THE SEASONAL YIELD AND NUTRIENT CONTENT OF NATIVE FORAGE SPECIES IN RELATION TO THEIR SYNECOLOGY

by

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THE SEASONAL YIELD AND NUTRIENT CONTENT OF NATIVE FORAGE SPECIES IN RELATION TO THEIR SYNECOLOGY

INTRODUCTION

Before the domestication of livestock, man was dependent upon the range to provide the raw forage materials which wild animals converted into useful products. Now, as before, a large segment of our economy depends upon the products of the range. With higher costs of production and narrow economic margins, intensive rather than extensive management is becoming more important. Because of the complexity of problems encountered, considerable research is necessary to enable decisions which will meet the increasing demands of intensive management.

Gordon and Sampson (12, p. 3) point out that a better understanding of plant nutrient content is obviously basic to the improvement and maintenance of the forage cover. According to Cook (3, p. 25), knowledge pertaining to range livestock nutrition is extremely meager, and is considered a limiting factor in livestock production. Stanley and Hodgson (24, p. 451) also state that little is known about the nutrient value of the native vegetation which abounds throughout the range area and serves as the sole source of feed for the greater portion of the livestock population. It may be said, then, that in spite of the work done on range nutrition, more information is needed for practical application of this science in making management decisions.

The work of Sampson et al (23, p. 19) emphasizes that correct appraisal of the livestock food value of range grasses and other forage plants presupposes a knowledge of the seasonal accumulation pattern of their more important organic and mineral constituents. These seasonal patterns, when known, have led to an appreciation of the importance of using each kind of range at the proper season. Graziers have long realized the need for fall, winter, spring, and summer ranges in some areas, but have not generally recognized that within each seasonal range unit there may be certain areas which can be grazed more effectively during a particular part of the grazing season.

This research was designed to provide information by range sites on the seasonal patterns of herbage yield and nutrient content of the major forage species. Results of the investigation present data which will have practical implications in aiding intensive management, as well as information necessary to a more complete understanding of the foothill range land in the Blue Mountains of northeastern Oregon.

The purposes of this study are to determine:

(a) the seasonal and total yields of herbage, crude protein, calcium, and phosphorus from native forages on three typical range sites in the foothills of the Blue

Mountains of eastern Oregon.

(b) the time at which these sites may be grazed most effectively, and

(c) the extent of grazing by deer and elk in the forementioned areas.

REVIEW OF LITERATURE

The Value of Forage Quality Studies

The opinions of writers vary when they are considering the value of studies of the nutritional quality of forage plants and how these studies should be conducted in order to be most effective in contributing to improved range use. Such information is, however, found useful in many ways. For example, Pickford and Reid (22, p. 15) state that knowledge of the seasonal values of range types can be utilized to determine the best salting, riding, and fencing practices in promoting the most efficient use of the ranges. Watkins *et al* (32, p. 1) pointed out that this information is useful to range nutritionists and ranchers when they are determining the areas to be grazed and the periods during which deficiencies of essential nutrients are most likely to occur in some of the important range forages. Gordon and Sampson (12, p. 91) proposed that forage quality studies should prove helpful in explaining plant succession. Information as to chemical constituents of the dominant species and seasonal changes in nutrient quality should point the way to a more scientific approach to range revegetation and maintenance by enabling refinement of methods for estimating the carrying capacity of the range.

According to Cook (3, p. 23-24) technical range managers need to be better informed in matters dealing with the nutritional qualities of the various plant species so that management may consider not only the effect of livestock upon forage but also the effect of forage upon livestock. The quantity of forage may be adequate, yet the animal diet may be deficient in one or more essential constituents. As an example, it has been well established that an adequate supply of minerals is important to animal growth and maintenance. Recent studies indicate that malnutrition and a number of diseases in range animals are definitely associated with deficiencies of minerals in the vegetation (9, p. 5: 23, p. 19). These can often be detected by chemical analysis of either plant or animal tissues.

Moreover, Stoddart and Greaves (26, p. 3) show that the specific seasonal nature of range forage production makes the study of seasonal variations in forage value important. In order that animals can make the most efficient use of range lands, it is important to understand the balance of various chemical constituents and the importance of deficiencies in the diet of animals existing wholly upon these native plants. They further state (26, p. 6) that chemical analysis alone gives only a partial picture of the adequacy of a given plant as livestock feed in that it ignores the availability of the various constituents to the animal. The digestion coefficient or per cent of each constituent actually digested by the animal would improve this type of data. As a general index to forage value, however, chemical analysis is considered to be of great value. Stanley and Hodgson (24, p. 451) state that problems concerning forage quality do not lend themselves readily to controlled experimental procedure because of the wide variability in the botanical composition of the forage, together with paramount difficulties in conducting grazing tests with livestock under range conditions. Chemical analysis of the forage, therefore, remains one of the most useful techniques for indexing forage quality.

Factors Affecting the Nutrient Quality of Forage

Much disagreement exists relative to the factors influencing the chemical composition of forage species. Hopper and Nesbitt (15, p. 4) state that the chemical composition and, consequently, the nutritive value of grass, like that of other plants, is known to vary widely. These variations are caused by a number of factors. Cook and Harris (5, p. 8) recognize that an appraisal of the nutritive value of range forage may be complicated by many physical factors that affect the chemical composition.

Thus, chemical analyses present information of limited usefulness unless all influencing factors have been recognized and properly evaluated. These factors, which all have a bearing on accurate sample description, include: (1) growing season and stage of maturity, (2) species differences, (3) plant part sampled, (4) soils and sites, (5) climatic factors, (6) altitude, (7) shade, and (8) livestock used.

Growing Season and Stage of Maturity

Many authors have stated that there is an orderly decline in plant content of crude protein, calcium, and phosphorus with increasing maturity (23, p. 21-22; 10, p. 11; 4, p. 57; 17, p. 105; 12, p. 89). While others agree as regards protein and phosphorus, they show that there is appreciable fluctuation in calcium content over the entire growing period, making calcium levels unpredictable, with no definite seasonal trend (18, p. 422; 31, p. 22-23; 26, p. 19; 24, p. 465; 29, p. 17). Along the same line Sampson et al (23, p. 18) say that while plant tissue is being formed, animal nutrition is usually satisfactory. Gordon and Sampson have shown that shortening of the growing season apparently results in a decrease in phosphorus and, in some species, in calcium; but it does not quantitatively influence the protein and potassium contents (12, p. 91).

The work of Cook and Harris shows that phosphorus content of both grasses and forbs decreased as the season advanced, whereas the phosphorus content of browse tended to increase (4, p. 57). Watkins et al indicate that phosphorus uptake by plants is more sensitive to yearly, seasonal, and local differences than is protein (32, p. 2). Cook and Harris have reported inconsistencies in seasonal trend in protein, finding that protein content of pasture grasses was high in the early season, later displaying a temporary drop and finally increasing slightly according to moisture conditions and soil fertility (32, p. 2).

Species Differences

Cook and Harris point out that species have characteristic nutrient composition, yet the variation in chemical values owing to the advancement of growth is greater within than between species (4, p. 53). Gordon and Sampson likewise state that, although species within a plant group have characteristic compositional levels, the variation in chemical values in the entire life cycle of plants of a given species is greater than that between the various species of the plant group for any single growth stage (12, p. 89). Oelberg concluded on the other hand that the plant is more important than the soil or management practices in determining the mineral composition of the forage. The effect of stage of maturity varies among species and within the same species, each species having a rather characteristic behavior pattern as the result of various stimuli (21, p. 22-23). Watkins et al state that some species of grasses run consistently higher in nutritive value than others (30, p. 17). Hopper and Nesbitt also report that different species of grasses have characteristically different chemical compositions. These depend on the inherent nature and to some extent on the physical character of the plant (15, p. 4). Hart et al state that the difference in composition between species is more marked than the variation within the same species (14, p. 51).

The inherent and physical characteristics are governed by genetics. Kik relates that the determination of nutritive value of forage species is complicated by the genetic variability of the plant involved in experimentation (16, p. 3). Other workers have shown that different strains of the same species show different physical and chemical characteristics (15, p. 15). Fraps and Fudge found wide differences in protein, phosphoric acid, and lime contents of different samples of the same species even at the same stage of growth, thus expressing genetic-environmental interactions on chemical analysis (8, p. 33; 10, p. 19; 9, p. 36). Gordon and Sampson state that, although species within a plant group have characteristic compositional levels, the variation in chemical values during the entire life cycle of plants of a given species is greater than that between the various species for any single growth stage (12, p. 89).

Gordon and Sampson have shown that the foliage of the deciduous shrubs and trees is in contrast to all of the other plant groups in that silica-free ash and calcium contents increase, while protein levels decrease as the season advances. In deciduous half-shrubs and nondeciduous shrubs the protein levels change relatively little, while the ash and calcium contents vary throughout the season according to the proportion of young foliage in the sample. The same authors show that in most grass, grass-like, and broad-leaved herbaceous species there is a continuous and orderly decline in protein, calcium, and phosphorus as maturity advances. The calcium content of the broad-leaved herbs was higher than that of the grass or grass-like species, while phosphorus was about the same in all three groups at corresponding stages of maturity (12, p. 89-90). Cook and Harris as well as Stoddart and Greaves in comparing the seasonal variation in nutritive value in browse, grasses, and forbs found that browse plants fluctuated least in nutrient content and grass fluctuated most, with forbs falling between. They noted an orderly decline in protein content of the three classes of forage from beginning to end of the grazing season. No trend in calcium content of grass or forbs was observed, although browse showed a general increase with season advancement. The phosphorus content of grasses and forbs decreased, while that of the browse increased with the advance in maturity (4, p. 57-62; 26, p. 9-16).

Hart et al state that the value of a range is dependent to a large extent upon the relative abundance of those species which maintain high nutritive value over a long period of the year. In one study the high calcium content of one species was shown to make up for deficient amounts in other species in the same area (14, p. 51; 31, p. 21). Thus, as pointed out by Cook and Harris (4, p. 61) and Watkins (30, p. 18) a diversified plant cover would be more desirable than a single forage class from the standpoint of a balanced ration.

Climatic Factors

Climatic factors, such as temperature, precipitation, humidity, light intensity, and altitude may be dominant in controlling the nutritive value of plants. Although plants are dependent upon soils for their mineral nutrients, climatic factors affect respiration, assimilation, photosynthesis, and metabolism to such an extent that the mineral and organic matter content of plants may be strongly modified by these factors even though grown on the same soil (21, p. 222).

That composition of a given species varies from one year to another and with seasonal climatic conditions is recognized by Hopper and Nesbitt (15, p. 17). Some workers have shown that the chemical content of desert forage plants on winter range change only slightly. They suggest that most of the effects of leaching or normal translocation of nutrients took place prior to the beginning of the winter grazing season (4, p. 61).

