AN ABSTRACT OF THE THESIS OF

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Title: EFFECTS OF SEEDING AND GRAZING ON A CLEARCUT-BURN IN A MIXED-CONIFEROUS FOREST STAND OF THE WALLOWA MOUNTAIN FOOTHILLS

Abstract approved: [redacted]
Dr. D. W. Hedrick

Research was conducted in a mixed-coniferous forest stand that was clearcut, burned, and seeded in order to study early plant succession, grazing influences on native and introduced species, big game use, and environmental relationships. Vegetation, animal, and environmental research was carried out from 1965 to 1967 in three, five-acre exclosures which had been constructed after treatment in 1963 and 1964. Radical treatments of clearcutting and burning were used to reduce infection of heart rot caused by Indian paint fungus (*Echinodontium tinctorium*) in grand fir (*Abies grandis*).

Four major tree species--Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), western white pine (*Pinus monticola*) and western larch (*Larix occidentalis*) were planted at a rate of 880 trees per acre. Minor quantities of grand fir, lodgepole pine

(Pinus contorta), and Engelmann spruce (Picea engelmannii) were used to give a total population of 1000 trees per acre.

Vegetation analyses showed bull thistle (Cirsium vulgare) to be the most abundant species in early stages of succession. Foliage cover of this species was significantly reduced when competing with introduced grass seedings which included a mixture of timothy (Phleum pratense), orchardgrass (Dactylis glomerata), tall oatgrass (Arrhenatherum elatius), smooth brome (Bromus inermis), white Dutch clover (Trifolium repens) and two pure stands of mountain brome (Bromus marginatus) and blue wildrye (Elymus glaucus). Most thistle and other weedy production were confined to unseeded plots.

Redstem ceanothus (Ceanothus sanguineus), ninebark (Physocarpus malvaceus), and birchleaf spirea (Spiraea betulifolia) were the most abundant shrubs in the study area. Canada milkvetch (Astragalus canadensis) and redstem ceanothus--both nitrogen fixing species--were absent from the uncut stand, and burning enhanced their establishment.

Crude protein analysis of the 15 major forage species showed the two nitrogen fixing species to be far superior to other forages from this standpoint. Introduced grass species were more sensitive to soil nitrogen levels than were native species.

Yearling replacement heifers stocked at a rate approximating one animal unit per acre were grazed in both cattle exclosures and later combined for grazing the game excluded area. A 1.5 and 2.1 pound per day gain was achieved over 42 and 35-day periods in 1966 and 1967, respectively. During these years, the heifers consumed 7.1 and 7.6 gallons of water per day which approximated one gallon per hundred pounds of body weight.

Heifers preferred Ross' sedge (Carex rossii), orchardgrass, blue elderberry (Sambucus cerulea), and Canada milkvetch. Different preferences might be noted if an earlier grazing season had been used. Some tree seedling browsing occurred in 1967, but this was believed to result from too high an animal concentration within a small area.

Game use in the cattle exclosures markedly reduced production of all browse and Canada milkvetch. Some woody species have been eliminated. Pellet count data supported the hypothesis that game, particularly mule deer, might be attracted to the area for feeding purposes. Digging and feeding activities of small mammals caused isolated effects on seral vegetation development.

Environmental measurements showed soil temperatures at two inches below the surface to be generally higher in the clearcut than uncut stand. Air temperatures and solar radiation at three feet above the soil were also higher in the clearcut. Surface soil moisture levels in the clearcut and uncut forest stands indicated that depletion rates were similar in both areas.

Due to the preliminary nature of these results, no management plans have been developed. It is believed that grazing and forest management are compatible and essential to maximize profits from the mixed-coniferous forest of northeast Oregon. When proper season of use and numbers of animals are determined, conflicts between range and forest interests should be minimized.

Effects of Seeding and Grazing on a Clearcut-Burn in a Mixed-Coniferous Forest Stand of the Wallowa Mountain Foothills

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

EFFECTS OF SEEDING AND GRAZING ON A CLEARCUT-BURN IN A MIXED-CONIFEROUS FOREST STAND OF THE WALLOWA MOUNTAIN FOOTHILLS

INTRODUCTION

Approximately eight million acres of densely forested land in eastern Oregon and Washington is presently considered as low value for livestock grazing. Of this total, a sizeable acreage is classified as the mixed-coniferous forest which is located primarily on north and northeast-facing slopes.

Many of these mixed-conifer stands are presently in a deteriorated and stagnant condition. The Eastern Oregon Experiment Station's Hall Ranch mixed conifer stands are not unique in this respect as the condition persists throughout the Blue and Wallowa Mountain foothills. Trees with a diameter of 20 inches and over on the Hall Ranch are not making any substantial increase in growth. Keniston (1968) reports that between 1962 and 1967, the total net increase in board feet per year by merchantable--over 15 inches dbh--mixed-conifer species was approximately 250.[1] This is only about one-half the rate expected in this area of northeast Oregon. Grand fir[2] (Abies grandis), climax species on this site is readily

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[1]Appendix E presents some stand data for this site.

[2]Common and scientific names of species are listed in Appendix A.

infected with Indian paint fungus (Echinodontium tinctorium) which causes heart rot, along with dwarf mistletoe (Arceuthobium americanum) infestations have reduced the value of timber on this site. Drastic improvement measures are needed to offset these low timber values and sparse understory vegetation now typical of many mixed-coniferous stands in northeastern Oregon.

More intensive management of our lands to serve an expanding population requires that new ideas developed through research be put to use. Of all the possibilities for forested land improvement in eastern Oregon and Washington, mixed-coniferous forest developments offer the most potential for success. Due to a high moisture retaining soil and its location on the most mesic slopes, chances for successful improvement appears to be high.

It is realized that this site should be managed to produce a healthy forest; however, the interim period after logging and before profits are again derived from timber products is quite long. Perhaps livestock grazing can be an important tool in forest management on these areas. To study these possibilities, a 30-acre tract of the mixed-conifer forest located on the Eastern Oregon Experiment Station Hall Ranch was clearcut and broadcast-burned before seeding grass and planting tree species. The income derived from beef production if consistent with other land uses can enable the private landowner to more nearly realize the potential of these productive sites.

Accordingly, the objectives of this research were:

(1) to carefully evaluate the compatibility of livestock grazing on introduced and native forage species without damaging tree seedlings;

(2) to follow and document early plant succession on the site after clearcutting and broadcast burning;

(3) to evaluate grass seedings from the standpoint of competitive ability, preference, and yield; and

(4) to make observations and measurements on game use and the different environmental conditions.

EXPERIMENTAL AREA

Relatively little research has been conducted on the vegetation communities in northeast Oregon. Even less information is available concerning the mixed-coniferous forest of the Wallowa Mountains. In order to lead up to the present study, a generalized review of past geological and ecological work is presented.

Geology and Physiography

Wallowa Mountains

The Wallowa Mountains were lifted to their present heights by diastrophic processes in late Tertiary-Quaternary time (Wagner, 1955). Subsequent erosion has dissected this area and caused the present condition of broad valleys, steep ridges, and alluvial plains at lower elevations.

Rock types involved in this mountain-building process include lavas of Tertiary age. Both crystalline and sedimentary rock types of Mesozoic age, and a highly metamorphosed series of interbedded volcanic and sedimentary rocks of late Paleozoic are present in these mountains.

Columbia River basalts of Miocene age flowed over this entire area, thus creating a complex of igneous, metamorphic, and sedimentary deposits (Russell, 1897). The thickness of horizontally-bedded basalt exposed along the walls of the Snake River canyon and in the adjacent Blue Mountains is approximately 5,000 feet.

According to Russell (1897), the Columbia River lava contains horizontal joints which cut the vertical columns of basalt--in some places for miles. The large vertical columns of lava, when weathered, occasionally show that they are composed of small horizontal columns which radiate from a confusedly-jointed central core. The joints which bound the large vertical columns furnished the cooling surfaces for the rocks they enclose. Ends of the radiating columns are frequently revealed on the surfaces of slightly weathered vertical columns by a patchwork similar to shrinkage cracks.

Smith *et al.* (1941) and Lindgren (1901) have evaluated and thoroughly discussed past geological events leading to a better understanding of the Wallowa Mountains uplift.

Hall Ranch

The Hall Ranch is entirely underlain by basalt and basaltic andesite (Wagner, 1955; Hampton and Brown, 1963). The Columbia River lava occurs as several different flows with minor amounts of interbedded sediments and pyroclastics.

Catherine Creek, while flowing into the Grande Ronde River and subsequently to the Columbia, bisects the Hall Ranch. The eastern portion of the ranch is underlain by lava flows tilted to the southwest. The western portion, however, is situated on a 3,000-foot fault escarpment. Elevations vary from 3,400 feet along the creek to 4,100 feet at the upper boundary.

The study area for this research is located on a sloping to moderately steep northeast exposure. The upper half of the slope is equivalent to Ruhe's (1960) pediment backslope while the lower part could be called a pediment footslope.

Field Design

During the summer of 1963 a 30-acre tract of the mixed coniferous forest was clearcut. All merchantable timber was removed from the area and other material was felled in an up-downhill direction. All slash was left in place for over-winter drying.

The following July the entire area was broadcast burned prior to seeding to selected grass species. Species used included a mixture of timothy (*Phleum pratense*), orchardgrass (*Dactylis glomerata*), tall oatgrass (*Arrhenatherum elatius*), smooth brome (*Bromus inermis*), and white Dutch clover (*Trifolium repens*). Also two pure stands of mountain brome (*Bromus marginatus*) and blue wildrye (*Elymus glaucus*) were seeded. Six pounds per acre was the seeding rate for the mixture while eight pounds of seed were placed in the pure stands.

Only 15 acres within the clearcut-burn were selected to conduct intensive research. Three, five-acre exclosures were constructed. Two of these were enclosed by four strands of barbed wire--cattle exclosures--and one had an eight-foot woven-wire surrounding it--game exclosure.

Within each five-acre exclosure, five, one-acre plots--statistical analysis replications--were established. In turn, one-half of each one-acre plot was objectively seeded to the introduced species while the remaining one-half was unseeded. The bottom one-half of each one-half seeded acre was seeded to the mixture and the upper portion was seeded to mountain brome or blue wildrye (Figure 1).

During April, 1965, four of the five, one-acre plots were planted with two and three-year-old tree seedlings. The other plot was left as a check. The four tree species, Douglas-fir (Pseudotsuga menziesii), Western larch (Larix occidentalis), Western white pine (Pinus monticola), and ponderosa pine (Pinus ponderosa) were each planted on a six by seven-foot grid giving 880 trees per acre. In addition, 120 grand fir, Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) were seeded at the top of the plots to give a total seeding rate of 1000 seedlings per acre.

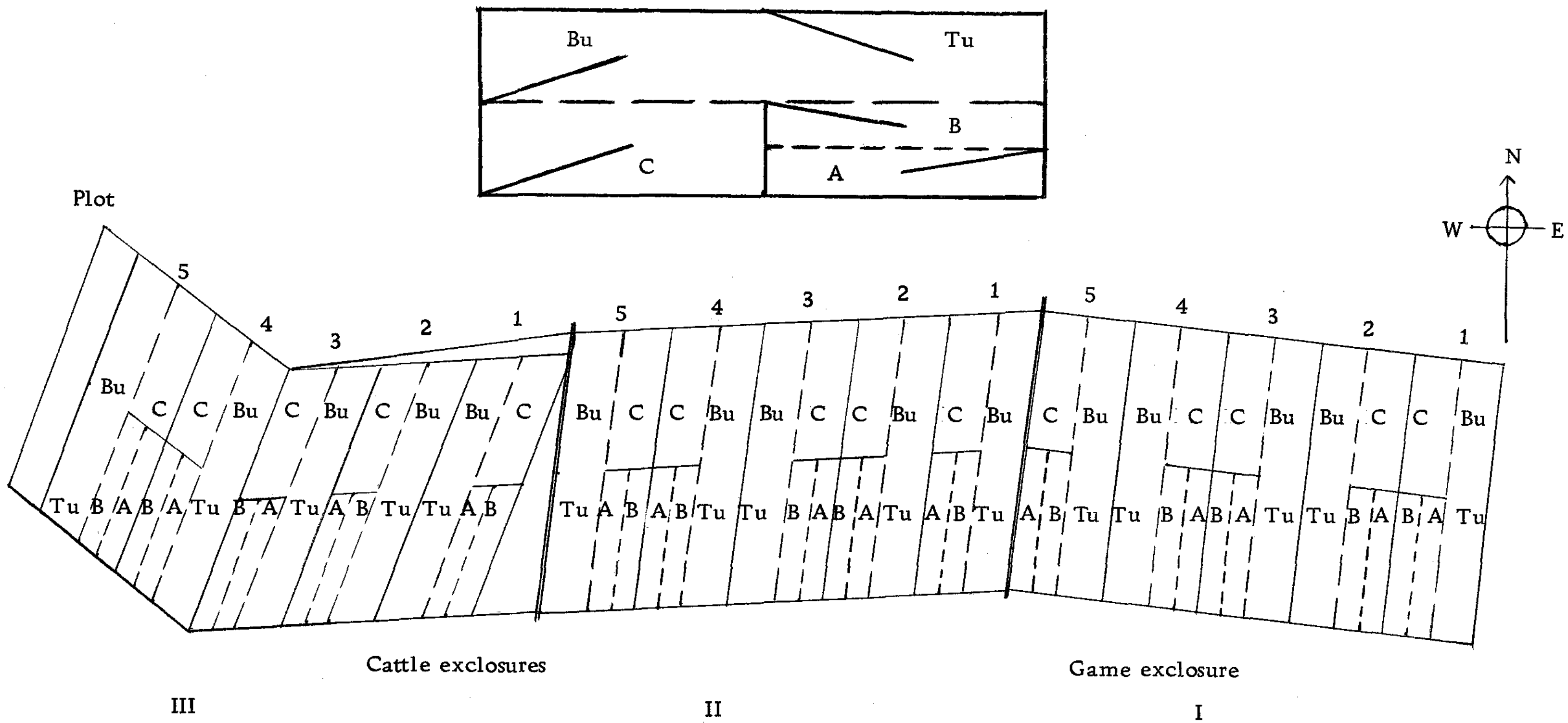

Figure 1. Field design showing placement of seeding treatments: A = Blue wildrye, B = Mountain brome, C = seeded mixture of orchardgrass, tall oatgrass, smooth brome, timothy, and white Dutch clover; Bu = bottom unseeded; and Tu = top unseeded. Top insert shows location of five, 100-foot belt transects randomly placed in game exclosure plot 5. Only plot two of exclosure three was sampled.

Soil on Study Area

A Tolo silt loam which has rather pure volcanic ash as parent material is the soil present on the study area. This soil series, present in much of the Wallowa and Blue Mountains, was proposed as Tolo in 1926 (Kocher et al., 1926). The ash supposedly resulted from the eruption of Mt. Mazama--now Crater Lake--in west central Oregon (Williams, 1942). Carbon dating has shown that the ash throughout this area is approximately 6,500 years old (Williams, 1953).

Underlying the ash mantle is either consolidated or fractured basalt or in some instances a buried soil. Depth to bedrock varies from 20 inches to more than 60 inches. Deepest ash deposits seem to occur on the pediment footslope.

A representative profile of the Tolo series is shown in Figure 2. This particular profile is located in the footslope of the game exclosure. Figure 3 depicts the topographical features of the study area.

This soil has a high moisture holding capacity--50 percent by volume--and is one of the primary reasons why a mixed-conifer forest can dominate the vegetation on this site (Strickler, 1965b).

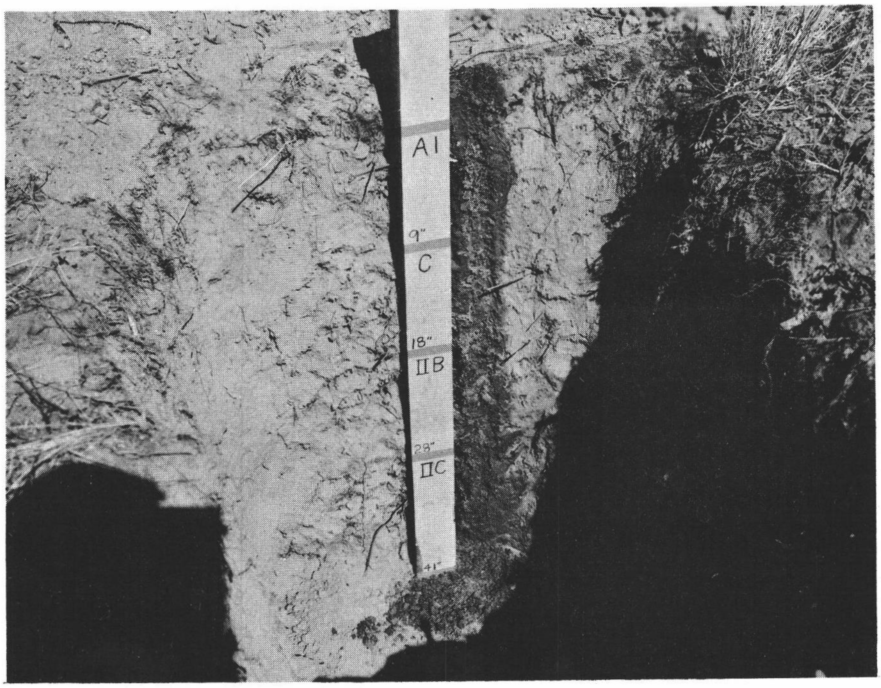

Figure 2. Typical Tolo silt loam profile found in footslope of game exclosure.

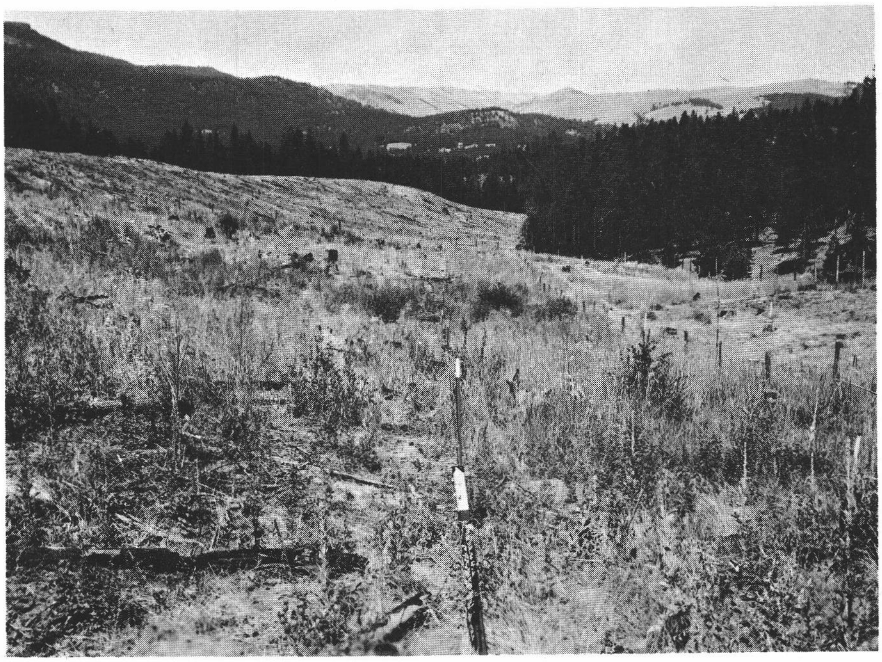

Figure 3. General view of research area showing pediment backslope and footslope.

Climate

The Hall Ranch receives the majority of its precipitation from snowfall in November to February. In late April to June frequent rain showers occur throughout the area, thus making conditions ideal for early season herbage growth.

A weather station located approximately 200 yards from the study area indicates that over 20 inches of precipitation occurs annually (Figure 4). With this amount of precipitation plus a highly porous soil in the study area, conditions are more mesic than on adjacent shallow soils of other aspects.

Throughout the summer and fall, small isolated electrical storms move through the area. Often times, however, only a few hundredths of an inch are received, thus making them ineffective for soil moisture replenishment.

Temperatures are quite cool throughout the year in the foothills of the Wallowa Mountains. Near freezing temperatures can be expected every month but areunusual in July and August. Highs seldom exceed 100° F. on southern exposures while the study area high temperatures are normally less than this.

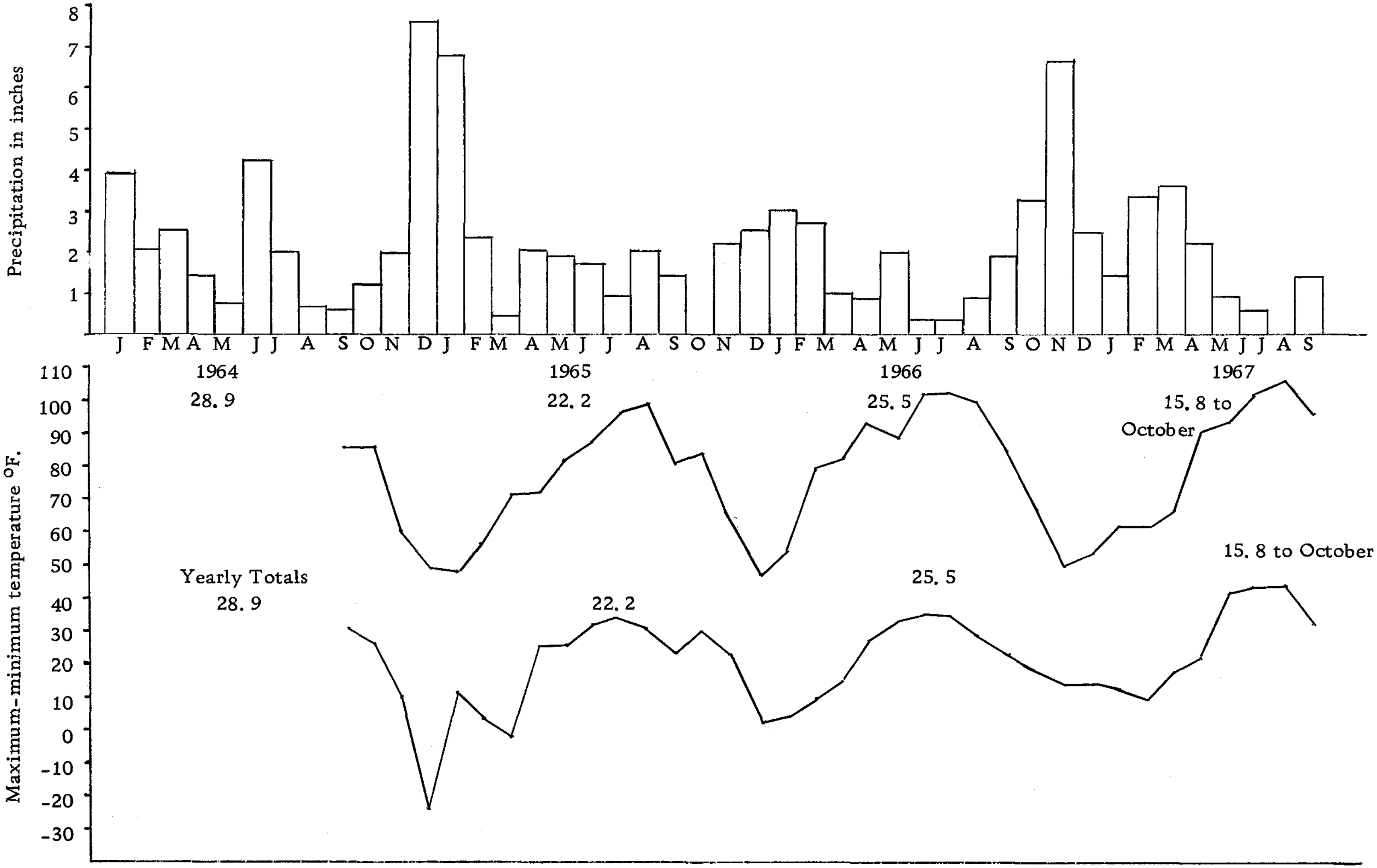

Figure 4. Monthly precipitation and temperature data recorded on area adjacent to clearcut-burn.

Ecology and Grazing History

Young (1965) carried out very intensive research on the mixed-conifer vegetation of the Hall Ranch. In order to study every condition and vegetative grouping, many stands were studied on all mixed-conifer forest sites of the Ranch. Young (1965) mentioned that many of the mixed-conifer sites were located at low elevations where normally ponderosa pine and Douglas-fir dominates. Due to their physiographic position on north-facing slopes and location on ash soils, they were proposed as being a topoedaphic climax.

Strickler (1965b) has described the vegetation and soil relationships on similar areas in the Blue Mountains. His results with Young's (1965) work have given a detailed picture of ecological relationships in the mixed-conifer forest.

