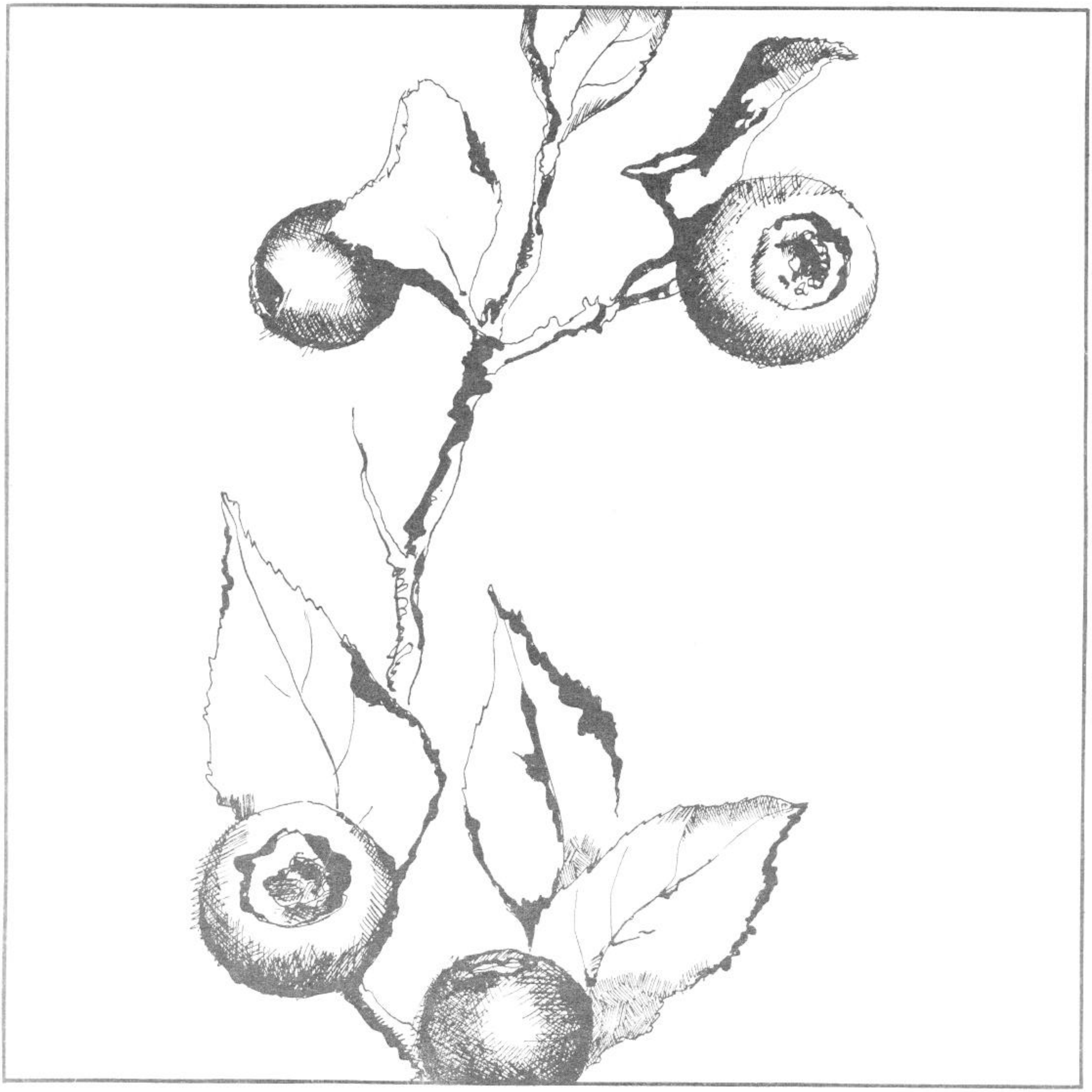
U.S. Department of Agriculture
Forest Service
Pacific Northwest Forest
and Range Experiment Station

General Technical Report
PNW-93 July 1979

Huckleberry Ecology and Management Research in the Pacific Northwest

Don Minore, Alan W. Smart and Michael E. Dubrasich



ABSTRACT

Big huckleberry (*Vaccinium membranaceum* Dougl. ex Hook.) berry production is declining in many northwestern huckleberry fields as they are invaded by subalpine trees. Seeking ways to halt this invasion and increase berry production, the authors studied huckleberries in the Cascade Range of Oregon and Washington from 1972 through 1977. They developed methods of growing huckleberries in the laboratory, tested several methods of controlling competing vegetation in the field, and recorded the changes in plant species composition and huckleberry production that resulted from applying these methods. This illustrated report includes descriptions of the experiments performed, results, conclusions, and management recommendations. It is a summary of the huckleberry research accomplished by personnel of the Pacific Northwest Forest and Range Experiment Station during the 6-year study period.

KEYWORDS: Huckleberries, Vaccinium, succession, research.

CONTENTS

This page was intentionally left blank

INTRODUCTION

For centuries before men learned to prevent and control them, wildfires periodically raced through northwestern forests. Often destroying the forests on large areas in catastrophic burns, these wildfires frequently created open, tree-free environments above 3,000 ft (914 m) that were suitable for the growth and development of wild huckleberries. Some of the resulting huckleberry fields were heavily used by Indians.

