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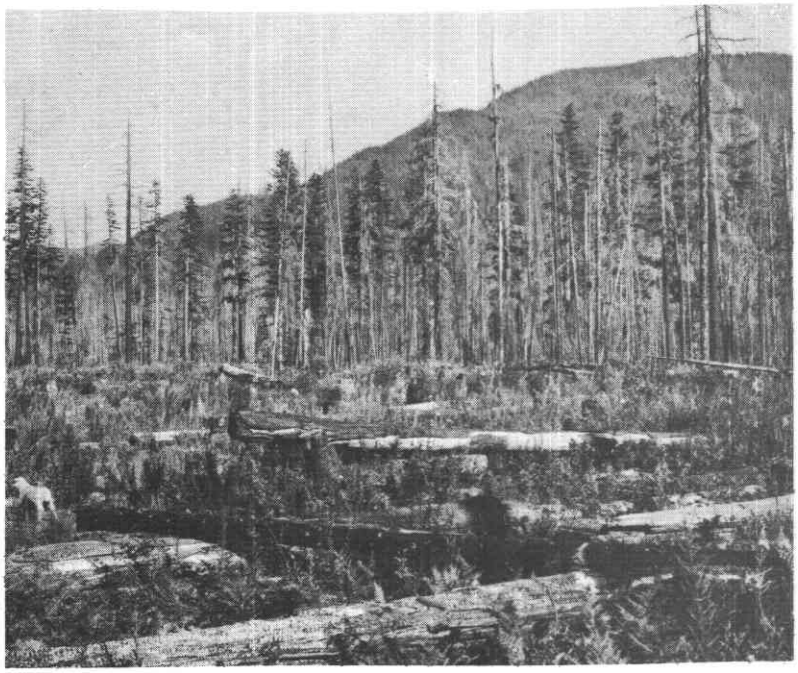

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PLANT SUCCESSION ON A CUT OVER, BURNED, AND GRAZED DOUGLAS FIR AREA

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In the Douglas fir region of Oregon and Washington the protection and use of cut-over forest land are matters of utmost importance. In view of the large acreage of cut-over land and the additions that are being made to it each year, any use of such land that will bring an immediate financial return, or reduce the fire hazard, without hindering the establishment of a new forest crop should be given careful consideration. Cut-over forest lands in this region have been looked to as a possible source of summer forage, as there is a shortage of summer range east of the Cascade Mountains and as the west-side lands produce an abundance of weed vegetation after timber is removed. It has been suggested that utilization of this forage would reduce the fire hazard and also give timberland holders a financial return, which would help defray protection costs during the seedling and sapling stages of the new timber stand.

Some owners of cut-over land on the west side are not interested in growing a second crop of timber, but wish to keep their cut-over lands for grazing purposes. Some of these owners look to reburning as a means of keeping down the brush that invariably comes in on logged and burned lands and crowds out the weeds.

The extent to which grazing can be practiced on cut-over lands depends on how it affects tree reproduction on areas where reforestation is desired, and on how it affects plant succession on areas where perpetual grazing use is desired. Likewise, the factor that should determine burning practice on areas of the latter class is the vegetative succession that follows the second and subsequent fires.

In order to obtain information on plant succession under different conditions of burning and grazing, a study was begun in 1925 near the Wind River Experimental Forest, 20 miles northwest of Carson, Washington, on plots known as the Camp Nine transect. L. A. Isaac had established this transect in the fall of 1924 for the purpose of studying natural reproduction of Douglas fir (Pseudotsuga taxifolia). (That study is covered in separate reports.) The transect is 173 chains long and one-tenth chain wide and is divided into 173 plots, each 1 chain long by one-tenth chain wide and containing 0.01 acre.