Other ecological work in the Wallowa Mountains has studied soil-vegetation relationships. Johnson (1959) carried out a rather detailed study on plant communities and intensities of grazing southeast of the present study area. Head (1959) has added a complete taxonomic study also. In this work, 464 species of plants were found in a small portion of the Wallowa Mountains. Sturges (1957) has presented some detailed mammal, bird, and plant community relationships in the northern part of the Wallowas.

Walton (1962) found a significant relationship between the nutritive value of forage and time of cutting. The mixed-conifer forage was found to contain higher crude protein percentages throughout the season than pine or meadow vegetation.

Hug (1961) reported that pioneers began settlement along Catherine Creek in the middle 1860's. The relatively level topography allowed an ideal passageway from much of the Wallowas to the Grande Ronde River basin or to the Blue Mountains located just west.

According to Experiment Station records, the Hall Ranch was heavily grazed by cattle and sheep from 1936 to 1956. In 1956 much of the area was in poor condition, particularly the meadows and open pine sites. Similar poor range conditions have been found throughout the Wallowa Mountains (Pickford and Reid, 1942; Strickler, 1961).

The mixed-conifer forest has been considered almost unusable for domestic livestock because of the rough topography, brush, and dense timber stands (Garrison, 1964).

In this research the foothill-mixed-conifer stand studied belongs to the community defined by the Society of American Foresters as one having grand fir as dominant with Douglas-fir and western larch subordinate species. The specific stand studied is slightly more xeric than the typical mixed-conifer community and occurs on ash soils currently called Tolo.

LITERATURE REVIEW

Seral Vegetation Relationships on Forest Sites

Little has been reported on the seral vegetation relationships in the mixed-conifer forest. Mueggler (1965), however, has thoroughly studied the cedar-hemlock zone of central Idaho. Many of his findings, particularly in relation to burning, are applicable to the present study. Species found to increase in frequency due to clear-cutting and broadcast burning include: ninebark (*Physocarpus malvaceus*), oceanspray (*Holodiscus discolor*), Scouler's willow (*Salix scouleriana*), wood rose (*Rosa gymnocarpa*), birchleaf spirea (*Spiraea betulifolia*), snowbrush (*Symphoricarpos albus*), and redstem ceanothus (*Ceanothus sanguineus*).

Garrison and Rummell (1950) found that grasses were drastically reduced by logging on ponderosa pine sites. This was believed to be a result of their shallow rooting habits which make them easily removed during the logging operation. Some shrubs such as serviceberry (*Amelanchier* sp.) and chokecherry (*Prunus* sp.) were scarcely affected by logging because they possess a deep taproot system.

Seral vegetation has been studied throughout Idaho by Daubenmire (1952). In this research a large part of Idaho has been classified according to vegetative zonation and plant communities.

Silviculture of Grand Fir

Hubert (1955) remarked that grand fir was an outstanding forest species. Its workability, rapid growth, light color, and high volume make it an ideal species in many forested areas. On the Hall Ranch and throughout much of northeast Oregon, however, grand fir is very susceptible to heart rot. Indian paint fungus is the primary species causing heart rot in grand fir. Grand fir greater than 16 inches in diameter at breast height on the Hall Ranch is assumed to be infected with heart rot (Keniston, 1957).

Aho (1966) used multiple regression equations to estimate percentage of grand fir infested with heart rot and other defects on 11 stands throughout the Blue Mountains. His results show that 75 percent of the grand fir of 200 years in age is defective.

It is currently believed that a pathologic cutting cycle for grand fir could improve the site considerably (Keniston, 1957; Hubert, 1955). Garrison (1964) also mentioned that this site was one of the largest and relatively untapped timber types in the West. He felt it would be very logical to judiciously manage the mixed-conifer forest by reforestation and possibly domestic livestock grazing in order to increase the value of this land.

Aussenac (1966) studied seed dispersal of 35-year old grand fir in France. His findings show that over 600,000 seeds per day per hectare are dispersed from this species in late September. By November 30, 96.3 percent of the total had been released.

Effects of Burning Forest Sites

Lutz (1960) suggested that tremendous problems are involved in the control of fires in coniferous forests. Although the problem is very delicate, this researcher believed that the possibility of beneficial use of fire does exist and should be explored. An extensive review of forest fire research has been ascertained by Ahlgren and Ahlgren (1960). These authors suggest that many contradictions appear in the literature as to how fire affects all ecological factors. Some general conclusions have been reached but each specific burning trial may give results quite different from others in similar areas. In general, however, soil acidity is lowered after burning while soil calcium, phosphorus, and potassium levels are increased. Also biotic nitrogen fixing is generally enhanced by burning.

Gaines *et al.* (1958) pointed out that controlled use of fire may reduce fuel for future fires. More information is needed on the conditions under which it is feasible and on techniques for its proper use. Weaver (1957) has found burning of ponderosa pine forests in Washington to be of silvicultural benefit. This research showed that controlled burning reduced the number of acres burned by 89.9 percent, damage by 94.3 percent, and cost of control by 79.3 percent.

None of these studies have been concerned with forage implications, wildlife numbers, or regeneration following fire. A study by Gratkowski (1964) indicated that varnish-leaf ceanothus (Ceanothus sp.) seed germination was maximized by heating from 80-105°C. A few seeds germinated at 45-65°C., but these numbers were significantly lower than at the higher temperatures.

Gockerell (1966) conducted research on a logged forest site in western Washington. His results show that fire reduced slash accumulations and mistletoe infection throughout the area. When comparing burned with unburned areas, it was found that natural tree seedlings were decreased by burning. Mean height of trees were greater on the unburned area while browsing by deer and elk were greater on the burned areas.

An intensive seeding program was initiated in northern British Columbia on burned forest land. Anderson and Elliott (1957) broadcast several grass and legume species in combination and separately to see what responses were obtained. Grasses appeared to do equally well seeded in late October when compared to April seedings. This study showed a marked evidence of nitrogen deficiency in the grass stands in the second and subsequent years after burning. A substantial increase in vigor was noted where volunteer legume plants occurred and where grass stands bordered legume plots.

Forest Grazing Practices

Grazing within forested areas of this country has caused mixed feelings among foresters and range managers. In the southeastern section of the United States, forest grazing has been practiced with considerable success. The 1960 passage of the Multiple Use Act prompted action to be taken to more fully utilize the resources of forested land, yet be consistent with good land management practices. Costello, Hill and Hickie (1955) suggested that the responsibilities involved in multiple use management should be integrated between professional forestry, range management, and wildlife management disciplines. To reach this goal a concentrated effort must be established. One of the problems in managing the grazing resources of forested land is to harvest the usable forage but to do so in a manner that does not prohibit the site from becoming reforested (Weber, 1957).

Intensive management of trees, cattle, and forage is essential to make forest grazing a profitable and compatible operation (Halls and Duvall, 1961). Although forest grazing is not a get-rich-quick business, returns on the investment are quite good. Part of the tax burden of land ownership can be defrayed by income derived from forest grazing. Halls (1959) mentioned that the coordination of grazing use with forest products contributed more to the economy than if each business was operated separately. Besides providing additional income, a noticeable reduction in forest fires results from forest grazing practices (Biswell and Foster, 1942). Oliver (1938) realized that cut-over lands in northwest Oregon could supplement the income of land owners if livestock grazing was allowed. Because of straying however, it was often not feasible to provide fencing to restrict movement of animals from the area.

Interactions of Forest and Grazing Management

Many factors are operative in the evaluation and success of a grazing-forestry management plan. Due to differences in abiotic and biotic influences from region to region, similar recommendations may not be applicable to both regions. Furthermore, within one rather narrow ecological unit emphasis may need to be placed on specific factors.

Cassidy (1937) stated that thirst in animals was the main factor influencing the browsing intensity. This author concluded that if animals were removed from the forested range when drinking water was lacking, little browsing damage could be noted. This conclusion or reason for browsing damage has not, to my knowledge, been substantiated by any other research.

Trampling damage appears to be the single most harmful effect on young regenerating trees (Cole, 1961; Moss, 1959). Cassady, Hopkins, and Whitaker (1955) acknowledged that trampling damage was greatest during the first year after planting. Seedlings are not well established at this time and can be dislodged quite easily by animal hooves.

Hall, Hedrick, and Keniston (1959) suggested that the grazing animal may be a very valuable tool to obtain good Douglas-fir management. These authors' research in western Oregon point out the necessity of understanding the soil-animal-vegetation complex before making concrete decisions. It appears, however, that by using the grazing animal as a tool, competition between tree seedlings and grass or forbs would be reduced. Hedrick and Keniston's (1966) findings show very well that grazing animals may be beneficial to tree growth. Halls (1959) also pointed out the necessity of understanding silvicultural and grazing interactions. Range and livestock practices important for the integration of timber and livestock production are using proper numbers and good distribution of animals (Campbell, 1954).

METHODS OF STUDY

Within plant communities many factors are interacting to change or modify species present. These "cause-and-effect" relationships may be very subtle and difficult to isolate. With technological advances in instrumentation, particularly biometerological instruments, many factors can be measured quantitatively. In order to assess some of the changes occurring in plant communities, it becomes necessary to study the entire soil-animal-plant complex.

Vegetation Measurements

Due to the heterogeneity of vegetation on the clearcut-burn, it was necessary to evaluate a large number of plots to characterize the change and nature of vegetation present. Many methods are available for making these determinations, but it is believed that frequency and cover data are most useful.

Frequency Data

Ideally each species requires a different size plot to achieve the most efficient sampling intensity. This; however, is unrealistic when many species are present in an area. In order to achieve optimum frequency sampling efficiency, Hyder *et al.* (1963) suggested that a plot size should be used which gives a frequency of 63 to 86 percent for the most abundant species.

Taking this into consideration, a 12-inch square plot was selected. One hundred of these were placed contiguously to form a 100-foot belt transect (Figure 1). Fifty-five belt transects were randomly placed in each seeding treatment and both the top- and bottom unseeded subplots. These transects were permanently marked to enable one to sample the same plots at yearly intervals.

Standard data sheets were used to record all species present in each square foot of the transect. Transects were sampled in late August of 1965 and in June of 1966 and 1967 prior to cattle grazing.

Cover Data

To get some idea of individual species influence within the study area, foliage cover of individual species in every square foot was recorded. This information was taken simultaneously with frequency data in 1966 and 1967 using a modification of Daubenmire's (1959) method.

The following classes were used.

Cover Class	Foliage Cover
1	0-5 percent

2	5-12.5 percent
3	12.5-25 percent
4	25-50 percent
5	50-75 percent
6	75-95 percent
7	95-100 percent

In order to determine the average vegetative cover per species, it was necessary to sum the midpoints of each foliage cover value.

Yield Data

Prior to livestock grazing in 1966 and 1967, herbage production was determined in plots one, two, and three of the game and plots one, three, and five of exclosure two, respectively. In 1965 yields were taken later in the season as no grazing had begun and plant development was slower this year. The weight-estimate, with occasional clipping, method to determine herbage production was used. Each plot and treatment were sampled with the same intensity per unit area in order to minimize sampling errors.

On all occasions most grasses were in the flowering or early-seed-head stage of development when clipped at approximately a two-inch height above the soil surface. Major species were separated and weighed in the field using 100- and 500-gram balances. Herbage was then transferred to the large-walk-in dryer at the Experiment Station Laboratory. Samples were dried overnight at approximately 160° F. before obtaining dry weights.

Chemical Analysis

Several factors influence the nutritive content of forage species. By evaluating animal gain responses with forage nutritive content, we can better understand the potential value of a particular site.

The major forage species, and others of interest, were collected in conjunction with yield sampling. All plant material above the two-inch clipping height was used for analysis. The Animal Nutrition Laboratory at Oregon State University conducted the dry matter and crude protein analyses.

Animal Measurements

To fully evaluate the ecological implications of an area, determination of biotic influences is necessary. These influences were most readily noticeable when caused by livestock grazing and game use. Of supposedly minor importance and more difficult to evaluate, were the effects of rodents and birds. The harvest of succulent forbs, grasses, and seeds was noticeable by the smaller biota.

The ability to quantitatively measure small animal influences is very difficult and was not undertaken in this study. Nevertheless, notes were taken on relative abundance and habits of the species present.

Deer and Elk Use

In early spring of 1966 and 1967, a detailed study was conducted to estimate approximate numbers of game animals which had used the study area for feeding purposes.

Thirteen, 1/200-acre belt transects randomly selected and corresponding with the permanently established vegetation sampling areas were examined for fecal deposits. All fecal groupings were recorded and separated, that is, deer vs. elk, before removal from the plot. By using the plot area as related to one acre, an approximation of deer and elk use was ascertained.

The purpose of conducting fecal counts in this study was to help evaluate the effects of game browsing on tree and shrubby growth. Clearcutting and burning have provided an ideal food source for the game and it was believed that they would be attracted to the study area.

Livestock Grazing

To obtain controlled grazing from the seeded grass and native species, a grazing trial was conducted. Competition between tree and grass seedlings undoubtedly results when they are planted together. By using domestic livestock as a tool to harvest grass and shrub growth, reduced root competition with tree seedlings should result.

On July 15, 1966, ten preweighed yearling replacement heifers were divided into two groups and placed into the two cattle exclosures. Grass species were in the early-seed-head stage of development at this time. Observations were made to determine forage preferences and grazing habits. Extreme caution was used to avoid overgrazing of forage species in order to minimize tree browsing. Believing that the exclosures could bear more grazing pressure, 14 yearling heifers were used in the 1967 grazing trial.

Individual animal weight gains were taken at two-week intervals with the exception of one weighing in 1967. Snow fence holding pens were constructed at the base of the clearcut. This enabled one to record weights after the customary overnight shrink. Portable scales were used to weigh the animals. Animals were then placed back into the exclosures for another two-week period.

Daily water consumption by the heifers was also calculated. Since all water had to be transported to the study area, it was quite easy to determine gallons per day that were consumed. Tubs, calibrated at five-gallon intervals, were used to run this test.

Observations of the water level in the tub made it possible to calculate consumption accurately. No corrections were made for evaporation losses since water was supplied daily.

Environmental Measurements

Effective precipitation is undoubtedly the major factor affecting plant growth in northeastern Oregon. Tremendous vegetation variability exists between north and south exposures. This is partially the result of a more mesic environment on north slopes which results from differential soil and air temperatures, snow accumulation, soil moisture, soil type, and solar radiation. These factors are interrelated and govern the ecological potential of a site to produce a given quantity and type of vegetation.

Soil Temperature

Several methods are available for measuring soil temperatures. Many of these are expensive and would not be feasible for the precision and accuracy needed in this study.

In this research, Taylor six-inch maximum recording thermometers were placed so the sensing bulb was two inches below the soil surface. Care was taken in placing these properly to avoid erroneous data which would result if insufficient contact was made between sensor bulb and soil particles.

These thermometers were subjectively placed in the seeding treatments and on a compacted skid trail on the clearcut. An area was chosen in the seeded treatments where logging procedures had not disturbed the soil surface and a good cover of herbaceous vegetation was present. After weekly maximum temperature readings, each thermometer was replaced within a few inches of where it had previously been.

In the uncut mixed-coniferous forest adjacent to the experimental area, two thermometers were placed at a similar depth in intermediate shade--21-40 percent canopy coverage--classes. Great care was taken in the placement of these thermometers as litter often interfered with depth estimation. Depth of the sensor varied from one to two inches in the uncut forest.

Air Temperature

The aboveground temperature environment often determines the success or failure of a species to reproduce. In order to measure aboveground temperatures two stations were placed in both the clearcut and uncut stands. Two Taylor maximum-minimum dial thermometers (No. 5321) at one-foot and three-foot aboveground were used at each station. In order to get an accurate reading of true air temperatures, each thermometer was placed in a white ventilated shelter.

It is believed that a good indication of the atmospheric evaporative potential could be estimated in this fashion. Readings were taken every Monday from June to mid-September for all soil and air temperature sensors.

Soil Moisture

Equally important to soil temperature measurements are soil moisture readings. The specific heat of water, being one calorie per gram, tends to influence the edaphic environment considerably. This, in turn, affects soil temperatures which indirectly affect vegetative growth.

The gravimetric method of soil moisture determination was used throughout 1966. This entailed obtaining specific increments of soil throughout the season and determining moisture content on a dry-soil-weight basis. Soil moisture samples were taken in undisturbed areas with good vegetative cover--excluding the unseeded treatment--for all seeding treatments. Duplicate samples at: (a) 0-6", (b) 6-12", (c) 12-24", (d) 24-36", and (3) 36-48" depths were made in each treatment. On several occasions it was impossible to get a sample below 36 inches because of bedrock; therefore, this depth was not sampled throughout the summer. The same procedure was used at two locations in the uncut forest. Each soil increment was immediately placed in soil tins to prevent drying. Samples were then transferred to the Experiment Station Laboratory where wet soil weight was recorded before drying for 24 hours in an oven at 105° C. Soil moisture percentages were then determined.

Because of extreme soil variability in the clearcut, it was decided to use electrical resistance determinations throughout the 1967 study period. J. D. Frost model F gypsum resistance blocks were used. With blocks it was possible to determine soil moisture trends at identical locations below the soil surface throughout the summer.

Resistance blocks were placed at 6, 12, 24, 36, and 48-inch depths where possible with two replications for each location. Readings were taken at weekly intervals using the Beckman Model 300 resistance meter.

Some difficulty was experienced when using the blocks as rodents were attracted to the sample locations and gnawed wires or dug up several of the blocks. In order to help alleviate this problem, cans with mothballs enclosed were placed over the wires.

Solar Radiation

Within plant communities solar radiation intensity is not normally considered too important a factor in determining vegetative composition. This depends, however, on how much radiation a particular species requires for survival. Many species are obligated to live in the shade. These, according to Daubenmire (1964), are called obligative sciophytes.

Upon clearcutting an area, an entirely different radiation load reaches many species which were formerly tolerable to only a low radiation intensity. The abundance of bull thistle and down-unburned slash provide radiation conditions similar to that found in the uncut forest. As this weedy species is eliminated, some of the sciophytic plants may be eliminated from the clearcut.

A non-expensive net radiometer similar to Suomi and Kuhn's (1958) and Lowry's (1957) instrument was used in this study. One radiometer was placed three feet above the soil surface at each air temperature station. By taking readings at short intervals throughout the day, it was possible to determine the differential solar radiation load reaching the soil in both the uncut stand and clearcut. This instrument also made it possible to determine when outgoing radiation exceeded incoming radiation.

Snowfall Accumulation

Snowfall accumulation is related to many environmental variables as well as to type of vegetation present. In the Columbia River watershed of Oregon and Washington, Griffin (1919) stated that snow remained 17 days longer in the forest than in an open area. This author mentioned that the conservation of snow varied directly with the density of the forest. Meagher (1938) studied snowfall accumulation in the Wind River Valley of Washington on a clearcut, partially cut, and virgin Douglas-fir forest. He observed that there was a noticeable absence of drifting in the old-growth forest which resulted in a uniform distribution of snow on the ground. In the clearcut; however, there had been considerable drifting, and thawing was greatly accelerated around stumps and logs, giving an uneven distribution of snow.

In this research only qualitative observations were made in both the clearcut and the adjacent uncut mixed-coniferous forest. Personal communication with Experiment Station staff and early spring visits to the area have provided information concerning snow accumulation and retention.

Soil Profile Characteristics

A modal soil, examined previously by a soil scientist using an auger, was examined in more detail. After opening a soil pit, textural classes, consistency, color, and structure and other observations were made according to the standard procedure. The previous soil profile description with modifications appears in Appendix F.

Chemical Analyses

Soil samples were collected by horizon from the modal soil used in the description. It is believed that, as a result of the burn, an abundance of plant nutrients was present in the clearcut surface soil horizon. Burning releases nutrients unavailable in the slash for immediate plant use.

Specifically, the following nutrients and pH were tested by the Oregon State University Soil Testing Laboratory: (a) available phosphorus, (b) potassium, (c) calcium, and (d) magnesium.

Statistical Evaluations

Due to the extremely heterogeneous conditions found on the clearcut, a detailed statistical analysis of results was not considered necessary. Results that were somewhat difficult to evaluate were compared using the standard F-test.

Bull thistle cover and frequency data are the only information tested. The hypothesis that bull thistle cover is reduced by grass seedings was tested. Frequency data were tested similarly.

RESULTS AND DISCUSSION

Results presented in this research may not fully agree with those found in another foothill-mixed-conifer stand. Highly variable compositions of understory species are found between stands. The elevation, canopy coverage, and severity of past disturbances all make each individual area unique in some respects. The close proximity of the experimental area to a drier site is no doubt responsible for the broad array of species in the seral stages under study.

It should be emphasized that these results are preliminary. Continued experimentation and additional facts need to be gathered before concrete recommendations can be made.

Vegetation Measurements

Many methods are availabe to characterize plant communities. The heterogeneous nature of low seral annuals intermixed with native perennial species warranted a measure of species frequency and cover to determine influences of these assemblages. Crude protein determinations, yield measurements, and autecological observations have provided information needed to determine potential competition and value of the site for grazing animals.

Species Frequency--1965

Eighty-seven species were recorded the first sampling year. Of this total, 44 forbs, 25 grass or grass-like, and 18 woody species were present. Severity of surface soil disturbance seemed to be directly related to the abundance or sparsity of certain species. Where highly disturbed conditions were present, few native perennials were found. Those perennial species with rhizomatous root systems were better able to persist after logging than species with fibrous roots.

Bull thistle (Cirsium vulgare), the most abundant forb on the study area, was found in 26 percent of the 5500 individual plots of the belt transects. Canada milkvetch (Astragalus canadensis) and two species of strawberry (Fragaria spp.) were the only other forbs having a frequency greater than ten percent.

Appendix B gives a complete list of species and their frequencies as found in the study area. Some of the annual and more weedy species showed a high degree of variability from one year to the next. The rapidity with which annuals can become established or disappear plus the influence of surface soil moisture play an important role in their abundance and dominance.

Ross' sedge (Carex rossii) was present in nearly 34 percent of the plots sampled. This native species is abundant in the undisturbed mixed-conifer forest but due to its low vigor and production is not believed to be an important component in the grazing animal's diet.

Other species with over nine percent frequency were the seeded species, mountain brome, blue wildrye, timothy, and orchardgrass. Pinegrass (Calamagrostis rubescens) which is important in unlogged stands had a frequency of only 2.6 percent. Severe soil disturbance plus competition from other species better adapted to low seral conditions have made pinegrass a minor component of the vegetation.

Redstem ceanothus (Ceanothus sanguineus), ninebark (Physiocarpus malvaceus), and birchleaf spirea (Spiraea betulifolia) were the most abundant shrubs on the study area two years after logging. It was difficult to distinguish redstem- from snowbrush ceanothus (Ceanothus velutinus) at this time. In most cases only two leaves were present above the soil surface. Figures 5 and 6 vividly show the encroachment of shrubs in the game exclosure. In the left part of the figure is a mountain brome seeding while blue wildrye is present on the right. Most shrubby growth consisted of both ceanothus species and an occasional plant of ninebark.

Frequency--1966

Again bull thistle was more abundant than all other species in the study area. In one year its frequency had doubled indicating that a tremendous seed crop was produced in 1965. Ample soil moisture

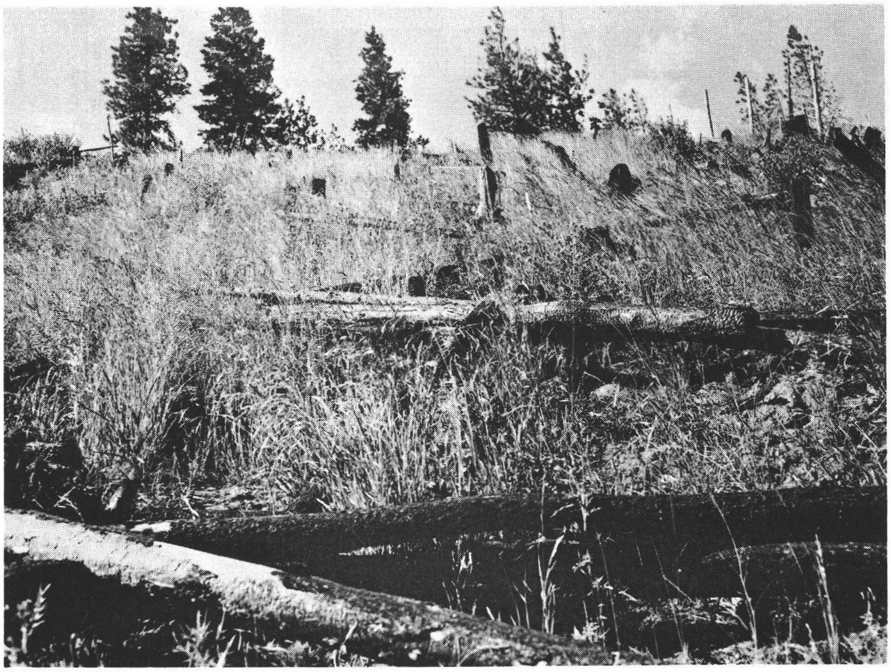

Figure 5. Pure stands seeded on backslope. Mountain brome on left and blue wildrye on right in 1965.