Indians apparently dried their huckleberries by placing them near campfires or slowly burning rotten logs ignited for that purpose. Some years, when dry conditions and high winds were favorable, these drying fires may have spread and reburned the berry fields. The Indians also may have deliberately set fires to reburn the heavily used fields during dry, windy periods. In any event, periodic fires kept trees out of many huckleberry fields and created new fields where postfire environmental conditions were favorable for huckleberry growth.

Twelve blueberry-like huckleberry species grow in Oregon and Washington (Minore 1972), and huckleberry fields occupy over 100,000 acres (40 469 ha) in these two states.[1] Unfortunately, this acreage is dwindling. Most large wildfires have been effectively prevented or controlled in recent years, and Indian-set fires have not burned over the most heavily used, high-elevation, huckleberry fields for several generations. As a result, trees of low timber quality have been invading many high quality huckleberry fields (figs. 1 and 2). These trees eventually form dense subalpine forests that crowd and shade the shrubs, eventually eliminating huckleberry production.

Berry production is surprisingly high in some of the fields. We measured a yield of 100 gal per acre (935 1 per ha) on one high quality huckleberry area in 1976. In 1977, when overall berry production tended to be poorer, another area produced 77 gal per acre (720 1 per ha). Fresh huckleberries sold for $10.00-11.00 per gal ($2.64-2.90 per 1) in 1977. Most berry pickers do not pick every berry on an area, but picking only half the berries would have produced economic yields of over $300 per acre ($741 per ha) on several areas sampled in 1977.

---

[1] Gerhart H. Nelson. Huckleberry management. 4 P. May 14, 1970. (Unpublished, on file at USDA Forest Service, Region 6, Portland, Oreg.)

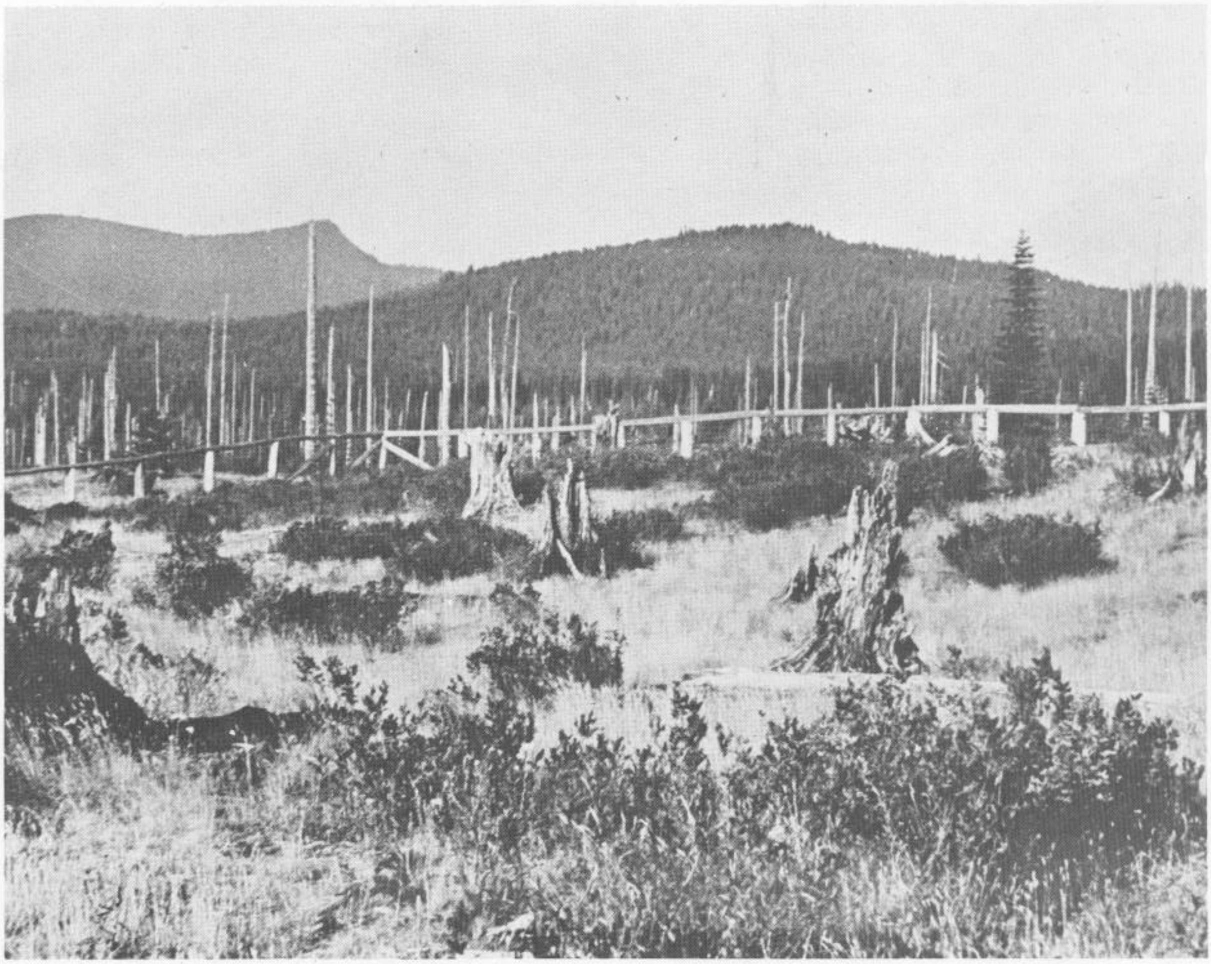


Figure 1.--A portion of the Sawtooth huckleberry field near Mount Adams, Washington in 1938. Note snags and open aspect.