The area through which the transect extends is a portion of the lava-filled valley floor of the Wind River. It is comparatively level, has deep soil, and is considered to be a class III site for Douglas fir. Before logging, the area supported a dense stand of overmature Douglas fir with a mixture of western hemlock (Tsuga heterophylla), western red cedar (Thuja plicata), lowland white fir (Abies grandis), noble fir

(Abies nobilis), silver fir (Abies amabilis), western white pine (Pinus monticola), and Pacific yew (Taxus brevifolia). Herbaceous cover was practically nil under the dense forest canopy, being limited to a sparse stand of shade-loving plants such as vanilla leaf (Achlys triphylla), twinflower (Linnaea borealis americana), inside-out-flower (Vancouveria hexandra), and beargrass (Xerophyllum tenax). A tangled mass of shrubs was present, together with coniferous reproduction. The chief shrub species were salal (Gaultheria shallon), Oregon hollygrape (Odostemon aquifolium), vine maple (Acer circinatum), huckleberry (Vaccinium spp.), pachistima (Pachistima myrsinites), and dogwood (Cornus spp.). The area was logged in 1919 and 1920 and for the most part was broadcast burned in the fall or spring following logging. On parts of it where logging took place at such a season that spring burning was impossible, an accidental summer burn consumed the slash. A part was accidentally reburned in 1924. One part, logged in 1919, was broadcast burned in the fall of 1921. Thus three conditions of burning exist on the different transect plots--a single burn after logging, a double burn, and a delayed single burn.

The purpose of the grazing study initiated on the area in 1925 was to ascertain, among other things, how grazing affected plant succession on cut-over Douglas fir lands burned (1) once soon after logging, (2) once soon after logging and again four years later, and (3) once two years after logging. Since time and funds did not permit study of the entire transect, 85 plots were selected as representative of the three burning conditions. Of these plots 20 are on the single burn, 44 on the double burn, and 21 on the delayed burn. Observations were taken on the 85 plots in each of the eight years 1925, 1926, 1927, 1928, 1929, 1930, 1932, and 1935. The studies were directed by Douglas C. Ingram from 1925 until 1928, and by L. A. Isaac from 1928 until 1935.

Beginning with 1925, the area was grazed at some time during each summer by a band of ewes and lambs. During the 3-year period 1925-27 the sheep were held on the area for about 3 to 4 months each summer. Utilization data recorded for 1925 and 1926 indicate that the area was very heavily grazed during the first few years of the experiment. Photographs published in Ingram's report,1/ showing certain areas before and after grazing, indicate that in 1925 and 1926 practically all the current growth of herbage and shrubs was eaten. In later years, grazing use was lighter and less prolonged. In 1936, forage values on the area as a whole had decreased to such a point that the cooperator objected to keeping his sheep on the experimental area more than a few days, and during that time kept them on one small portion where good feed was available.

Data on density and composition of plant cover were obtained on the plots in each of the years previously mentioned, before the area was grazed. Since the observations were made on the same plots and by the same general method, an opportunity exists to trace the plant succession on these plots over the 10-year period. Ingram's report discusses the

1/ Ingram, D. C. Vegetative Changes and Grazing Use on Douglas Fir Cut-over Land. Jour. Agr. Research 43: 387-417, illus.

changes on the plots for the period 1925-27 in detail. It is the purpose of this report to summarize Ingram's findings and to extend the analysis to cover the whole of the 11-year period 1925-35.

Digest of Ingram's Conclusions

After careful analysis of the data for the three years 1925-27, Ingram reached the following conclusions in regard to plant succession on Douglas fir lands as affected by timber cutting, burning, and grazing under the conditions represented in the study:

1. Fireweed (Chamaenerion angustifolium), bracken (Pteridium aquilinum pubescens), and blackberry (Rubus laciniatus), the principal species on newly cut-over Douglas fir lands, come into abundance rapidly after cutting and broadcast slash burning. After a few years, shrub species become more important and various grasses and sedges appear.

2. Delaying the slash burning for about two years after logging, or reburning after an interval of about four years, results in a lower density of vegetation, a higher percentage of bracken, and a lower composition percentage and density of the more palatable plants commonly found on cut-over areas.

3. Grazing of herbaceous species, and trampling of unused vegetation into the ground, materially reduce the amount of inflammable material and its inflammability.

4. Grazing tends to decrease the density of the more palatable plants, except for grasses and sedges, which seem to increase under grazing use.

5. Bracken, a plant low in palatability, increases in density under grazing use.

Analysis of Plant Succession

Method of Analysis

The 1925-27 data on density and composition of plant cover were analyzed statistically in order to check Ingram's major conclusions. The 1925-35 data were analyzed in order to determine whether the trends noted by Ingram continued to the end of the experiment and to discover any additional trends that might appear in the data for years following 1927.