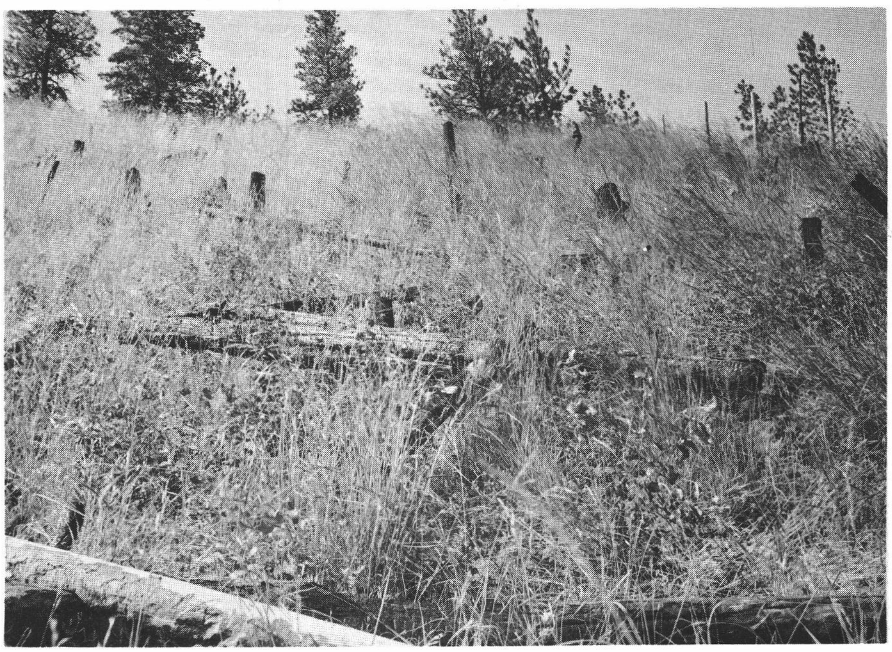

Figure 6. Same seeding in 1967 showing increase in shrub cover. Most of shrubby growth is redstem ceanothus.

throughout 1965 plus a minimal quantity of competing vegetation in unseeded plots allowed vigorous thistle plants to mature.

Canada milkvetch increased in abundance by nearly 50 percent. This species, which reproduces by seed as well as by rootstocks, has a deep root system and is able to obtain soil moisture that is unavailable to many shallower rooting forbs and grass species.

Among the more abundant species, autumn willowweed (*Epilobium paniculatum*) had the greatest frequency increase from 1.49 to 13.64 percent. Of all species recorded, 67 increased in frequency between 1965 and 1966. The remaining species either decreased or remained unchanged. Several new species were recorded in 1966, whereas five species found in 1965 were absent.

Frequencies of perennial grasses were much more stable than were forb frequencies. Most grasses did show an increase but this was only a few percent higher than the previous sampling period.

Shrubby species showed a more stable frequency than grasses which partially results from the reproducing ability of the shrubs. Very little seed production was noted on the shrubs in 1965, and crown bud reproduction was the primary method of increasing their frequency.

Frequency--1967

By 1967 the frequency increases of most species had been decelerated. Bull thistle, strawberry, sheep sorrel (Rumex acetosella) and a few other forb species showed a much smaller increase this year than formerly. Based on three years of data it was still impossible to predict maximum frequencies for any of the species found in the study area. It was obvious that the near exponential increase of many species had ceased; however, it may take three or four more years to obtain a somewhat stable plant population. The dynamic processes involved in plant succession, particularly when altered by man and climate, are difficult to analyze precisely.

The most notable increase in species abundance occurred in autumn willowweed and cheatgrass brome (Bromus tectorum). These annuals, because of a prolific seed production, can germinate and reproduce in a disturbed area more readily than most other species.

Vegetation Foliage Cover

Since foliage cover estimations were not calculated in 1965, only generalized conclusions can be made. It was evident that bull thistle cover was much greater the first sampling year than in 1966 and 1967, as confirmed by yield data which will be discussed later.

Canada milkvetch, conversely, had a very low cover during 1965. As germination of the hard seeds progressed, the value of this important legume rose abruptly in 1966. Cover values of other species were low in 1965 except for the introduced grasses.

Table 1 presents the average foliar cover of the 16 most abundant species in the clearcut. All values within seeding treatments from the game exclosure represent an average cover from 500 individual square foot plots whereas 600 sample plots were used to obtain comparable values in the cattle exclosures.

These data show many interesting changes and comparisons among years and treatments. Of major interest was the similarity in foliage cover between seeded and unseeded plots. Although cover was generally higher in seeded areas, the difference was assumed to be nonsignificant. In all cases, total cover for these species increased from 1966 to 1967. The highest increase in cover was 32.6 percent found in the bottom unseeded treatment of the game exclosure. It can be observed that vegetative cover is increasing at a more rapid rate in all unseeded plots than seeded areas. Cover in unseeded plots may eventually surpass that in seeded areas because of a much greater diversity of native species with a notable layering effect.

Thistle cover was consistently higher in unseeded treatments. Importance of bull thistle is represented three-dimensionally in Figure 7. In unseeded treatments, most thistle was found to have a low cover per plot, or a high frequency in cover class one. In the

Table 1. Average foliage cover of the 16 most abundant species found in the clearcut treatments.

	Bottom unseeded				Top unseeded				Mixture			
	Game		Cattle		Game		Cattle		Game		Cattle	
	1966	67	66	67	66	67	66	67	66	67	66	67
BROMUS MARGINATUS	T[1]	.2	-	T	.3	1.4	1.9	2.1	-	T	-	-
ELYMUS GLAUCUS	.1	.1	-	T	.6	1.1	.4	.9	-	-	-	T
PHLEUM PRATENSE	2.6	5.1	1.4	2.3	-	T	.1	.3	19.0	26.1	16.7	17.8
DESCHAMPSIA ELONGATA	1.4	2.3	2.0	4.0	.9	1.6	.7	1.3	.2	.3	T	T
BROMUS TECTORUM	.3	3.1	1.2	4.1	1.6	8.4	5.6	15.8	.2	.2	.1	1.3
CAREX ROSSII	8.9	13.1	11.0	16.4	5.3	7.3	8.0	11.7	3.5	5.8	8.0	8.5
CIRSIUM VULGARE	6.2	13.7	11.8	22.8	5.4	15.4	10.1	18.8	2.4	2.4	4.1	4.0
ASTRAGALUS CANADENSIS	15.9	22.0	2.5	5.9	14.3	11.5	5 4	6.2	18.0	25.0	7.6	8.7
FRAGARIA SPP.	3.7	4.5	.9	1.4	1.6	2.7	1.7	2.8	1.6	2 6	1.9	2.6
VIOLA ADUNCA ADUNCA	.6	.4	.5	.8	.2	.3	.6	.6	.4	.3	.5	.4
EPILOBIUM PANICULATUM	1.8	8.6	.5	1.0	2.7	10.1	.5	1.2	.1	.2	.1	.1
COLLINSIA PARVIFLORA	1.5	1.1	.4	1.1	.9	.9	.5	1.3	.2	.3	.1	.5
RUMEX ACETOSELLA	1.1	1.2	3.1	5.8	.9	1.0	2.9	3.5	.3	.3	.8	1.1
SPIRAEA BETULIFOLIA	.7	1.6	1.1	1.2	1.7	2.1	1.5	1.5	9	1.4	.9	.7
PHYSOCARPUS MALVACEUS	.9	1.3	.2	.4	4.1	5.3	1.9	1.8	.6	.5	.1	.1
CEANOTHUS SANGUINEUS	.3	.3	.2	.1	3.3	4.4	1.5	1.9	.4	.5	.2	.1
	46.0	78.6	36 8	67.3	43.8	73.4	43.3	71.7	47.8	65 9	41.1	45.9

[1] (T) represents less than .05 percent foliage cover.

Table 1. Continued

	Mountain brome				Blue wildrye			
	Game		Cattle		Game		Cattle	
	1966	67	66	67	66	67	66	67
BROMUS MARGINATUS	30.2	32.8	29.3	29.2	.1	.7	.4	.3
ELYMUS GLAUCUS	.1	.1	1.0	2.0	28.8	41.6	25.0	38.9
PHLEUM PRATENSE	.6	.7	.3	.5	.5	.4	.4	.3
DESCHAMPSIA ELONGATA	-	.4	T	.4	T	.1	.1	.2
BROMUS TECTORUM	1.4	2.6	.4	1.7	.2	.3	.7	1.3
CAREX ROSSII	3.6	5.4	5.8	6.8	5.1	5.4	5.0	6.1
CIRSIUM VULGARE	.8	2.1	5.2	5.8	1.6	1.9	8.3	8.6
ASTRAGALUS CANADENSIS	12.6	11.9	2.9	3.9	17.8	17.5	6.6	6.3
FRAGARIA SPP.	.4	.8	1.2	2.1	1.4	1.6	2.0	3.3
VIOLA ADUNCA ADUNCA	.1	.1	.5	.4	.1	.1	.5	.4
EPILOBIUM PANICULATUM	.4	1.0	.4	1.5	1.3	.5	.2	.7
COLLINSIA PARVIFLORA	.5	.7	.2	1.1	.1	.5	.2	.7
RUMEX ACETOSELLA	.3	.7	1.8	1.1	.5	1.2	.4	.3
SPIRAEA BETULIFOLIA	1.4	1.9	.9	.7	1.0	1.2	.4	.3
PHYSOCARPUS MALVACEUS	6.7	8.4	1.5	.9	2.8	2.2	.4	.2
CEANOTHUS SANGUINEUS	6.1	10.5	.9	1.4	1.1	1.3	.9	.9
	65.2	80.1	52.3	59.5	62.4	76.5	51.5	68.8

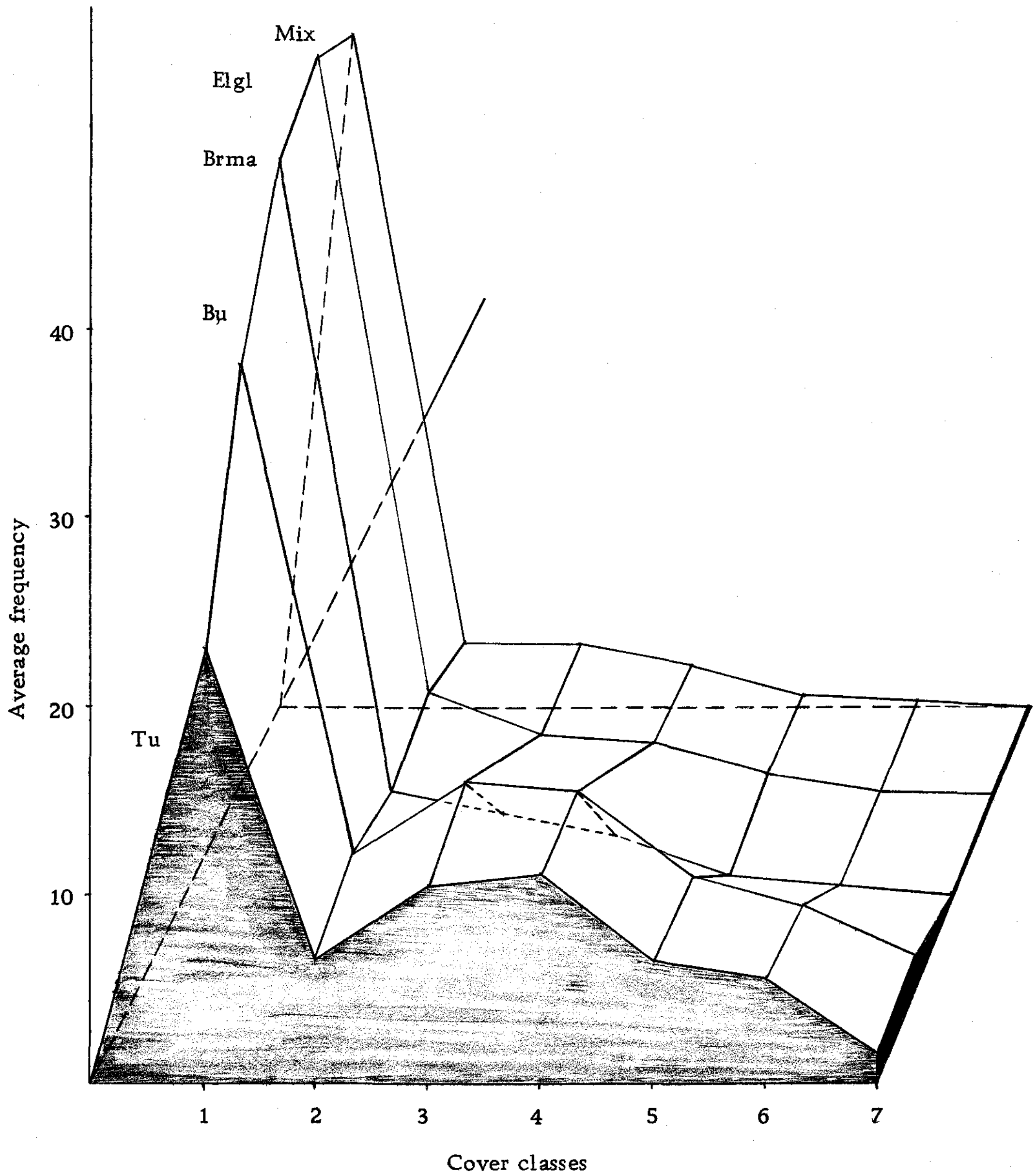

Figure 7. Average frequency of bull thistle in each cover class and seeding treatment--Tu, top unseeded; Bu, bottom unseeded; Brma, mountain brome; Elgl, blue wildrye; and Mix, seeded mixture--for 1967.

intermediate cover classes, most thistle was again found in unseeded plots but much lower values were found in the seeding treatments. This points out that seeded species are effective in minimizing the vigor of bull thistle.

Since bull thistle is a biennial, it appears as a small rosette the first year and becomes a mature plant the second year after germination. This fact helps account for the predominance of plants in the one cover class.

Further analysis of thistle cover points out an increase in cover from 1966 to 1967 except in the grass mixture seeding which was most effective in controlling thistle dominance. It is believed, however, that mountain brome and blue wildrye would be similarly effective if grass seedling establishment had been more uniform. Bull thistle was important in areas where a sparsity of mountain brome and wildrye had left bare soil upon which weed colonies could form.

Mountain brome did not appear to be a preferred forage species. It was often infected with smut and throughout 1967, its vigor was low due to an aphid infestation. Other species were unaffected by these pests.

Statistical analysis of thistle cover in the game and cattle exclosures showed a significant decrease due to grass seedings. In the cattle exclosures there was also a significant difference in cover between years. Analysis of variance tables appear in Appendix H.

Within a specific seeding treatment, thistle cover was always greater in the cattle compared with the game exclosure. It is hypothesized that this was primarily due to the differential vegetative competition existing within the game and cattle exclosures. Impact of game use, particularly on Canada milkvetch and shrub species, had reduced the total herbage which caused less competition for soil moisture, thus allowing thistle to become more vigorous. If sampling errors had caused these differential findings, cover differences would not have been as consistent. Overall, the mean cover of thistle in the cattle exclosures was slightly less than twice the cover in the game exclosure.

Foliage cover of the three most abundant shrubs, birchleaf spirea, ninebark, and redstem ceanothus was 1.7, 5.4, and 3.1 percent greater, respectively, in the game exclosure than in the cattle excluded area. These findings are in accord with browsing data presented in a later section.

Shrub cover was noticeably higher in plots located on the steeper backslope than those on the footslope of the study area. Footslope treatments which included bottom unseeded and seeded mixture, had a particularly sparse cover of redstem ceanothus and ninebark while birchleaf spirea was found more abundantly on the footslope. It is assumed that the concentration of shrubby growth in a forested region is the result of specific habitat factors making the site conducive to good shrub growth and to the nature of the undisturbed overstory before clearcutting. Method of propagation also plays an important role in definite plant distribution patterns.

Of the seeded species, blue wildrye cover increased the most from 1966 to 1967. This species produced an excellent seed crop in 1965 and 1966 which could have initiated the large cover increase.

In nearly all treatments Ross sedge cover was higher in the cattle exclosures than game exclosure. This can probably be attributed to less competition from shrubby and milkvetch growth. Ross sedge frequency data indicated that little difference in total frequency was found between cattle and game exclosure.

Herbage Yield

All treatments were sampled at an equal intensity per unit area. Based on vegetation heterogeneity, the following number and size of plots were sampled to obtain yield data in both game and cattle exclosures: (1) unseeded--60, 9.6 square-foot plots; (2) mixture--30, 9.6 square-foot plots; and (3) mountain brome and blue wildrye--30, 4.8 square-foot plots. These data, at best, represent only an estimation of herbage yield since many more plots would be needed for increased precision (Table 2). Needless to say, herbage production

Table 2. Total herbage production for the three study years.

	Game Exclosure			Cattle Exclosure		
	1965	1966	1967	1965	1966	1967
Unseeded	950 ± 138	1134 ± 324	1159 ± 202	1885 ± 336	574 ± 53[illegible]	685 ± 1
Seeded Mixture	1054 ± 214	1344 ± 259	1890 ± 246	1347 ± 99	1003 ± 232	963 ± 57
Mountain brome	1271 ± 180	1889 ± 516	1573 ± 5	1567 ± 365	1128 ± 526	756 ± 35
Blue wildrye	1256 ± 329	1496 ± 293	1144 ± 249	2016 ± 494	1183 ± 137	1205 ± 248

will become less variable when a forest canopy forms but when this occurs is influenced by a number of factors.

These data show that precision within the cattle exclosure increased for the 1967 sampling period. Still a high degree of variability in herbage production was found in the game exclosure. It is clear that more samples are needed to more nearly approximate herbage production in the clearcut-burn.

Figure 8 shows the average herbage production of all treatments combined within exclosures. Most of the forb production in 1965 consisted of bull thistle in both the game and cattle exclosure. The 1966 and 1967 forb production consisted of different major vegetative components. In the cattle exclosure, 19 percent of the forb production was Canada milkvetch in 1966 while milkvetch made up 18 percent of the forbs in 1967. This species produced 90 percent of the total forb herbage in the game exclosure during 1966 and 45 percent in 1967. This ably points out that Canada milkvetch production is severely limited when not protected from game.

Shrub growth was greater in the game excluded area all years of the study. Growth increments were continuing at a rapid rate, whereas not much increase existed in the cattle pasture. It is hoped that livestock will subdue shrubby growth in the game exclosure to help minimize competition with tree seedlings.

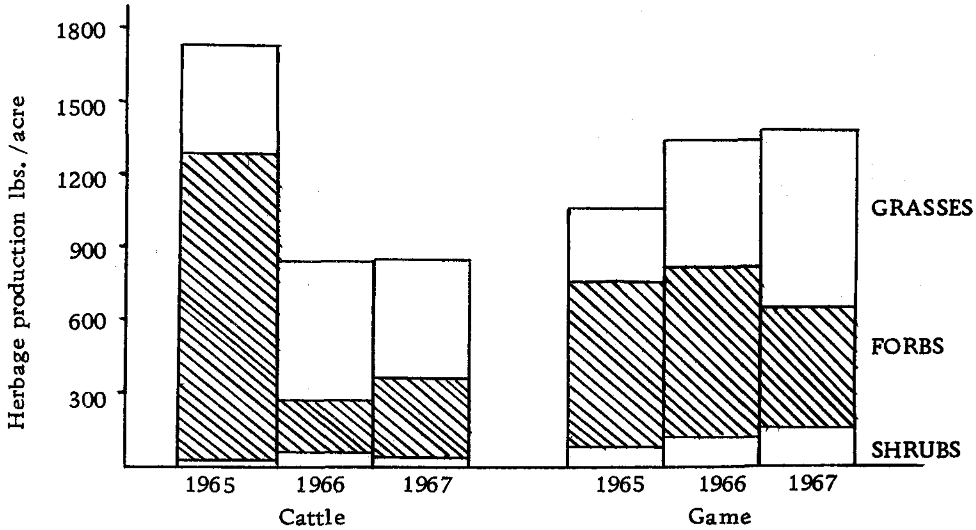

Figure 8. Showing comparisons of the herbage production components between the game and cattle exclosure.

Figure 9 demonstrates that thistle was a high contributor to total herbage production in 1965. In all cases the unseeded area had the highest proportion of its total yield made up of thistle. Blue wildrye, seeded mixture, and mountain brome, in increasing effectiveness, reduced thistle production the most. During 1966 and 1967 thistle production sharply declined in all treatments; however, most was found in the unseeded plots.

The dry summers in 1966 and 1967 along with competition from perennial species had decreased thistle yield considerably. In the future, competition from perennial species should limit thistle yield regardless of moisture conditions.

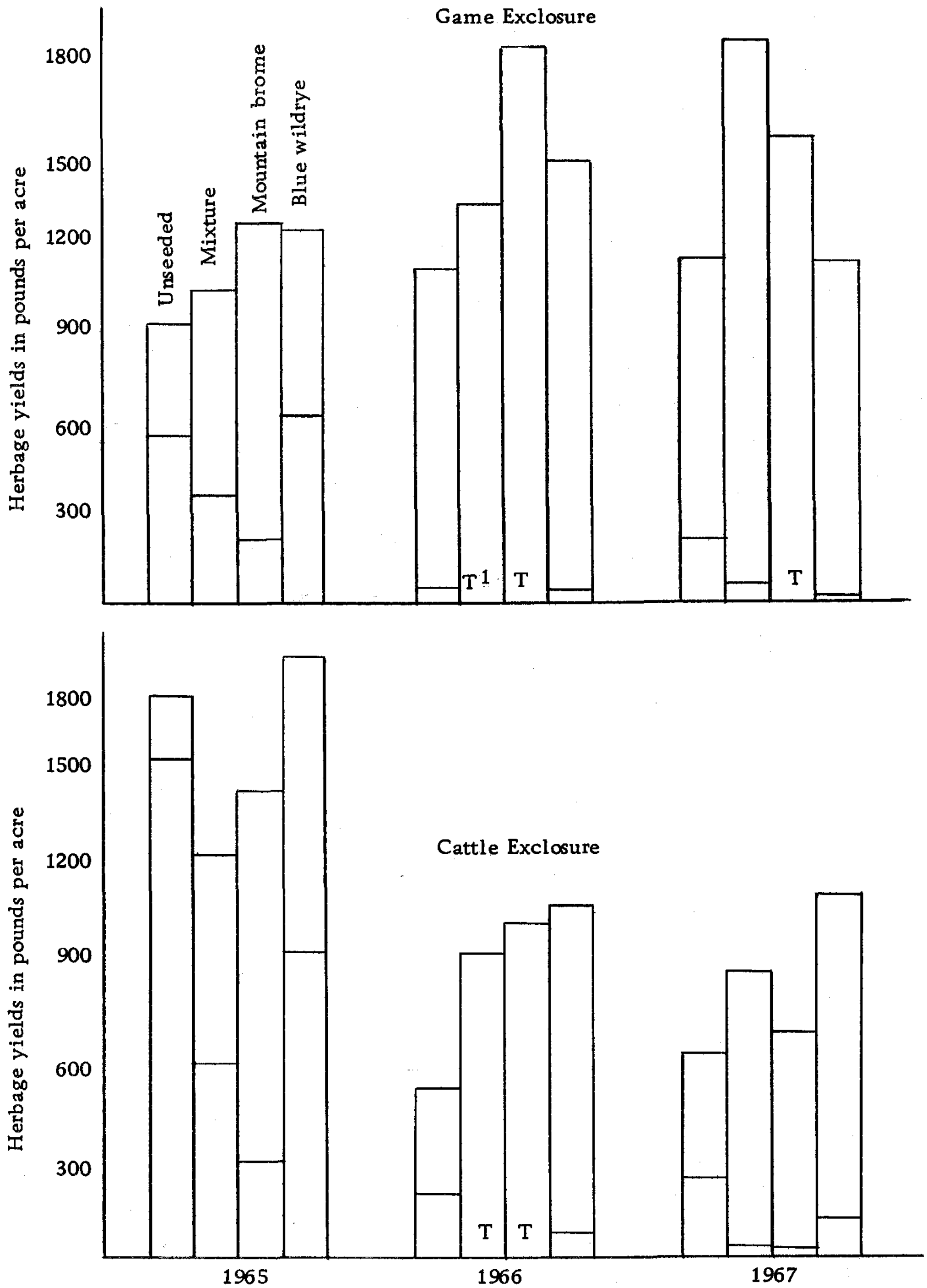

Figure 9. Showing proportion of total herbage yield occupied by bull thistle--lower portion of bars--for cattle exclosure and game excluded area.

[1](T) indicates less than ten pounds of bull thistle production.

Crude Protein Content

A random sample for crude protein was obtained by clipping at approximately two inches above the soil surface many individual plants of the same species. When composited this material gave a complete sample--stem plus leaves--of aboveground plant parts.