Watkins states that highest protein production is correlated with highest monthly precipitation and vigorous growth (31, p. 11). He also states that the intensity of phosphorus deficiency depends upon the fall and winter precipitation which occurs after the forage is mature and that the duration appears to be controlled to a large extent by spring and summer rains, which accelerate new growth (31, p. 21). Watkins and other workers have shown that a season of heavy rainfall produces hay of a low calcium and a high phosphorus content. Conversely, a season of light rainfall produces a hay high in calcium and low in phosphorus. He reports the average loss of calcium by wintering or leaching to be about 26 per cent, whereas phosphorus losses were approximately 78 per cent (30, p. 5-24; 6, p. 651). Guilbert _et al_ have noted that the greatest per cent of loss from leaching was in silica-free ash, which represents that portion of the minerals in the plant that are available to the animal. This loss varied from 25 to 67 per cent in different samples (13, p. 25).

Soils and Sites

Fudge and Fraps observed that protein and phosphoric acid in immature samples of forage, on an average, increased with increase in either total nitrogen or active phosphoric acid in the soil. They also mentioned that the relationship between immature samples and soil nitrogen is much closer than in mature ones. The phosphoric acid content of forage from different soil groups did not change as markedly or as regularly as the protein. Calcium increased in the forage at all stages of growth with increase in soil lime. A knowledge of soil nutrients and plant nutrient levels and familiarity with their relationships may make it possible to predict the relative chemical composition of forage grown on soil types whose general chemical composition is already known (9, p. 28-31; 10, p. 46-55).

Cook and Harris concluded that there is no general agreement on how most environmental factors operate to modify either the influence of plants upon soil composition or, conversely, the influence of soil upon plant composition (5, p. 17). They further say that the availability of minerals in the soil is determined not only by the chemistry of the soil but also by the many biological factors involved (5, p. 35).

Oelberg states that the physical and chemical properties of soil may determine the nutrients that the plant is able to absorb; for example, phosphorus is most available between pH # 6 and pH # 7. The physical properties of soil, such as texture and porosity act more or less indirectly. Poorly aerated soils greatly limit the absorption of essential elements, especially phosphorus. Soils rich in biotic life show enhanced aeration and fertility. Other workers also indicate that pH is an important factor in making nutrients available to plants (12, p. 4).

Stoddart found that in collecting plants for complete analysis, attention must be given to soil type and site. He reports that site usually had a significant effect upon protein, the good sites yielding more than the poor ones. Phosphorus showed a highly significant relation to soil but not to site. Calcium content in plants showed no change among different soil types. Plants from poor sites tend to have slightly more calcium than those from good ones (25, p. 732-737).

Midgley states that soil texture has a pronounced effect on the availability of moisture and plant nutrients. Fine-textured soils are better able to store up and hold these materials than more sandy types. It is evident that soil type has a marked effect on the quality and quantity of herbage (19, p. 501-502). Ward indicates that plants require optimal levels of all required nutrients for maximum growth commensurate with the prevailing climatic conditions. A balanced nutrient supply usually results in forage of approximately the same mineral nutrient composition, varying only in yield (29, p. 288).

Plant Part Sampled

Gordon and Sampson recognize that different parts of the plant may vary in composition and also that seeds of the grasses and the broad-leaved herbs have approximately the same amount of calcium and more phosphorus as compared with mature herbage (12, p. 5, 91). The calcium content of stems and leaves varied among grass, browse, and forbs. Cook and Harris found that when plant parts were considered separately the protein increased in some cases as the growth stage advanced. The composition of grass varied with the season largely because of change in the stem-to-leaf ratio. This accounted for part of the seasonal decrease in protein and phosphorus (5, p. 34-38; 4, p. 43-57).

Livestock Used

Oelberg found that various classes of livestock exhibited different behavior patterns and forage preferences (21, p. 223). According to Kik the genetic variability in the animals involved is a factor in determining the nutritive value of forage species (16, p. 3).

McLean and Tisdale show that the interpretation of experimental results from fall range forage is complicated by the effect of selective grazing on parts of plants (18, p. 422). Along this line Cook and Harris have shown that, although the chemical composition of the assumed diet of grazing sheep varied from period to period, for the most part, the range furnished adequate nutrition during the summer season. The protein, calcium, and phosphorus were decidedly higher in the diet than in the plants. Their data indicate how the selective behavior of sheep for more nutritious parts of the plant accounts for the lack of seasonal trend in the chemical content of the diet as compared to the chemical content of the current year's growth in plants. These data show that the chemical content of plants has general trends as the season advances, whereas the constituents in the diet may not vary or may exhibit these trends to a reduced degree (4, p. 59).

Altitude

McCreary has shown that at higher altitudes, growth of grasses starts much later, but is more rapid. The plants at higher altitudes contain more nitrogen at the same growth stage than plants at lower altitudes (17, p. 105). Other workers have found that as grasses grew at higher altitudes, there was generally a marked increase in the per cent of crude protein and nitrogen-free extract and a decrease in crude fiber (15, p. 17-18). Thus, it seems that the western forage plants increase in feeding value with increase in altitude. However, changes in climate and soils or site must be considered along with variations in altitude.

Shade

Cook and Harris state that areas having more shade produce vegetation higher in protein and phosphorus than more open sites (5, p. 34-37). Hopper and Nesvitt have shown that shading causes an increase in crude protein and a decrease in nitrogen-free extract (15, p. 18). The effect on crude fiber is reported as variable among species. Pickford and Reid indicate that most areas with a dominant tree canopy and understory may be recognized as waste areas because of a rather scant supply of suitable forage (22, p. 21).

Application of Ecology

One of the greatest uses of ecology in land management is in delineating range sites. McLean and Tisdale (18, p. 405) as well as Daubenmire (7, p. 302-303) recognize, for instance, that the great variety in topographic, climatic, edaphic, and biotic conditions occurring on the range lands are associated with a corresponding variety of range types and plant species. Daubenmire states that the collective area which one plant association occupies or will come to occupy as succession advances is called a habitat type (7, p. 303). He also states that the maximum utility of the habitat type concept to land managers would result from mapping the land surface on the basis of habitat types, with secondary subdivisions to indicate the status of vegetation now occupying the land (7, p. 326). This study was designed on the basis of a prior habitat type classification of the area.

DESCRIPTION OF STUDY AREA

The Hall Ranch study area is located about eleven miles southeast of Union, Oregon, specifically in Township 5, South, Range 41 East of the Willamette meridian in the Catherine Creek drainage. The annual precipitation varies from 26 to 30 inches. The total crop year precipitation for the 1959 grazing season was 12.92 inches from October 1958 to June 1959. For the 1960 grazing season it was 12.04 inches from October 1959 to June 1960. The elevation is approximately 3,000 to 3,300 feet. The monthly precipitation and mean temperatures occurring during the sampling period are represented in Figures 1 and 2 (28).

A detailed ecological map of the entire Hall Ranch area was prepared by C. E. Poulton and E. Wm. Anderson according to range and forest site guides developed by the latter (27). The same area was subsequently mapped in an equally detailed soil survey by a group of experienced Soil Conservation Service soil surveyors, together with C. T. Youngberg, Forest Soils Scientist, from Oregon State University. This latter survey followed national standards of soil survey, and all soils and vegetation delineations were resolved. From among these pre-typed areas, three range sites were selected as representative of typical vegetation resources on the experimental area. These three sites, which are considered habitat types were:

the pine site (214), the fir site (315), and the meadow site (424). From comparison of each location with normal characteristics as described in the Soil Conservation Service Range Site Handbook for the Blue Mountain Land Resource Area of Oregon (27), representative examples of each were selected by a panel of experienced ecologists.

The pine site (214) represents a ponderosa pine, Douglas fir/pinegrass association. It is found, in this instance, on Hall Ranch silty loam soil. The vegetation is characterized by a ponderosa pine, Douglas fir overstory, snowberry, oceanspray, ninebark, snowbrush shrub layer and a Kentucky bluegrass, elk sedge, pinegrass understory (Figure 3). For a detailed description of the soils and vegetation, including scientific names, see Appendices IX to XV.

The fir site (315) is considered a mixed fir forest association on a grand fir climax site. It is found in this instance on a moderately deep Tolo silt loam soil. The present overstory is predominantly Douglas fir, grand fir, and western larch. The shrub layer is composed mainly of oceanspray, ninebark, snowberry, huckleberry, and spirea. The understory is dominated by pinegrass, elk sedge, wild pea, meadowrue, and twinflower, with prince's pine an important site indicator (Figure 4).

The meadow site (424) is a dry mountain meadow site found on an uncorrelated series tentatively named an Argenti silty clay loam. The vegetation is predominantly Kentucky bluegrass, Canadian bluegrass, cheatgrass, tarweed, silvery lupine, yarrow, and Canadian thistle (Figure 5). The vegetation and soils of the study areas were described with an ecological reconnaissance method published by Anderson and Poulton (1).