Figure 2.--The same area shown in figure 1, 34 years later. These two photographs, taken at the same point, illustrate the rapid invasion by trees of this highly productive huckleberry field. Subalpine forest will soon reduce berry production.

Economic yields do not adequately reflect the importance of the northwestern huckleberry resource, however, for the intangible values of fresh air, mountain scenery, and berry buckets they have filled themselves are far more important than market values to most huckleberry pickers. Many people pick berries just for fun. Over a thousand vehicles were tallied in one ranger district's berry fields during a single huckleberry-season weekend in 1971. On another district, 163,000 visitor-days were recorded in one heavily used field during 1969 (see footnote 1).

Considered either economically or recreationally, deterioration of the northwestern huckleberry resource is serious. Several factors are involved: natural succession in the, absence of wildfires; huckleberry regeneration, growth, and berry production; meteorological effects; and the regeneration, growth, and competition of associated species. Seeking a better understanding of these factors, we studied huckleberries from 1972 through 1977. Field phenomena were investigated in two areas near Mount Adams, Washington, and Mount Hood, Oregon. We conducted laboratory and greenhouse studies at the USDA Forestry Sciences Laboratory in Corvallis, Oregon. This report is a summary of the research at all three locations during the 6-year study.

FIELD RESEARCH IN THE MOUNT ADAMS AREA

History

The huckleberry fields near Mount Adams have been heavily used by berry pickers for many years. Members of the expedition led by Captain George B. McClellan noted the extensive burned-over areas in this vicinity and found many Indians picking and drying berries there in 1853. One member recollected "a full tribe" and wrote "I never saw so many (Indians) and so ma kinds of berries in all my life" [2]

Eighty-one years later, in 1934, an animal exclosure was constructed to monitor the effects of grazing in the berry fields. Vegetation within the exclosure and on an adjacent unfenced plot was observed yearly until 1942. The Forest Service observers concluded that sheep benefited the berries by reducing vegetative competition and lightly browsing the huckleberry shrubs. [3] In 1937, all trees were

[2] George Henry C. Hodges. Personal recollection. Page 146, Washington State Historical Society Publication. Volume 2, 1907 to 1914. (On file at USDA Forest Service Gifford Pinchot National Forest. Vancouver, Wash.)

[3] K. C. Langfield. Effect of grazing on huckleberry production. 2 p. December 9. 1942. (Unpublished, on file at Mount Adams Ranger District, Trout Lake, Wash.)

felled on 5 acres (2 ha) of berry field in the same Mount Adams area. 4/ Later (1963), more trees were felled, and 6 acres were disked in an attempt to control vegetative competition. 5/ Berry production was not measured on these felled or disked areas, but disking apparently stimulated rhizome sprouting. A huckleberry management plan was formulated for the Mount Adams huckleberry resource in 1968, but never implemented (see footnote 5).

Dr. Perry C. Crandall (Washington State University, personal communication, March 17, 1972) applied replicated herbicide treatments near Mount Adams in 1969. He found that Casaron, Simazine, Atrazine, and Paraquat were ineffective in selectively controlling vegetation competing with huckleberries. Crandall's huckleberry pruning trials (50 percent and 80 percent top removal) were also ineffective, damaging the huckleberry shrubs rather than improving them.

1972 Experiment

AREA DESCRIPTION

We established a vegetation control experiment 13 mi. (21 km) southwest of Mount Adams during the summer of 1972 in sec. 16, T. 7 N., R. 8 E. Located in a portion of the Sawtooth Huckleberry Field already invaded by subalpine forest, this experimental area is at an elevation of 4,000 ft. (1 219 m), with a gently sloping WSW aspect. Lodgepole pine, western white pine, subalpine fir, Douglas-fir, mountain hemlock, and Engelmann spruce comprise most of the forest canopy (see table 1, fig. 3).61

The 1972 experimental area occupies soil that is shallow, coarse-textured, gravelly, low in nutrients (table 2), and subject to erosion. Invading trees are short and poorly formed, often showing considerable snow damage. Snow packs usually are deep and long-lasting, and the growing season is cool and short.

[4]George A. Bright. Buckleberry release from reproduction. 3 p. September 24, 1937. (Unpublished, on file at Mount Adams Ranger Station, Trout Lake, Wash.)

[5]Donald E. Wermlinger. Twin Buttes huckleberry management plan. 25 p. January 5, 1968. (Unpublished, on file at Mount Adams Ranger Station, Trout Lake, Wash.)

[6]Table 1 lists scientific names for all plants mentioned in this report.

