a dish and decanted under a slow stream of water. The pulp floated away, leaving the seeds in the dish bottom. These seeds were air-dried, then sown on moist peat kept at cool growthchamber temperatures (18° C or 64° F, 12-h days and 13° C or 55" F, 12-h nights were satisfactory). Seed stratification was not necessary, and germination occurred in 16-21 days.

The resulting seedlings grew rapidly when watered periodically with a nutrient solution based on the macronutrient proportions published by Ingestad (1973) and the micronutrients listed by Minton, Hagler, and Brightwell (1951):

Macronutrient Solution (in 1 liter H_2O)

0.048 g $NH_4H_2PO_4$

0.095 g KC1

0.041 g Ca $(NO_3)_2 \cdot 4H_2O$

0.086 g $MgSO_4 \cdot 7H_2O$

0.341 g NH_4C1

Micronutrient Stock Solution[13]

0.90 g manganese chloride/500 ml H_2O

0.10 g zinc sulfate/500 ml H_2O

0.05 g cupric sulfate/500 ml H_2O

0.50 g boric acid/500 ml H_2O

0.08 g molybdic acid/500 ml H_2O

19.23 g sequestrine NaFe/500 ml H_2O

[13] One ml of each stock solution was added to each liter of macronutrient solution.

Excellent growth occurred in chambers set for 20° C (68° F), 14-h days and 14° C (57° F), 10-h nights. When well watered, the plants also grew satisfactorily in greenhouse and lathhouse conditions.

When *V. membranaceum* plants were grown from seed, they first bloomed during their third growing season. Rhizomes were first formed during the third growing season (fig. 21). Rhizome formation in *V. deliciosum* apparently occurs much earlier--we found rhizomes on 1-year-old growthchamber seedlings.

Using *V. membranaceum* cultured from seed, we cooperated with an Oregon State University graduate student who studied the relation of nutrients and pH in a greenhouse and in the field (Nelson 1974). He found in both places that vegetative growth increased with added nitrogren. Better growth in the greenhouse occurred at pH 5.0 than at 3.0, 4.0, or 6.0. *V. membranaceum* seedlings were also used in a study of the comparative tolerances of huckleberry and lodgepole pine to boron and manganese (Minore 1975a).

Figure 21.--V. membranaceum *rhizome produced during the third growing season in a lathhouse. Our growth chamber, greenhouse, and lathhouse plants formed no rhizomes during their first two growing seasons.*

The pine was more tolerant to boron. We used seedlings of *v. membranaceum, V. deliciosum,* and *V. globulare* in a carefully controlled study of frost tolerance (Minore and Smart 1978). *v. deliciosum* was significantly more frost tolerant than the other species.

Beargrass is a major competitor in the huckleberry fields and in high elevation clearcuttings, but herbicides, burning, and grazing have been ineffective in controlling it. Past attempts to culture beargrass have been hampered by the inability to germinate the seeds. After trying several methods, we obtained successful (64 percent) germination by stratifying the seeds for 16 weeks (Smart and Minore 1977). The seedlings were successfully cultured under the same nutrient, temperature, and photoperiod regimes used in growing *V. membranaceum.*

DISCUSSION

Although we tested vegetation control methods in only two areas, these areas appear to be typical of the berryfields that occur at elevations of 4,000-6,000 ft (1 220-1830 m) in the Cascade Range of Oregon and Washington. Lodgepole pine, western white pine, beargrass, lupines, and grasses are the most important huckleberry competitors in the areas studied. Burning the slash created by cutting or pushing over all trees with a tractor eliminated the lodgepole and white pine competition. Beargrass, lupines, and grasses, however, were not satisfactorily controlled. Indeed, grass growth was stimulated by burning.