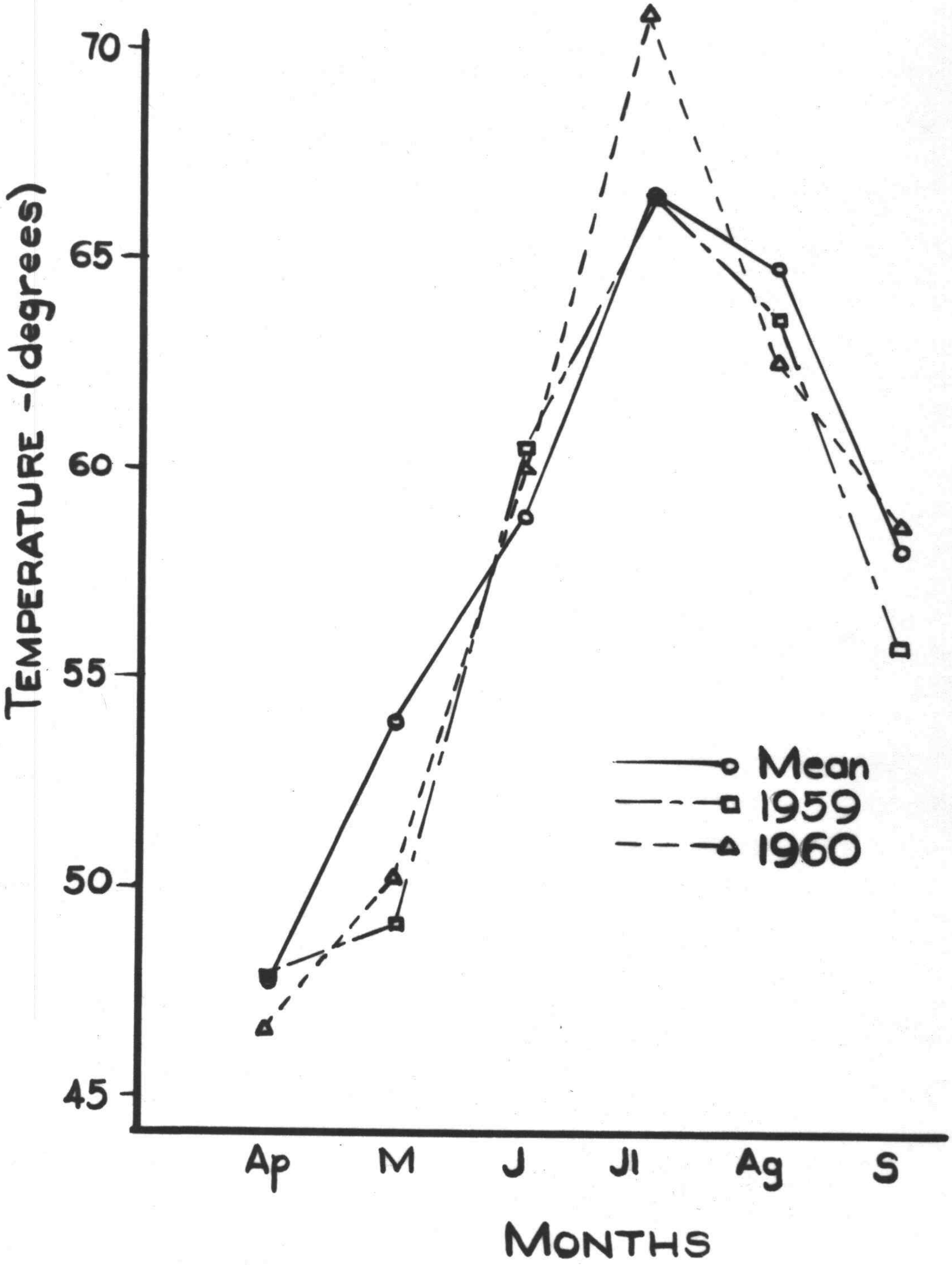

Figure 1

Mean Monthly Temperature during Grazing Season

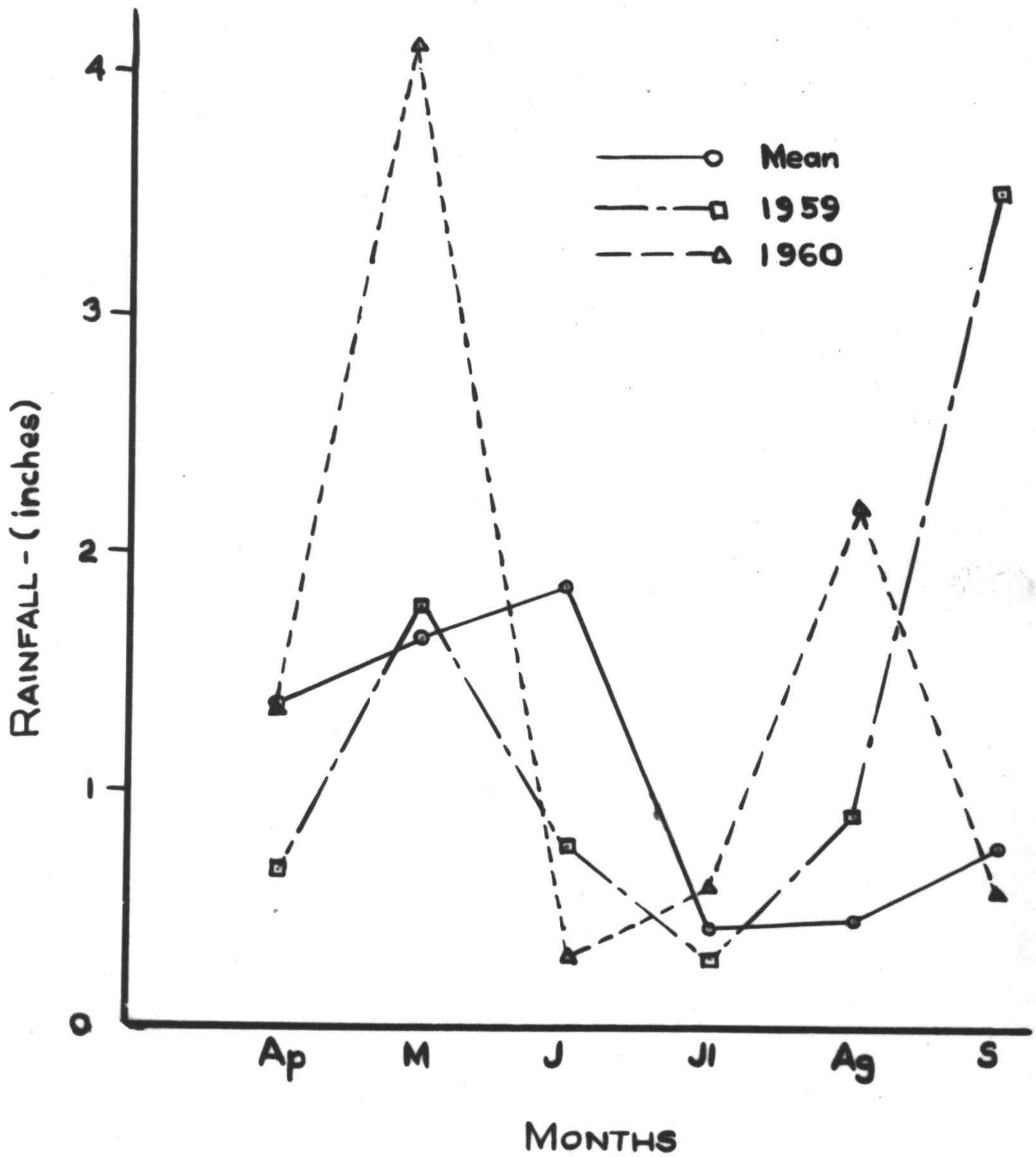

Figure 2

Monthly Precipitation during Grazing Season

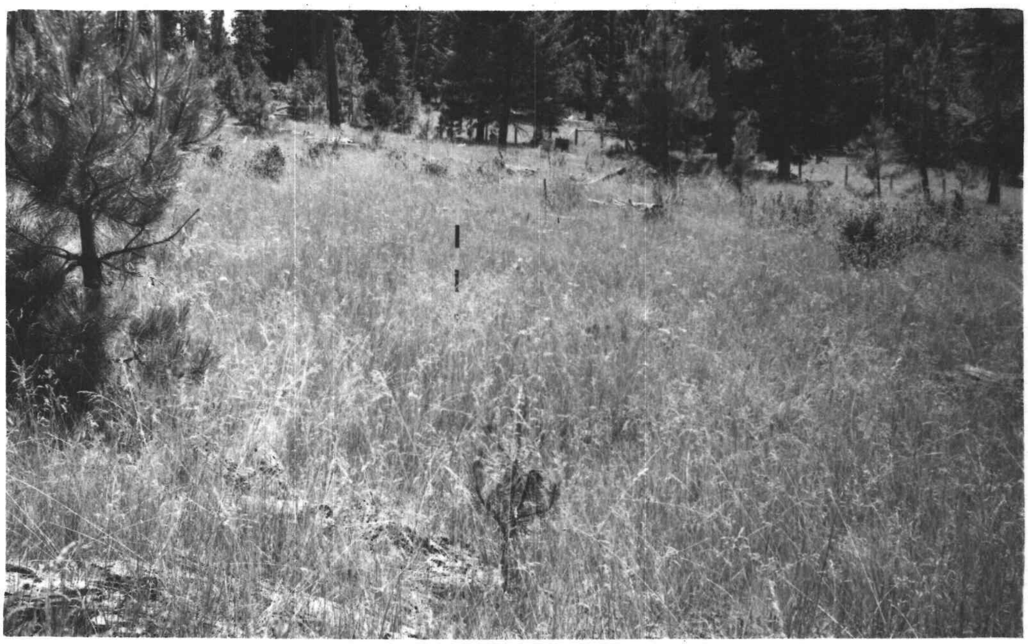

Figure 3

Cattle Exclosure, Pine Site (214)

Figure 4

Cattle Exclosure, Fir Site (315)

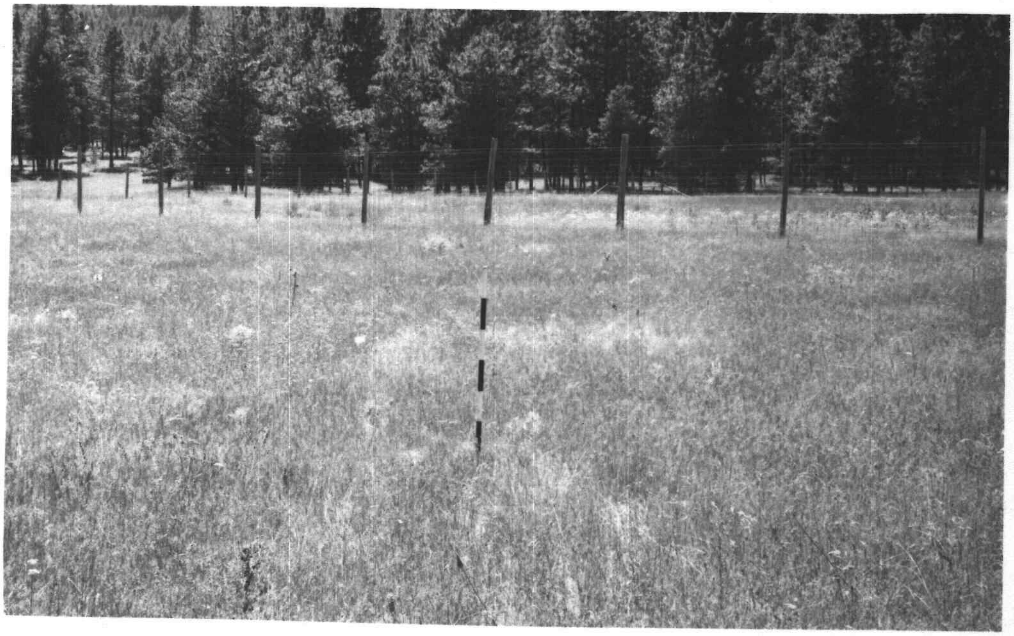

Figure 5

Deer Exclosure, Meadow Site (424)

METHODS AND PROCEDURES

Sampling and Experimental Design

The nutritive quality and yield data presented in this paper were based on a split-plot factorial design.

Exclosures were established on three range sites typical of the Blue Mountains of northeastern Oregon. The soils and vegetation of the three sites are described in the previous section. They may each be considered an example of different habitat types. Exclosures in the meadow and pine sites were built in 1958, and on the fir site in 1960. Each site contains two exclosures: a cattle exclosure surrounded by a four-foot cattle-tight fence, and a deer exclosure surrounded by a nine-foot deer-tight fence. For sampling purposes, each exclosure was divided into quadrants. Five random samples of yield by species were taken from each quadrant, making twenty samples per exclosure and forty samples from each site for each cutting date. Quadrants were numbered and sampled in a clockwise manner, beginning in the northwest corner and finishing in the southwest corner. The yield samples were taken from a 4.8 square foot circular plot on the meadow and pine sites and a 9.6 square foot circular plot on the fir site, allowing for more sparse vegetation on the latter site. The herbaceous species were cut at ground level, and samples of the current year's growth only of the browse species were included. Clippings were made each year as nearly as possible at comparable growth stages of the native bluegrass irrespective of chronological dates--a method similar to that described by Gordon and Sampson (12, p. 89). Two cuttings were made in 1959 and three in 1960, at the emergent, hay, and early fall stages of development. The June cutting, taken in 1960 only was made at the emergent stage, when the seed heads of the bluegrass were beginning to leave the sheath. The July cutting, taken in 1959 and 1960, was made at the hay stage, when the bluegrass seed was in the dough stage and could have been cut for hay. The August cutting, taken in 1959 and 1960, was termed an early fall cutting. It was taken when the bluegrass had matured and the seeds were beginning to shatter. All three cutting times fell in the middle of the grazing season on this summer range.