Table 1--Names of plants [1]

Common name	Scientific name
Agoseris , orange	*Agoseris aurantiaca* Greene
Beadlily, Queencup	*Clintonia uniflora* (Schult.) Kunth
Beargrass	*Xerophyllum tenax* (Pursh) Nutt.
Blueberry, eastern lowbush	*Vaccinium angustifolium Ait.*
Bramble, dwarf	*Rubus lasiococcus* Gray
Bunchberry	*Cornus canadensis* L.
Cinquefoil, Drummond	*Potentilla drummondii* Lehm.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Everlasting, pearly	*Anaphalis margaritacea* (L.) B. & H.
Fescue, sheep	Festuca *ovina* L.
Fescue, western	*F.* occidentalis Walt.
Fir, grand	Abies grandis (Dougl.) Lindl.
Fir, noble	*A. procera* Rehder
Fir, Pacific silver	*A. amabilis* (Dougl.) Forbes
Fir, subalpine	*A. lasiocarpa* (Hook.) Nutt.
Fireweed	*Epilobium angustifolium* L.
Hawkweed, white	*Hieracium albiflorum* Hook.
Hemlock, mountain	*Tsuga mertensiana* (Bong.) Carr.
Hemlock, western	*T. heterophylla* (Raf.) Sarg.
Huckleberry, big	*Vaccinium membranaceum* Dougl. ex Hook.
Huckleberry, blue	*V. globulare* Rydb.
Huckleberry, blueleaf	*V. deliciosum* Piper
Huckleberry, evergreen	*V. ovatum* Pursh
Huckleberry, red	*V. parvifolium* Smith
Lupine	Lupinus spp.
Mountain-ash	*Sorbus* spp.
Oatgrass, timber	Danthonia *intermedia* Vasey
Phlox, pink annual	*Microsteris gracilis* (Hook.) Greene
Pine, lodgepole	*Pinus contorta* Dougl. ex Loud.
Pine, western white	*P. monticola* Dougl. ex D. Don
Pussy-toes, rose	*Antennaria rosea* Greene
Redcedar, western	*Thuja plicata Donn*
Sedge	*Carex* spp.
Sorrel, sheep	*Rumex acetosella L.*
Spirea	*Spiraea* spp.
Spruce, Engelmann	*Picea engelmannii* Parry ex Engelm.
Strawberry, western wood	*Fragaria vesca* L.
Violet	*Viola* SPP.
Wildrye, blue	*Elymus glaucus* Buckl.
Willow	Salix spp.
Willow-herb, alpine	*Epilobium alpinum L.*
Willow-herb, small flowered	*E.* minutum Lindl. ex *Hook.*
Woodrush, field	*Luzula campestris* (L.) DC.

[1] Nomenclature follows Fernald (1950), Garrison et al. (1976), and Hitchcock and Cronquist (1973). Some of the common names were obtained from Peck (1961).

Figure 3.--A portion of the experimental area near Mount Adams before treatment. Note invading trees.

Table 2--Soil properties at the Mount Adams experimental area [1]

Property	Depth (cm) [2] 0-15	16-30	31-46
pH	5.6	5.6	5.8
Cation exchange capacity (meq/lOO g)	13.19	13.10	11.66
Total nitrogen (percent)	.ll	.07	.05
Phosphorus (pm)	14.00	6.00	3.00
Potassium (pm)	28.40	16.40	11.20
Calcium (meq/lOO g)	1.04	.70	.39
Magnesium (meq/lOO g)	.08	.07	.05
Sodium (meq/lOO g)	.02	.02	.03
Boron (pm)	.22	.22	.20
Acetate extractable iron (pm)	42.00	53.00	168.00

[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.

OBJECTIVES

The primary objective of this 1972 experiment was the development of a method that could be used to control competing species without reducing huckleberry[7] growth or berry production. Ideally, such a method would increase berry production by creating a more favorable environment for the plants. Secondary objectives included a study of plant succession after disturbance and assessments of the effects of sheep grazing on huckleberry growth and berry production and on forest regeneration.

EXPERIMENTAL DESIGN

We used a completely random experimental design in 1972, with five treatments replicated four times. The following treatments were randomly assigned to a grid of 20 plots (fig. 4): sheep grazing; cut and burn; burn; borax application; and control (no treatment). Each plot is 120 ft (37 m) square, occupying an area of 1/3 acre (0.14 ha).

[7]Throughout this report, "huckleberry" refers to Vaccinium membranaceum. Names of other Vaccinium species mentioned are given in table 1.

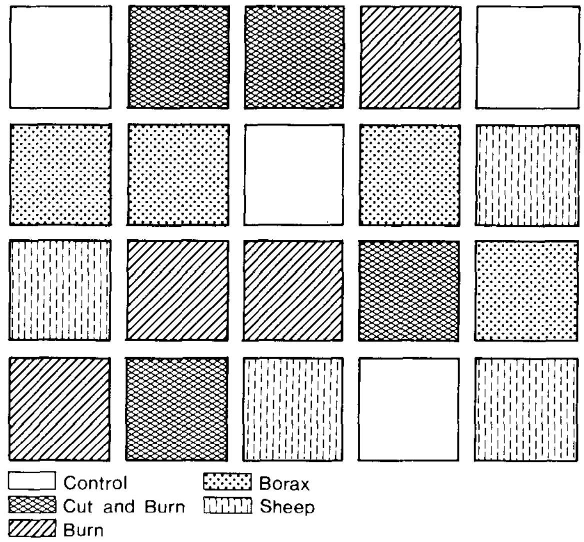


Figure 4.--1972 experimental plots near Mount Adams. Each 1/3-acre (0.14-ha) plot is 120 ft (37 m) square, with 10-ft (3-m) buffer strips between.