Controlled burning is exceedingly difficult in northwestern huckleberry areas at these elevations. Without dry slash to carry the fire, burning appears impossible except during hazardous meteorological conditions; it seems counterproductive when short-term benefits are desired. Abundant berries did not occur after our fires. Although the huckleberry bushes sprouted almost immediately after being burned, the sprouts did not begin to bloom until the third growing season. Significant berry production was delayed for at least 5 years and perhaps much longer. Meanwhile, tree seedlings from adjacent unburned stands began to invade the burned area. Unless this area is very large (comparable to the areas burned by wildfires in former years), reinvasion of burned areas by trees may be almost as fast as huckleberry recovery.

Spring burning increased *V. globulare* stem density within 1 year in the larch/Douglas-fir forests of western Montana (tiller 1977), but Montana results may not apply to huckleberry in Oregon and Washington. Western Montana environments differ from Pacific Northwest environments. Furthermore, the morphology and sprouting behavior of *V. globulare* in Montana resemble that documented for *V. angustifolium* (Miller 1978); behavior of big huckleberry does not resemble that of *V. angustifolium,* so it probably also differs from that of *v. globulare. V. globulare,* like *V. angustifolium,* may recover from fire more rapidly than big huckleberry.

Season of burning--not species differences--probably was responsible for higher stem density on some of the Montana fire plots. Density-increasing burns there occurred in the spring, when soil moisture was higher and heat penetration was shallower than in the autumn. The Montana autumn burns, like our burning treatments, reduced stem densities. As our Mount Adams burning treatments were applied less than 2 weeks after an early autumn snowfall, however, and as the Mount Hood burning was done only 5 weeks after the disappearance of a heavy winter snow pack, our burns may have occurred under soil moisture conditions similar to those of a Montana spring. In any case, snow cover makes spring burning impossible in most northwestern huckleberry fields. Summer and autumn burning reduced both stem density and berry production for at least 5 years.

Sheep grazing--even severe overgrazing--did not damage the huckleberries. It may even have benefited them by adding nitrogen to the soil. Unfortunately, added nitrogen is of little value to huckleberries growing under a closed forest canopy, and sheep grazing does not eliminate this forest canopy or retard its closure.

Applications of karbutilate eliminated the forest canopy, but they also eliminated the huckleberries growing under that canopy. The huckleberries could recover and sprout again, but the prospects are not encouraging. Boron applications are even less encouraging and should not be considered further.

Successful *Phellinus weirii* inoculations probably would maintain an open overstory indefinitely. As yet, the inoculations have not been successful, however, and we will have to wait several more years to see if this form of biological control merits further investigation.

Application of 2,4-D amine to frills cut in each treated tree certainly deserves further investigation. The method is expensive in dense stands like those treated near Mount Hood, but it would be an economical way to eliminate trees at earlier seral stages when stand density is much lower. We found no evidence of the 2,4-D moving out of treated trees. Applied in frills, the herbicide appeared to be safe as well as efficient.

Dense shade is detrimental to huckleberry production, and some sort of overstory control is needed to preserve and maintain existing berry fields. Partial shade does not seem to be harmful, however, and the slight overstory protection afforded by dead snags or a thin overstory canopy may even be beneficial. Absolutely open conditions, without shade of any kind, may be less desirable than this light partial shade.

Shrub disturbance is detrimental to production of huckleberries. Old shrubs continue to produce berries year after year, without pruning or other rehabilitation. When these old shrubs are burned, cut, or otherwise disturbed, they stop producing berries and start producing vigorous new shoots. Unfortunately, vigorous new shoots do not produce many berries.

Vigorous new shoots should produce many berries eventually, however. When they do, areas that were disturbed by burning may be more productive than undisturbed areas. The long-term benefits of burning might then exceed the short-term benefits obtained by applying 2,4-D in frills. We will continue to monitor all of our experimental plots to see if this occurs.