The clipped plant material from each plot was divided into the species or species groups considered of greatest importance for forage value on each site. These species and species groups are listed below:

Pine Site (214)	Fir Site (315)	Meadow Site (424)
Bluegrass	Pinegrass	Bluegrass
Elk sedge	Elk sedge	Perennial forbs
Clover	Perennial forbs	Annual forbs
Perennial forbs	Wild pea	
Oceanspray	Oceanspray	
Snowberry	Snowberry	
	Huckleberry	

The bluegrass on the meadow site is a composite of Kentucky and Canadian bluegrass. The "perennial" and "annual forb" observations are composites of all annual or perennial forbs not considered individually important as forage. If there appeared to be more than five grams of an individual annual or perennial species which would normally be included in the composite sample, it was weighed and recorded individually and then composited with the rest for chemical analysis. Each individual sample was stored in a paper sack.

Processing of Samples

As soon after sampling as possible, each green sample was brought in from the field and weighed on a Toledo scale to the nearest gram. The samples were then placed in a forage dryer until the grass stems would snap and the leaves of all species would crumble. Air-dry weights were taken at this time. The samples were ground through a Wiley-mill and composited, by exclosure, into the previously mentioned species or species groups for chemical analysis.

Chemical Analysis

The composited samples were analyzed for per cent dry matter, crude protein, calcium, and phosphorus according to the standard procedures of the Association of Official Agricultural Chemists and under the direction of J. E. Oldfield in the Animal Nutrition Laboratory at Oregon State University.

Processing of Data

The raw data were punched on I. B. M. cards to facilitate the computation of the yield in pounds per acre of herbage, crude protein, calcium, and phosphorus for each quadrant, exclosure, and site, as well as for each species included therein. The statistical analysis was done under the direction of R. G. Petersen, Agricultural Experiment Station Statistician, Oregon State University.

RESULTS

Total Yield in Pounds/Acre

The details of the analysis of variance are given in Appendices I to VIII.

1959 Herbage Production in Pounds/Acre

The 1959 herbage yields are presented in Table 1, and the analysis of variance is given in Appendix I. These data indicate that there are differences in herbage yield among sites. No difference in yield existed between the pine and meadow sites. They each, however, yield 600 to 700 pounds per acre more than the fir site. A difference between exclosures on the various sites was noted, the deer exclosures tending to yield approximately 100 pounds more than the cattle exclosure. There was a difference between July and August cutting times, with July cuttings yielding about 200 pounds more than August cuttings. The interaction between cutting date and site showed a difference between the high July cutting and the low August cutting, which represented about 100 pounds difference on the pine site and about 400 pounds difference on the meadow sites. There were no differences between dates on the fir site. The interaction between cutting dates and exclosure yields showed that there is no difference between cutting dates on the cattle exclosures, while there was a 343 pound difference between dates on the deer exclosures.

1960 Herbage Production in Pounds/Acre

The 1960 herbage production data presented in Table 5 showed a difference between sites. No real difference was noted between the 803 pounds per acre yield on the pine site and the 747 pounds per acre yield on the meadow site, but they were each considerably higher than the fir site. On the pine site the cutting date times site interaction for July and August was not significant, but each was lower than the 943 pounds per acre June cutting. No difference between cutting dates on the fir and meadow sites was noted. The analysis of variance is in Appendix V.

1959 Protein Yield in Pounds/Acre

From the 1959 protein data presented in Table 2 it is evident that there is a real difference between site yields. The 56 and 50 pounds per acre yields on the pine and meadow sites showed no differences, but they were each considerably higher in protein yield than the fir site at 24 pounds per acre. In general, the July cutting, 50 pounds per acre, yielded more protein than the August cutting, 33 pounds per acre. In the cutting times location interaction, no difference in crude protein yield by cutting date on the pine site were observed, while the July cutting of 25 and 64 pounds per acre was higher than the August cutting of 11 and 35 pounds per acre on the fir and meadow sites respectively. The yield of exclosures by cutting date showed no difference on the cattle exclosures, but a higher yield on the deer exclosures in July than in August was noted. The analysis of variance is in Appendix II.

1960 Protein Yield in Pounds/Acre

The 1960 protein data are given in Table 6 and the analysis of variance of these data is given in Appendix VI. The crude protein yields were the same on the pine and meadow sites, while each was higher than the fir site by 25 to 30 pounds per acre. The June cutting yielded 10 pounds per acre more crude protein than the July and August cuttings, which each yielded 43 pounds per acre. On the pine site the June cutting yielded more than the July and August cuttings, with no difference between the latter two cuttings. No differences exist between cuttings on the fir site, which maintained about 21 pounds of crude protein per acre over the sampling period.

1959 Calcium Yield in Pounds/Acre

The meadow site (Table 3) yielded 0.57 to 1.44 pounds per acre more of calcium than the pine or fir sites. The pine site yielded 0.87 pounds more than the fir site. The July cutting yielded 0.58 pounds per acre more calcium than the August cutting, which yielded 0.92 pounds of calcium per acre. The analysis of variance is in Appendix III.

1960 Calcium Yield in Pounds/Acre

The 1960 calcium yields are presented in Table 7, and the analysis of variance is given in Appendix VII. No difference in the calcium yield per acre was noted between the pine (1.71 pounds per acre) and the meadow sites (2.08 pounds per acre), nor between the pine and fir sites (1.33 pounds per acre), but the meadow site, however, yielded more than the fir site.

1959 Phosphorus Yield in Pounds/Acre

No real difference in phosphorus yield per acre was noted between the pine site, which produced 1.69 pounds per acre, and the meadow site, which produced 1.81 pounds per acre, but they yielded higher than the fir site, which produced 0.19 pounds per acre (Table 4). In general, the deer exclosures yielded 0.40 pounds per acre more than the cattle exclosures. The July cuttings were 0.88 pounds per acre higher than the August cuttings. On the pine and meadow sites the July cutting was about 0.60 to 1.63 pounds per acre higher in phosphorus than the August cutting, but no differences were observed between cutting times on the fir site, which maintained about 0.19 pounds per acre. No differences between cutting dates on the cattle exclosures were noted, while the July cuttings on the deer exclosures were 1.50 pounds per acre higher in phosphorus than the August cuttings. The analysis of variance is given in Appendix IV.

1960 Phosphorus Yield in Pounds/Acre

In phosphorus yields in pounds per acre (Table 8) the pine, yielding 1.00 pounds per acre and the meadow sites, yielding 1.33 pounds per acre, were statistically the same, each being higher in yield than the fir site, which produced 0.04 pounds per acre. The analysis of variance is given in Appendix VIII.

TABLE 1

1959 HERBAGE YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time July 1959	August 1959	Mean of the Site Means
Pine Site 214	Cattle	780	925	
	Deer	1063	727	
	Site mean	922	826	874
Fir Site 315	Cattle	170	146	
	Deer	269	152	
	Site mean	220	149	184
Meadow Site 424	Cattle	825	560	
	Deer	1200	624	
	Site mean	1013	592	802
Mean of the Site Means by Cutting		718	523	

MEAN PRODUCTION OF ALL LIKE EXCLOSURES ON THE SITES

Exclosure	Cutting Time July 1959	August 1959	Mean
Cattle	592	544	568
Deer	844	501	673
Mean	718	523	

LSD on Site at the five per cent level	113.1094
LSD on Exclosure at the five per cent level	92.3537
LSD on Cutting at the five per cent level	51.3926
LSD on Cutting x Site at the five per cent level	89.0131
LSD on Cutting x Exclosure at the five per cent level	72.6799
LSD on Cutting x Exclosure x Site at the five per cent level	99.5587

TABLE 2

1959 PROTEIN YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time July 1959	August 1959	Mean of the Site Means
Pine Site 214	Cattle	50	62	
	Deer	68	44	
	Site Means	59	53	56
Fir Site 315	Cattle	19	11	
	Deer	31	12	
	Site Means	25	11	24
Meadow Site 424	Cattle	52	34	
	Deer	77	35	
	Site Means	64	35	50
Mean of the Site Means by cutting		50	33	

MEAN PRODUCTION OF ALL LIKE EXCLOSURES ON THE SITES

Exclosure	Cutting Time July 1959	August 1959	Mean
Cattle	40	36	38
Deer	59	30	44
Mean	50	33	

LSD on Site at the five per cent level	8.4376
LSD on Cutting at the five per cent level	3.6389
LSD on Cutting x Site at the five per cent level	6.3030
LSD on Cutting x Exclosure at the five per cent level	5.1474
LSD on Cutting x Exclosure x Site at the five per cent level	8.9145

TABLE 3

1959 CALCIUM YIELDS IN POUNDS/ACRE

Site	Exclosure	Cutting Time July 1959	August 1959	Mean of the Site Means
Pine Site 214	Cattle	1.25	1.25	
	Deer	2.00	0.75	
	Site Mean	1.63	1.00	1.31
Fir Site 315	Cattle	0.50	0	
	Deer	1.25	0.025	
	Site Mean	0.88	0.013	0.44
Meadow Site 424	Cattle	2.25	1.25	
	Deer	1.75	2.25	
	Site Mean	2.00	1.75	1.88
Mean of the Site Means, by cutting		1.50	0.92	

MEAN PRODUCTION OF ALL LIKE EXCLOSURES ON THE SITES

Exclosure	Cutting Time July 1959	August 1959	Mean
Cattle	1.33	0.83	1.08
Deer	1.67	1.01	1.33
Mean	1.50	0.92	

LSD on Site at the five per cent level	0.56
LSD on Cutting at the five per cent level	0.33
LSD on Cutting x Exclosure x Site at the five per cent level	0.81

TABLE 4

1959 PHOSPHORUS YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time July 1951	August 1959	Mean of the Site Means
Pine Site 214	Cattle	1.25	1.75	
	Deer	2.75	1.00	
	Site Mean	2.00	1.38	1.69
Fir Site 315	Cattle	-	-	
	Deer	0.75	-	
	Site Mean	0.38	-	
Meadow Site 424	Cattle	2.25	1.00	
	Deer	3.00	1.00	
	Site Mean	2.63	1.00	1.81
Mean of the Site Means, by cutting		1.67	0.79	