Table 3 gives a three-year summary of the crude protein and dry matter contents of 15 species found on the area. Other species analyses were added or deleted from the sampling depending on their relative importance.

Crude protein content of all seeded grass species and Ross sedge decreased in 1966 while pinegrass and slender hairgrass (*Deschampsia elongata*) showed an increase. Canada milkvetch decreased whereas all shrub protein contents increased the second year of sampling. The most important factor causing this decrease in seeded species is the different phenological stage of grasses sampled in 1966. Another possibility is that seeded species are not as well adapted to the site as native species and did not respond to an inherent soil nitrogen deficiency the second year. Early spring maximum temperatures were 11 to 17° F. warmer in 1966. This undoubtedly allowed plants to begin growth earlier than in 1965 and 1967.

Soil moisture content was similar at all sampling dates.

Table 3. Dry matter (DM) and crude protein (CP) content of most important forage species in clearcut-burn.

	1965		1966		1967	
Grass and Grass-like	CP%	DM%	CP%	DM%	CP%	DM%
Stage of development	Flowering		Early seed head		Flowering	
BROMUS MARGINATUS	9.2	44.7	5.0	37.2	7.3	32.2
BROMUS INERMIS	14.0	43.8	4.2	42.9	7.7	34.5
ELYMUS GLAUCUS	7.0	55.2	5.4	44.4	6.3	35.5
DACTYLIS GLOMERATA	10.4	31.1	4.6	36.3	7.8	30.9
ARRHENATHERMUM ELATIUS	8.7	42.4	3.9	44.2	7.7	33.9
PHLEUM PRATENSE	7.8	40.4	3.5	44.1	6.0	34.4
CALAMAGROSTIS RUBESCENS	6.2	63.7	6.2	41.2	6.8	43.2
DESCHAMPSIA ELONGATA	2.6	74.2	4.7	54.2	5.7	41.0
CAREX ROSSII	9.6	44.8	7.4	42.4	8.0	42.2
Forbs						
ASTRAGALUS CANADENSIS	21.4		15.7	27.6	22.4	24.7
CIRSIUM SPP.	-[1]		8.9	17.5	9.7	15.8
Woody						
PHYSOCARPUS MALVACEUS	8.5	40.2	8.5	37.9	10.8	30.6
SYMPHORICARPOS ALBUS	8.6		9.0	39.5	8.6	38.5
SPIRAEA BETULIFOLIA	6.8	51.5	8.3	38.5	6.3	39.2
CEANOTHUS SANGUINEUS	9.8	-	11.2	31.5	14.9	29.1
SALIX SPP.	12.1	-	-		-	
HOLODISCUS DISCOLOR	5.1	-	-		-	
OTHER WOODY	8.7	46.8	-		-	
Others						
Perennials	-	37.6	9.4	34.5	8.1	27.2
Annuals	-	39.5	6.6	30.6	5.7	35.7

[1] No data collected at this time.

Measurements in 1966 and 1967 showed the profile to be near saturation when plant samples were taken. The 1965 samples were collected September 13. Under usual circumstances, vegetation would be mature at this date, but late seed germination and a cool summer made species development slow.

Samples were collected on July 6, 1967, just after the beginning of livestock grazing. Plants were in the flowering stage of development. Results point out that crude protein contents had increased above levels found in 1966. Soil moisture again was plentiful for vegetative growth.

It was clearly evident that the two nitrogen-fixing species, Canada milkvetch and redstem ceanothus, contained more crude protein than all other species. Future sampling of redstem ceanothus will be of special interest as notable crude protein increases were found at yearly intervals. Crude protein changes in this species may be indicative of how much nitrogen is being fixed by it.

Future research is needed to explain some of the soil-vegetation-nutrient interactions. Data collected in this research cannot lead to any conclusive statement concerning plant nutrients.

<u>Seral Vegetative Development</u>

A complex assemblage of species are currently found growing in the clearcut. Tremendous surface soil variability exists in the area due to logging and burning practices. For instance, skid trails, differential slash accumulations, and slope differences are responsible for a wide diversity of ecological niches.

Where the surface soil was not disturbed, species native to the mixed-conifer forest predominated. For example, pinegrass, elk sedge (Carex geyeri), tall trisetum (Trisetum canescens), meadow rue (Thalictrum fendleri), and oniongrass (Melica bulbosa) were restricted to completely undisturbed areas. The vigor of these species; however, increased considerably in the clearcut.

Many of the weedy species were nearly ubiquitous. Cheatgrass brome, littleflower collinsia (Collinsia parviflora), autumn willow-weed, and smooth willow-herb (Epilobium glaberrimum) were found throughout the study area. Their abundance also fluctuated more rapidly than others. Prolific seed bearing and some morphological adaptations for dispersal make these species particularly successful in migrating to open areas for ecesis.

Invasion of weedy species into the clearcut was the rule rather than the exception. Many species formerly found only along roadsides or cultivated fields are not present in the study area. Tarweed (Madia sp.), tumblemustard (Sisymbrium altissimum), soft chess (Bromus mollis), and Bicknell's geranium (Geranium bicknellii) are examples of these. In nearly all instances they were restricted to small colonies in highly disturbed areas. As perennial species "close" the plant communities these plants are eliminated from the clearcut. The geranium best exemplifies this tendency at present.

Most species increased in cover and frequency after clear-cutting and burning. Studies in pine sites of the Blue Mountains show that at least seven years after logging are required for under-story vegetation to reach its original cover (Garrison, 1960). Because of the radical treatments used in this research, a longer period of time will be required for the vegetative understory to reach relative stability. Severity of the disturbance is an important variable when predicting time of vegetative stability. That is, a timber thinning operation does not as severely denude an area as does clear-cutting and burning.

Herbage production in pine sites is decreased immediately following logging. Reynolds (1962), in Arizona, found that maximum sedge, perennial grass, and forb production was reached six years after logging. Current research in a mixed-conifer stand on the Hall ranch where a sanitation-salvage logging was undertaken in 1960 shows that total herbage production was leveling off in 1965 (Young, 1965).

Figure 10 shows the successional sequence of vegetation taken at yearly intervals in the cattle exclosure. Immediately after burning in 1964, no vegetation was standing and a surface cover of ash varying from a trace to more than two inches was present over the

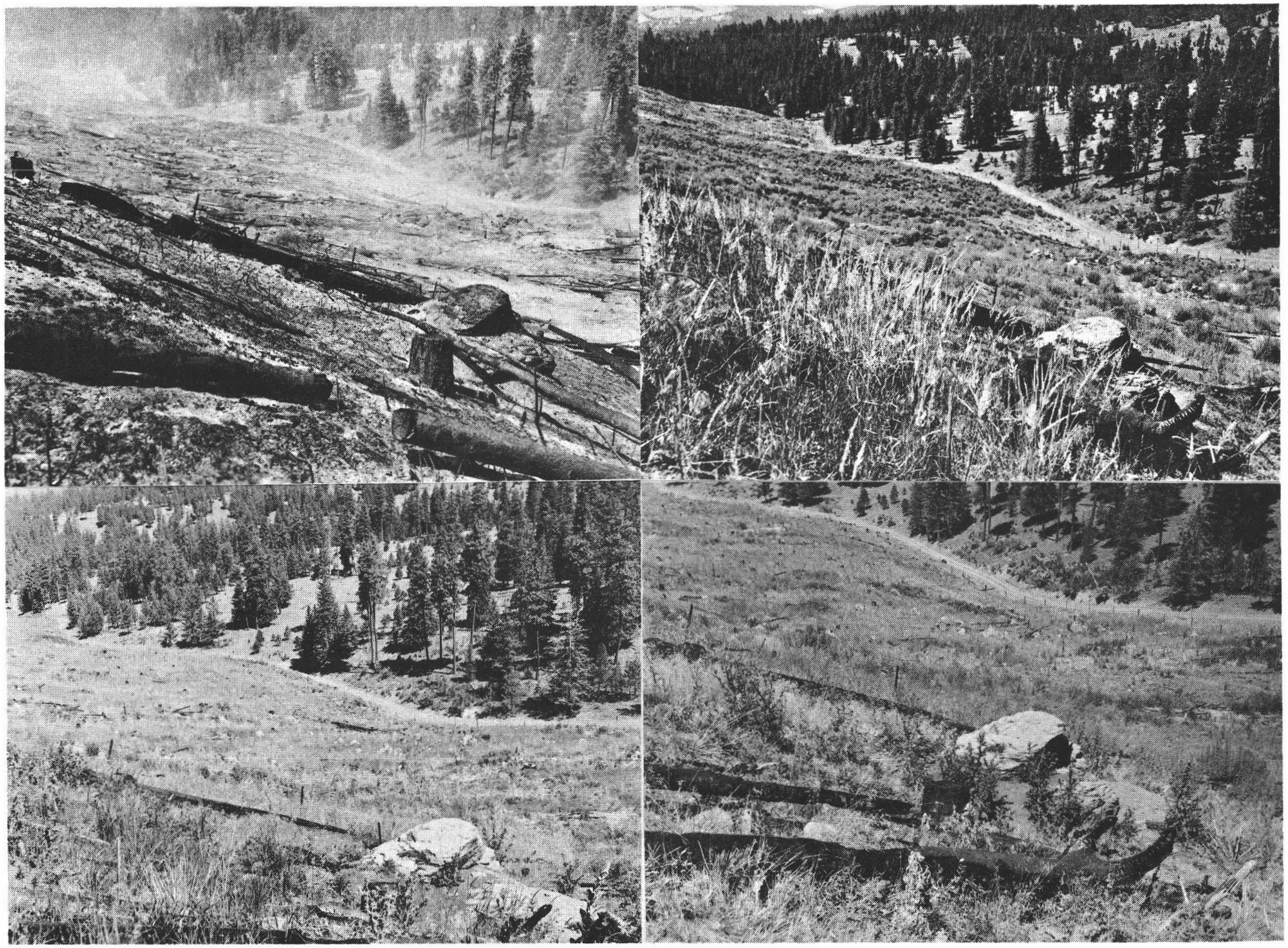

Figure 10. Successional changes in seral vegetation development from 1964 to 1967 showing a completely denuded area following burning to a good stand of vegetation.

area. As can be noted, not all slash was completely burned.

In 1965, vegetative growth became vigorous. Pinegrass, present in the foreground, was robust and produced a good seed crop whereas under a canopy, pinegrass may not flower some years. The bulk of the vegetation in the lower part of the study area was bull thistle. On occasions plants over six-foot tall were observed and in areas of heavy soil disturbance, it became difficult to walk through dense patches of thistle.

A denser cover of vegetation was observed in 1966. Thistle production had decreased considerably. In the foreground pinegrass was not prominent as annual species had moved into the area.

Changes in 1967 were not too visible from this point. In general, vegetative appearances were not too different from 1966, but to the right of the basaltic outcrop, can be noted a large clone of Canadian thistle (Cirsium arvense). This was not present prior to 1967 and could present a problem in clearcuts of this region. While bull thistle is losing dominance in the study area, Canadian thistle is continuously becoming more vigorous. In the future, control measures may be necessary.

A similar successional sequence was observed in the game exclosure (Figure 11). After burning no vegetation was present. It can be noted that all slash was felled in an up-downhill direction to facilitate livestock movement throughout the area.

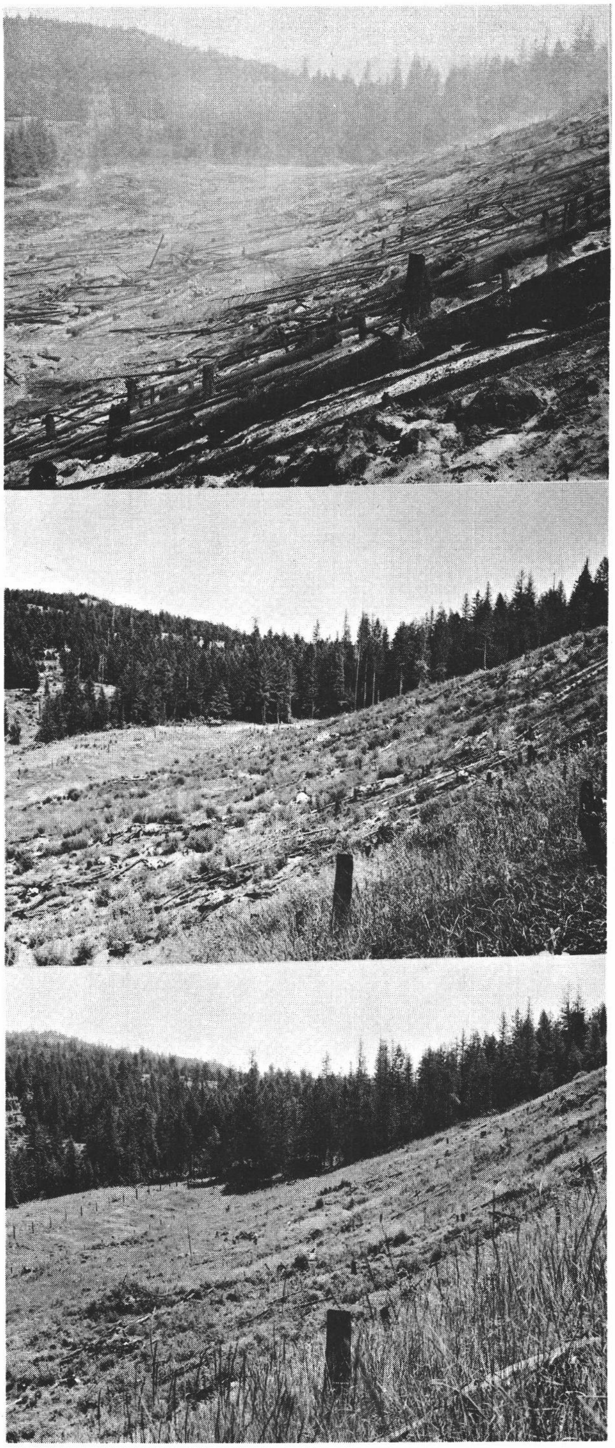

Figure 11. Early successional stages in plant development within the game exclosure from 1964 to 1966.

Foreground vegetation in 1965 shows the blue wildrye seeding treatment. In the background an abundance of bull thistle is evident. The 1966 view shows that thistle has been reduced and other species are becoming more important in the study area.

Autecological Observation of Selected Species

The objectives of this research were not to become involved in autecological evaluation; however, several species were of interest primarily from the standpoint of their nitrogen-fixing ability and/or their palatability to grazing animals. Species considered to be worthy of additional study were Ross sedge, Canada milkvetch, and redstem ceanothus.

Ross Sedge

This species is abundant in the mixed-conifer forest but is of relatively little importance for grazing. Low vigor and inadequate forage for grazing are responsible for this. Elk sedge is more robust and grows in larger clones which makes it a valuable forage species in an uncut stand.

The clearcut-burn has released an abundance of nutrients for immediate plant use. Ross' sedge has responded to this treatment causing a tremendous increase in plant vigor (Figure 12a and b). Most of the Ross sedge in the clearcut has leaves approaching

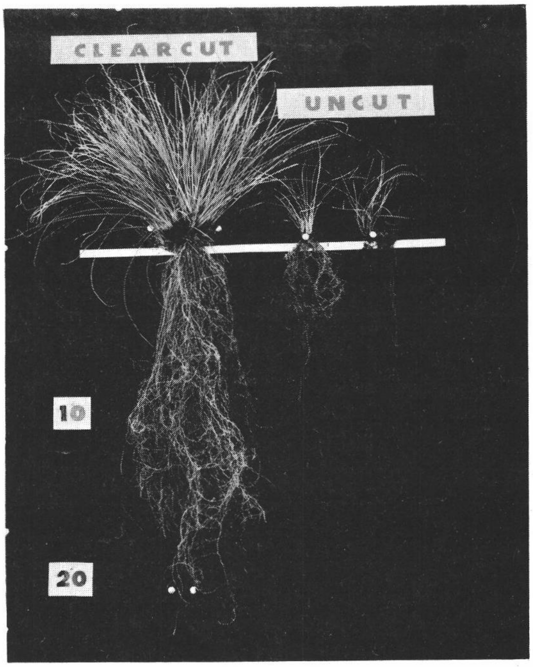

Figure 12a. General view of Ross' sedge root systems taken from clearcut and uncut stand.

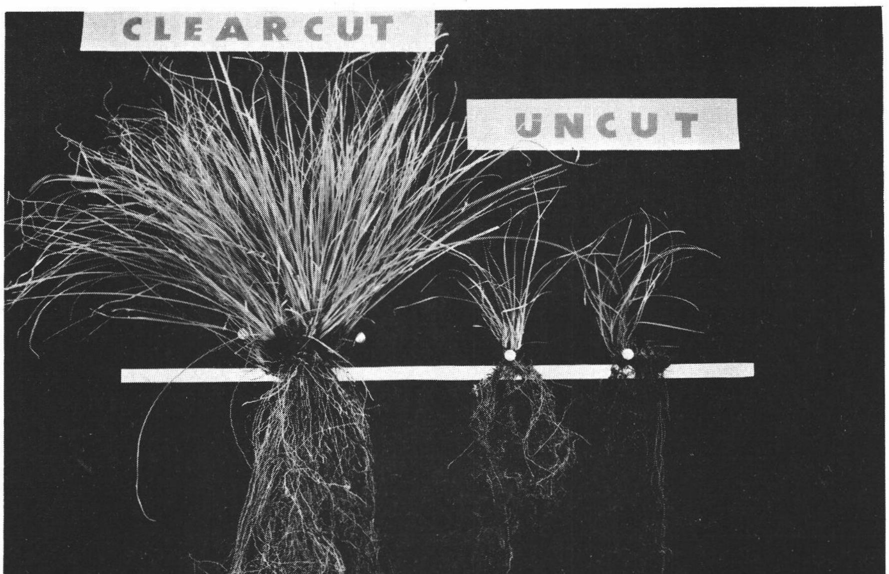

Figure 12b. Close-up of 12a showing increased vigor of Ross' sedge when growing in clearcut.

one-foot in length. It appears as though overgrazing should not severely limit this species as many of the lower leaves are not immediately available to livestock.

A prolific fibrous root system characterizes this species. The specimen taken from the clearcut had roots penetrating horizontally as much as two feet from the culms but rooting depth was not investigated.

Canada Milkvetch

Canada milkvetch is of special interest because of its high palatability, high crude protein content, and its apparent ability to fix nitrogen. Prior to clearcutting and burning, milkvetch was absent from the stand. It is believed that burning is of great importance in the initiation of germination.

Apparently viable seeds of this species were present in the mineral surface soil, but germination did not occur or only occurred infrequently in the absence of fire. Seed coats of this species are very hard and impermeable to water, which without some means of scarification, may lie in the soil for years.

It is postulated that Canada milkvetch was formerly quite abundant in the study area. As plant succession progressed, this species could not tolerate shaded conditions and was eliminated from the community. Current burning research has been initiated in other mixed-conifer stands in order to study early plant recolonization in small-burned plots.

Redstem Ceanothus

This species, although found sparsely in the mixed-conifer forest, has much potential for increasing site quality. Its ability to fix nitrogen has been demonstrated in other areas of Oregon. An abundance of nodules are present on its root systems as well as on milkvetch. Figure 13 shows the partial root systems of redstem ceanothus, Canada milkvetch, and old-dead brush roots taken from a monolith. As can be noted, a congested mass of roots are found where a heavy cover of milkvetch and redstem ceanothus are present.

The white arrows to the right show locations of nodules. Maximum depth of nodules was approximately 27 inches, where their abundance was low. On the other hand, zone of maximum nodule concentration was between six and ten inches--between two top arrows. Figure 14 shows a close-up of the zone of maximum nodule concentration. All nodules appeared to be functional as coloration was excellent.

The role that these two species might play in increasing soil fertility has not been investigated. Research in other areas has indicated that nitrogen-fixing species enhance plant growth and development, particularly on immature soils. Since the Tolo silt

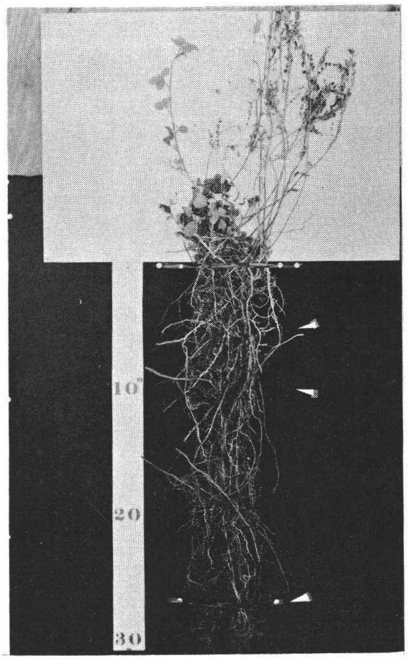

Figure 13. Monolith of redstem ceanothus, Canada milkvetch, and old-dead brush roots showing large mass of roots. Lower arrow indicates location of deepest nodule found.

Figure 14. Area of maximum nodulation on redstem ceanothus and Canada milkvetch between six and ten inches below the soil surface.

loam is inherently low in nitrogen, profitable returns may be gained by managing to keep these two species on this site.

Animal Measurements and Implications

One of the better measures of an area's productivity is to measure total pounds of beef produced per unit area of land. Along with this water consumption, grazing patterns, species preferences, and browsing influences could be determined.

Impact of big game animals and small mammal populations also play an important role in early plant succession.

Yearling Heifer Grazing Study

On July 15, 1966, ten yearling heifers were randomly selected from the replacement heifers on the Hall Ranch. After shrinking overnight, weights were taken and five were assigned to be placed in each cattle exclosure. After grazing the cattle exclosures for 28 days, both groups were combined and placed in the game exclosure. Table 4 shows the bi-monthly and total gains for all heifers for the 42-day grazing trial.

Results show that there is a great deal of variability between individual animals. No reasonable explanation can be given for this variation as all animals were handled similarly. Possibly the amount of forage ingested prior to the overnight shrink period, amount of

Table 4. Initial weights and gains of all heifers grazing clearcut exclosures in 1966 and 1967.

		Initial weight	14-day weight	28-day weight	42-day weight	Total gain
Exclosure #2 1966		698	729	737	758	59
		760	795	798	828	68
		751	768	781	795	44
		702	744	745	778	76
		661	724	726	738	77
	Total	3572	3760	3787	3896	324
	Average	714.4	752	757.4	779.2	64.8±6.5
Exclosure #3 1966		676	706	720	720	44
		679	725	742	740	61
		709	766	760	777	68
		778	809	822	828	50
		730	786	783	790	60
	Total	3572	3792	3827	3855	283
	Average	714.4	758.4	765.4	771	56.6±4.8
Exclosure #2 1967		682	744	754[1]	770	80
		720	766	771	794	74
		670	697	693	730	60
		676	721	728	748	72
		714	781	784	807	93
		710	767	776	806	96
		706	758	756	795	89
	Total	4878	5234	5262	5450	572
	Average	696.9	747.7	751.7	778.6	81.5 ±5.1
Exclosure #3 1967		688	722	737	744	56
		780	816	827	850	70
		792	811	831	854	62
		714	760	765	772	58
		730	764	781	807	.77
		668	707	722	737	69
		605	639	646	664	59
	Total	4977	5219	5309	5428	451
	Average	711	745.6	758.4	775.4	64.4±3.0

[1] This was a 21-day gain rather than 28-day as in 1966 because tree browsing had begun in the cattle exclosures.

fecal-urinal material could have caused this variation.

A total of 607 pounds of animal product was harvested for the 42-day grazing period. Of this total, 470 pounds were obtained from the two cattle exclosures while the remaining 137 pounds of gain came from the game exclosure. The primary reason for this reduction in weight gains can be attributed to the extreme dryness and unpalatability of the available forage in late August. Throughout the grazing period a 1.45 pound per day gain was achieved. This figure is comparable to gains made on the meadows of the Ranch.

In 1967, 14 heifers were selected in a similar manner as in 1966 and were divided into two groups to be placed into the cattle exclosures on June 30. Table 4 shows the beginning weights with seasonal gains. This year 1023 pounds of beef were produced on the 15-acre study area which was a notable increase over the preceding year. Due to the dry conditions, heifers were left in the cattle exclosures for 21 rather than 28 days. At this time some tree seedlings had been browsed. In order to eliminate this it was imperative to move the animals into the game exclosure. Of the total animal product produced, 716 pounds came from the cattle exclosures.

Figure 15 gives an indication of the trend in animal gain comparing both grazing seasons and the three exclosures. This very ably points out that 1967 was a better forage year than 1966.