The plots were divided, according to Ingram's classification, into groups A, "one burn soon after logging"; B, "two burns"; and C, "one burn two years after logging." The density of each species, that is, the percentage of ground surface covered by it, was computed for each plot. Species were grouped into grasses and grasslike plants, weeds, shrubs, and bracken, and the density of each group was computed. Average changes

in density and composition on each group of plots between 1925 and 1927, 1927 and 1935, and 1925 and 1935 were then computed for each of the four species groups, and, in addition, for each of four principal weed and shrub species: Fireweed, blackberry, vine maple, and salal.[2] The density changes of the individual plant groups and species from year to year on each plot for the period under consideration were computed and the averages of these changes were determined. The reliability of the averages was determined by the use of Fisher's "t" test for paired smples.[3]

The density changes of important species and of the main species groups, naturally, differed somewhat among the three burn conditions. Whether this resulted from differences in burning treatment or merely from variations in sampling was determined by a modification of the "t" test. In this test, the mean difference between the average density changes of a group or individual species for the same period under each of two burning conditions was determined, and was divided by the square root of the sum of the individual variances. The significance of the quotients was determined by referring to Miles' new table of odds.[4]

Results of Analysis

Vegetative changes[5] on all plots during the period covered by the study were pronounced (table 1).

In 1925, at the beginning of the study, the vegetative cover was about twice as dense on the single-burned as on the double- and delayed-single-burned plots. This can be attributed to the fact that the vegetation on the single burn had had six years in which to become established, whereas that on the other plot series had been weakened by recent burning. During the period 1925-35 the average density increased by 8.5 percent on the single burn, 35.4 percent on the double burn, and 47.5 percent on the delayed burn, with the result that in 1935 it was 61 percent, 64 percent, and 73 percent on the three burns, respectively. The similarity of the 1935 densities indicates that all the plot groups sampled areas of similar productivity.

An outstanding change in the vegetative cover between 1925 and 1935 was the sharp decrease in weed density. Prior to grazing use, in

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2/ Species that came in after burning but were less abundant are Oregon hollygrape, peavine, huckleberry, dogwood, hawkweed, willow herb, rose, snowbrush, hazel, dogbane, thistle, snowberry, pachistima, lupine, willow, elder, and serviceberry.

3/ Fisher, R. A. Statistical Methods for Research Workers. 339 pp., illus. Edinburgh, 1936.

4/ Miles, S. R. New Table of Odds Based on Student's Table of Probability. Jour. Amer. Soc. Agron. 26: 341-6.

5/ Unless otherwise stated, wherever an increase or decrease in density or a difference between densities is mentioned in this paper as real the statistical odds against its being due to sampling are 99:1 or greater.

TABLE 1.--AVERAGE DENSITY[1] AND COMPOSITION[2] OF PLANT COVER

CLASS A PLOTS (BURNED ONCE SOON AFTER LOGGING)

Species	1925		1927		1935		Change[3] in density		
	Density	Composition	Density	Composition	Density	Composition	1925-27	1927-35	1925-35
Bracken	2.3	4.4	2.0	5.6	6.6	10.8	-0.3	°4.6	°4.3
Grasses and grasslike	6.9	13.1	7.2	20.3	17.6	28.9	0.3	°°10.4	°°°10.7
Weeds									
Fireweed	12.2	23.3	2.5	7.1	2.5	4.1	°-9.7	0.0	°-9.7
Other	13.8	26.2	9.2	26.0	3.5	5.7			
Total	26.0	49.5	11.7	33.1	6.0	9.8	°-14.3	-5.7	°-20.0
Shrubs									
Blackberry	6.7	12.8	4.4	12.5	5.5	9.0	-2.3	1.1	-1.2
Vine maple	4.7	9.0	4.6	13.0	12.3	20.2	-0.1	7.7	7.6
Salal	0.2	0.4	0.4	1.1	0.7	1.1	0.2	0.3	0.5
Oregon hollygrape	1.0	1.9	0.6	1.7	2.8	4.6	-0.4	2.2	1.8
Other	4.7	8.9	4.5	12.7	9.5	15.6			
Total	17.3	33.0	14.5	41.0	30.8	50.5	-2.8	°16.3	°13.5
All vegetation	52.5	100.0	35.4	100.0	61.0	100.0	-17.1	25.6	8.5