MEAN PRODUCTION OF ALL LIKE EXCLOSURES ON THE SITES

Exclosure	Cutting Time July 1959	August 1959	Mean
Cattle	1.17	0.92	1.04
Deer	2.17	0.67	1.42
Mean	1.67	0.79	

LSD on Site at the five per cent level	0.40
LSD on Exclosure at the five per cent level	0.32
LSD on Cutting at the five per cent level	0.31
LSD on Cutting x Site at the five per cent level	0.53
LSD on Cutting x Exclosure at the five per cent level	0.43
LSD on Cutting x Exclosure x Site at the five per cent level	0.75

TABLE 5

1960 HERBAGE YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time June 1960	July 1960	August	Mean of the Site Means
Pine Site 214	Cattle	985	700	791	
	Deer	882	698	764	
	Site Mean	934	699	777	803
Fir Site 315	Cattle	174	230	182	
	Deer	233	208	217	
	Site Mean	204	219	199	207
Meadow Site 424	Cattle	716	718	707	
	Deer	768	714	857	
	Site Mean	741	716	782	747
Mean of the Site Means by cutting		626	545	586	
LSD on Site at five per cent level					114.6222
LSD on Cutting x Site at the five per cent level					117.7348

TABLE 6

1960 PROTEIN YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time: June 1960	July 1960	August 1960	Mean of the Site Means
Pine Site 214	Cattle	66	42	46	
	Deer	63	43	46	
	Site Mean	65	43	46	51
Fir Site 315	Cattle	20	22	16	
	Deer	28	21	19	
	Site Mean	24	22	17	21
Meadow Site 424	Cattle	53	43	38	
	Deer	52	44	48	
	Site Mean	52	43	43	46
Mean of the Site Means		47	36	35	
LSD on Site at the five per cent level					7.0362
LSD on Cutting at the five per cent level					4.2467
LSD on Cutting x Site at the five per cent level					7.3572

TABLE 7

1960 CALCIUM YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time June 1960	July 1960	August 1960	Mean of the Site Means
Pine Site 214	Cattle	2.25	1.75	1.50	
	Deer	1.75	1.25	1.75	
	Site Mean	2.00	1.50	1.62	1.71
Fir Site 315	Cattle	1.00	1.00	1.00	
	Deer	1.50	1.75	0.75	
	Site Mean	1.25	1.38	1.38	1.33
Meadow Site 424	Cattle	1.75	1.75	1.50	
	Deer	2.75	2.00	2.75	
	Site Mean	2.25	1.88	2.12	2.08
Mean of the Site Means by cutting		1.83	1.58	1.71	
LSD on Site at the five per cent level					0.49

TABLE 8

1960 PHOSPHORUS YIELD IN POUNDS/ACRE

Site	Exclosure	Cutting Time June 1960	July 1960	August 1960	Mean of the Site Means
Pine Site 214	Cattle	1.25	0.75	1.00	
	Deer	1.25	1.00	0.75	
	Site Mean	1.25	0.88	0.88	1.00
Fir Site 315	Cattle	-	-	-	
	Deer	0.25	-	-	
	Site Mean	0.12	-	-	0.04
Meadow	Cattle	1.25	1.00	1.50	
	Deer	1.25	1.50	1.50	
	Site Mean	1.25	1.25	1.50	1.33
Mean of the Site Means by cutting		0.88	0.71	0.79	
LSD on Site at the five per cent level					0.49

Yield by Individual Species

This section presents the herbage yield, per cent concentration of crude protein, calcium, and phosphorus in individual species and species groups as well as their per cent of total composition of yield and crude protein by site, year, and cutting time.

The writer has not relied as heavily upon the 1959 as upon the 1960 data in stating apparent trends in per cent nutrient content and herbage yield of the individual species. He does not feel that two cuttings are as adequate as three in determining actual trends. It also appears that in many instances the July and August cuttings were made too late in the season for pre-maturity trends to be determined. There also appears to be a year interaction which causes the statistics to vary between years.

Pine Site (214)

On this pine site the herbage yield of bluegrass, elk sedge, oceanspray, and snowberry (Table 9) appeared to fluctuate in 1960 from June to August, being higher in June and in August than in July. This does not appear to be true for all of these species in 1959. The composited perennial forbs and clover decreased in yield with advance of time. Generally, bluegrass was the highest in yield, 593 pounds per acre; followed by elk sedge, 160 pounds per acre; perennial forbs, 60 pounds; snowberry, 12 pounds; oceanspray, 5 pounds; and clover, 1 pound respectively.

Bluegrass (Table 10) made up about 70 per cent of the total herbage composition, followed by elk sedge, 19 per cent; perennial forbs, 9 per cent; and snowberry and oceanspray, 1 per cent. Bluegrass and elk sedge maintained the same per cent composition over the seasons; perennial forbs became less important, i.e. percentage composition declined, while oceanspray and snowberry appeared to increase slightly as the season advanced.

The protein content in all species (Table 9) tends to decrease from cutting time to cutting time, with perennial forbs and clover being the highest in per cent composition, followed by the two browse species and bluegrass and elk sedge. The per cent of total protein production by individual species (Table 10) followed herbage production trends in the same way, with the same percentages of total composition being evident in each species, as was represented in herbage production.

The calcium and phosphorus content of the individual species (Table 9) did not appear to follow any definite trends; the calcium fluctuated widely; and the phosphorus barely changed.

Fir Site (315)

Pinegrass, snowberry, and oceanspray on the fir site increased as the season advanced (Table 11), while perennial forbs and wild pea decreased. In 1959 the situation was different, as the pinegrass showed a decline from July to August. Elk sedge and huckleberry fluctuated from cutting time to cutting time. Pinegrass yielded the highest, with 99 pounds per acre, followed by perennial forbs, 41 pounds; wild pea, 36 pounds; elk sedge, 9 pounds; oceanspray, 6 pounds; huckleberry, 5 pounds; and snowberry, 3 pounds. Pinegrass (Table 12) made up 51 per cent of the total herbage production, followed by perennial forbs, 20 per cent; wild pea, 17 per cent; elk sedge, 4 per cent; oceanspray and huckleberry, 3 per cent; and snowberry, 2 per cent. Pinegrass, snowberry, oceanspray, and huckleberry appeared to increase in per cent of herbage composition as the season advanced, while perennial forbs and wild pea decreased, with elk sedge remaining constant.

All species and the species groups usually decline in per cent crude protein as the season advances (Table 11). Wild pea has the highest initial crude protein content, 14.3 per cent. It is followed respectively by perennial forbs, 9.76 per cent; huckleberry, 9.35 per cent; oceanspray, 9.12 per cent; pinegrass, 8.51 per cent; and elk sedge, 7.52 per cent. In per cent of the total crude protein produced on the site (Table 12) pinegrass was the highest, with a 45 per cent average. It was followed by wild pea, 24 per cent; perennial forbs, 21 per cent; elk sedge and oceanspray, 3 per cent; and snowberry and huckleberry, 2 per cent. Pinegrass, elk sedge, snowberry, and oceanspray increased in their contribution to the total production of crude protein as the season advanced, while perennial forbs and wild pea decreased. Huckleberry fluctuated, with a slight tendency to increase.

The calcium content of the plants studied (Table 11) usually increased with chronological age. Wild pea showed the highest content, 1.42 per cent, followed by perennial forbs, 1.11 per cent; oceanspray, 0.97 per cent; snowberry, 0.78 per cent; huckleberry, 0.77 per cent; pinegrass and elk sedge, each 0.33 per cent.

Pinegrass decreased in phosphorus content as the season advanced (Table 11). Elk sedge, wild pea, snowberry, and huckleberry increased from June to July and then decreased in August. Perennial forbs remained the same during the sampling season, while oceanspray showed a tendency to increase. On the average, perennial forbs were the highest in phosphorus content, 0.59 per cent, followed by oceanspray, 0.50 per cent; huckleberry, 0.31 per cent; pinegrass and elk sedge, each 0.22 per cent.

Meadow Site (424)

Perennial forbs and annual forbs (Table 13) decreased in herbage yield as the sampling season advanced, while bluegrass had a tendency to decrease in 1959 and from June to July of 1960, increasing in August. Bluegrass yielded 664 pounds per acre, followed by perennial forbs, 59 pounds, and annual forbs, 41 pounds. Bluegrass (Table 14) made up the bulk of the herbage on this site, 86 per cent, followed by perennial forbs at 8 per cent and annual forbs at 6 per cent. Bluegrass increased in per cent composition as the season advanced, while annual and perennial forbs decreased.

Calcium content (Table 13) showed no definite trends on this site. Perennial forbs at 0.81 averaged the highest per cent composition, followed by annual forbs, 0.51, and bluegrass, 0.20.

Phosphorus content (Table 13) showed the general tendency in the species to decrease with advancement of season. Perennial forbs averaged the highest per cent composition, 0.41, followed by annual forbs, 0.28, and bluegrass, 0.21.

Calcium to Phosphorus Ratio

On the basis of total yield of each constituent in pounds per acre, the calcium to phosphorus ratios were computed for all sites. The ratio never exceeded 2.5:1.0 and was usually about 2.0:1.0 or 1.0:1.0.

TABLE 9

PINE SITE (214) AVERAGE YIELD AND PER CENT PROTEIN, CALCIUM, AND PHOSPHORUS BY CUTTING TIME

	Cutting Time					Mean of both Years
	1959		1960			
	July	August	June	July	August	
Lbs./Acre Yield						
Bluegrass	674	554	662	514	562	593
Elk sedge	126	197	186	136	153	160
Perennial forbs	89	62	71	41	39	60
Clover	7	-	-	-	-	1
Snowberry	15	8	14	9	14	12
Oceanspray	11	5	-	-	9	5
Per Cent Protein						
Bluegrass	5.87	6.50	6.70	5.81	5.78	6.13
Elk sedge	6.10	6.55	6.82	6.57	5.85	6.38
Perennial forbs	9.59	4.09	9.50	7.33	7.25	7.55
Clover	9.29	-	-	-	-	9.29
Snowberry	8.98	6.26	8.68	7.12	6.08	7.42
Oceanspray	8.36	7.11	-	-	6.42	7.30
Per Cent Calcium						
Bluegrass	0.12	0.14	0.16	0.21	0.21	0.17
Elk sedge	0.20	0.12	0.28	0.32	0.26	0.24
Perennial forbs	0.66	0.12	0.60	0.63	0.83	0.57
Clover	1.29	-	-	-	-	1.29
Snowberry	0.55	0.34	0.47	0.50	0.88	0.55
Oceanspray	0.59	0.72	-	-	0.73	0.68
Per Cent Phosphorus						
Bluegrass	0.23	0.22	0.16	0.16	0.16	0.19
Elk sedge	0.20	0.19	0.16	0.17	0.16	0.18
Perennial forbs	0.51	0.25	0.34	0.32	0.34	0.35
Clover	0.54	-	-	-	-	0.54
Snowberry	0.52	0.26	0.38	0.42	0.36	0.39
Oceanspray	0.50	0.42	-	-	0.28	0.40