MANAGEMENT RECOMMENDATIONS

Huckleberry management will be expensive, and the areas to be managed should be carefully selected. Access, public use, and berry production should all be considered. In many areas, the public already is using easily accessible areas that are known to produce good berry crops. Preserving and maintaining these traditional picking grounds should be given highest priority. The following recommendations are applicable to huckleberry areas at 4,000-6,000 ft (1 220-l 830 m) in the Cascade Range of Oregon and Washington.

Overstory trees should be controlled in the areas to be managed. If berry production is to be maintained or increased without delays of 5 years or longer, this must be done with minimal disturbance of the huckleberry understory.

A one-to-one solution of 2,4-D amine and water, applied to frills cut in the individual trees, effectively kills a conifer overstory without disturbing the huckleberries. It should be applied in the spring, just as conifer buds are breaking. Where herbicide use is undesirable, individual tree girdling would produce the same result at somewhat higher cost. Frilling and girdling will be least expensive when done before a dense overstory canopy develops.

Where dense overstory canopies occupy large areas that are to be managed for huckleberries, and where berry production delays of 5 years or longer are acceptable, the bulldoze-and-burn treatment should be considered. Using a crawler-type tractor with raised bulldozer blade, all trees in a large area should be pushed over and allowed to dry for a year before burning is attempted. Burning should then be done while soil moisture remains high, as soon as the slash will carry a fire. This method has a severe visual impact on the landscape, it will eliminate berry production for several years, and long-term berry production benefits are unknown. Nevertheless, it is much cheaper than frilling or girdling where dense unmerchantable overstories are to be removed. Where merchantable overstories exist, conventional clearcutting probably would be just as effective. Unfortunately, merchantable overstories do not always occur on areas capable of producing good huckleberry crops.

Sheep grazing is compatible with huckleberry production, but sometimes incompatible with huckleberry pickers. Wherever possible, grazing should be scheduled so that sheep are out of the berry fields before the huckleberries ripen.

Where optimal growth and berry production are desired, nitrogen fertilization is beneficial. Nelson's work (1974) indicated that 40 lb of nitrogen per acre (44.8 kg/ha) produced a response nearly equal to the maximum possible response from field fertilization. To supply this amount of nitrogen, he used 191 lb of ammonium sulfate/acre (214 kg/ha).

If intensive huckleberry management is ever attempted, the young shrubs probably should be planted in heavily used berry fields or recent clearcuttings in berry-producing areas. Cultural techniques are available, and these shrubs can be produced from seed with little difficulty. In high elevation areas where spring frosts cause frequent crop failures, the frost-resistant blueleaf huckleberry could be introduced and managed. It is low-growing and difficult to pick, however, and seems to be less productive than big huckleberry. Mixtures of these two species probably should be grown where frequent frosts occur in the growing season.

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Table 4—Average understory cover on the Mount Adams experimental area[1]