TREATMENTS

Sheep Grazing

We constructed a 3-ft (0.9-m) high woven wire fence around the entire experimental area and fenced all four sheep plots during July 1972. A cooperator provided 320 dry ewes. On August 22, eighty of these sheep were penned on each 1/3-acre (0.14-ha) sheep plot. They were confined on these small plots for 3 days, then returned to the cooperator. The resulting grazing intensity far exceeded anything that occurs during normal grazing operations, even exceeding the local intensity produced in bedding grounds. This deliberate overgrazing was an attempt at controlling competing vegetation, but it also served as a severe test of possible sheep damage to the huckleberry resource. (Many huckleberry pickers claim that grazing damages the huckleberries; they strongly oppose allowing sheep in the berry fields.)

Cut and Burn

All trees on the four cut-and-burn plots were felled by chain saw during the second week in August 1972; cut trees remained where they had fallen. Firelines were constructed around each plot during the first week in September.

We attempted to burn during the second week in September. Drip torches and slash fuel were used to ignite the l-month-old slash, but it was not dry enough to burn. An early autumn storm covered the experimental area with 4 in (10 cm) of snow on September 25. The snow melted by September 29, however, and snowmelt was followed by several days of warm, dry weather and strong east winds. When burning was attempted again October 3 to 7, a weather station 5 mi (8 km) away, at the same elevation, recorded 2:00 p.m. relative humidities averaging 35 percent, average maximum temperatures of 66" F (19° C), dry east winds averaging 7 mi/h (11 km/h), and 10 percent average fuel moisture (10-h lag).[8]/ This time we used a flamethrower and about 150 gal (568 1) of diesel oil. Although the resulting fire would not spread through the slash, all of the plots were burned by applying the flamethrower over the entire area. Fine fuels, herbaceous vegetation, and huckleberry leaves were consumed by the oil-fueled flame. Coarse fuels, duff, and huckleberry stems were blackened, but not consumed (fig. 5).

Burn

Burning previously untreated plots was even more difficult than burning the slash on cut-and-burn plots; little fuel was present under the uncut trees, and a fire could not be kindled or spread. Nevertheless, by using about 150 gal (568 1) of diesel oil and the flamethrower, we burned all four plots from October 3 to 7. Huckleberry shrubs, herbaceous vegetation, and lower tree branches were burned deliberately. Burning intensity was slightly less than that obtained on the slash-covered plots. Fine fuels, herbaceous vegetation, and huckleberry leaves were consumed, but coarse fuels, duff, and huckleberry stems were only blackened (fig. 6). A few huckleberry stems survived.

[8]As measured with fuel moisture sticks, the 10-h lag represents the moisture content in 1/4-l in (O-6-2.5 cm) material.

Figure 5.--Cut-and-burn plot near Mount Adams, immediately after burn. October 1972.

Figure 6.--Burn plot near Mount Adams, immediately after burning in October 1972.

Borax Application

When borax was applied to eastern lowbush blueberry fields at the rate of 1 or 2 lb per 100 ft^2 (4.8 or 9.8 kg per 100 m^2), it killed or injured several weedy species without injuring the berry bushes (Smith, Hodgdon, and Eggert 1947). Although the eastern lowbush blueberry is quite different from our western huckleberry, we applied similar quantities of borax powder to four plots during the third week of September 1972. Dividing each plot into 49 equal areas, we scattered 5 lbs (2.27 kg) on each area--a total of 245 lb (111 kg) of borax per 1/3-acre (0.14-ha) plot. Borax is $Na_2B_4O_7.10H_2O$, so the actual amount of boron applied was 27.8 lb (12.6 kg) per plot, or 83.3 lb/acre (93.4 kg/ha).

Control

All four control plots were inside the fence constructed to prevent indiscriminate grazing, but they received no other treatment,

DATA COLLECTION AND PROCESSING

Vegetation

We measured species composition and cover on all but the cut-and-burn plots in 1972, before treatment. (Cutting occurred before pretreatment vegetation could be measured on the cut-and-burn plots.) These measurements were repeated on all plots (including those cut and burned) in 1973, 1974, 1975, and 1977.

We used the line interception method described by Canfield (1941). Four 120-ft (37-m) lines were established at equal intervals on each plot. Measurements were taken along a tape stretched 3.3 ft (1 m) above the soil surface. Linear species coverage--first below and then above the tape--was recorded to the nearest 0.1 ft (3 cm) along the entire line each time. Thus, 480 ft (146 m) of line were measured on each of the 20 plots.

Except for grasses, linear measurements were converted to percentage cover for each plant genus. Linear grass measurements and total grass cover were recorded; grass species were identified, but separating percentage cover of individual grass genera and species proved to be impractical from the l-m tape height. Dominance estimates were substituted for linear measurements of grass species. Sedges were recorded as *Carex* spp. Several other plant species were identified while blooming, but recorded as genera during cover measurements.