TABLE 10

PINE SITE (214) PER CENT OF TOTAL COMPOSITION BY SPECIES BASED ON YIELD IN POUNDS/ACRE

	Cutting Time 1959 July (per cent)	1959 August (per cent)	1960 June (per cent)	1960 July (per cent)	1960 August (per cent)	Mean of both Years
Yield						
Bluegrass	73	66	71	73	72	70
Elk sedge	13	24	20	20	20	19
Perennial forbs	10	8	8	6	5	9
Clover	1	-	-	-	-	-
Snowberry	2	1	1	1	2	1
Oceanspray	1	1	-	-	1	1
Protein						
Bluegrass	67	70	68	70	71	68
Elk sedge	13	23	20	21	20	20
Perennial forbs	15	5	10	7	6	9
Clover	2	-	-	-	-	-
Snowberry	2	1	2	2	2	2
Oceanspray	1	1	-	-	1	1

TABLE 11

FIR SITE (315) AVERAGE HERBAGE YIELD AND PER CENT PROTEIN, CALCIUM, AND PHOSPHORUS BY CUTTING TIME

	Cutting Time 1959 July	1959 August	1960 June	1960 July	1960 August	Mean of both Years
Lbs./Acre Yield						
Pinegrass	104	95	85	95	117	99
Elk sedge	18	4	8	7	9	9
Perennial forbs	58	25	49	43	28	41
Wild pea	42	2	53	56	25	36
Snowberry	1	4	2	4	6	3
Oceanspray	3	7	3	6	11	6
Huckleberry	2	8	3	7	3	5
Per Cent Protein						
Pinegrass	9.56	7.71	8.84	7.94	7.50	8.31
Elk sedge	7.81	6.83	7.94	8.02	6.99	7.52
Perennial forbs	11.33	7.73	11.23	10.16	8.36	9.76
Wild pea	17.82	10.69	17.60	13.33	12.10	14.31
Snowberry	9.23	6.26	9.62	9.99	7.44	8.51
Oceanspray	9.24	7.51	10.59	8.97	9.29	9.12
Huckleberry	10.56	7.46	11.12	9.02	8.06	9.35
Per Cent Calcium						
Pinegrass	0.25	0.22	0.26	0.52	0.49	0.33
Elk sedge	0.30	0.26	0.27	0.26	0.55	0.33
Perennial forbs	0.82	1.22	1.02	1.18	1.32	1.11
Wild pea	1.44	1.45	1.38	1.05	1.78	1.42
Snowberry	0.73	0.74	0.58	0.89	0.94	0.78
Oceanspray	0.72	1.39	0.51	1.01	1.23	0.97
Huckleberry	0.64	0.65	0.83	0.86	0.88	0.77
Per Cent Phosphorus						
Pinegrass	0.28	0.21	0.24	0.20	0.19	0.22
Elk sedge	0.28	0.26	0.19	0.22	0.17	0.22
Perennial forbs	0.72	0.60	0.54	0.54	0.54	0.59
Wild pea	0.48	0.38	0.33	0.36	0.26	0.36
Snowberry	0.50	0.45	0.43	0.47	0.40	0.45
Oceanspray	0.58	0.43	0.39	0.47	0.54	0.50
Huckleberry	0.36	0.26	0.32	0.34	0.29	0.31

TABLE 12

FIR SITE (315) PER CENT OF TOTAL COMPOSITION BY SPECIES BASED ON YIELD IN POUNDS/ACRE

	Cutting Time					Mean of both Years
	1959		1960			
	July (per cent)	Aug. (per cent)	June (per cent)	July (per cent)	Aug. (per cent)	
Yield						
Pinegrass	47	64	42	45	59	51
Elk sedge	4	3	5	3	4	4
Perennial forbs	27	18	24	19	14	20
Wild pea	19	2	26	27	13	17
Snowberry	1	2	1	2	3	2
Oceanspray	1	5	1	1	5	3
Huckleberry	1	6	1	3	2	3
Protein						
Pinegrass	39	63	32	36	52	45
Elk sedge	3	3	3	3	4	3
Perennial forbs	26	20	23	21	15	21
Wild pea	29	2	39	34	18	24
Snowberry	1	2	1	2	4	2
Oceanspray	1	4	1	1	6	3
Huckleberry	1	6	1	3	1	2

TABLE 13

MEADOW SITE (424) AVERAGE HERBAGE YIELD AND PER CENT PROTEIN, CALCIUM, AND PHOSPHORUS BY CUTTING TIME

	Cutting Time 1959 July	Cutting Time 1959 Aug.	Cutting Time 1960 June	Cutting Time 1960 July	Cutting Time 1960 Aug.	Mean of both Years
Lbs./Acre Yield						
Bluegrass	816	480	652	628	743	664
Perennial forbs	78	44	62	82	29	59
Annual forbs	90	68	28	7	10	41
Per Cent Protein						
Bluegrass	5.95	5.91	6.77	5.82	5.36	5.96
Perennial forbs	9.83	6.04	10.16	7.78	7.78	8.32
Annual forbs	7.26	4.66	7.04	7.46	7.07	6.70
Per Cent Calcium						
Bluegrass	0.13	0.20	0.23	0.20	0.25	0.20
Perennial forbs	0.77	1.00	0.80	0.78	0.68	0.81
Annual forbs	0.46	0.26	0.48	0.68	0.68	0.51
Per Cent Phosphorus						
Bluegrass	0.25	0.24	0.20	0.16	0.18	0.21
Perennial forbs	0.59	0.39	0.42	0.38	0.28	0.41
Annual forbs	0.34	0.27	0.20	0.33	0.26	0.28

TABLE 14

MEADOW SITE (424) PER CENT OF TOTAL COMPOSITION BY SPECIES BASED ON YIELD IN POUNDS/ACRE

	Cutting Time					Mean of both Years
	1959		1960			
	July (per cent)	Aug. (per cent)	June (per cent)	July (per cent)	Aug. (per cent)	
Yield						
Bluegrass	81	81	88	88	95	86
Perennial forbs	8	7	8	11	4	8
Annual forbs	11	12	4	1	1	6
Protein						
Bluegrass	75	83	84	84	93	84
Perennial forbs	13	8	12	15	6	11
Annual forbs	12	9	4	1	1	5

DISCUSSION AND CONCLUSIONS

The writer wishes again to point out that he has not relied as heavily upon the 1959 data as the 1960 in determining trends in per cent nutrient content and herbage yield of the individual species, because the latter included three separate cutting time observations.

Herbage Yield by Site and Species

In a discussion of yield it must be remembered that each species has a characteristic growth curve for the production of dry matter and that it should be a typical sigmoid curve (2, p. 322-324). Although the samples were taken at three distinct or definite periods, with respect to the normal growth curve of bluegrass, the sampling time did not necessarily encompass comparable parts of the growth curve of each species. Inherent factors, which regulate the slope of each portion of the growth curve and the general chronological time when each phase of growth will start in a given species are apparent (11, p. 336).

The grazing season, as defined in general, does not encompass the whole growth curve of all species represented in a specific area, i.e., chronological date of clipping does not necessarily correspond to the same phenological stage in all species. This difference in phenology of all species present is of little concern in that the grazing season is based on a few of the species of major forage importance. Grazing on subordinate species must be regulated by development of the "key" forage plants regardless of stage of maturity of the subordinate forages.

The yield data presented in this paper for individual species correspond with the physiological growth stage of the species represented. In general, the more succulent plants, such as those represented by perennial forbs and clover on the pine site, wild pea and perennial forbs on the fir site, and perennial forbs on the meadow site were exhibiting a normal downward trend in yield after maturity, while other species, such as pinegrass, elk sedge, and the browse species on the fir site continued to show growth. This could be related to the inherent nature of the species or to the effect of shade on a fairly closed tree canopy site in delaying maturity.

The erratic growth of bluegrass on the meadow and pine sites and elk sedge on the pine site may have been caused by an above-normal amount of precipitation and heat at the end of the 1960 growing season (Figures 1 and 2). This reaction to climate by bluegrass has been noted by other workers (30, p. 5).

The increase in production of annual forbs in the middle of the sampling season on the meadow site is probably caused by the growth of tarweed, which dominated the annual forb production on this site and which does not usually reach full maturity until mid-July.

Since forb species, as represented by the composite of perennial forbs, clover, and wild pea, usually declines in yield rather rapidly because of the weathering of the tissues and the sloughing of natural tissue, it is evident that species such as pinegrass, bluegrass, elk sedge, and browse, which do not decline in yield as readily or are still growing, should make up a larger percentage of the total plant composition as the growing season progresses.

With regard to total herbage yields, it should be noted that different sites have different potentials. The trends in herbage production over the sampling period are a reflection of the trends of the dominant species of that particular site.

The lack of statistical difference between the more open meadow and pine sites and the low-producing fir site was to be expected. Other workers have found this to be generally true in the Blue Mountain area (21, p. 21). The increased production on the fir site in 1960 may have been related to the opening up of the plant community by logging in mid-summer of 1960, as this tends to give advantage to the forage species.

The exclosure differences found within sites may be explained by the difference in vegetation rather than to use by deer or elk. The fir site exclosure was not finished until 1960. On the other sites signs of use by deer were not evident, except for the pine site, where slight use was evident. This problem needs special and more detailed study.

Decrease in forage yield was expected as the season advanced. On the meadow and pine sites in 1960 the increase in production was probably caused by the forementioned increase in bluegrass and elk sedge respectively.

Per Cent Protein Yield by Species And in Pounds/Acre by Sites

In most species a decline in per cent crude protein was noted as the plants reached maturity. Exceptions to this were probably caused by climatic conditions or by the growth habit of the species. In general, the more succulent species were higher in per cent crude protein than the browse species, and the latter group was higher in crude protein than the grass or grass-like species.

The factors that affected herbaceous yield also appear to have influenced the yield in protein in pounds per acre.

Per Cent Calcium Yield by Species and In Pounds per Acre by Sites

In observing the seasonal patterns in per cent calcium, the writer tends to agree with the other workers cited in the review of literature who state that trends in this factor in most species are highly unpredictable. Browse species on the fir site do show an upward trend. This can be attributed to the growth habits of these species, which evidently accumulate more calcium than do other growth forms as they mature.

The more succulent forbs usually contain more calcium than the browse species, and the latter group is higher than the grass and grass-like species.

The same factors which affect the herbage and protein yield also appear to affect the calcium yield.

Per Cent Phosphorus by Species and in Pounds Per Acre of Production by Sites

A general lack of trend in per cent phosphorus in the species on the pine and fir sites is noted, while the species represented on the meadow site tend to decrease in per cent phosphorus as the season advances. The writer attributes this to species characteristics and to site differences, which cause different trends in the same species.

Generally, it may be said that the more succulent forbs and browse species are higher in phosphorus than the grass and grass-like species. The higher percentage of phosphorus is probably related to species and growth form differences. It is reasonable to assume that the same factors affecting differences in pound per acre yields in herbage, crude protein, and calcium also affect yields of phosphorus.