CLASS B PLOTS (DOUBLE BURN)

Bracken	6.7	23.5	8.3	37.0	34.6	54.1	1.6	°26.3	°27.9
Grasses and grasslike	1.8	6.3	2.5	11.2	7.0	11.0	0.7	°4.5	5.2
Weeds									
Fireweed	14.0	49.1	3.8	17.0	2.0	3.1	°-10.2	-1.8	°-12.0
Other	2.0	7.0	1.8	8.0	2.8	4.4	-0.2	1.0	0.8
Total	16.0	56.1	5.6	25.0	4.8	7.5	°-10.4	-0.8	°-11.2
Shrubs									
Blackberry	1.5	5.3	3.3	14.7	6.0	9.4	1.8	2.7	4.5
Vine maple	0.8	2.8	0.8	3.6	2.3	3.6	0.0	1.5	1.5
Salal	0.2	0.7	0.4	1.8	3.3	5.2	0.2	2.9	3.1
Oregon hollygrape	0.4	1.4	0.6	2.7	1.4	2.2	0.2	0.8	1.0
Other	1.1	3.9	0.9	4.0	4.5	7.0	0.0	4.4	4.4
Total	4.0	14.1	6.0	26.8	17.5	27.4	°2.0	°11.5	°13.5
All vegetation	28.5	100.0	22.4	100.0	63.9	100.0	-6.1	41.5	35.4

CLASS C PLOTS (BURNED ONCE 2 YEARS AFTER LOGGING)

Bracken	8.6	34.3	11.1	49.1	49.9	68.8	2.5	°38.8	°41.3
Grasses and grasslike	0.4	1.6	0.8	3.6	4.0	5.5	0.4	°3.2	°3.6
Weeds									
Fireweed	8.4	33.5	2.7	11.9	0.6	0.8	°-5.7	°-2.1	°-7.8
Other	3.0	11.9	1.9	8.4	1.3	1.8	-1.1	-0.6	-1.7
Total	11.4	45.4	4.6	20.3	1.9	2.6	°-6.8	-2.7	°-9.5
Shrubs									
Blackberry	1.4	5.6	2.5	11.1	3.3	4.5	1.1	0.8	1.9
Vine maple	0.7	2.8	0.9	4.0	1.8	2.5	0.2	0.9	1.1
Salal	0.3	1.2	0.8	3.5	4.2	5.8	0.5	3.4	3.9
Oregon hollygrape	1.3	5.2	1.0	4.4	1.6	2.2	0.3	0.6	0.3
Other	1.0	3.9	0.9	4.0	5.9	8.1	-0.4	5.6	5.2
Total	4.7	18.7	6.1	27.0	16.8	23.1	1.4	°10.7	°12.1
All vegetation	25.1	100.0	22.6	100.0	72.6	100.0	-2.5	50.0	47.5

1/ Percentage of area covered. 2/ Percentage of total density.

3/ Odds that change was actual are indicated as follows: 99:1 or greater, °; 72:1, °°; approximately 37:1, °°°.

1925, weeds composed from 45 to 56 percent of all vegetation on the three groups of plots. The decrease in weed density from 1925 to 1927 averaged 60 percent, ranging from 55 percent on the single burn to 65 percent on the double burn. No material decrease of weed density occurred on any plots after 1927. In 1935 weeds formed less than 10 percent of the plant cover on the single and double burns, and less than 3 percent on the delayed burn.

Fireweed, a good forage plant, was the predominant weed in 1925, representing 47 percent of the total weed density on the single burn, 88 percent on the double burn, and 74 percent on the delayed burn. By 1927 the density of this weed had decreased 79 percent on the single burn, 73 percent on the double burn, and 68 percent on the delayed burn. Except on the delayed burn, the decline shown in fireweed density from 1927 to 1935 had no statistical significance.