Year and treatment	Big huckle-berry	Bear-grass	Lupine	Grasses	Lodge-pole pine2/	Western white pine2/	Western wood strawberry	Pearly ever-lasting	Sedges
1972 (before treatment):									
Control	22.1	19.7	12.1	4.8	9.3	4.9	1.6	1.3	1.1
Borax	23.2	19.4	12.4	8.3	7.8	5.4	1.2	2.4	1.8
Sheep	24.7	20.5	13.6	6.6	4.8	4.1	1.4	1.3	0.4
Burn	18.4	17.9	13.3	9.5	9.7	2.7	1.3	2.9	1.3
Cut and burn 4/	--	--	--	--	--	--	--	--	--
1973:									
Control	18.2	17.4	13.7	3.0	7.3	4.1	1.6	1.2	0.8
Borax	17.7	12.4	15.4	6.2	7.6	4.6	1.8	0.7	1.3
Sheep	11.2	10.2	15.8	4.1	4.1	3.7	2.6	0.9	1.7
Burn	5.7	3.3	18.2	5.7	0.2	0.1	1.6	2.0	1.6
Cut and burn	4.1	4.1	14.9	5.7	0	0	1.6	2.1	2.2
1974:									
Control	22.5	16.8	6.8	3.7	6.6	3.0	2.7	1.4	0.8
Borax	22.0	11.0	7.6	8.2	6.8	4.2	2.7	1.0	1.9
Sheep	21.2	9.6	9.5	5.8	3.3	3.5	4.4	1.5	1.8
Burn	15.1	6.3	7.6	9.8	0.6	0	2.5	3.7	2.9
Cut and burn	8.8	6.3	8.5	10.4	0	0	2.8	3.7	3.3
1975:									
Control	22.6	16.6	3.1	2.4	8.1	3.8	2.3	0.8	1.0
Borax	22.7	11.0	3.1	7.7	6.9	5.0	2.0	0.5	2.0
Sheep	22.3	12.0	3.4	4.5	4.4	4.1	3.4	1.1	1.7
Burn	18.1	7.9	1.3	8.9	0.6	0.1	2.0	2.2	3.6
Cut and burn	6.7	5.4	0.6	8.2	0	0	1.3	1.5	2.1
1977:									
Control	24.4	15.2	18.4	3.4	5.5	3.4	2.5	1.1	0.5
Borax	25.6	8.6	19.2	7.5	6.3	4.5	2.6	1.1	0.9
Sheep	23.7	11.2	20.9	6.0	3.4	2.8	3.2	2.2	0.7
Burn	18.8	10.6	19.2	11.6	0.7	0.1	3.1	3.7	2.0
Cut and burn	11.6	9.1	12.6	13.9	0.1	0	3.6	4.0	3.0

1/ Each average represents 4 treatment plots. Averages within a common bracket are not significantly significant at P<0.05).

2/ Tallied as understory cover when encountered below the 1-m height of our intercept tape.

3/ Absence on most treatment replications made statistical analyses impractical.

4/ No vegetation data were collected on the cut-and-burn treatment plots in 1972.

Dwarf bramble	Sheep sorrel	Spirea	Fire-weed	Field wood-rush	Sub-alpine fir2/	Douglas-fir2/	Pink annual phlox	White hawk-weed	Mountain-ash	Queen cup Bead-lily	Orange agoseris
0.9	0.2	0.4	0.2	0	0.4	0.7	0	0	0.1	0	0
1.2	0.2	0.4	0.2	0	1.2	0.5	0	0.1	0.2	0	0
0.7	0.2	1.0	0.3	0	0.1	0.4	0	0.2	0.2	0	0
0.7	0.3	0.8	0.4	0	1.6	0.5	0	0	0.2	0.1	0
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1.0	0.2	0.3	0.3	0.2	0.2	0.7	0	0.2	0.2	0.1	0.1
1.6	0.6	0.4	0.5	0.8	1.0	0.3	0.2	0.1	0.2	0.1	0.1
1.3	0.7	0.8	0.5	0.7	0.2	0.5	1.8	0.2	0.2	0.1	0.2
1.3	0.6	0.4	0.8	1.6	0	0	0.1	0.2	0.1	0.2	0.4
0.8	0.9	0.3	0.6	1.2	0	0	0.4	0.2	0.1	0.3	0.3
1.4	0.3	0.6	0.3	0.1	0.6	0.4	0	0.2	0.3	0.2	0
2.1	0.7	0.5	0.6	0.4	1.0	0.3	0.2	0.1	0.2	0	0.2
1.7	0.9	0.8	0.5	0.2	0.2	0.2	0.5	0.4	0.1	0.2	0.3
1.7	0.9	0.7	1.3	0.7	0	0	0.3	0.3	0.2	0.2	0.4
1.3	1.9	0.4	0.6	0.6	0	0	0.4	0.3	0.2	0.8	0.4
1.3	0.3	0.4	0.2	0.3	0.5	0.7	0	0.2	0.2	0.1	0
1.7	0.6	0.6	0.3	0.8	1.4	0.5	0.1	0.1	0.2	0.1	0.2
1.7	0.8	0.9	0.4	0.5	0.1	0.2	0.3	0.2	0.2	0.1	0.2
1.2	1.2	0.7	0.8	0.9	0	0	0.2	0.2	0.2	0.2	0.2
0.5	1.0	0.1	0.5	0.7	0	0	0.2	0.1	0	0.2	0.2
1.6	0.2	0.6	0.4	0.2	0.9	0.9	0	0.3	0.3	0.4	0
2.2	0.4	0.8	0.4	0.5	2.3	0.5	0	0.1	0.3	0.1	0.1
1.7	0.5	1.0	0.5	0.2	0.4	0.3	0	0.4	0.1	0.1	0.1
1.8	1.5	1.2	1.4	0.8	0	0	0.1	0.3	0.2	0.2	0.3
1.2	1.6	1.0	0.9	0.8	0	0	0.1	0.2	0.2	0.4	0.3