It is evident that the factors affecting herbage yield of a given species or a given site would also affect the yield of the component nutrients, such as crude protein, calcium, and phosphorus. A species which is dominant in a plant community should usually produce more pounds per acre of these constituents than a species which is in lower dominance and is higher in per cent concentration of these substances. This is true in the case of pinegrass compared with wild pea on the fir site.

In discussing seasonal trends with advancement of season, Cook and Harris state that a lack of orderly trend is not surprising when data are expressed in per cent of dry matter (5, p. 35). An increase or decrease in per cent of any constituent as the season advances does not necessarily mean that a plant has added or lost that amount, but rather that this constituent has not increased in the same proportion as the increase in dry matter brought about by increased growth.

Nutrient Quality of the Forage as Affecting Livestock

Using as a basis the recommendations of the National Research Council (20) for the feed requirements of the lactating cow, the writer feels that the calcium to phosphorus ratio of the species on the sites is adequate for normal production. The National Research Council recommends a calcium to phosphorus ratio of between 1:1 or 2:1. The per cent composition of calcium and phosphorus by individual species is also sufficient for normal growth provided these constituents are available to the animals. The per cent crude protein of the species on the meadow and pine sites appears to be about one to two per cent too low for normal production at all cutting times, while the species on the fir site appear to be adequate nutritionally at all cutting times.

TABLE 15

A COMPARISON OF THE RANGE OF NUTRITIVE VALUES BY SITES, WITH NUTRIENT REQUIREMENTS FOR LACTATING COWS

	Per Cent Crude Protein	Per Cent Calcium	Per Cent Phosphorus
Nutrient Requirements	8.3	0.24	0.18
Range of Values Measured			
Pine Site	4.09 - 9.59	0.12-1.29	0.16-0.54
Fir Site	6.26- 17.82	0.22-1.78	0.17-0.72
Meadow Site	5.36- 10.16	0.13-1.00	0.16-0.57

For comparison of Table 15 with the nutrient values of the forages presented in this paper see Tables 9, 11, and 13. The apparent deficiencies in the species on the meadow and pine sites may not, however, constitute a deficiency in the diet of the grazing animal, because the animals do not graze in the same manner as the plots were clipped. The clipped sample includes many components, such as dried leaves and matured stems that the animals may not eat. Thus their diet may be more nutritious than the data indicate (4, p. 59).

Conclusions

(1) The herbage production of the three sites studied appears to be affected most by the differences in site potential and cutting times. The composition of organic and mineral constituents are most affected by species differences and climatic conditions.

(2) It does not appear to make much difference when the meadow and pine sites are grazed in relation to each other. The writer recommends, however, that the meadow site be grazed first because of a possible chance under favorable climatic conditions of getting some early fall grazing from regrowth on this site. In agreement with Pickford and Reid (22, p. 21) the writer does not recommend grazing the fir site because of the density of timber and shrub species and scarcity of forage, which makes it a place cattle avoid. Its greatest use is for timber or for an emergency supply of forage in case of temporary shortage, but even under these conditions it would not be used until after all other sites had been heavily grazed.

(3) In consideration of the forage contribution to the site by individual species, grass and grass-like species are of major importance on all sites, with forb species and browse being next in importance.

(4) The data indicate that the forage on each site is

adequate at all sampling times in per cent crude protein, while deficiencies may be involved on the meadow and pine sites.

(5) The data include only samples taken from the middle of the grazing season. The writer feels it is necessary that a broader spectrum of the growth curve for species on each site be encompassed. This necessitates sampling over a longer period of time, ideally encompassing the entire growing season. This type of information should be more useful in determining trends in yield and nutrient content.

(6) Not enough time has elapsed in the study to determine deer or elk use on these sites.

SUMMARY

With higher costs of production and narrow operating margins, intensive rather than extensive management of range resources is becoming more important. Because of the complexity of problems encountered, considerable research is needed to enable decisions which will meet the increasing demands of intensive management. The objectives of the project under which this research was conducted are to determine: (1) the seasonal and total yields of herbage, crude protein, calcium, and phosphorus of native forages on three range sites, (2) the time at which these sites may be grazed most effectively, and (3) the extent of grazing by deer and elk on each study area. The research presented in this paper was designed to provide information by grazing types on the seasonal patterns of yield and nutrient content of the major forage species on three range sites in the Blue Mountains of northeastern Oregon.

The research was conducted in the summers of 1959 and 1960 on the Hall Ranch, eleven miles southeast of Union in the foothills of the Blue Mountains of northeastern Oregon. This is part of the Eastern Oregon Branch Experiment Station used as a summer range for the station-owned herd of Hereford cattle.

The three study areas, including a pine site, a fir site, and a meadow site, were chosen from detailed

ecological and soil survey maps prepared by trained mappers from Oregon State University and the Soil Conservation Service.

Deer and cattle exclosures were built on each site. Random herbage yield samples were harvested from twenty plots in each exclosure. Green and dry herbage weights were determined for the species and species groups present on each site at two cutting dates in 1959 and three cutting dates in 1960. The species harvested by site included:

Pine Site

Bluegrass	*Poa pratensis*
Elk sedge	*Carex geyeri*
Clover	*Trifolium* sp.
Perennial forbs	(a composite)
Oceanspray	*Holodiscus discolor*
Snowberry	*Symphoricarpos albus*

Fir Site

Pinegrass	*Calamagrostis rubescens*
Elk sedge	*Carex geyeri*
Perennial forbs	(a composite)
Wild pea	*Lathyrus* sp.
Oceanspray	*Holodiscus discolor*
Snowberry	*Symphoricarpos albus*
Huckleberry	*Vaccinium membranaceum*

Meadow Site

Bluegrass	*Poa pratensis* plus *Poa compressa*
Perennial forbs	(a composite)
Annual forbs	(a composite)

Ground samples of the species and species groups were analyzed in the Animal Nutrition Laboratory at Oregon State University for per cent dry matter, crude protein, calcium, and phosphorus. The raw data were punched on I. B. M. cards for computation of the yield in pounds per acre of herbage, crude protein, calcium, and phosphorus for each exclosure and site as well as for each species or species group. These data are presented in the paper, and specific results are discussed.

The herbage production on the three sites appears to be most affected by the differences in site potential and cutting times. The composition of organic and inorganic constituents are most affected by species differences, stage of maturity, and climatic conditions.

Insufficient time has elapsed to determine the effect of deer or elk use on these sites.

Grazing of the meadow site before the pine site was recommended, as well as exclusion of the fir site from grazing unless emergency feed is needed.

Grass and grass-like species are of major importance on all three sites, with forb and browse species being next in importance.

The data indicate that the forage available on each site is adequate in the per cent composition of calcium and phosphorus and in calcium: phosphorus ratio. Forage on the fir site is adequate in per cent crude protein at all sampling times, while protein deficiencies may be involved on the meadow and pine sites during the latter part of the grazing season.

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APPENDICES

APPENDIX I

STATISTICAL ANALYSIS ON 1959 HERBAGE YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	47		
Site	2	2299858.0	99.2 **
Exclosure	1	131462.0	5.67*
Site x Exclosure	2	39493.0	1.70
ERROR (a)	18	23186.0	-
Cutting	1	458252.0	63.8 **
Cutting x Site	2	152275.0	21.2 **
Cutting x Exclosure	1	260191.0	36.2 **
Cutting x Exclosure x Site	2	37937.0	5.28*
ERROR (d)	18	7180.0	-

APPENDIX II

STATISTICAL ANALYSIS ON 1959 PROTEIN YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	47		
Site	2	6556.50	50.67**
Exclosure	1	487.00	3.76
Site x Exclosure	2	182.50	1.41
ERROR (A)	18	129.39	-
Cutting	1	3250.00	89.58**
Cutting x Site	2	596.00	16.43**
Cutting x Exclosure	1	1717.00	47.33**
Cutting x Exclosure x Site	2	153.50	4.23*
ERROR (b)	18	36.28	-

** Highly significant (at the 1 per cent level)
 * Significant (at the 5 per cent level)

APPENDIX III

STATISTICAL ANALYSIS ON 1959 CALCIUM YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	47		
Site	2	7.6458	13.26**
EXclosure	1	1.0209	1.77
Site x Exclosure	2	0.1458	0.25
ERROR (a)	18	0.5764	-
Cutting	1	3.5209	11.79**
Cutting x Site	2	0.2708	0.91
Cutting x Exclosure	1	0.0207	0.07
Cutting x Exclosure x Site	2	2.0209	6.77**
ERROR (b)	18	0.2986	-

APPENDIX IV

STATISTICAL ANALYSIS ON 1959 PHOSPHORUS YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	47		
Site	2	13.0834	45.96**
Exclosure	1	1.6875	5.93*
Site x Exclosure	2	-	-
ERROR (a)	18	0.2847	-
Cutting	1	9.1875	35.76**
Cutting x Site	2	1.7500	6.81**
Cutting x Exclosure	1	4.6875	18.25**
Cutting x Exclosure x Site	2	0.7500	2.92*
ERROR (b)	18	0.2569	-

** Highly significant (at the 1 per cent level)
 * Significant (at the 5 per cent level)

APPENDIX V

STATISTICAL ANALYSIS ON 1960 HERBAGE YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	71		
Site	2	2596852.0	72.71**
Exclosure	1	4232.0	0.12
Site x Exclosure	2	18501.0	0.52
ERROR (a)	18	35716.0	-
Cutting	2	39612.0	2.94
Cutting x Site	4	41946.0	3.11*
Cutting x Exclosure	2	6482.0	0.48
Cutting x Site x Exclosure	4	7323.0	0.54
ERROR (b)	36	13468.0	-

APPENDIX VI

STATISTICAL ANALYSIS ON 1960 PROTEIN YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	71		
Site	2	6326.04	47.01**
Exclosure	1	53.39	0.40
Site x Exclosure	2	30.43	0.23
ERROR (a)	18	134.58	-
Cutting	2	1037.79	19.74**
Cutting x Site	4	208.71	3.97**
Cutting x Exclosure	2	24.68	0.47
Cutting x Exclosure x Site	4	46.97	0.89
ERROR (b)	36	52.58	-

** Highly significant(at the 1 per cent level)
 * Significant (at the 5 per cent level)

APPENDIX VII

STATISTICAL ANALYSIS ON 1960 CALCIUM YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	71		
Site	2	5.0972	7.92**
Exclosure	1	1.6805	2.61
Site x Exclosure	2	1.7639	2.74
ERROR (a)	18	0.6435	-
Cutting	2	0.5972	1.37
Cutting x Site	4	0.3889	0.89
Cutting x Exclosure	2	0.0972	0.22
Cutting x Exclosure x Site	4	0.6806	1.56
ERROR (b)	36	0.4352	0

APPENDIX VIII

STATISTICAL ANALYSIS ON 1960 PHOSPHORUS YIELD IN POUNDS/ACRE

Source of Variation	D.F.	Mean Square	F
Total	71		
Site	2	10.7916	47.58**
Exclosure	1	0.1250	0.55
Site x Exclosure	2	0.0417	0.18
ERROR (a)	18	0.2268	-
Cutting	2	0.1667	0.97
Cutting x Site	4	0.2084	1.22
Cutting x Exclosure	2	0.1667	0.97
Cutting x Exclosure x Site	4	0.0833	0.49
ERROR (b)	36	0.1713	-

** Highly significant (at the 1 per cent level)
* Significant (at the 5 per cent level)

APPENDIX IX

THE HALL RANCH SERIES FOUND ON THE PINE SITE (214)

The Hall Ranch series consists of well-drained, moderately fine-textured, forested soils developed from andesite residuum. They occur on gently sloping upland plateaus and on moderately to steeply sloping south and west exposures under a vegetative cover of mixed ponderosa pine, Douglas fir, pine, and grass. They also occur to a much lesser extent on north and east slopes. However, in these positions, the profile is influenced by volcanic ash. Rock outcrops of platy andesite are common. Platy chips of andesite are common throughout the entire profile. Hall Ranch has a weak to moderate textural and structural development. The A horizon is very dark brown (10 YR 2/2 when moist) loam to silt loam; the B horizon is dark brown to dark grayish brown (10 YR 3/3 to 2.5 & 4/2 when moist) loam to light clay loam with moderate to weak subangular blocky structure. The Dr horizon consists of soft, partially decomposed platy andesite over solid bedrock.