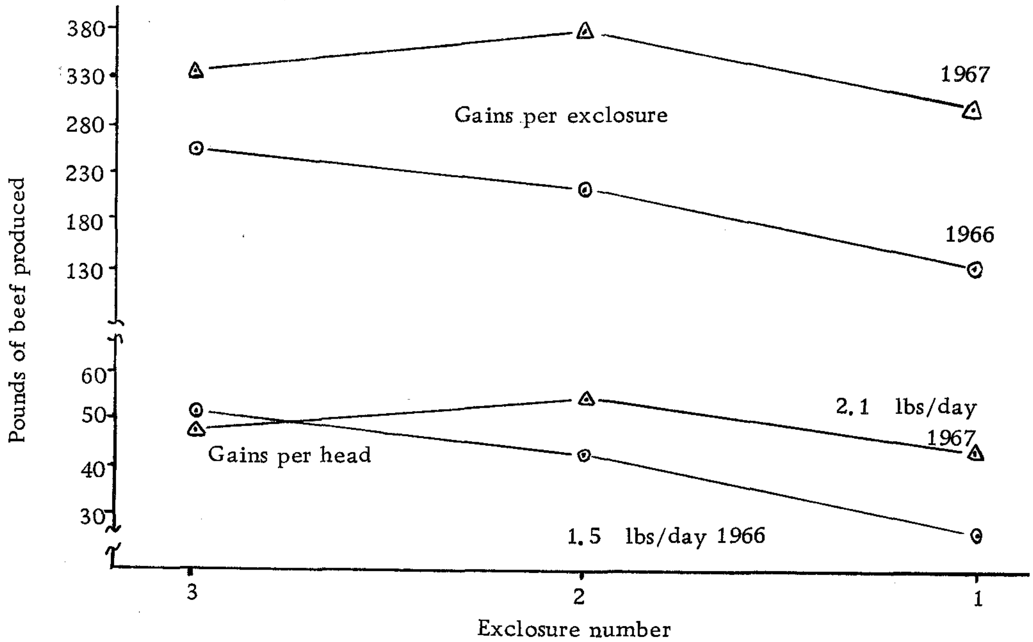

Figure 15. Weight gains by heifers grazing in game--1--and cattle exclosures 2 and 3--for 1966 and 1967.

Patterns of Grazing

Since all slash trees were felled in an up-downhill direction, little restriction to heifer movement throughout the exclosures was noted. It was obvious, particularly in the deer exclosure, that the least grazing occurred on the steep backslope. The footslope and toeslope of the hill where the mixed-grass species were planted was the most attractive to grazing.

No shade was available on the study area, therefore, the heifers often rested and ruminated at the top of the slope throughout the hotter period of the day. Most grazing either occurred before nine in the morning or after five in the afternoon. If a cloud cover was present, the heifers would begin to graze again. Due to air temperatures of over 100° F. on several occasions in 1967, more grazing was restricted to cooler periods of the day than in 1966.

Apparent Animal Preferences

When turned into the study area, no noticeable species preference could be noted. At first the heifers grazed unseeded and mixture plots. Later in the day a few animals were observed eating seed heads of mountain brome. After becoming adjusted to the pastures and forage available, definite preferences were observed.

Ross sedge, throughout the grazing period both years, was the preferred species. Animals were observed selecting almost a complete diet of sedge at times and later would begin grazing seeded species. Figures 16 and 17 show the degree of utilization of Ross sedge before and two weeks after grazing in cattle exclosure two. When the sedge had been utilized to this degree, mixture species were grazed most readily. When sedge plants were partially covered by bull thistle, the animals grazed the sedge in such a manner as to avoid the sharp spines. Orchardgrass was the preferred seeded species.

After the first two-week grazing period in 1967, the top one-third of pinegrass had been utilized. Seldom did the animals graze

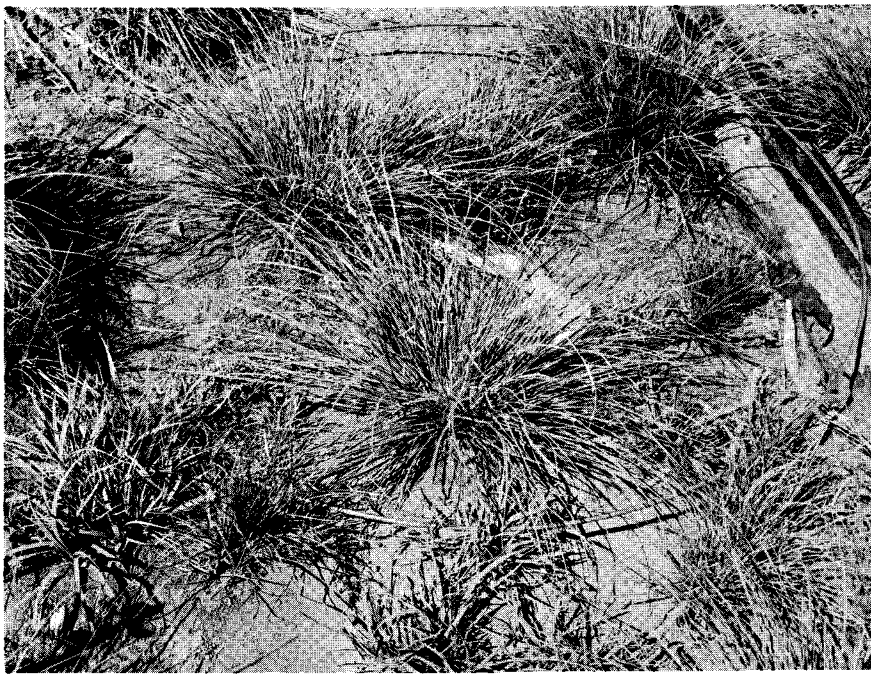

Figure 16. Characteristic growth of Ross' sedge before livestock grazing.

Figure 17. The same plot after two weeks of grazing showing Ross' sedge heavily utilized.

more than one-half of the pinegrass, even when good forage was sparse.

It should be mentioned that preferences as observed in these two years might not have been so obvious if an earlier turn-out date was used. Most seeded grass species were in the early-seed-head stage of development when grazing began. Mountain brome and blue wildrye growing on the steep slope matured rapidly and were unpalatable. Future plans are to graze the area earlier in order to get better forage quality and a more even utilization. Nevertheless, in both years, none of the seeded species were more than moderately--50 percent removed, by weight--utilized. Mountain brome and blue wildrye were just lightly used.

Canada milkvetch provided an abundance of very high quality forage, particularly in the game exclosure. Heavy game use in early spring had removed much of this species prior to livestock grazing in the cattle pastures. Crude protein analysis of this species indicated that it was by far the highest protein source in the area. After seed pods were formed, animals were observed to be eating these.

Very little use was obtained from the remaining forbs. The weedy annuals, cheatgrass and autumn willowweed, present in large quantities, were not grazed. Of course, bull thistle was never or only slightly utilized.

Sparseness of shrub growth in the cattle exclosures, resulting from heavy game use, made this a relatively unimportant component in cattle diets. The tall shrubs, ninebark, oceanspray, snowberry (Symphoricarpos albus), redstem ceanothus and willow (Salix spp.) were severely hedged by elk and deer while birchleaf spirea and rose were not. Snow cover is believed to be the primary reason for lack of browsing on these two species.

In the game exclosure, on the other hand, a profuse growth of shrubs was present. Livestock browsed these to some extent but it appears that the degree of utilization may not control the shrub growth completely. Some willow and ninebark plants are growing beyond the reach of cattle. Utilization of other species should prevent excessive competition among the shrubs, trees, and grass species but only if livestock are carefully controlled and manipulated.

Perhaps the "ice-cream" woody species in the study area is blue elderberry (Sambucus cerulea). This species has practically been eliminated from the cattle exclosures and is receiving excessive use from cattle in the game exclosure. As can be noted in Figure 18 growth is very vigorous prior to grazing. However, after two weeks the same plant appears as in Figure 19. Branches of over one-half inch in diameter have been browsed. The only remaining leaves are those above reach of the cattle. Eventually this severe browsing may weaken and kill the plants.

During 1966 very little browsing of the tree plantations could be

Figure 18. Blue elderberry, the woody species preferred by livestock before grazing in 1967.

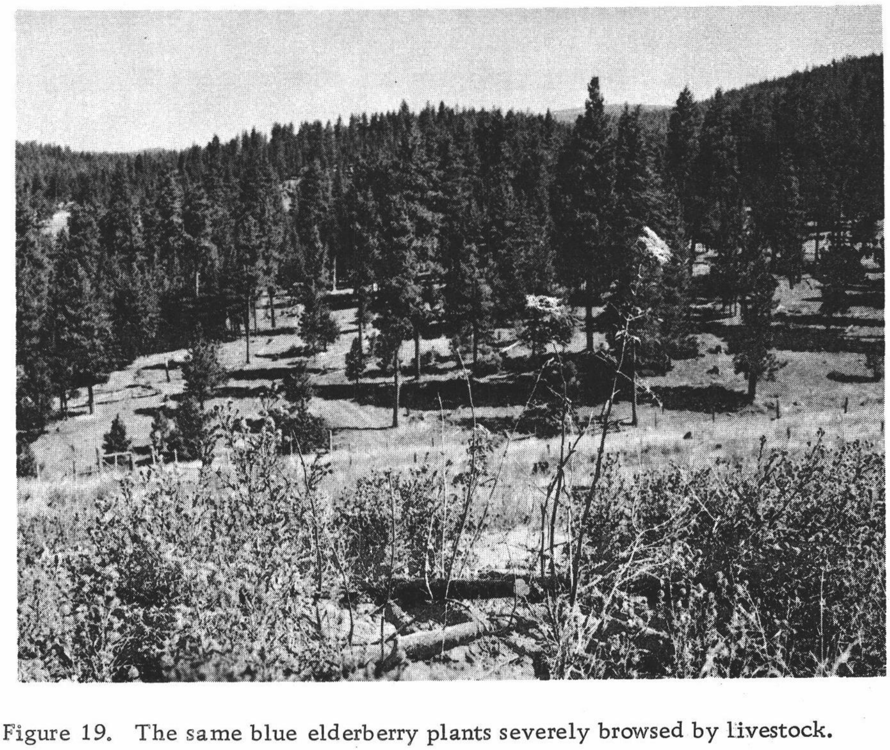

Figure 19. The same blue elderberry plants severely browsed by livestock.

attributed to livestock. Only two out of 1347 trees had been killed by cattle browsing. Fourteen tree fatalities resulted from trampling effects which were more severe in the game exclosure than cattle exclosures. A steeper slope, heavier livestock concentration, plus a very dry surface soil in August all contributed to the trampling damage in the game exclosure.

Heifer Water Consumption in 1966

Water intake measurements revealed that no significant difference in water consumption occurred throughout the 42-day grazing period. The five heifers drank 7.1 and 6.7 gallons per day while grazing in exclosures two and three, respectively. When combined and placed in the game exclosure, water consumption rose to 7.4 gallons per day. This increase in consumption could be attributed to an increased dryness of forage. Maximum air temperatures were similar throughout the period. Figure 20 shows water consumption by exclosure being grazed for 1966 and 1967. Appendix D includes detailed figures on the variability in water consumption and the time readings were taken for both years of the study. For the entire grazing period, approximately 2983 gallons of water were drunk by ten heifers. When calculated on a per head per day basis, each heifer consumed an average of 7.1 gallons per day which approximates one gallon of intake per 100 pounds of body weight.

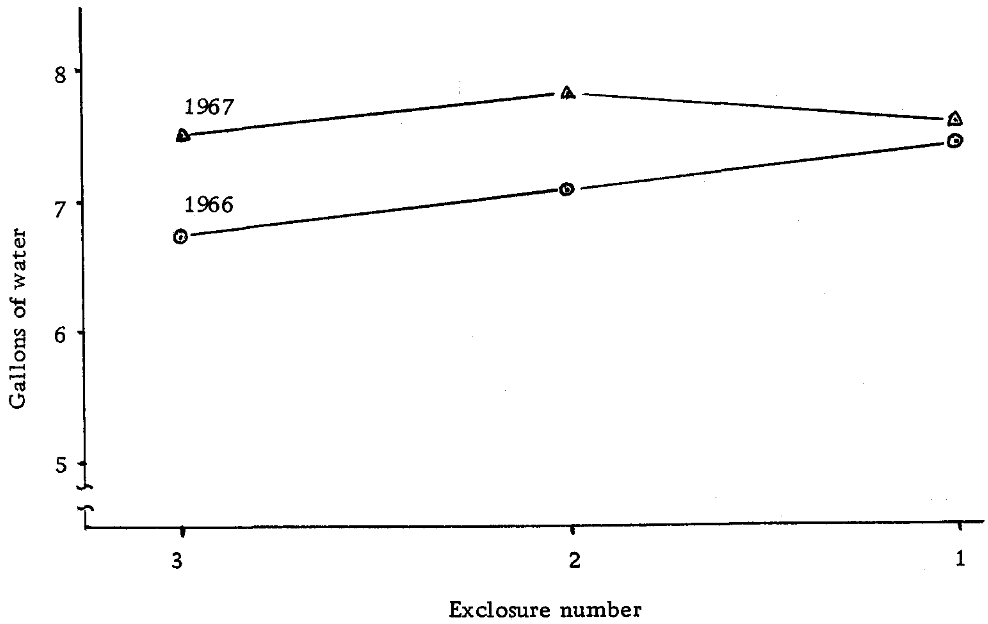

Figure 20. Average daily water consumption by heifers for two years of study in game--1--and cattle exclosures.

Heifer Water Consumption in 1967

Throughout the 35-day grazing period, approximately 3743 gallons of water were consumed by 14 yearling heifers. Air temperatures were somewhat higher this year than in 1966 but the forage moisture content was similar. Average daily consumption per heifer per day increased to 7.6 gallons. Perhaps a higher evaporative ability of the air caused some of the increase over 1966, but it is believed that consumption was higher due to the increased air temperatures.

Other Mammal Influences

It is difficult to evaluate the effects of use on these lands by non-domesticated mammals. Man normally has limited influences on rodent and big game use in an area unless specific control measures are undertaken. The purpose of this research was not to obtain detailed measurements of these mammals and their influences, but to include observations on their role in modifying plant succession.

Deer and Elk Use

The Hall Ranch provides a home range for resident deer populations. Numbers and effects of mule deer (Odocoileus hemionus Raf.) have not been evaluated or assessed for this area of the Wallowa Mountains. Estimates could be made based on hunter success ratios but these are often quite inaccurate. Fluctuations in food supply and other factors make a precise survey difficult using present methodology.

Rocky Mountain elk (Cervus canadensis Erx.) numbers are even more difficult to measure than deer as the annual migration varies considerably. Snowfall accumulation is the primary factor controlling date and rate of down-elevation migration. The Hall Ranch supports an elk population part of the winter and early spring; however, only casual observations have been used to estimate numbers of elk using forage on the Ranch.

The clearcut-burn has provided an ideal forage supply for big game. An abundance of shrubby regrowth and forbs plus the plantation of tree seedlings makes the clearcut a haven for game concentrations.

A pellet group counting technique was used to evaluate relative game use on the experimental area. This method is used quite extensively in the West in spite of its inadequacies. Some of the major difficulties are: (1) rate of defecation by game animals on different forage types, (2) aging of pellet groups, (3) similarity between young elk and adult deer fecal deposits, and (4) difficulty of identifying a single pellet group. Ability and experience of the personnel doing the sampling is of utmost importance in this type of work.

On April 21, 1966, counts of elk and deer pellet groups were made on 13, 1/200-acre permanent belt transects in cattle exclosure two. After recording the groups, all pellets were removed from the plot. This enabled us to obtain future counts without old pellet groups accumulating on the plots. On an undisturbed pine site adjacent to the clearcut, 15 plots of similar size were analyzed as on the clearcut to get comparative figures of game use.

Table 5 shows the number of pellet groups observed on the clearcut in April, 1966, and May, 1967. Also values are given for the undisturbed pine site. These results clearly point out that deer

Table 5. Numbers of elk and deer pellet groups found in 1/200-acre belt transects located in clearcut and adjacent pine site.

	Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Clearcut	Deer	5	6	3	9	8	2	3	12	15	8	9	5	6		
1966	Elk	1	0	2	1	1	0	0	1	1	2	1	0	2		
Clearcut	Deer	1	0	0	0	3	2	1	2	0	0	3	0	0		
1967	Elk	1	0	0	1	2	0	1	0	0	0	0	0	1		
Adjacent Pine Stand	Deer	0	0	1	1	2	2	3	1	2	6	1	1	3	3	2
	Elk	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0

are the major game animals using the study area. Using 12.7 pellet groups per day as a normal defecation rate, 110 deer days per acre was attributed to deer on the clearcut-burn. On the other hand, only 29 deer days per acre were found on the adjacent pine site. Similarly, 12 percent of the pellet groups on the clearcut were left by elk compared with ten percent on the pine site. The May, 1967 results on the clearcut showed only 16 deer days per acre use. As can be noted, this is approximately a seven-fold decrease in deer use. This finding is questionable as one would not normally expect such a large reduction in deer use. Possible explanations for this decrease are: (1) extremely concentrated game use during the winter of 1965 reduced the amount of shrubby growth, thus making the area less attractive for future use; (2) since there is difficulty in telling age of pellet groups, the 1966 sampling may have been an accumulation of two years use; and (3) possibly lower game numbers were present in the area because of a general lack of feed on all the foothill range. It is believed that a combination of these factors and not differences in snow cover have contributed to this reduction in game use.

Figure 21 three-dimensionally represents the cover, frequency, and height growth of the three most important browse species on the clearcut. Superimposed within the larger blocks--game exclosure--are quantities of shrubs found in the cattle exclosure. This

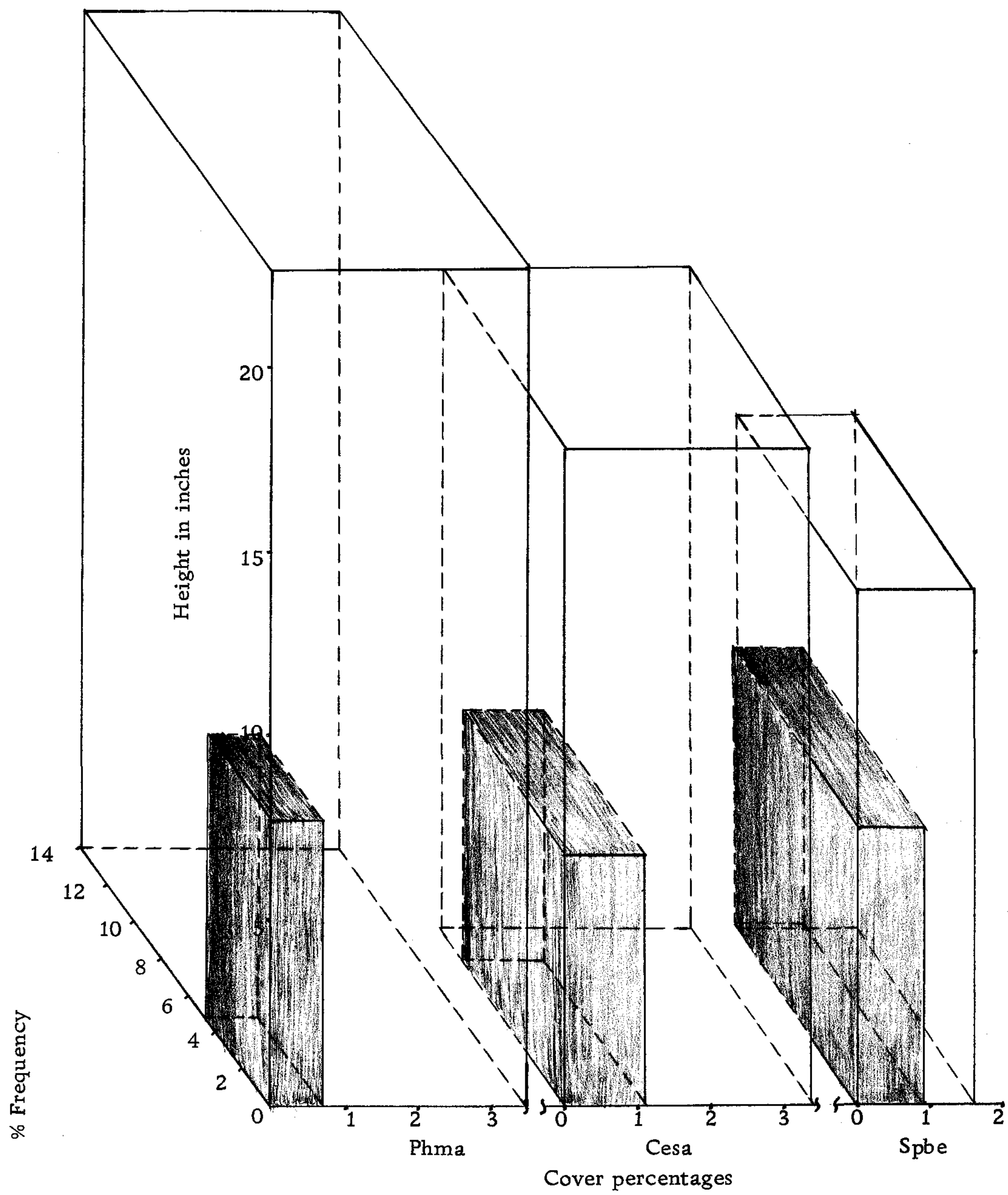

Figure 21. Relative importance of ninebark (Phma), redstem ceanothus (Cesa), and birchleaf spirea (Spbe) in game and cattle--shaded--exclosures.

information shows the differential production of shrubs when game animals are excluded from browsing an area. Frequency of redstem ceanothus and birchleaf spirea was similar in both the game and cattle exclosure, while ninebark frequency was considerably less in the cattle exclosure. However, cover and height values in all cases point out the differential effects of game versus no game use. Interactions concerning competition of shrubs with tree species are likely to be present, but at this stage, evaluation is difficult.

Observations of Small Mammal and Bird Effects

It is evident that deer and elk had the greatest influence on vegetational development in the study area. However, rodents such as the Columbian ground squirrel (*Citellus columbianus* Ord) and yellow-pine chipmunk (*Eutamias amoenus* J. A. Allen) caused only isolated vegetation effects. Porcupines (*Erethizon dorsatum* L.) and rabbits (*Lepus* sp.) were observed to be only of minor importance in their effects on vegetation. Overall, the most destructive small mammal was the badger (*Taxidea taxus* Schreber). Numerous badgers were observed throughout the study period to have a pronounced destructive effect on vegetation.

Ground squirrels are commonly attracted to highly disturbed areas in northeastern Oregon and consume a great deal of vegetation. The forb preferred by these herbivores was probably miner's lettuce which was heavily used. Young succulent blades of grass were also readily eaten by the ground squirrel. When the permanent belt transects used in the vegetation analysis passed over a rodent-grazed area, it was difficult to identify plant species since grasses were eaten to the ground level and all forbs were normally absent.

Badgers, being carnivorous, were attracted to the clearcut by the high population of ground squirrels. While digging in the loose ash soil, they uprooted or buried large areas of vegetation. As the ground squirrel population decreases, badgers should become less plentiful, but they still have a noticeable effect on plant succession.

One of the minor influences on the vegetation is the chipmunk. These mammals, being primarily seed eaters, might play an important role in succession on unseeded plots if their seed caches would germinate.

The effect of birds on the rate of plant succession can be assessed only from an observational point of view. Due to the abundance of bull thistle seed production in 1965, a large population of pine siskin (Spinus pinus Wil.) fed on the study area for a considerable period. It is believed that this effect was of only minimal importance.

Environmental Measurements

Environmental measures have been made in an attempt to evaluate the changes when an area has been clearcut. It was not possible to get precise measurements of soil and air temperatures, solar radiation, and soil moisture trends as instrumentation was insufficient in number to detect variability in the existing extremely heterogeneous conditions. In all cases, areas which represented relatively undisturbed conditions were used; therefore, only generalizations can be made about environmental measures reported in this study.

Soil Temperatures

A very noticeable difference was observed between soil temperature readings at a two-inch depth in the clearcut and adjacent uncut forest (Figure 22). Clearcut readings were based on an average of four thermometer readings whereas uncut forest soil temperature readings represent a mean of two sensors.

In all cases, soil temperatures were higher in the clearcut than in an uncut stand. A 2.4°C. difference was the least observed between the two areas on August 15, 1966, while the maximum differential temperature was 6.4°C on July 4. Similar data were collected in 1967, but the maximum difference was not as pronounced. Weekly readings of each thermometer are shown in Appendix H.

These data clearly show that the surface soil microclimate has been altered by clearcutting the area. The effect that this has on microfaunal action is unknown; however, it can be assumed that alterations have taken place. Perhaps of greater importance than direct temperature effects is the influence on surface soil evaporation. There may be a larger vapor loss of water from the clearcut soil surface or, on the contrary, a mulching effect in the clearcut would actually conserve vapor loss.