During the period 1925-27 the grasses and grasslike group, shrubs, and bracken failed to show reliable density changes, with the exception of a small increase in shrubs on the double burn. From 1927 to 1935, shrubs, grasses, and bracken showed density increases on all three groups of plots. The density percentage of bracken increased by 26 and 39 on the double burn and the delayed burn, respectively, and increased only slightly on the single burn. By 1935 bracken composed more than half the plant cover on the double and delayed burns. Shrubs increased in density uniformly and importantly on all three groups of plots from 1927 to 1935. The density increase of grasses in 1927-35 on the double and delayed burns was too small to be of practical importance. On the single burn the grass density increased by 250 percent, but odds for significance were only 72:1. Such a high increase with only moderate statistical confirmation indicates that not all single-burn plots reacted in the same way to treatment. Further check disclosed that 11 of the single-burn plots, located in a natural "sink" or "swale", have a heavy black soil very different from the dry, rather loose soil of the remainder of the transect. In 1935, 95 percent of all grass density on the single burn was found on the 11 swale plots. On the lighter and drier soils of the single burn, grass density increased in 1927-35 by less than 1 percent. It is probable, therefore, that the disproportionate increase in grasses noted on the single burn is due to a difference in soil rather than in treatment.

A comparison of density changes on the three series of plots is shown in table 2 and in figure 1. Only one plant, bracken, is found to have responded differently to the various treatments. Between 1925 and 1935 bracken increased 6.5 times as much on the double burn and 9.6 times as much on the delayed single burn as it did on the single burn (figure 1). It spread 1.5 times as much on the delayed single burn as it did on the double burn. The large differences in the spread of bracken occurred after 1927; between 1925 and 1927 the density increase of bracken was practically equal for plot groups B and C and was only a little less for group A. Shrubs, weeds, and grasses varied but little in their response to the three burning treatments.

TABLE 2.--COMPARISON OF CHANGES[1] IN PLANT DENSITY[2] ACCORDING TO BURNING TREATMENT

SPECIES, AND PLOT GROUPS COMPARED	INCREASE OR DECREASE IN DENSITY		
	1925-35	1925-27	1927-35
ALL SHRUBS			
A OVER B	0.0	°-4.8	4.8
A OVER C	1.4	-4.2	5.6
B OVER C	1.4	0.6	0.8
ALL WEEDS			
A OVER B	8.8	3.9	4.9
A OVER C	10.5	7.5	3.0
B OVER C	-1.7	-3.6	1.9
BRACKEN			
B OVER A	°23.6	°1.9	°21.7
C OVER A	°37.0	°2.8	°34.2
C OVER B	°13.4	0.9	°12.5
FIREWEED			
B OVER A	2.5	0.5	-1.8
A OVER C	-1.9	-4.0	°2.0
B OVER C	-4.2	-4.5	0.3
GRASSES AND GRASSLIKE			
A OVER B	5.5	°-0.7	5.9
A OVER C	7.1	-0.1	7.2
B OVER C	1.6	0.3	1.3

1/ FOR VALUES MARKED WITH °, ODDS THAT CHANGE WAS ACTUAL ARE 99:1 OR GREATER.

2/ PERCENTAGE OF AREA COVERED.