Berry Production

Huckleberry production was measured by picking and weighing the berries on 16 one-mil-acre (0.0004 ha) subplots in each treatment plot. These subplots were systematically located and permanently marked at equal intervals along the vegetation intercepts. The berries were picked in late August each year, combined on each plot, then weighed while fresh. All berries were picked and weighed on each of the 320 subplots (20 treatment plots) during 1972, 1973, 1974, 1975, and 1977. Random subsamples of ripe berries and of all berries harvested were then counted and weighed on each plot. The average weight of a ripe berry on that plot was then determined, as was the average weight of a harvested berry. (All berries, ripe and green, were harvested.) Harvested weight on each treatment plot was then converted to ripe weight by using the following equation:

$$\text{Ripe weight} = (\text{Harvested weight}) \times \left(\frac{\text{Average weight of a ripe berry}}{\text{Average weight of a harvested berry}}\right)$$

Statistical Analyses

Both vegetation and berry-production data were subjected to analyses of variance each year. Coverage of each plant species or species group and ripe berry weights were compared among treatments in these analyses. Where significant differences occurred, Scheffé (1959) multiple comparison tests were used to identify the treatments.

RESULTS

Overstory Vegetation

As expected, the cut-and-burn treatment completely eliminated all overstory competition. Burning alone was less effective, but it also reduced the overstory cover. The burning killed many trees immediately. Others were severely injured and died several years later (fig. 7). By 1977, total

Figure 7.--The same burn plot shown in figure 6, 5 years after burning. August 1977.

overstory canopy on the burn plots was significantly 9/ less than that on the control, borax, or sheep plots (table 3). The sheep and borax treatments did not significantly affect overstory canopy composition or cover. Overstory canopy results are graphically compared in figure 8.

9Unless otherwise noted in this report, significance refers to statistical significance at P< 0.05 as indicated by Scheffe tests.

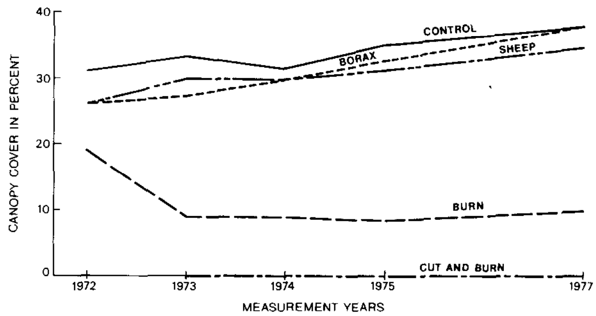


Figure 8.--Average overstory canopy at the Mount Adams experimental area. Treatments were applied between the 1972 and 1973 measurements.

Table 3—Average overstory cover (percent) on the Mount Adams experimental area[1]

Year and treatment	Lodgepole pine	Western white pine	Douglas-fir	Subalpine fir2/	Pacific silver fir2/	Noble fir2/	Engelmann spruce2/	Mountain hemlock	Western hemlock	Willow	Total overstory cover
1972 (before treatment):											
Control	22.1	5.3	2.1	0.3	1.2	0	0	0.1	0	0	31.1
Borax	16.3	3.8	5.4	0.1	0	0	0.3	0	0	0.2	26.1
Sheep	16.8	5.3	2.7	0	0	0.6	0	0.1	0	0.6	26.1
Burn	11.8	2.6	0.3	1.3	0	0	0.4	1.7	0	1.0	19.1
Cut and burn 3/	--	--	--	--	--	--	--	--	--	--	--
1973:											
Control	22.2	5.8	3.1	0.3	1.1	0	0	0.4	0	0.5	33.4
Borax	17.0	4.0	5.7	0.1	0	0	0.3	0	0	0.2	27.3
Sheep	19.2	5.6	2.6	0	0	0.7	0	0.1	0	1.7	29.9
Burn	7.9	0.6	0.1	0	0	0	0.1	0.5	0	0	9.2
Cut and burn	0	0	0	0	0	0	0	0	0	0	0
1974:											
Control	20.2	6.0	3.0	0.3	1.2	0	0	0.3	0	0.5	31.5
Borax	18.6	4.6	5.9	0.2	0	0	0.3	0	0	0.2	29.8
Sheep	19.2	5.2	2.8	0	0	0.8	0.2	0.1	0	1.3	29.6
Burn	8.4	0	0	0	0	0	0.2	0.3	0	0	8.9
Cut and burn	0	0	0	0	0	0	0	0	0	0	0
1975:											
Control	23.8	5.8	3.2	0.3	1.3	0	0	0.4	0	0.2	35.0
Borax	21.4	5.0	5.5	0.3	0	0	0.4	0	0	0.1	32.7
Sheep	20.9	5.7	3.0	0	0	0.7	0	0	0	0.9	31.2
Burn	8.5	0	0	0	0	0	0.1	0	0	0	8.6
Cut and burn	0	0	0	0	0	0	0	0	0	0	0
1977:											
Control	24.4	6.4	3.8	0.3	1.3	0	0	0.6	0.3	0.6	37.7
Borax	24.4	6.1	6.1	0.6	0	0	0.5	0	0	0.1	37.8
Sheep	22.1	6.5	3.3	0.1	0	0.7	0.5	0.6	0.1	0.9	34.8
Burn	8.6	0.2	0	0	0	0	0.5	0.5	0	0	9.8
Cut and burn	0	0	0	0	0	0	0	0	0	0	0

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

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

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

Understory Vegetation

Burning significantly affected understory cover and composition. Huckleberry and beargrass cover percentages initially dropped on the burned plots, then recovered. By 1977, no significant differences occurred among treatments for these two species (table 4). Understory trees did not recover as quickly, and the understory cover of lodgepole pine, western white pine, subalpine fir, and Douglas-fir was lower on burned than on unburned plots in 1977.