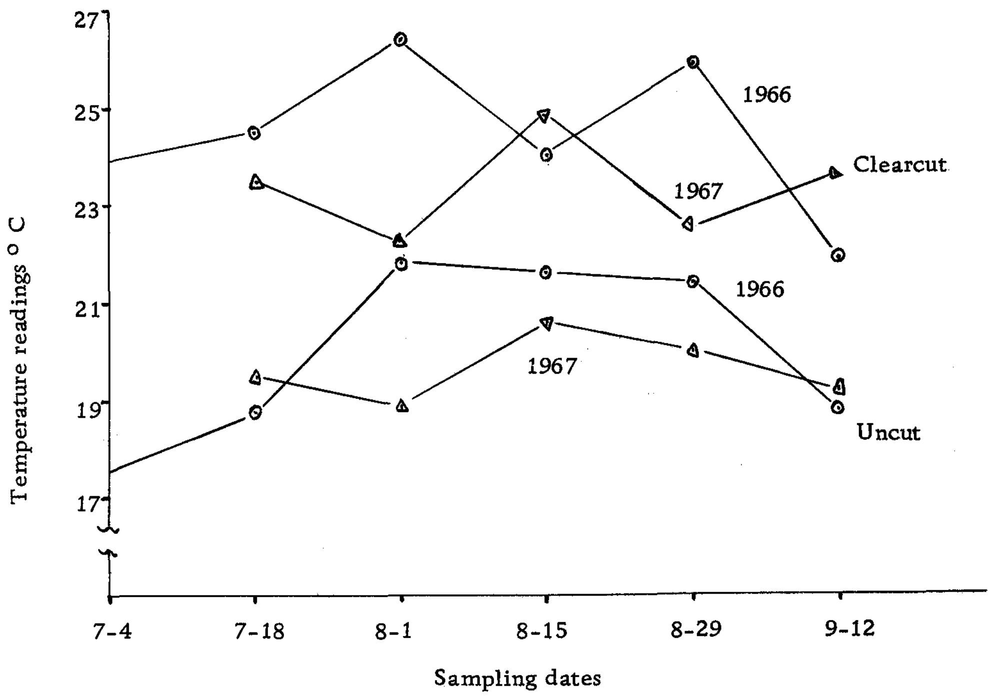

Figure 22. Soil temperatures recorded at approximately two inches below the soil surface.

There apparently are two reasons for having a cooler surface soil in the uncut than in the clearcut stand. These are: (1) less solar radiation has penetrated the canopy, thus reducing the heat load in the soil; and (2) the insulating effect of litter on the forest floor which prevented a comparable rise in the soil temperature. The former explanation is believed to be of major importance.

Air Temperatures

Air temperatures were recorded at two locations and heights above the soil surface in the clearcut and uncut forest only during 1967. Figure 23 shows the average maximum and minimum temperature for each weekly interval at the three-foot height. Results clearly point out that higher maximum temperatures consistently occur in the clearcut. The largest differential maximum temperature between the clearcut and uncut occurred the week prior to June 19 when a 5.6°C difference was measured. On two other occasions a 5.0°C difference was found.

The minimum temperature response at three-foot showed no marked difference between areas. Reradiation from the clearcut was greater than in the uncut forest but herbaceous vegetation must have restricted this loss so that minimum temperatures remained about equal.

Table 6 lists the maximum and minimum temperatures in both areas and also shows the temperature differential between the three-foot and one-foot level. Some interesting relationships can be seen here. On nearly all occasions the highest maximum temperature in the forest was recorded at the one-foot level. Lowest maximum readings, on the other hand occurred at three-foot above the soil surface. In the clearcut the highest maximum temperature occurred at the three-foot level until the middle of July. After this time maximum highs were recorded one-foot above the soil. Except on September 11, the coldest temperatures in the clearcut occurred at the one-foot level. This minimum temperature differential between the one- and three-foot level was 4.2°C on July 3.

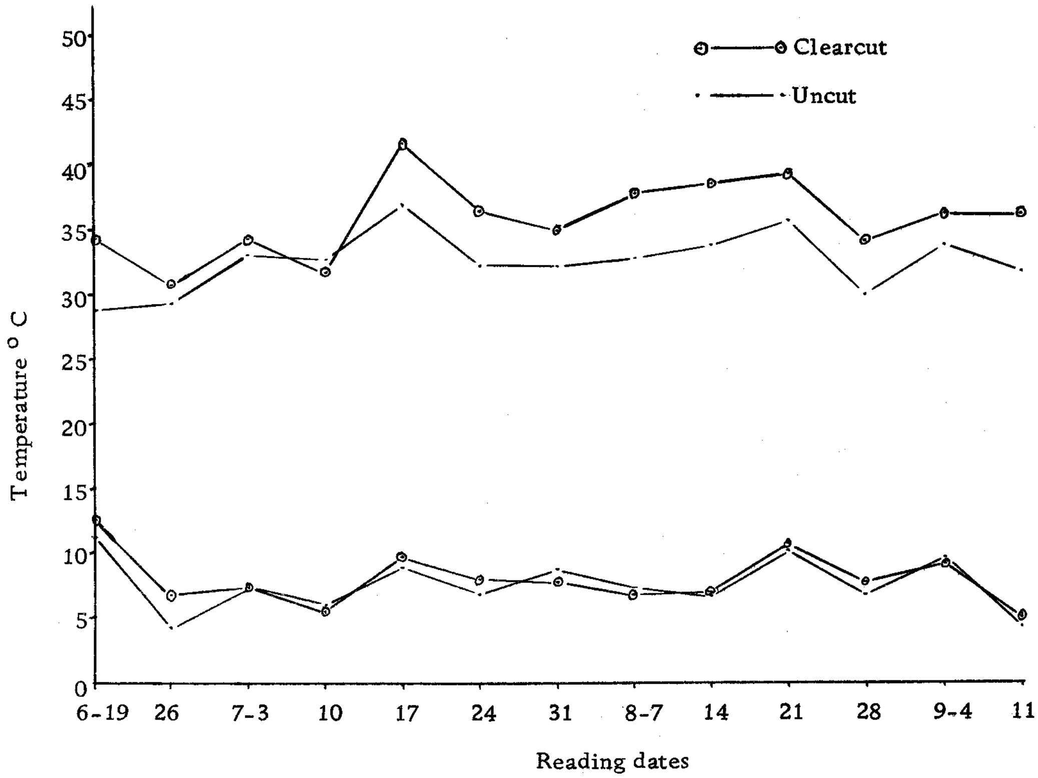

Figure 23. Maximum and minimum air temperatures at three-foot above the soil surface in clearcut and uncut stand.

Table 6. Maximum and minimum temperatures (°C.) taken at three-foot (top) and one-foot (bot.) above the soil surface in forest and clearcut. The differential (diff.) is obtained by subtracting the bottom from the top reading.

	Maximum						Minimum					
	Forest			Clearcut			Forest			Clearcut		
	Top	Bot.	Diff.	Top	Bot.	Diff.	Top	Bot.	Diff.	Top	Bot.	Diff.
June 19	28.9	30.0	-1.1	34.4	33.0	+1.4	11.4	12.2	-.8	12.5	10.6	+1.9
26	29.4	31.7	-2.3	30.6	29.4	+1.2	4.1	6.1	-2.0	4.1	3.3	+ .8
July 3	33.0	33.9	- .9	33.9	33.3	+ .6	7.5	6.1	+1.4	7.5	3.3	+4.2
10	32.5	30.0	+2.5	31.7	32.2	- .5	5.8	7.5	-1.7	5.3	3.0	+2.3
17	36.7	37.8	-1.1	41.7	39.4	+2.3	8.9	10.8	-1.9	9.7	4.4	+5.3
24	32.2	33.0	- .8	36.1	36.9	- .3	6.7	8.6	-1.9	7.5	9.4	+3.1
31	32.2	32.8	- .6	35.0	36.4	-1.4	8.9	10.6	-1.7	7.8	5.8	+2.0
Aug. 7	32.8	33.3	- .5	37.8	38.6	- .8	7.2	8.9	-1.7	6.9	6.1	+ .8
14	34.1	34.4	- .3	38.6	39.7	-1.1	6.7	8.3	-1.6	6.9	4.4	+2.5
21	35.6	36.7	-1.1	39.7	40.6	- .9	11.1	12.5	-1.4	11.7	10.8	+ .9
28	30.3	31.9	-1.6	34.1	35.0	- .9	6.9	8.3	-1.4	7.2	4.7	+2.5
Sept. 4	34.1	35.3	-1.2	39.1	38.9	+ .2	9.7	11.1	-1.4	9.4	7.5	+1.9
11	31.9	33.6	-1.7	36.1	36.9	- .8	4.4	5.3	- .9	5.0	5.8	- .8

Interpretations of what has caused these responses are not immediately clear. It is believed, however, that level of maximum energy exchange between atmosphere and soil are different in both cases. That is, this maximum energy exchange level occurs on the soil surface under the forest canopy, but is found above the layer of herbaceous vegetation in the clearcut. As the vegetation became drier in the clearcut, the level of maximum solar energy exchange shifted to the soil surface. The cooling effect of transpiring vegetation has also probably caused some apparent anomalies in these data.

Soil Moisture

Since two different methods have been used to measure soil moisture, each will be described separately. In 1966, the gravimetric method was used while resistance blocks were used in 1967.

Throughout the summer of 1966, a noticeable decrease in soil moisture in the clearcut and uncut stand was measured (Figure 24). In early June the clearcut profile was nearly saturated while the soil in the forest was quite dry at an early date in the growing season. The reason for this early season differential was the lack of winter precipitation to adequately saturate the soil (Figure 4). Low canopy interception of precipitation by vegetation enabled the forest soil to become recharged in the clearcut.

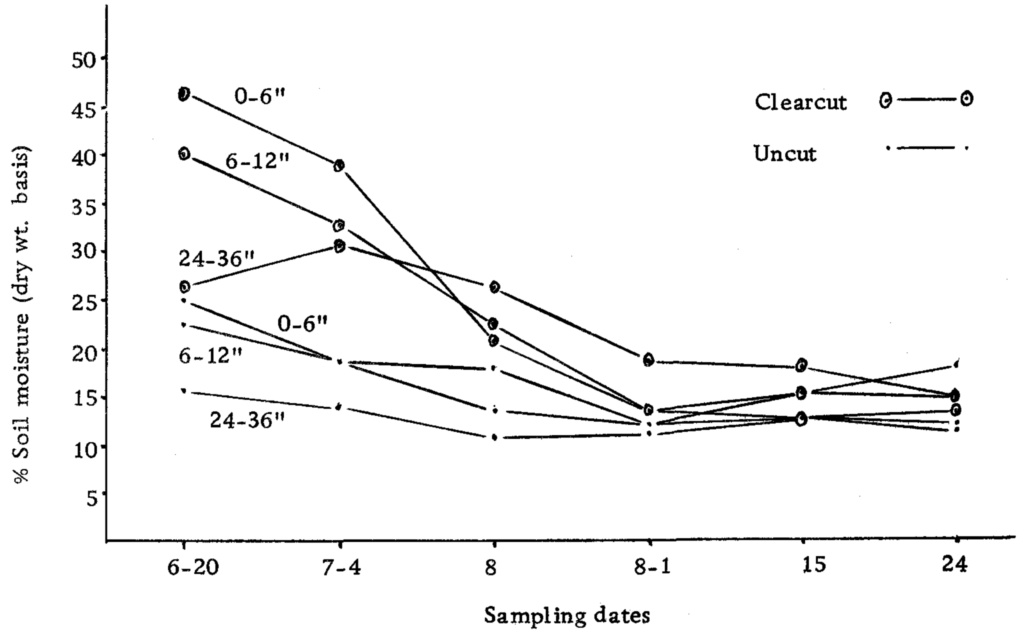

Figure 24. Soil moisture trends in study area throughout 1966.

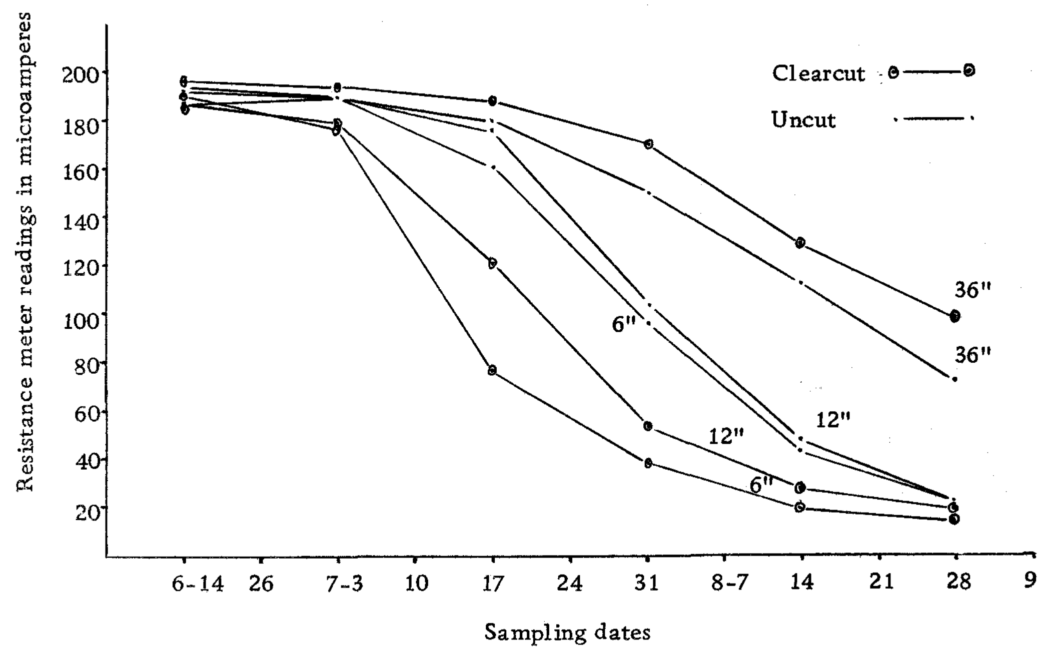

Figure 25. Soil moisture trends in clearcut and uncut forest throughout 1967 using resistance blocks.

However, as the growing season progressed, the soil moisture supply was drawn from both areas. In late August there was little difference in soil moisture between the clearcut and uncut stand at all depths sampled. This clearly points out that much more soil water was removed by the clearcut vegetation than by forest vegetation. Permanent wilting points were not determined, but it appeared that the soil was very near this point in August.

The apparent increase in soil moisture at the 24 to 36-inch depth between June 20 and July 4 on the clearcut has to be a sampling error. Since no rainfall was received, it would be impossible to have this increase in soil moisture content.

From November, 1966, until February 1, 1967, 12.4 inches of precipitation were recorded on an area 200 yards from the study area. This amply saturated both the clearcut and uncut forest soil profiles. Figure 25 shows the soil moisture trends in both uncut and clearcut area for 1967. On June 19, all depths gave a high reading on the resistance meter. This would correspond to approximately 50 percent soil moisture.

Throughout July a steep downward trend in soil moisture was noted, particularly at six and 12-inch levels. Near the end of August, only the 36-inch level had any appreciable soil moisture supply remaining.

It is quite clear that the surface one-foot of soil dries more readily due to the heavy herbaceous stand in the clearcut than in the forest. On the other hand, the clearcut profile was more moist at 36 inches than was the forested soil. These results point out that grass and herbaceous vegetation in the clearcut are primarily surface moisture users while shrubby growth in the forest uses more subsoil moisture.

No corrections for soil temperature changes have been made in the resistance meter readings as this accuracy was not deemed necessary. Also, no curve has been constructed to convert resistance readings into soil moisture content percentages. Roughly, however, 20 microamperes would correspond to 13 percent soil moisture which is near the permanent wilting point.

These results substantiate the findings of Hallin (1967) who found similar soil moisture statuses in soils beneath a cut-over and adjacent uncut Douglas-fir stand in southwest Oregon. The abundance of herbaceous vegetation in the cut-over stand was concluded to require as much soil moisture as old growth trees.

Solar Radiation

Results show that differential energy loads reached the radiometers placed in the clearcut and uncut forest. Figure 26 shows that incoming radiation exceeded reflected radiation in the clearcut at 7:30 A.M. This continued until 5:45 P.M. when more heat was lost from the system than was received. In the forest, incoming radiation exceeded outgoing from 11 A. M. to approximately 2:15 P. M.

These results are not too meaningful from a quantitative standpoint as no conversions to calories per square centimeter have been established. Qualitatively speaking, it can be observed that the canopy modifies and reduces the amount of energy reaching the soil surface. This would play an important role in soil moisture evaporation, plant transpiration rates, and snowmelt.

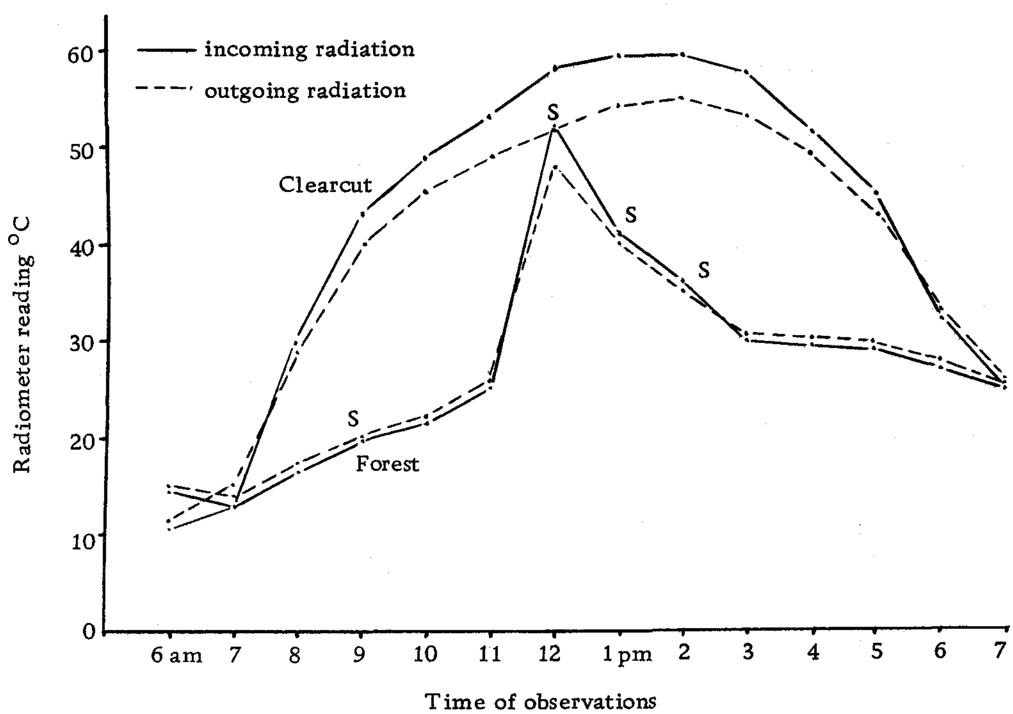

Figure 26. Incoming and outgoing solar radiation reaching the forest and clearcut radiometers. (s) indicates radiometer is in direct sunlight.

Snow Accumulation

In the absence of snow gauges all results in this study are observational. More total snow appeared to reach the soil surface in the clearcut than under the uncut forest. Canopy interception explains this. In the clearcut little drifting occurred, although more snow accumulated in the game exclosure which was closer to the uncut stand than cattle excluded areas.

Although less snow reached the forest floor, it remained longer in the spring than snow on the clearcut. Approximately a two week delay in melting was noted in the uncut stand.

Because snow remained in the game exclosure longer than in the cattle exclosures, plant growth was delayed in the spring. Although this appeared to have no effect on grazing results, it is believed that vegetation data were affected. Annuals, in particular, germinated and began growth earlier in the cattle exclosures.

Soil profile moisture replenishment within the clearcut and uncut forest did not appear to be affected by snow accumulation. Total winter moisture was adequate to saturate the soil except during the winter of 1967. Soil in the clearcut is supersaturated in early spring as indicated by free water that can be squeezed from the soil.

Soil Profile Characteristics

A wide range of variants and phases are included within the central concept of the Tolo silt loam soil. To be called Tolo, the soil must be over 20 inches deep and have properties which make it a distinct soil series.

A three-inch auger was used to determine soil depth variability in this study. Shallow phases of the soil were found on the upper part of the steep backslope. In the clearcut, typical backslope soil depth averaged 37 inches. The range, however, was from 22 to 43 inches.

In the footslope area a deeper soil was present. Forty-seven inches was the average soil depth found at 12 locations. This figure is conservative as the auger was placed to over 60 inches on three occasions without contacting any obstacle.

Appendix F gives the description of the profile viewed in Figure 2. X-ray diffraction research should be conducted to see if the material below 18 inches is actually a lithologic discontinuity. Some former surveys indicated that buried soil exists in this area. Since it is believed that the ash resulted from aeolian deposits mineralogically different than the underlying material, a lithologic discontinuity would be the correct description.

Cherty-basalt fragments varying from 1/4-inch to over two inches in diameter are present throughout the Tolo soil profile in the study area. These fragments are not too evident when excavating pits, but monolith washing revealed an abundance of these. Origin of these is not clear. Colluvial movement of the aeolian deposited ash might be a satisfactory explanation, but fragments are sharp which indicates that little movement has taken place. Further work concerning origin and mode of transport of the ash must be conducted before conclusions are drawn.

Within the soil profile, pockets of heterogeneous material are present. These appear ashy but colors vary as much as two hues from the surrounding soil. Some factor other than rodent burrowing activities is believed to be responsible for this source of variation.

Chemical Analyses

Results of soil chemical analyses on samples taken near the center of each horizon as described in Appendix are included in Table 7.

Soil chemical analyses as such do not enable one to evaluate site productivity. Colloidal clay, pH, soil water, and microbial interactions are often so intricately complex that these data are of little value. Basically then, available soil nutrient statuses are not a stable entity, and must be tested by plant growth in the greenhouse and field. An estimation of the general fertility of the site can

Table 7. The standard elemental analyses of all horizons of the Tolo silt loam soil.

Horizon	P ppm	K me/100 g	Ca me/100 g	Mg me/100 g	pH
AI 0-9"	107.6	1.88	13.1	2.3	6.5
C 9-18"	45.1	2.00	11.8	3.8	6.6
IIB, 18-28"	16.0	1.79	12.3	4.6	6.5
IIC, 28-41"	17.5	1.65	9.4	4.8	6.4
84"[1]	10.2	0.96	11.4	7.9	-

[1] An auger was used to obtain this sample from between large boulders at the bottom of the soil pit.

be determined by soil chemical analyses, however.

Results given in Table 7 show that the four basic mineral nutrients are available in quantities adequate for plant growth. Tisdale and Nelson (1966) mentioned that generally never more than a few parts per million (ppm) and frequently less than one ppm of phosphorus ions in soil are available for plant use. The Tolo silt loam apparently has adequate phosphorus for plant growth.

Thompson (1957) reported that typical Prairie soils contain 0.2 to 0.3 millequivalents (me) of potassium per 100 g of soil. Again the study area soil was found to contain eight to ten times this amount. Similarly, calcium and magnesium levels in this ash soil are high.

No test for nitrogen was conducted; however, fertilizer experimentation on an area contiguous to the study area showed marked yield increases of adapted grasses to nitrogen fertilization. This response to nitrogen emphasizes the value of having nitrogen-fixing species on the site.

Vegetation-Grazing Interactions

At this early stage, it would be difficult to formulate a suitable management plan based on these research findings. Results are still preliminary and implications involving the use of livestock as a tool to integrate forest and grazing management are not completely clear. Enough information has been collected to suggest that livestock grazing is compatible with good forest management, but numbers of animals and the best season to use the clearcut-burn have not been fully decided.

From information gathered up to this time, it appears that too many animals grazing in a confined area will browse tree seedlings. It is believed, however, that all animals do not respond in a like manner. For instance, a sizeable number of young tree seedlings were browsed in cattle exclosure two in 1967 while little damage occurred in exclosure three. When all heifers were combined and placed in the game excluded area, immediate tree browsing began which indicated that not all animals were responsible. Ponderosa pine was browsed most heavily with lodgepole pine also getting considerable use. Douglas-fir, Western white pine, and Western larch were only occasionally browsed. This would lead to the conclusion that cattle do have the ability to discern different herbaceous and woody species. Whether this is a taste or visual phenomena cannot be definitely answered.

An earlier turn-out date is suggested in order to obtain more even utilization of seeded grass species. Most grasses were becoming coarse at the early-seed-head stage of development which caused the plants to be less preferred by the grazing animal.

To precisely evaluate the differential forage production between game and cattle exclosures, all pastures should be grazed simultaneously. This would enable one to obtain a statistical test of weight gains between areas. Also the influence of big game browsing would be more fully understood. Possibly game and livestock compete more intensely for forage than is presently believed. These answers will be obtained through continued research.

Application of Results and Future Needs

These results have provided a framework upon which other factors can be studied in greater detail. Soil moisture trends, seral vegetation development, game influence on vegetation and other relationships have been studied. In each instance follow-up research needs to be carried out.