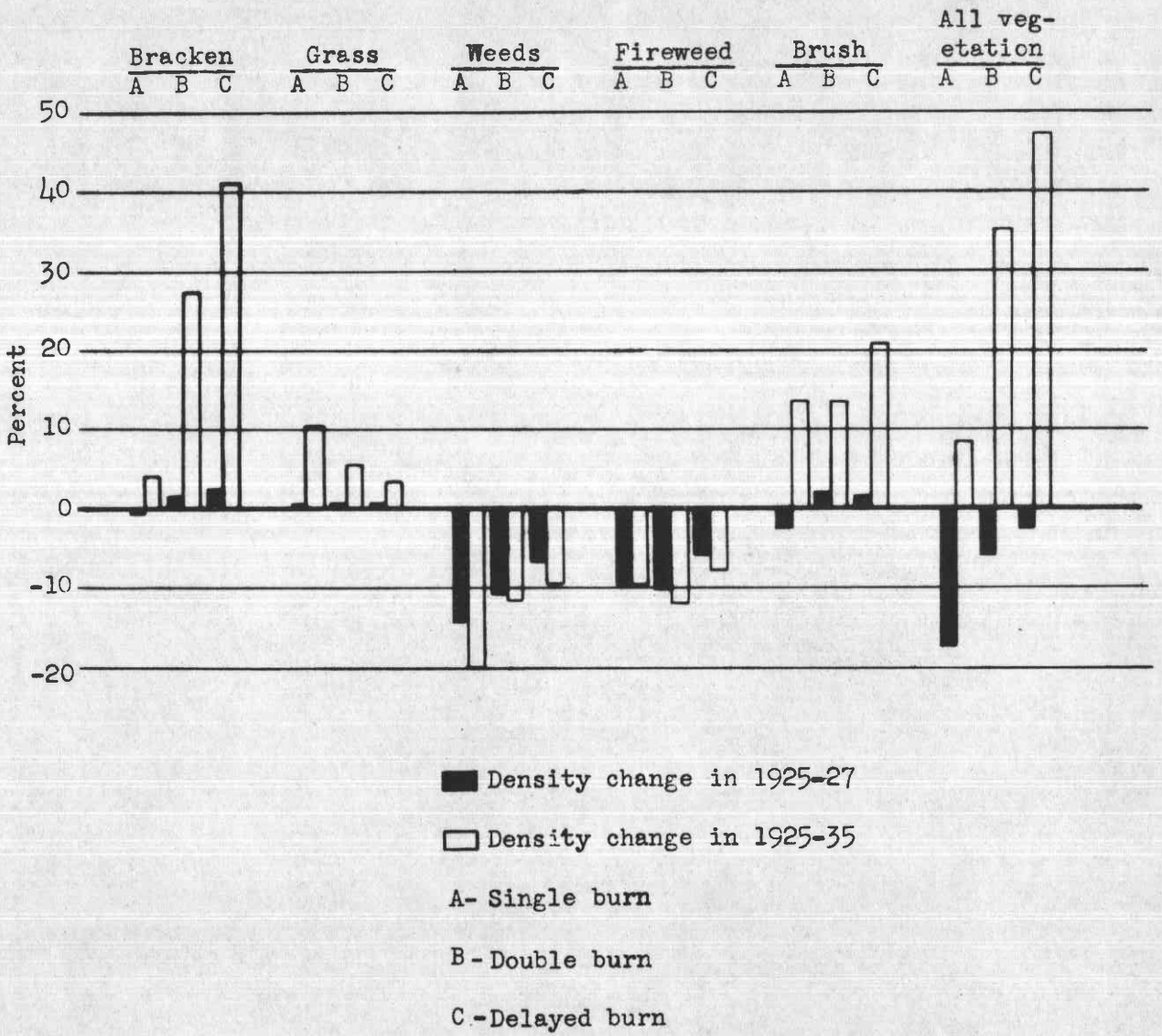
Discussion

It is noteworthy that at the beginning of the experiment, in 1925, the vegetation on each of the three types of burn was similar to the extent that about 50 percent of the vegetation on each was weeds. This early successional stage is common to most cut-over and burned Douglas fir lands west of the Cascade Mountains. An interesting variation in the weed cover of the three types of burn at that time is in the proportion of fireweed. On the single burn, which had been slash-burned in 1919, fireweed totaled 47 percent of all weeds; on the delayed burn and the double burn, where firing had occurred in 1921 and 1924, respectively, fireweed formed 74 percent and 88 percent of the total weed density. These figures indicate that fireweed sprang up in profusion the year following slash burning, reached its maximum density soon thereafter, and declined by approximately one-half in 5 years of competition with other vegetation. This may illustrate the plant's characteristic behavior on logged and burned Douglas fir lands.

In 1925, the total density on the double and delayed burns was only about half that on the single burn. On the double and delayed burns as compared with the single burn, weeds, grass, and shrubs were all considerably less dense and the ratio of shrubs and of grass to all vegetation was much less. Conversely, the density of bracken was 3 and 4 times as great, respectively, on the double and delayed burns as on the single burn and its ratio to total plant density was 5 and 8 times as great, respectively. From these observations it appears that the interval since fire on the double and delayed burns had been insufficient for recovery by the shrubs but sufficient for recovery by bracken, which is thought to be damaged little by repeated burning. The higher grass density on the single burn was probably due to the soil difference previously mentioned rather than to difference in treatment.