Grasses were not significantly affected at first, but they began to increase 2 years after being burned. By 1977 (5 years after treatment), grass cover was significantly greater on the burned plots than it was on unburned plots. Species composition was also affected. The dominant grass species on the burned plots in 1977 was timber oatgrass; dominant grasses on the unburned plots were blue wildrye, western fescue, and sheep fescue. Sedges, pearly everlasting, rose pussytoes, sheep sorrel, and fireweed all responded like the grasses--no significant differences were recorded for 1 or 2 years after burning, but by 1977 they were significantly more abundant on the burned plots. Few significant differences appeared among burning treatments; burning with and without slash had similar effects on the understory. These effects are illustrated in figures 7 and 9.

Understory vegetation on the control, sheep, and borax plots was not significantly affected by the 1972 treatments--with one exception. Pink annual phlox, a tiny herb, invaded the sheep plots 1 year after grazing to create a significantly greater cover there. By 1974 this seral species began to fade away on the sheep plots, and by 1977 it was found only where burning had occurred.

Berry Production

Both burning treatments significantly reduced huckleberry production on the Mount Adams experimental area (table 5). The huckleberry plants sprouted during the next growing season (fig. 10), but no flowers or berries were produced on these sprouts until 1975--3 years after the burning treatments were applied. Five years after treatment, a few berries occurred on the burned plots, but the bushes still had not completely recovered. Control plots produced 7 times as many berries as the burn plots and almost 300 times as many berries as the cut-and-burn plots in 1977. Although some of these 1977 differences in berry production were associated with differences in overstory protection from a severe local hailstorm, very few flowers or berries *were* present on the burned plots before or after the August storm.

Overgrazing by sheep reduced berry production for 2 years, but increased it during the 3d year after treatment. The borax treatment had little effect on berry production.

Table #4 which should appear on pages 17 & 18 will be found at back of book.

This page was intentionally left blank

Figure 9.--The same cut-and-burn plot shown in figure 5, 5 years after burning (1977). Note grass cover and sprouting huckleberries.

Table 5 --Average berry production on the Mount Adams experimental areal 1/

Treatment	Berry production by year				
	1972 2/	1973 3/	1974	1975	1977 5/
	Kilograms per hectare 4/				
Control	99.30	0	132.15	137.53	35.06
Borax	61.43	0	43.22	69.07	44.98
Sheep	81.24	0	38.03	167.03	41.00
Burn	83.01	0	0.03	1.81	4.90
Cut and burn	--	0	0	0.27	0.15

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

2/ Berries were picked before the treatments were applied. No production data were collected on the cut-and-burn treatment plots.

3/ Unusual cold and very little snow during the 1972-73 winter, followed by severe spring frosts, destroyed the 1973 berry crop.

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

5/ A severe August hailstorm destroyed most of the berries on the experimental area.

Figure 10.--Sprouting huckleberry shrub on a Mount Adams cut-and-burn plot, 1 year after treatment. Note old shoots killed by the fire. August 1973.

Miscellaneous Treatment Effects

Although the borax treatment produced no statistically significant differences in overstory cover, understory cover, or berry production, it did affect vegetation. Conifer needles developed brown tips during the spring of 1973. In the fall, the new foliage on subalpine firs treated with borax was blue-green and seemed unusually vigorous. Beargrass plants were damanged slightly by the borax; they developed abnormal inflorescences and produced few seeds in 1973. Furthermore, average beargrass cover on the borax plots declined after treatment. It equaled the control cover before treatment in 1972, but was less than 60 percent of control cover in 1977 (table 4). Unlike the sudden decline and subsequent recovery after burning of beargrass, its slow decline on borax plots seems to be continuing.

Intensive overgrazing by sheep in 1972 did not significantly affect the cover of forest tree species. It did significantly reduce the number and average growth of tree seedlings on the sheep plots (table 6). Terminal bud nipping and trampling by the crowded, confined sheep seem to have been responsible. The sheep also added an estimated 2,000 lb of manure/acre (367 kg/ha) to the overgrazed plots.

Combustion of flamethrower oil probably was not complete when the burn and cut-and-burn plots were treated in 1972. Some contamination of the soil probably occurred from the 300 gal (1 136 1) of diesel oil used in burning the 2.7 acres (1.1 ha) occupied by these plots.

CONCLUSIONS

None of the four treatments successfully controlled competing species without damaging the huckleberries. Those treatments that controlled the competition (burning, cutting and burning) also reduced huckleberry production. Those that did not damage huckleberry (borax, sheep grazing) did not control competing species.