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Mountain hemlock2/3/	Willow2/3/	Rose pussytoes	Pacific silver fir2/3/	Small flowered willow herb	Englemann spruce2/3/	Drummond cinquefoil3/
0.3	0	0	0.7	0	0	0
0	0.3	0	0	0	0.2	0
0.2	0.4	0	0	0	0	0
1.4	0.6	0	0	0	0.4	0
--	--	--	--	--	--	--
0.2	0.3	0.1	0	0.1	0	0
0	0.2	0	0	0.1	0.2	0.1
0.1	0	0	0	0.1	0	0
0	0	0.1	0	0.2	0.1	0
0	0.1	0.1	0	0.3	0	0.2
0.4	0	0	0.5	0	0	0
0	0	0.1	0	0	0.3	0
0	0.1	0.1	0	0.1	0	0.1
0	0.2	0.2	0	0.1	0	0
0	0.2	0.2	0	0.1	0	0.3
0.6	0.2	0.1	0.4	0	0	0
0	0.1	0	0	0	0.2	0
0	0	0	0	0	0	0.1
0	0	0.3	0	0.2	0.1	0
0	0.1	0.2	0	0.2	0	0.2
0.4	0	0.1	0.5	0	0	0
0.1	0	0.1	0	0.1	0.2	0
0.1	0.4	0	0	0.1	0.1	0
0	0	0.4	0	0.1	0.1	0
0	0.1	0.7	0	0.2	0	0.3

Bunch-berry	Noble fir2/3/	Violet	Alpine willow-herb3/	Grand fir2/3/	Total huckleberry competition
0.1	0	0	0	0	58.8
0	0	0	0	0	63.2
0.1	0.1	0	0	0	56.6
0	0	0	0	0	65.6
--	--	--	--	--	--
0.1	0	0	0	0.1	53.5
0	0	0	0	0.1	56.6
0	0.2	0	0	0	50.7
0	0	0.1	0	0	38.9
0	0	0.1	0	0	36.5
0.1	0	0	0	0	47.2
0	0	0	0	0	50.1
0.1	0.2	0.1	0.1	0	46.3
0	0	0	0.1	0	40.7
0.1	0	0	0.1	0	42.9
0.2	0	0	0.1	0.2	44.1
0	0	0	0.1	0	45.2
0	0.2	0.1	0.1	0.2	40.9
0	0	0	0.1	0	33.1
0	0	0	0	0	23.3
0.2	0.1	0.1	0	0	57.2
0	0	0	0	0	58.9
0.1	0.2	0.2	0	0	56.9
0	0	0	0	0	59.4
0.1	0	0.1	0	0	54.5

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly. Spills of herbicides or spray adjuvants should immediately be cleaned from work surfaces and mixing platforms. Spray adjuvants such as Vistik, Dacagin, Norbak, and foaming agents are especially slippery and should be immediately flushed off with water.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

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