In 11 years, the vegetation on the experimental area changed from what had been essentially a weed type to a bracken-shrub or shrub-bracken type. From the standpoint of fire protection the immediate effect of weed reduction was highly desirable, since fireweed and associated weeds are highly inflammable fuels. Its later effect varied according as the weeds were replaced chiefly by shrubs or by bracken. Blackberry, vine maple, and the other shrubs that increased following the regression of weeds are distinctly less inflammable than weeds. Bracken, on the other hand, is a serious fire menace; it grows rankly, and as it cures and accumulates tends to become almost as inflammable as fireweed. The bracken/shrub ratios in 1935 were as follows: Single burn, 1:5; double burn, 3:2; delayed burn, 7:2. The spread from the shrubs which survived the later fires on the double and delayed burns was more rapid during 1925-35 than that from the shrubs on the single burn, which had not been disturbed for 6 years; it did not, however, compensate the reduction in shrub density resulting from the later fires. The trend from weeds to shrubs on the single burn resulted in permanent reduction of fire hazard and considerably improved conditions for establishment of a new timber crop. On the double and the delayed burn, where bracken composed 54 percent and 69 percent of the plant cover in 1935, it is doubtful that

Figure 1.--DENSITY CHANGES ON THE THREE SERIES OF PLOTS



the fire hazard was any less at the end of the study period than it had been at the beginning.

If slash burning is practiced, these data would indicate, it should closely follow logging, in order that bracken may be held to the minimum. Delaying the slash burn for 2 or more years probably favors bracken at least as much as a reburn 3 to 5 years after slash disposal.

Deductions regarding influence of grazing on plant succession are restricted by the fact that insufficient ungrazed plots were available for comparison with the grazed plots. It is significant, however, that whereas weeds, which are eaten readily by sheep, formed approximately 50 percent of the vegetation present on all the plots in 1925, average weed density diminished by more than half in 1925-27, the period of heaviest grazing, and did not change greatly thereafter. The rapid and militant invasion of bracken on the double and delayed burns, which took place almost entirely after 1927, may have been due in some measure to grazing. It seems highly probable that bracken, which is not eaten by sheep, has in general a better opportunity to increase in density on an area where most of the other herbaceous vegetation is currently removed by grazing.

For all burning treatments, the data indicate that the period during which cut-over Douglas fir lands such as those used in this experiment can be grazed is short; that much feed for livestock is available in the first 3 to 7 years after burning, but that the forage supply must then be expected to dwindle, owing to the encroachment of shrubs, bracken, or forest growth, until at the end of from 11 to 15 years very little grazing use will be possible.

It should be remembered that the results presented here have been obtained on a single area, where conditions may or may not be similar to those on other cut-over Douglas fir lands west of the Cascade Mountains. Until the results have been proved or disproved by experimentation in other localities, they should not be considered to apply generally to cut-over lands in the Douglas fir region.

Summary

On a cut-over and burned Douglas fir area adjacent to the Wind River Experimental Forest, in southwestern Washington, observations as to plant succession were made during the period 1925-35, inclusive. Of the 85 plots on which observations were made, 20 had been burned over once, soon after logging, in 1919; 44 had been burned over soon after logging and after a 4-year interval had been reburned, in 1924; and 21 had been burned over once, 2 years after logging, in 1921. All the plots were subjected to grazing by sheep from 1925 to 1935. Grazing removed practically all the current growth of herbs and shrubs in 1925 and 1926; in later years, it was lighter and less prolonged. By 1935, the composition of the vegetation had so changed that grazing use was impractical.

Weeds, principally fireweed, formed approximately 50 percent of the total plant cover in 1925, 1 to 5 years after burning. In 1935, weeds were but a minor part of the vegetation, having been replaced by bracken on the double burn and the delayed burn and by shrubs (blackberry, vine maple, etc.) on the single burn. Reduction of weeds took place almost entirely between 1925 and 1927, the period of heaviest grazing.

Fire hazard was temporarily lowered by removal of the highly inflammable fireweed. On the double and delayed burns, the initial decrease in fire hazard was counteracted by the rapid and militant encroachment of bracken, which tends to become almost as inflammable as fireweed. On the single burn, substitution of shrubs for weeds has resulted in permanent reduction of fire hazard and considerably improved conditions for reforestation.

Grazing probably hastened the reduction in density of weeds, which are eaten readily by sheep, and thus favored increase in bracken or shrubs.

The data indicate that on cut-over Douglas fir lands similar to those used in this study and subjected to similar treatments the forage supply is ample during the 3 to 7 years following burning but dwindles thereafter, and that the potential duration of grazing on such lands is approximately 11 to 15 years.