Privately owned lands of this type can be improved by clear-cutting, burning, and seeding. If burning and seeding practices are not used, it is believed that the full potential of this site would not be realized. Broadcast burning is thought to be of importance in two respects. These are: (1) nutrients are immediately available for plant use, and (2) seed germination of the nitrogen-fixing species requires scarification--in this case fire. Seeding is essential to curtail the invasion of weeds and to provide immediate usable forage for livestock grazing.

Of the seeded grass species, orchardgrass is preferred by livestock. From a nutritional standpoint, it contains as much crude protein as other species with the possible exception of smooth brome. However, if a good stand of brome became established, more competition would occur with regenerating tree species. Timothy, mountain brome, tall oatgrass and blue wildrye do not appear to be as suitable as orchardgrass for seeding these lands but earlier grazing may provide different results.

Priorities in future research should be to conduct nitrogen-fixation and game-livestock-forage interaction trials. If milkvetch and redstem ceanothus are fixing sufficient atmospheric nitrogen to increase site fertility, a new outlook on this type of culture may occur. Artificially applied nitrogen sources are expensive and the carry-over effect is short lived. New Zealand researchers have definitely shown that nitrogen fixation is necessary to obtain maximum forage from their lands. It is believed that similar results could be found in mixed-conifer forest sites of northeastern Oregon.

The feasibility of this type of study might be questioned by some. Conversely, these same persons might not be aware that this mixed-conifer forest is of no or only little value in its present condition. Apparently mixed feelings occur between forage and timber managers who may be competing for the use of this site. Researchers and devoted land managers should strive to integrate their programs to make livestock grazing and forest management compatible.

Until this is done, it is doubtful if maximum profits can be obtained from the mixed-conifer forest.

SUMMARY

Objectives of this research were to evaluate the compatability of livestock grazing on seeded and native grass species in plantations of four tree species; follow and document early plant succession; evaluate grass seedings from standpoint of competition with natural species, animal preference, and yield; and make observations and measurements on game use in the mixed-coniferous forest.

On the Eastern Oregon Experiment Station Hall Ranch, ten miles southeast of Union, Oregon, a 30-acre tract of the mixed-coniferous forest was clearcut in the summer of 1963. Merchantable timber was removed, slash broadcast, and remaining trees were felled in an up-downhill direction. Slash dried overwinter and spring, and the area was broadcast burned in the summer of 1964.

Intensive research was initiated on 15 acres which had been enclosed in three, five-acre exclosures--one game and two cattle. Within each exclosure five, one-acre plots were established for the tree plantations. After burning, seeding treatments were randomly assigned to one-half of each plot. The bottom one-half of each seeded area consisted of a mixture of timothy, tall oatgrass, smooth brome, orchardgrass, and white Dutch clover. The upper seeded area was split into subplots seeded to pure stands of mountain brome and blue wildrye.

During April, 1965, two to three-year old Douglas-fir, western larch, western white pine, and ponderosa pine were planted in a six by seven-foot grid to give 880 trees per acre. One hundred twenty Engelmann spruce, grand fir, and lodgepole pine were planted at the upper portion of each exclosure to give a total planting rate of 1000 tree seedlings per acre.

Fifty-five permanent belt transects, one by 100-foot, were established to record changes in vegetative cover and frequency from 1965 to 1967. Herbage yields were obtained by weight estimates checked by occasional clippings. Samples were also gathered to determine crude protein content.

Yearling heifers were grazed in the two cattle exclosures separately in 1966 and 1967 before combining them for grazing in the game excluded area. A 42-day grazing period was used in 1966 and a 35-day period in 1967. Weight gains were taken at two-week intervals.

Data were taken on daily water intakes, forage preferences, and grazing patterns. Relative measurments of big game and small animal influences were also obtained.

Environmental measurements were taken in the clearcut and adjacent uncut mixed-coniferous forest to better understand changes and alterations caused by clearcutting and burning these areas. Soil temperatures at two inches below the soil surface were recorded using six-inch maximum reading thermometers while dial-type maximum-minimum thermometers recorded air temperatures at one and three feet above the soil surface.

Soil moisture measurements were taken at eight locations in the clearcut and two locations in the uncut forest using the gravimetric method in 1966 and resistance blocks in 1967.

Solar radiation was determined in August, 1967, using net radiometers located three feet above the ground surface. Two locations in the clearcut and adjacent forest gave comparisons in total heat loads reaching this level.

Bull thistle was the most abundant forb throughout the study period. Its frequency increased from 26 percent in 1965 to 59 perc-cent in 1967. Other forbs with a frequency of over ten percent throughout the three-year study period were Canada milkvetch and strawberry. Hook violet, littleflower collinsia, autumn willow-weed, and sheep sorrel were other dominant forbs in the study plots.

Ross' sedge was the most abundant native grass or grass-like species while pinegrass frequency was low. Mountain brome, blue wildrye, timothy, and orchardgrass were abundant seeded species.

The three most important shrubs were found to be redstem ceanothus, ninebark, and birchleaf spirea.

Foliage cover of bull thistle was consistently lower in the seeded than unseeded plots. Also this species cover was two times greater in the cattle than game exclosure. Cover of Canada milkvetch and all shrub species were greater within the area from which game had been excluded.

Herbage yield data showed wide fluctuations from year to year. In general, most of the production in the unseeded areas during 1965 could be attributed to bull thistle. As succession progressed thistle became less and the native perennial species more important.

Irrespective of seeding treatments, twice as much shrubby growth was present in the area where game were excluded compared with the cattle exclosures. Differential production of Canada milkvetch between exclosures was even more pronounced.

Crude protein content of forages showed Canada milkvetch to contain the highest percentage of all species. Redstem ceanothus, the other nitrogen-fixing species, contained less crude protein than milkvetch but substantial increases were found each year. Seeded grass species were more sensitive to a low soil nitrogen content than native species.

The yearling heifers averaged 1.45 pounds per day gain over a 42-day grazing period in 1966 while a 2.09 pound per day gain for 35 days was obtained in 1967. Late grazing permitted mountain brome and blue wildrye to mature beyond the preferred stage. Preferred forage species were Ross' sedge, orchardgrass, blue elderberry and Canada milkvetch.

Each heifer, on the average, drank 7.1 gallons of water per day in 1966 and 7.6 gallons in 1967. Increased air temperatures throughout 1967 were believed to cause this increase. Water consumption averaged one gallon per 100 pounds of live animal weight in both years.

Pellet group counts indicated that game use was heavy in the cattle exclosures. The abundance of Canada milkvetch and shrubby regrowth has been reduced in the cattle exclosures by the possible attraction of game onto the area.

Small mammals influenced early plant succession by their digging and feeding activities. Badgers destroyed more vegetation than all other species.

Soil temperatures at a two-inch depth were consistenly--2.4 to 6.4°C.--higher in the clearcut than uncut stand. Two reasons that might account for this were: (1) less solar radiation in the forest and (2) an insulating effect of litter under the forest canopy.

Maximum air temperatures at three feet above the soil surface were as much as 5.6°C. warmer in the clearcut whereas minimum air temperatures were similar in both areas. The level of maximum solar energy exchange between the atmosphere and soil surface or atmosphere and herbaceous vegetation canopy occurred in the clearcut during July.

Soil moisture levels were similar in both areas during late summer. Herbaceous and shrubby vegetation in the clearcut appeared to use as much or more moisture than the trees in the uncut stand.

Incoming radiation exceeded outgoing radiation from 7:30 a.m. to 5:45 p.m. in the clearcut and from 11 a.m. to 2:15 p.m. in the forest. This is believed to play an important role in evapotranspiration and snowmelt. More snow accumulated in the clearcut than uncut area, but snow cover remained longer in the forest which influenced phenological development of plants.

Many variations existed in the soil profile but no causal factors were isolated. Chemical analyses of the soil showed phosphorus, potassium, calcium, and magnesium levels to be adequate for plant growth.

This study is still in the preliminary stages and no concrete recommendations for management are, as yet, in order. It is believed that livestock can be successfully manipulated to integrate forest and grazing management. Specific planted tree seedlings were browsed but an earlier turn-out date and a lower concentration of livestock numbers should minimize this form of damage.

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APPENDICES

APPENDIX A

Common and Scientific Names of the Plants Found in the Clearcut-Burn

Common Name	Scientific Name
Grass and Grass-like	
Mountain brome	BROMUS MARGINATUS (Nees)
Blue wildrye	ELYMUS GLAUCUS (Buckl.)
Timothy	PHLEUM PRATENSE (L.)
Orchardgrass	DACTYLIS GLOMERATA (L.)
Smooth brome	BROMUS INERMIS (Leyss.)
Western fescue	FESTUCA OCCIDENTALIS (Hook.)
Oniongrass	MELICA BULBOSA (Geyer.)
Tall oatgrass	ARRHENATHERUM ELATIUS (L.) Presl.
Kentucky bluegrass	POA PRATENSIS (L.)
Slender hairgrass	DESCHAMPSIA ELONGATA (Hook.) Munro ex Benth.
Cheatgrass brome	BROMUS TECTORUM (L.)
Spike bentgrass	AGROSTIS EXARATA (Trin.)
Canada bluegrass	POA COMPRESSA (L.)
Pinegrass	CALAMAGROSTIS RUBESCENS (Buckl.)
Big subalpine needlegrass	STIPA COLUMBIANA NELSONI (Scribn.) Hitchc.
Bluegrass	POA SP.
Foxtail barley	HORDEUM JUBATUM (L.)
Pacific fescue	FESTUCA PACIFICA (Piper)
Rattle brome	BROMUS BRIZAEFORMIS (Fisch. & Mey.)
Bottlebrush squirreltail	SITANION HYSTRIX (Nutt.) J. G. Sm.
Soft brome	BROMUS MOLLIS (L.)
Winter bentgrass	AGROSTIS SCABRA (Willd.)
Tall trisetum	TRISETUM CANESCENS (Buckl.)
Smooth-flowered soft cheat	BROMUS RACEMOSUS (L.)
Northwestern sedge	CAREX CONCINNOIDES (Mack.)
Elk sedge	CAREX GEYERI (Boott.)
Ross sedge	CAREX ROSSII (Boott.)
Rush	JUNCUS SP.
Hairy common woodrush	LUZULA MULTIFLORA COMOSA (E. Mey.) Fern. & Wieg.
Forbs	
Bull thistle	CIRSIUM VULGARE (Savi) Airy-Shaw
Canada milkvetch	ASTRAGALUS CANADENSIS MORTONII (Nutt.) Wats.
Strawberry	FRAGARIA SPP.
Hook violet	VIOLA ADUNCA ADUNCA (Sm.)
Littleflower collinsia	COLLINSIA PARVIFLORA (Lindl.)
Sheep sorrel	RUMEX ACETOSELLA (L.)
Heartleaf arnica	ARNICA CORDIFOLIA (Hook.)
Large-leaved sandwort	ARENARIA MACROPHYLLA (Hook.)
Smooth willow-herb	EPILOBIUM GLABERRIMUM (Barb.)
Oregon anemone	ANEMONE OREGANA (Gray)
Fragrant bedstraw	GALIUM TRIFLORUM (Michx.)

Common Name	Scientific Name
Forbs (Continued)	
Lowland cudweed	GNAPHALIUM PALUSTRE (Nutt.)
Autumn willowweed	EPILOBIUM PANICULATUM (Nutt. exT. & G.)
Glannel mullein	VERBASCUM THAPSUS (L.)
Fendler meadowrue	THALICTRUM FENDLERI (Engelm. ex Gray)
Common dandelion	TARAXACUM OFFICINALE (Weber)
Prickly lettuce	LACTUCA SCARIOLA (L.)
Wild pea	LATHYRUS SPP.
Bicknell's geranium	GERANIUM BICKNELLII (Britt.)
Varied-leaved phacelia	PHACELIA HETEROPHYLLA (Pursh)
Horseweed	CONYZA CANADENSIS (L.) Crong.
Minerslettuce	MONTIA PERFOLIATA (Donn) How.
Western yarrow	ACHILLEA MILLEFOLIUM LANULOSA (Nutt.) Piper
Gland cinquefoil	POTENTILLA GLANDULOSA (Lindl.)
Little tarweed	MADIA EXIGUA (J. E. Sm.) Gray
Slender cudweed	GNAPHALIUM MICROCEPHALUM (Nutt.)
Clover	TRIFOLIUM SPP.
Western hawkweed	HIERACIUM ALBERTINUM (Farr)
Rattlesnakeplantain	GOODYERA OBLONGIFOLIA (Raf.)
Canada thistle	CIRSIUM ARVENSE (L.) Scop.
Slender cryptantha	CRYPTANTHA AFFINIS (Gray) Greene
Prostrate knotweed	POLYGONUM AVICULARE (L.)
Yellow-flowered peppergrass	LEPIDIUM PERFOLIATUM (L.)
Rush pussytoes	ANTENNARIA LUZULOIDES (T. & G.)
Purplish sweet cicely	OSMORHIZA PURPUREA (C. & R.) Suksd.
Common plantain	PLANTAGO MAJOR (L.)
Short-stemmed navarretia	NAVARRETIA DWARICATA (Torr.) Greene
False Solomon's seal	SMILACINA STELLATA (L.) Desf.
Washington lupine	LUPINUS POLYPHYLLUS BURKEI (Wats.)C. L. Hitchc.
Bigflower collomia	COLLOMIA GRANDIFLORA (Dougl. ex Lindl.)
Wormleaf stonecrop	SEDUM STENOPETALUM (Pursh)
Daisy fleabane	ERIGERON SP.
Northwest cinquefoil	POTENTILLA GRACILIS (Dougl. ex Hook.)
Fireweed	EPILOBIUM ANGUSTIFOLIUM (L.)
Douglas knotweed	POLYGONUM DOUGLASII (Greene)
Tumblemustard	SISYMBRIUM ALTISSIMUM (L.)
Ragwort	SENECIO SP.
Pigweed	AMARANTHUS SP.
Western burnet	SANGUISORBA OCCIDENTALIS (Nutt.)
Speedwell	VERONICA SERPYLLIFOLIA HUMIFOSA (L.)
Pale lambstongue fawnlily	ERYTHRONIUM GRANDIFLORUM PALLIDUM
Yellow salsify	TRAGOPOGON DUBIUS (Scop.) (St.) John
Towermustard rockcress	ARABIS GLABRA (L.) Bernh.
Longtube twinflower	LINNAEA BOREALIS LONGIFLORA (Torr.)
Shrubs and Trees	
Willow	SALIX SPP.
Snowbrush ceanothus	CEANOTHUS VELUTINUS VELUTINUS (Dougl. ex. Hook.)

Common Name	Scientific Name
Shrubs and Trees	
Mallow ninebark	PHYSOCARPUS MALVACEUS (Greene) Kuntze
Baldhip rose	ROSA GYMNOCARPA (Nutt.)
Common snowberry	SYMPHORICARPOS ALBUS (L.) Blake
Creambush rockspirea	HOLODISCUS DISCOLOR (Pursh) Maxim.
Birchleaf spirea	SPIRAEA BETULIFOLIA LUCIDA (Dougl.) C. L. Hitchc.
Saskatoon serviceberry	AMELANCHIER ALNIFOLIA (Nutt.)
Big whortleberry	VACCINIUM MEMBRANACEUM (Dougl. ex Hook.)
Blueberry elder	SAMBUCUS CERULEA (Raf.)
Creeping western barberry	BARBERIS REPENS (Lindl.)
Rubber rabbitbrush	CHRYSOTHAMNUS NAUSEOSUS (Pall.) Britt.
Sticky currant	RIBES VISCOSISSIMUM (Pursh)
Redstem ceanothus	CEANOTHUS SANGUINEUS (Pursh)
Wax currant	RIBES CEREUM CEREUM (Dougl.)
Interior Douglas-fir	PSEUDOTSUGA MENZIESII GLAUCA (Beissn.) Franco
Engelmann spruce	PICEA ENGELMANNII (Parry)
Ponderosa pine	PINUS PONDEROSA (Laws.)
Western white pine	PINUS MONTICOLA (Dougl. ex D. Don)
Western larch	LARIX OCCIDENTALIS (Nutt.)
Grand fir	ABIES GRANDIS (Dougl.) Lindl.

APPENDIX B

Total Frequency of all Species Recorded in 55-100' x 1' Belt Transects on Hall Ranch Clear-cut Burn from 1965 - 1967.

FORBS	1965		1966		1967	
	Hits	% Freq.	Hits	% Freq.	Hits	% Freq.
CIRSIUM VULGARE	1448	26.33	2871	52.20	3225	58.64
ASTRAGALUS CANADENSIS MORTONII	565	10.27	1345	24.45	2029	36.89
FRAGARIA SPP.	563	10.24	779	14.16	943	17.15
VIOLA ADUNCA ADUNCA	521	9.47	550	10.00	516	9.38
COLLINSIA PARVIFLORA	443	8.05	519	9.44	902	16.40
RUMEX ACETOSELLA	321	5.84	529	9.62	605	11.00
ARNICA CORDIFOLIA	274	4.98	388	7.05	447	8.13
ARENARIA MACROPHYLLA	168	3.05	196	3.56	236	4.29
EPILOBIUM GLABERRIMUM	136	2.47	282	5.13	264	4.80
ANEMONE OREGANA	128	2.33	187	3.40	211	3.84
GALIUM TRIFLORUM	102	1.85	127	2.31	94	1.71
GNAPHALIUM PALUSTRE	88	1.60	19	.35	15	.27
EPILOBIUM PANICULATUM	82	1.49	750	13.64	1372	24.95
VERBASCUM THAPSUS	71	1.29	88	1.60	82	1.49
THALICTRUM FENDLERI	62	1.13	78	1.42	71	1.29
TARAXACUM OFFICINALE	60	1.09	83	1.51	104	1.89
LACTUCA SCARIOLA	59	1.07	38	.69	42	.76
LATHYRUS SPP.	17	.31	70	1.27	106	1.93
GERANIUM BICKNELLII	21	.38	8	.15	16	.29
PHACELIA HETEROPHYLLA	19	.35	16	.29	80	1.45
CONZYA CANADENSIS	43	.78	29	.53	47	.85
MONTIA PERFOLIATA	34	.62	102	1.85	298	5.42
ACHILLEA MILLEFOLIUM LANULOSA	30	.55	105	1.91	230	4.18
POTENTILLA GLANDULOSA	4	.07	12	.22	14	.25
MADIA EXIGUA	9	.16	27	.49	12	.22
GNAPHALIUM MICROCEPHALUM	43	.78	25	.45	71	1.29
TRIFOLIUM SPP.	59	1.07	4	.80	10	.18
HIERACIUM ALBERTINUM	8	.15	4	.07	2	.04
GOODYERA OBLONGIFOLIA	1	.02	---	---	---	---
CIRSIUM ARVENSE	15	.27	23	.42	30	.55
CRYPTANTHA AFFINIS	26	.47	59	1.07	124	2.25
POLYGONUM AVICULARE	10	.18	10	.18	5	.09
LEPIDIUM PERFOLIATUM	1	.02	---	---	---	---
ANTENNARIA LUZULOIDES	4	.07	2	.04	3	.05
OSMORHIZA PURPUREA	4	.07	6	.12	4	.07
PLANTAGO MAJOR	1	.02	2	.04	---	---
NAVARRETIA DIVARICATA	2	.04	---	---	2	.04
SMILACINA STELLATA	7	.13	3	.05	1	.02
LUPINUS POLYPHYLLUS BURKEI	1	.02	3	.05	3	.05
COLLOMIA GRANDIFLORA	2	.04	10	.18	37	.67
SEDUM STENOPETALUM	3	.05	---	---	2	.04

FORBS	1965		1966		1967	
	Hits	% Freq.	Hits	% Freq.	Hits	% Freq.
ERIGERON SP.	1	.02	2	.04	1	.02
POTENTILLA GRACILIS	---	---	1	.02	1	.02
EPILOBIUM ANGUSTIFOLIUM	---	---	5	.09	3	.05
POLYGONUM DOUGLASSII	26	.47	13	.24	24	.44
SISYMBRIUM ALTISSIMUM	4	.07	10	.18	17	.31
SENECIO SP.	---	---	2	.04	2	.04
AMARANTHUS SP.	---	---	1	.02	1	.02
SANGUISORBA OCCIDENTALIS	---	---	---	---	1	.02
VERONICA SERPHYLLIFOLIA NUMIFOSA	---	---	---	---	2	.04
ERYTHRONIUM GRANDIFLORUM PALLIDUM	---	---	---	---	4	.07
TRAGOPOGON DUBIUS	---	---	---	---	7	.13
ARABIS GLABRA	---	---	---	---	2	.04
LINNAEA BOREALIS LONGIFLORA	---	---	1	.02	---	---

GRASSES

	1965 Hits	1965 % Freq.	1966 Hits	1966 % Freq.	1967 Hits	1967 % Freq.
BROMUS MARGINATUS	809	14.71	1006	18.29	1139	20.71
ELYMUS GLAUCUS	930	16.91	1064	19.35	1152	20.95
PHLEUM PRATENSE	1032	18.75	1035	18.82	1126	20.47
DACTYLIS GLOMERATA	540	9.82	635	11.55	718	13.05
BROMUS INERMIS	7	.13	109	1.98	190	3.45
FESTUCA OCCIDENTALIS	82	1.49	129	2.35	213	3.87
MELICA BULBOSA	5	.09	21	.38	45	.82
ARRHENATHERUM ELATIUS	64	1.16	212	3.85	360	6.55
POA PRATENSIS	59	1.07	94	1.71	148	2.69
DESCHAMPSIA ELONGATA	107	1.95	303	5.51	470	8.55
BROMUS TECTORUM	101	1.84	360	6.55	988	17.96
AGROSTIS EXARATA	30	.55	27	.49	36	.65
POA COMPRESSA	3	.05	8	.15	11	.20
CAREX GEYERI	153	2.78	269	4.89	199	3.62
CAREX ROSSII	1846	33.56	1628	29.60	1577	28.67
CALAMAGROSTIS RUBESCENS	143	2.60	160	2.91	146	2.65
STIPA COLUMBIANA NELSONI	19	.35	31	.56	27	.49
POA SP.	8	.15	9	.16	14	.25
HORDEUM JUBATUM	9	.16	16	.29	18	.33
FESTUCA PACIFICA	11	.20	7	.13	13	.24
BROMUS BRIZAEFORMIS	1	.02	---	---	2	.04
SITANION HYSTRIX	2	.04	4	.07	---	---
BROMUS MOLLIS	3	.05	2	.04	2	.04
CAREX CONCINNOIDES	--- 1/	--- 1/	686	12.47	690	12.55
AGROSTIS SCABRA	---	---	5	.09	11	.20
LUZULA MULTIFLORA COMOSA	19	.35	26	.47	26	.47
JUNCUS SP.	1	.02	3	.05	3	.05
BROMUS RACEMOSUS	---	---	5	.09	27	.49
TRISETUM CANESCENS	---	---	13	.24	13	.24

WOODY	1965		1966		1967	
	Hits	% Freq.	Hits	% Freq.	Hits	% Freq.
SALIX SPP.	112	2.04	112	2.04	76	1.38
CEANOTHUS VELUTINUS VELUTINUS	678	12.33*	17	.31	39	.69
PHYSOCARPUS MALVACEUS	547	9.95	471	8.56	461	8.38
ROSA GYMNOCARPA	71	1.29	74	1.35	71	1.29
SYMPHORICARPOS ALBUS	85	1.55	98	1.78	103	1.87
HOLODISCUS DISCOLOR	43	.78	65	1.18	44	.80
SPIRAEA BETULIFOLIA LUCIDA	493	8.96	506	9.20	496	9.02
PSEUDOSTUGA MENZIESII GLAUCA	75	1.36	43	.78	40	.73
AMELANCHIER ALNIFOLIA	4	.07	4	.07	1	.02
VACCINIUM MEMBRANACEUM	12	.22	12	.22	7	.13
PICEA ENGELMANNII	6	.12	4	.07	2	.04
SAMBUCUS CERULEA	5	.09	4	.07	4	.07
PINUS PONDEROSA	18	.36	20	.36	16	.29
BERBERIS REPENS	8	.15	8	.15	8	.15
PINUS MONTICOLA	20	.36	17	.31	13	.24
LARIX OCCIDENTALIS	1	.02	17	.31	14	.25
CHRYSOTHAMNUS NAUSEOSUS	1	.02	7	.13	3	.05
RIBES VISCOSISSIMUM	121	2.20	207	3.76	116	2.11
CEANOTHUS SANGUINEUS	---1/	--- 1/	622	11.31	454	8.25
RIBES CEREUM CEREUM	---	---	3	.05	10	.18
ABIES GRANDIS	---	---	2	.04	1	.02

1/ These data were included with Ceanothus velutinus velutinus

APPENDIX C

Average Foliage Cover of 16 Most Abundant Species in Each Seeding Treatment[1]