Sheep grazing did not damage the huckleberries. Although some browsing of the berry bushes occurred, this mechanical influence was more than offset by the nitrogen added as sheep manure. The damage to conifer seedlings (table 6) that resulted from overgrazing the sheep plots probably would be less severe under normal grazing practices.

Table 6 --Average tree seedling density and growth on sheep and control plots at the Mount Adams experimental area[1]

Species	Seedlings per ha[2] in 1976		Avg 1973 growth		Avg 1975 growth	
	Sheep plots	Control plots	Sheep plots	Control plots	Sheep plots	Control plots
	Number		Centimeters[3]			
Lodgepole pine	5,752	12,046	4.9	7.2	6.0	6.3
Western white pine	2,179	2,832	4.9	8.2	4.8	6.5
Subalpine fir	1,905	2,090	3.3	5.1	4.1	4.8
Pacific silver fir	0	1,529	--	3.5	--	3.5
Grand fir	46	139	0	3.0	3.0	4.3
Noble fir	0	46	--	4.0	--	15.0
Douglas-fir	324	1,158	6.4	5.4	7.7	6.0
Mountain hemlock	46	185	2.0	7.2	6.0	11.2
Englemann spruce	139	46	1.3	12.0	1.3	16.0
All species	10,391	20,071	4.6	6.7	5.4	6.0

1/ Based on sixteen 12.5 m^2 (134.6 ft^2) circular samples systematically located on each of the 8 plots (4 sheep plots and 4 control plots). Significant ($P<0.05$) differences are underlined.

2/ To obtain seedlings per acre, multiply by 0.405.

3/ To obtain growth in inches, multiply by 0.394.

Recovery of the huckleberry bushes after fire seemed to be slow and several competing species appeared to recover faster. Burning was difficult and large quantities of diesel oil were applied, which may have influenced our results. These results should be compared with those obtained in similar burning experiments. Burning eastern lowbush blueberry (Black 1963, Smith and Hilton 1971) is not comparable, however, for the morphology and physiology of this eastern species are very different from the morphology and physiology of big huckleberry. Differences also occur among the western *Vaccinium* species, so conclusions about *V.* membranaceum should be based on *V. membranaceum* experiments.

Additional Mount Adams Field Research

Although our primary emphasis was on control of competing vegetation in the Mount Adams area, several other aspects of the huckleberry problem were investigated in smaller, previously published field studies. When the rhizome system and root structure of big huckleberry were investigated by hydraulic excavation (Minore 1975b), numerous robust rhizomes were found 8-30 cm (3-12 in) below the soil surface. The soluble solid contents of shaded and exposed huckleberry fruits sampled throughout one berry-picking season showed no significant exposure differences, but the berries were sweetest after beargrass began shedding seeds (Minore and Smart 1975). Finally, high huckleberry abundance was related to an optimum soil pH of 5.5 and the presence of seven associated plant species in a study of huckleberry environments (Minore and Dubrasich 1978).

FIELD RESEARCH IN THE MOUNT HOOD AREA

Area Description

Seven miles (11 km) southwest of Mount Hood, at an elevation of 4,800 feet (1 463 m), we established three field experiments in a uniform area where competing species are inhibiting huckleberry production. All three are in SE1/4, NW1/4 sec. 10, T. 4 S, R. 8 E.; and all are on gently sloping western aspects. A dense young conifer forest now occupies the site (fig. 11), but vegetatively vigorous huckleberry shrubs persist in the understory without producing many berries. Average overstory composition is 86 percent lodgepole pine, 7 percent noble fir, 4 percent Douglas-fir, 2 percent mountain hemlock, and 1 percent composed of scattered western white pine, subalpine fir, grand fir, western hemlock, Engelmann spruce, and western redcedar.

Figure 11.--Dense young conifer forest at the Mount Hood experimental area. There are 5,800 trees per acre (14,332 trees per ha) in the stand (55% are taller than 4.5 ft (1.4 m), 45% are seedlings). Big huckleberry is abundant in the understory, but berry production is poor.

Although its elevation is greater, the Mount Hood experimental area is warmer than the Mount Adams area during summer. Winter snow packs remain there longer than at Mount Admas, however, and huckleberry development (bud burst, blooming, berry ripening) is later at Mount Hood. On July 9, 1974, we had to use a toboggan to transport equipment over 2 mi (3.2 km) of snow-covered road, and 3 ft (0.9 m) of snow still covered portions of the access road on July 23.

Soil in the Mount Hood experimental area is shallow and rocky, but less subject to erosion than the soil encountered in the 1972 Mount Adams experiment. Like the Mount Adams soil, it is low in nutrients (table 7). Nevertheless, analyses of variance indicated that cation exchange capacity and contents of potassium, sodium, and boron are significantly higher in the Mount Hood soil than in the Mount Adams soil. Phosphorus and acetate-extractable iron are lower.

Bulldoze-And-Burn Experiment

OBJECTIVES

To test the effectiveness of mechanized overstory removal and subsequent slash burning for control of competing vegetation in the huckleberry fields, we conducted a bulldoze-and-burn to answer several questions: Does bulldozing provide suitable slash fuel for burning upper elevation huckleberry fields? If so, does it provide this fuel at less cost than tree-cutting with chain saws? Does the bulldoze-and-burn treatment seriously reduce huckleberry growth or berry production?