1966		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Brma	Tu	.56	.84	---	18.79	---	3.53	---	---	4.09	---	3.59
	Bu	---	---	.19	---	---	---	---	---	---	---	---
	Mix	---	---	---	---	---	---	---	---	---	---	---
	Brma	29.16	23.28	21.66	41.19	35.72	45.22	19.88	38.56	26.00	13.22	32.72
	Elgl	.03	.09	.50	---	---	.91	---	---	.09	---	1.25
Elgl	Tu	2.84	---	.16	---	---	.06	.69	---	---	.71	.44
	Bu	---	---	.38	.28	---	---	---	.03	---	---	---
	Mix	---	---	---	---	---	---	---	---	---	---	---
	Brma	.22	---	.03	.03	---	.88	2.16	---	---	3.09	.06
	Elgl	22.53	29.72	25.59	28.69	37.69	19.28	26.44	24.91	23.88	37.06	18.28
Phpr	Tu	---	---	---	---	---	---	.38	.06	---	---	---
	Bu	5.50	2.75	1.25	.13	3.44	4.47	1.09	.38	.47	.31	1.59
	Mix	19.84	22.84	21.41	15.34	15.31	17.31	18.78	17.00	22.59	12.16	12.38
	Brma	---	.38	.94	---	1.56	---	---	---	1.00	.88	---
	Elgl	.59	---	.91	1.13	---	.09	1.75	---	.31	.41	---
Deel	Tu	2.75	.03	1.66	.03	.13	---	---	---	.38	---	3.97
	Bu	.13	4.91	.09	1.06	.59	2.59	---	3.75	4.34	.97	.25
	Mix	.09	.13	.03	.53	.19	.06	---	---	.03	.03	.06
	Brma	---	---	---	---	---	---	---	.03	---	.09	.06
	Elgl	.03	---	.09	---	---	.06	---	---	---	.28	.28
Brte	Tu	.19	3.25	4.31	---	.28	5.34	1.00	1.59	10.25	9.69	5.44
	Bu	.09	.22	.56	.50	.13	---	4.28	1.97	.03	---	.94
	Mix	---	---	---	---	.78	---	---	.34	---	.03	.25
	Brma	2.81	3.97	.03	---	.03	.09	.47	.31	.09	1.47	---
	Elgl	.09	.47	.28	---	.03	1.78	1.06	1.16	.19	---	---

1966		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Caro	Tu	2.56	2.44	5.78	6.31	9.56	7.50	9.69	13.06	8.34	3.91	5.22
	Bu	3.66	10.59	16.50	9.41	4.34	10.78	12.19	5.19	16.47	13.25	8.22
	Mix	3.16	.56	1.41	3.97	8.25	3.81	7.63	1.84	8.09	15.50	11.13
	Brma	2.97	.41	9.66	1.56	3.44	.47	5.38	2.44	15.69	8.63	2.22
	Elgl	4.81	3.00	9.59	7.53	.78	4.53	6.59	3.41	7.34	2.44	5.47
Civu	Tu	4.97	1.72	3.16	6.41	10.47	7.41	13.63	10.69	11.81	11.91	5.25
	Bu	8.50	4.13	5.66	8.78	3.81	4.94	6.53	25.56	14.28	12.81	6.63
	Mix	2.56	2.19	2.47	1.63	2.91	2.28	3.19	3.97	6.09	5.34	3.44
	Brma	.25	.41	.03	.91	2.41	1.63	6.00	8.09	3.94	6.06	5.59
	Elgl	2.94	1.28	.72	1.06	1.84	10.53	6.25	14.03	8.44	4.66	5.94
Asmo	Tu	1.03	.66	5.44	33.09	31.29	---	11.28	15.81	5.09	---	.41
	Bu	9.28	8.09	22.63	22.75	16.84	---	6.75	---	---	.03	8.00
	Mix	10.66	4.88	26.75	41.25	6.22	3.63	19.19	9.63	1.97	3.25	8.00
	Brma	---	---	27.97	4.22	30.56	---	5.69	7.19	.59	3.78	---
	Elgl	17.31	10.34	21.78	35.94	3.38	2.75	18.31	4.69	10.47	1.81	2.31
Frcu	Tu	4.91	.69	1.34	.38	.81	.03	1.59	2.19	1.22	1.53	3.72
	Bu	.31	5.63	6.22	4.44	2.03	.41	.59	.84	1.47	2.34	---
	Mix	.59	.56	.03	1.97	4.88	1.09	1.63	.03	3.13	2.69	2.81
	Brma	.03	---	1.34	.22	.31	.06	2.47	.19	.94	3.53	.13
	Elgl	2.88	1.72	1.56	.94	---	1.19	3.56	3.19	---	---	3.81
Viad	Tu	.56	---	.03	.22	.38	---	.88	1.13	.75	.41	.44
	Bu	.56	.38	1.06	.56	.41	.09	.72	.09	.44	.94	.69
	Mix	1.06	.09	.09	.19	.34	.66	.44	.03	.47	.50	.97
	Brma	.03	---	.22	.19	.03	---	.69	.31	.34	1.09	.34
	Elgl	.19	.03	.28	.13	.03	.47	1.16	.66	.31	---	.59

1966		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Eppa	Tu	2.88	1.13	3.47	2.63	3.53	.50	.59	.91	.38	.19	.38
	Bu	1.31	2.66	.63	3.31	1.25	.03	.59	.19	1.19	.03	1.22
	Mix	.73	.31	.06	---	.06	---	.13	.06	.09	.13	.09
	Brma	.69	.28	.28	.41	.38	.16	.31	1.06	.34	.38	.38
	Elgl	3.16	.41	.44	.28	1.94	.25	.06	.03	.41	.38	.22
Copa	Tu	1.97	1.50	.81	.06	.34	.38	.31	1.16	.28	.47	.25
	Bu	.22	3.91	1.78	.94	.78	---	1.06	.16	.38	.41	.06
	Mix	.31	.16	---	.19	.09	.09	.13	---	.03	.19	.09
	Brma	.25	2.06	.06	.19	---	.03	.34	.19	.50	.31	---
	Elgl	.16	.22	.09	.19	---	.50	.13	.53	.09	.06	.03
Ruac	Tu	1.06	2.00	.03	---	1.28	---	.53	2.41	2.06	10.03	2.13
	Bu	.03	2.25	2.66	.22	.31	.75	---	---	.06	13.19	4.63
	Mix	.38	.09	---	.53	.44	---	.03	---	.75	.75	2.94
	Brma	---	1.41	---	---	---	.22	1.75	2.94	3.31	2.47	.28
	Elgl	.03	.19	2.06	.09	.03	---	.28	3.34	.03	.06	4.28
Spbe	Tu	3.19	1.81	1.63	1.47	.25	3.47	1.56	.75	.22	2.75	.31
	Bu	1.41	.13	---	1.38	.75	3.38	1.63	.19	---	1.59	---
	Mix	1.50	.06	.16	1.38	1.13	4.47	.13	---	.28	.56	.19
	Brma	1.75	2.06	2.34	---	.81	2.03	.59	.03	.03	1.91	.66
	Elgl	.84	.91	.34	2.38	.66	.06	.31	.63	1.22	---	.44
Phma	Tu	2.56	11.19	3.91	.66	2.25	7.38	.59	.41	1.69	1.09	.47
	Bu	1.88	1.88	.13	.75	.03	.31	---	---	---	.78	.28
	Mix	1.25	.50	---	1.00	.19	.47	---	---	---	.06	.06
	Brma	15.25	6.19	4.72	6.28	1.06	5.22	.09	.53	.28	1.09	1.81
	Elgl	2.81	1.69	2.75	3.59	3.31	.69	.03	.66	.75	---	.44
Cesa	Tu	.16	11.81	1.25	2.34	.94	3.59	1.16	3.22	.91	.03	.19
	Bu	.41	.03	.50	.47	.16	.38	.03	.19	.03	---	.56
	Mix	.03	.09	1.66	.03	.06	.28	.03	.19	.03	.25	.09
	Brma	7.25	2.44	1.25	17.22	2.34	.66	1.09	3.69	.53	1.25	.06
	Elgl	---	1.50	.09	2.66	1.13	3.59	---	---	1.47	.25	.25

1967		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Brma	Tu	2.03	1.38	.34	2.22	.91	5.84	---	.03	4.44	---	2.46
	Bu	.28	.16	.59	---	.03	.03	.03	---	.09	---	---
	Mix	---	.03	---	---	---	---	---	---	---	---	---
	Brma	26.75	26.16	31.97	35.41	43.69	48.72	18.34	35.53	32.75	14.72	25.19
	Elgl	.31	.53	2.69	---	---	.91	---	.03	.19	---	.91
Elgl	Tu	4.44	---	1.00	---	.09	.31	.63	---	.03	2.50	1.78
	Bu	---	---	.19	.53	---	---	---	.13	---	---	---
	Mix	---	---	---	---	---	---	---	---	---	.03	---
	Brma	.34	---	---	.22	---	1.59	5.19	---	---	4.84	.28
	Elgl	39.16	41.22	35.84	42.53	49.16	30.09	45.56	39.56	33.53	52.66	32.09
Phpr	Tu	.03	---	---	---	.03	---	1.25	.47	---	---	---
	Bu	8.47	6.06	1.66	.19	9.22	3.75	.84	.75	.78	2.16	3.25
	Mix	25.91	19.69	31.16	34.16	19.78	17.22	19.81	11.19	23.88	21.03	13.66
	Brma	---	.72	.84	---	2.00	---	---	---	.91	1.84	---
	Elgl	1.31	---	.03	.41	---	.09	1.61	---	---	.22	---
Deel	Tu	2.88	---	3.03	1.28	.88	---	.03	.06	1.25	---	6.53
	Bu	.59	5.59	.75	1.03	3.66	4.97	---	5.47	5.59	2.25	1.50
	Mix	.03	.28	---	.75	.41	---	---	---	---	---	.09
	Brma	---	.84	.94	---	.06	.03	.09	.41	.03	.19	1.63
	Elgl	---	---	.56	.03	---	.13	.06	.13	---	.53	.56
Brte	Tu	1.66	17.56	16.53	1.41	5.06	18.97	6.41	9.38	24.53	22.38	13.22
	Bu	1.34	1.53	5.34	6.72	.78	1.34	8.19	2.50	.25	.53	7.44
	Mix	.03	---	---	.22	.50	---	---	3.19	.16	---	4.56
	Brma	3.47	9.31	---	.19	.03	.38	1.63	1.06	1.88	3.63	1.56
	Elgl	.19	.28	.84	.03	.31	1.72	.97	3.28	1.38	.44	.03
Caro	Tu	4.09	1.94	6.56	10.19	13.47	19.19	13.78	15.10	12.59	3.75	5.91
	Bu	3.84	13.47	29.66	9.28	9.03	14.56	13.16	7.28	22.50	14.06	10.31
	Mix	5.19	1.41	2.81	7.81	12.00	4.72	10.78	1.50	6.44	15.72	11.72
	Brma	7.03	.53	13.53	1.41	4.63	.75	10.63	3.03	12.31	8.97	4.88
	Elgl	2.91	1.25	14.75	7.41	.78	2.53	10.84	2.44	9.81	1.88	9.19

1967		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Civu	Tu	9.66	.31	5.50	34.19	27.31	13.50	30.94	20.53	19.50	18.13	9.94
	Bu	12.44	12.22	10.63	22.50	10.78	16.13	12.47	31.41	25.53	17.44	11.19
	Mix	2.94	1.78	3.06	2.47	1.63	2.66	2.56	6.81	3.06	5.63	3.19
	Brma	.13	.97	1.56	1.65	6.06	1.47	7.44	7.25	5.28	4.59	8.56
	Elgl	1.81	1.53	2.81	2.03	1.19	15.25	4.03	15.97	6.75	4.28	5.38
Asmo	Tu	1.13	.75	3.97	18.06	33.34	---	19.44	11.94	4.72	---	.94
	Bu	8.34	18.97	33.41	18.88	30.09	.81	10.09	5.31	5.03	.28	8.03
	Mix	16.06	2.84	36.66	52.06	17.16	6.28	22.69	7.88	1.06	4.81	9.56
	Brma	---	---	24.56	4.91	30.00	---	8.63	9.47	1.69	3.59	---
	Elgl	16.56	14.53	25.44	25.59	5.34	3.31	21.69	3.75	4.34	3.25	1.56
Frcu	Tu	6.94	.97	1.69	.94	2.69	.03	2.06	3.03	1.72	1.84	7.94
	Bu	.81	4.53	8.38	4.44	4.22	.38	.97	.59	1.28	3.88	---
	Mix	.53	.69	.19	3.31	8.06	1.97	2.28	---	2.22	3.09	5.97
	Brma	.06	.09	2.97	.31	.47	.03	4.06	.19	1.34	6.72	.34
	Elgl	2.91	1.72	2.63	.94	---	1.13	5.91	5.44	---	---	7.22
Viad	Tu	.56	---	.13	.25	.50	---	.63	.75	.69	.94	.59
	Bu	.50	.25	.88	.13	.38	.16	.38	.19	1.78	.63	.63
	Mix	.59	.16	.19	.28	.38	.44	.34	.06	.41	.50	.78
	Brma	---	.13	.34	.09	.03	---	.69	.16	.31	.78	.47
	Elgl	.16	.06	.13	.13	.03	.16	.91	.54	.19	---	.41
Eppa	Tu	6.31	.94	4.72	24.69	13.66	1.09	.63	1.81	1.00	.47	2.31
	Bu	6.41	3.22	2.72	18.22	12.34	.19	1.38	.19	.50	.66	1.81
	Mix	---	.84	---	.13	.19	.06	.19	.25	.09	.13	.06
	Brma	1.56	.69	.72	.84	1.41	.44	.78	2.44	2.41	1.44	1.69
	Elgl	2.91	1.19	1.25	.78	2.47	.88	.22	.25	1.66	1.63	.81
Copa	Tu	.63	1.47	1.75	.16	.59	.72	.47	1.28	.34	3.25	1.88
	Bu	.50	1.16	1.03	1.78	.88	.06	2.19	.72	1.03	1.00	.41
	Mix	.09	.09	.06	.72	.41	.31	.47	.09	.19	.53	1.50
	Brma	.53	2.03	.16	.69	.09	1.28	.94	.72	.56	2.41	.91
	Elgl	.84	.34	.44	.69	.03	1.03	1.03	1.63	.41	.06	.09

1967		Deer Exclosures					Cattle Exclosures					
		No. 1					No. 2					No. 3
Species		Plot 1	2	3	4	5	Plot 1	2	3	4	5	Plot 2
Ruac	Tu	.38	2.84	.16	---	1.72	---	.44	1.47	.63	15.06	3.13
	Bu	.06	1.13	3.56	.09	1.22	.78	.09	---	.06	13.31	14.91
	Mix	.25	.06	.09	.84	.13	.03	---	---	.31	.28	5.88
	Brma	---	3.59	---	---	---	.31	.56	.78	2.44	1.44	1.25
	Elgl	.31	.72	1.19	---	---	---	.88	7.53	---	.16	4.84
Spbe	Tu	2.56	1.66	2.94	1.28	1.88	3.03	1.53	1.06	.22	2.63	.75
	Bu	1.72	.13	---	1.38	4.63	3.13	1.28	.19	---	1.19	---
	Mix	.72	.06	2.16	2.03	1.78	3.22	.16	---	.07	.25	.16
	Brma	2.63	2.25	3.66	---	.81	1.84	.34	---	.13	1.06	.78
	Elgl	1.44	.81	.13	2.88	.56	.25	.06	.50	.63	---	.47
Phma	Tu	2.56	16.13	4.41	.63	2.91	6.16	1.03	.25	1.75	1.09	.56
	Bu	2.59	2.22	.06	1.19	.19	.25	---	---	---	.84	.72
	Mix	.94	.66	---	.56	.09	.31	---	---	---	---	.03
	Brma	18.38	7.66	7.19	7.00	1.69	3.72	.09	.25	.22	.56	.41
	Elgl	.19	.56	2.13	4.69	3.47	---	---	.69	.31	---	.34
Cesa	Tu	.06	17.25	2.72	.78	1.25	3.63	2.13	3.81	1.78	---	.31
	Bu	.03	.09	1.22	---	---	.38	.09	.09	.03	---	---
	Mix	---	.03	1.75	.25	.22	.38	.03	.09	---	.03	.03
	Brma	8.47	5.63	1.63	32.56	4.03	.50	1.41	4.69	.59	1.41	.03
	Elgl	---	2.03	.06	2.94	1.56	2.91	---	---	1.88	.41	.03

[1] (Tu) top unseeded; (Bu) bottom unseeded; (Mix) Mixture; (Brma) Mountain brome; (Elgl) Blue wildrye.

APPENDIX D

Water Consumption by Heifers Clearcut - 1966

DATE	TIME	Cattle Exclosures 2	Cattle Exclosures 3
7-15	--	32 gal.	34 gal.
7-16	9:40 am	21	21
7-17	8:30 am	28	35
7-19	5:00 pm	47	60
7-20	3:15 pm	40	36
7-22	4:45 pm	70	50
		238	236
7-24	10:15 am	75	70
7-25	4:10 pm	62	49
7-27	4:15 pm	76	63
7-29	12:00 am	70	60
		283	242
7-31	9:30 am	72	57
8-1	4:50 pm	67	59
8-3	4:10 pm	87	76
8-5	8:30 am	65	45
		291	237
8-6	3:30 pm	53	64
8-8	9:00 am	25	65
8-10	3:00 pm	78	69
8-11	2:00 pm	26	29
		182	227
		994	942

DATE	TIME	Deer Exclosure 1
8-13		103
8-15	9:15 am	143
8-17		145
8-18		133
		524
8-20	9:40 am	78
8-22	11:00 am	163
8-23	8:40 am	85
8-24	1:00 pm	93
8-25		104
		523
		1047

2983 is total drank by 10 heifers for 42 days. This is 71.02 gallons/day or 7.1 gallons/day/heifer.

Water Consumption by Heifers Clearcut - 1967

DATE	TIME	Cattle Exclosures 2	3
7-1	9:30 am	55 gal.	55 gal.
7-2	9:15 am	70	70
7-3	8:30 am	57	58
7-4	8:15 am	55	57
7-5	8:30 am	67	64
7-6	8:40 am	47	36
7-7	8:40 am	58	75
		409	415
7-8	9:00 am	45	51
7-9	8:15 am	60	40
7-10	9:00 am	70	62
7-11		66	66
7-12	8:35 am	70	55
7-13	8:45 am	60	68
7-14	11:10 am	67	53
		438	395
7-15	8:40 am	45	19
7-16	8:40 am	55	60
7-17	8:25 am	31	45
7-18	8:20 am	51	34
7-19	8:35 am	53	47
7-20	8:20 am	51	44
7-20	4:50 pm	18	43
		304	292

		Deer Exclosure 1
7-22	8:35 am	99
7-23	9:50 am	132
7-24	8:30 am	102
7-25	8:30 am	98
7-26	8:30 am	117
7-27	8:35 am	119
7-28	8:35 am	127
		794
7-29	7:45 am	80
7-30	8:45 am	131
7-31	8:40 am	102
8-1	8:40 am	109
8-2	8:25 am	84
8-3	8:30 am	126
8-4	8:35 am	64
		696

14 heifers drank a total of 3743 gallons of water in 35 days. This is 267.36 gallons/heifer. Over the 35 day period, this averages 7.64 gallons/day.

APPENDIX F

Modal Soil Profile Description of Tolo Silt Loam in Clearcut

	1/2-0"	Burned duff
A1	0-9"	Dark brown (10 YR 3/3, moist), silt loam, structureless, loose, friable, non-sticky, non-plastic, gradual-smooth boundary. Many fine tubular pores, roots abundant, pH 6. 5.
C	9-18"	Dark-yellowish brown (10 YR 4/4, moist), silt loam, very weak medium subangular blocky structure, loose, friable, non-sticky, non-plastic, roots abundant, pH 6. 6.
II B	18-28"	Dark-reddish brown (5 YR 4/3, moist), clay loam, moderate-medium subangular blocky structure, firm, sticky, plastic, many fine tubular pores, clear wavy boundary, shrub roots present. pH 6. 5.
II C	28-41"	Brown (7. 5 YR 4/2, moist), silty clay loam; medium subangular blocky structure, firm, sticky, plastic, many shrub roots. pH 6. 4.
	41" +	Boulders occupy most of the soil volume, however an auger was put down between boulders to 84 inches at this location.

Range in Characteristics - This soil varies from 20 to more than 80 inches in depth. Below 50 inches large basaltic boulders are common.

Relief - on footslope, slightly concave

Drainage - highly permeable throughout, infiltration high

Vegetation - Grand fir, Douglas-fir, Western larch, and few ponderosa pine

Use - Primarily forested land

Distribution - Throughout northeastern Oregon and Southeastern Washington. Is found almost entirely on north and northeast exposures. In some areas, ravines and ridgetops contain ash deposits.

APPENDIX G

Analysis of variance tables for cover and frequency data of bull thistle

Thistle frequency in cattle exclosures

Source	d. f.	SS	MS	F
Replication	5	4961. 8	992. 4	7. 38[1]
Treatment	2	112. 4	56. 2	. . 42
Error (A)	10	1345. 2	134. 5	
Years	2	13289	6644. 5	124. 3[1]
Error (B)	10	534. 6	53. 5	
Years x Trt.	4	826. 9	206. 7	2. 17
Error (C)	20	1904. 2	95. 2	
Total	53	22974. 1		

[1] significant at . 05 level of significance

Thistle frequency in game exclosure

Source	d. f.	SS	MS	F
Replication	4	4175. 1	1043. 8	2. 77
Treatment	2	1889. 2	944. 6	2. 55
Error (A)	8	3018. 4	376. 8	
Years	2	5837. 7	2918. 9	7. 24[1]
Error (B)	8	3224. 4	403. 1	
Years x Trt.	4	499. 1	124. 8	1. 21
Error (C)	16	1654. 1	103. 4	
Total	44	20298		

[1] significant at . 05 level of significance

Thistle cover in cattle exclosures

Source	d. f.	SS	MS	F
Replication	5	147. 4	29. 5	. 83
Treatment[2]	2	498. 2	249. 1	7. 04[1]
Error (A)	10	353. 6	35. 4	
Years	1	90. 0	90. 0	30. 0[1]
Error (B)	5	15. 0	3. 0	
Years x Trt.	2	135. 1	67. 6	10. 99[1]
Error (C)	10	61. 5	6. 2	
Total	35	1300. 8		

[1] significant at . 05 level of significance

[2] only backslope treatments--top unseeded, blue wildrye, and mountain brome--were used in these analyses.

APPENDIX G (CONTINUED)

Thistle cover in game exclosure

Source	d. f.	SS	MS	F
Replication	4	254.3	63.6	1.35
Treatment	2	515.6	257.8	5.48[1]
Error (A)	8	376.7	47.1	
Years	1	112.6	112.6	4.25
Error (B)	4	105.9	26.5	
Years x Trt.	2	144.1	72.0	3.01
Error (C)	8	191.6	23.9	
Total	29	1700.8		

[1] significant at .05 level of significance

APPENDIX H

Soil temperature maximums in clearcut and uncut stand stations (°C.) 1/

Sampling date	Dense stand of Canada milkvetch and redstem ceanothus		Skid trail		Dense Canada milkvetch		Dense timothy and orchardgrass		Near ninebark		Near oceanspray	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
6-27	18.0	-	-	-	22.0	-	17.0	-	15.0	-	15.0	-
7-4	18.6	-	28.9	-	28.4	-	19.6	-	18.0	-	17.0	-
7-11	19.0	-	29.5	-	27.0	-	19.9	-	18.9	-	17.2	-
7-18	22.9	25.5	30.2	27.0	23.0	20.5	21.9	21.0	19.5	20.5	17.9	18.5
7-25	22.0	25.0	33.6	24.4	22.5	20.0	24.6	19.5	21.0	19.0	22.5	18.0
8-1	24.0	25.0	33.0	23.5	23.0	19.1	25.5	21.1	23.5	19.0	20.0	18.7
8-8	27.0	25.0	34.0	23.0	26.0	19.6	25.8	19.6	22.3	19.5	21.0	18.0
8-15	23.0	27.9	28.0	26.7	21.0	21.2	24.0	23.8	22.5	22.1	20.6	19.1
8-22	26.0	30.7	27.0	27.8	20.6	22.0	23.0	23.1	21.0	22.6	19.8	22.0
8-29	25.6	26.3	29.0	22.0	25.0	21.5	23.8	20.2	20.9	17.9	21.9	18.0
9-5	21.9	29.0	24.6	28.5	18.0	22.3	20.0	22.8	17.5	20.9	17.1	19.3
9-12	21.9	29.1	22.0	23.8	21.0	20.6	20.7	21.0	18.9	19.2	18.6	19.1
Season Average	22.5	26.4	29.1	25.2	23.1	20.8	22.2	21.3	19.9	20.1	19.1	19.0

1/ From left to right, the first 8 columns are readings from clearcut stations while last four columns are readings from forest.