The Hall Ranch soils are associated with Tolo and very shallow, very stony soils. Tolo soils occur on plateaus and on moderately steep to steep slopes with north aspects. They may also occur on the toe of south slopes below the Hall Ranch soils. Tolo soils are brown and yellowish brown-colored Regosels, derived from volcanic ash, and they have a selum free from gravels and stones. The Klicker soils differ in being more strongly influenced by loess and having 7.5YR hue in the B horizon.

Hall Ranch occurs at elevations of 2,500 to 5,000 feet, in a semi-humid climate, having a mean annual precipitation of 17-30 inches, with approximately one-half of the yearly precipitation as snow and the remainder as rain in fall and spring months. The summers are cool, with an average July temperature of 60°F. and average January temperature of 20°F., a mean annual temperature of 40°F., and a frost-free period of 40 to 60 days. Hall Ranch, which is mapped in the Blue Mountains of Eastern Oregon, is important for range and timber production.

SOIL PROFILE		HALL RANCH LOAM (FOREST)
Acc	2$\frac{1}{2}$"	Pine needles
Ac	$\frac{1}{2}$-0"	Duff and litter
A11	0-2"	Grayish brown (10YR 5/2 loam, very dark brown (10YE 2/2 when moist; weak thin platy structure; friable, slightly sticky, slightly plastic; plentiful roots pH 6.3; clean, smooth lower boundary. 1 to 4 inches thick.
A12	2-7"	Dark grayish brown (10YR 4/2 loam, very dark brown (10YE 2/2 when moist; weak fine subangular blocky structure; friable, slightly sticky, slightly plastic; plentiful roots; few fine pores; pH 6.4 clear, smooth lower boundary. 0 to 7 inches thick.

SOIL PROFILE		HALL RANCH LOAM (FOREST)
B1	7-15"	Grayish brown (10YR 5/2 loam, very dark grayish brown (10YR 3/2) when moist; weak fine subangular blocky structure; friable, slightly sticky, slightly plastic; abundant roots; few common fine and medium tubular pores; few thin patchy clay films; pH 6.4; clear smooth lower boundary. 6 to 10 inches thick.
B21	15-26"	Brown clay loam, dark brown (10YR 3/3 when moist; moderate very fine subangular blocky to weak very fine subangular blocky structure; friable, slightly sticky, slightly plastic; common roots, few fine medium pores; few thin patchy clay films; pH 6.6; clear smooth lower boundary. 6 to 13 inches thick.
B22	26-30"	Light brownish gray (2.5Y 6/2 clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate fine to medium subangular blocky structure; friable, slightly sticky, slightly plastic; few roots; common fine pores; many thin patchy clay films; pH 6.7; clean, wavy lower boundary. 10 to 18 inches thick.
Cpr	30-38"	Dark gray (2.5Y 4/0 moist) partially decomposed platy andesite; massive, nonsticky, nonplastic; pH 6.7; 0 to 10 inches thick.
Dr	38"+	Bedrock
RANGE IN CHARACTERISTICS:		The color of the A horizon are hues of 10 YR with values from 4 to 5 and chroma from 2 to 3 when dry. Textures of the A horizon are gritty loams as siliceous coatings on the peds of the B. Colors of the B horizon range from hue 2.5Y to 10YR. The closer to the decomposing rock the B occurs the yellower the B horizon becomes. Textures of the B horizon range from heavy loams to clay loams. The depth of the profile ranges from 2 to 5 feet.

<u>TOPOGRAPHY</u>:	Moderately steep to steep slopes and undulating plateaus.
<u>DRAINAGE AND PERMEABILITY</u>:	Well drained. Surface runoff is moderate; internal drainage is moderate; permeability is moderate.
<u>VEGETATION</u>:	Ponderosa pine, pinegrass, or ponderosa pine, Douglas fir, pinegrass.
<u>SERIES PROPOSED</u>	First Union SCD, Union County, Oregon, 1957. (Source of name is old ranch near type location.)
<u>DISTRIBUTION</u>:	Blue Mountains of Eastern Oregon.
<u>TYPE LOCATION</u>:	NE $\frac{1}{4}$ of SW$\frac{1}{4}$, Section 6, T. 5 S.; R 41 E.; 500 feet west of Center Section 6, Union County, Oregon.

APPENDIX X

THE TOLO SERIES FOUND ON THE FIR SITE (315)

The Tolo series consist of well-drained medium-textured Tegosol soils in a "western" Brown Forest zone that are developed from volcanic ash. These soils occur in mountainous areas on broad ridgetops and on moderately steep to steep slopes with north and northeast exposures under a conifer forest vegetation. The parent material is rather pure wind-deposited volcanic ash, which is underlain by unrelated buried soils or unrelated bedrock, principally basalt. Tolo soils are characteristically weakly developed, with no B horizon. The A_1 horizon is thin, commonly 2 inches thick on ridgetops and 3 to 4 inches thick on moderately steep or steep slopes. Color of the A_1 ranges from dark grayish brown to very dark grayish brown. The AC and C horizons are weak subangular blocky to massive in structure and lacking in clay films or clay bridges.

The Tolo series is geographically associated with the Underwood (Klicker), Rock Creek, Albee, and Couse soils. Underwood soils may have an admixture of volcanic ash in the A horizon, but they are derived primarily from basalt residium, and the B horizon is moderately fine textured. Rock Creek soils are very stony, 5 to 11 inches thick, and derived from basalt residuum primarily. The B horizon is moderately fine-textured. Rock Creek soils occur on nearly level to gently sloping ridgetops under grass land vegetation. Albee soils are moderately fine-textured and developed from volcanic ash, loess, and basalt residuum. The A_1 horizon is 3 to 6 inches thick, with a dry color value of 5 or less, a moist color value of 3 or less, and a chroma of 2 or more, commonly 3. Couse soils are dominantly from loess in the upper part and clayey alluvium in the lower part, with an abrupt A_2-B_{2b} boundary. Dry color of the A_1 horizon ranges from 10 YR 5/2 to 4/2 and moist color from 3/2 to 2/2.

The Tolo soils occur at elevations of 2,800 to 5,500 in a subhumid climate, having a mean annual precipitation of 20 to 30 inches, with one-third of the yearly precipitation as snow. The average January temperature is 23°F., and the average July temperature is 61°F. Tolo soils are important forest soils, and they are extensive in the Blue Mountain Area of Oregon and Washington.

<u>SOIL PROFILE</u> <u>TOLO SILT LOAM (FORESTED)</u>

A_{co}	1¼-1¼"	Litter mainly of pine and fir needles. 0 to 2 inches thick.
A_c	¼-0"	Dark grayish brown (10YR 4/2) when moist, coarse silt loam or loam; weak thin platy breaking to weak fine granular structure; friable, slightly sticky, slightly plastic; abundant roots; pores mainly interstitial; pH 6.0 to 6.6; clear smooth lower boundary. 2 to 4 inches thick.
AC	4-10"	Dark brown (10YR 3.5/3) when moist, coarse silt loam or loam; weak fine subangular blocky to single grain structure; friable, slightly sticky, slightly plastic; abundant roots; pores mainly interstitial; pH 6.2 to 6.6; gradual, smooth lower boundary. 2 to 14 inches thick.
C_{12}	18-34"	Dark yellowish-brown (10YR 4.5/4 when moist, very fine sandy loam; weak fine subangular blocky structure; friable, slightly sticky, slightly plastic; plentiful roots; pores mainly interstitial; pH 6.4 to 6.8; abrupt, wavy lower boundary. 0 to 20 inches thick.
D_1	34-43"	Dark brown (10YR 4/3) when moist, silty clay loam; weak fine subangular blocky structure; friable, sticky, plastic; plentiful roots; common, fine tubular pores; pH 6.4 to 6.8; abrupt wavy lower boundary. 0 to 30 inches thick.
D_2	43"	Basalt bedrock.

RANGE IN CHARACTERISTICS

Color of the A_1 ranges from 10 YR 4/2 to 3/2 and in a few places to 3/3, when moist. Textures of all horizons above the unrelated materials are clustered around silt loam, loam, and very fine sandy loam. Depth to buried soils or bedrock ranges from about 12 to 40 inches. The significant gradient between the broad ridgetops and the north and northeast exposures occurs around 8 per cent. Underlying buried soils range in texture from loams or silt loams to clays and these materials are commonly stony. In many places Tolo soils lie directly on basalt or other bedrock.

TOPOGRAPHY: Tolo soils most commonly occur on broad ridgetops on slope gradients of about 1 to 8 per cent and on north and northeast exposures on slope gradients of about 8 to 35 per cent.

DRAINAGE AND PERMEABILITY: Well-drained. Runoff is slow and internal drainage is medium. Permeability in the underlying buried material is moderately slow and very slow in the bedrock.

VEGETATION: Common tree species include Douglas fir, white fir, larch, and Ponderosa pine, with an understory of such plants as snowberry, ninebark, oceanspray, bearberry, huckleberry, spirea, strawberry, lupine, arnica, pinegrass, and elk sedge.

USE: Primarily used for timber production. Small areas in the Grande Ronde Valley are under cultivation.

DISTRIBUTION: Blue Mountains of northeastern Oregon and southwestern Washington and possibly north central Idaho.

SERIES ESTABLISHED: Medford Area, Oregon, 1911.

TYPE LOCATION: NW section 27, T 3 S, R 34 E, Union County, Oregon, on the Starkey Forest and Range Experiment Station.

APPENDIX XI

TENTATIVE ARGENTI SERIES FOUND ON THE MEADOW SITE (424)

The tentative Argenti series, consisting of colluvium or alluvium, was found on a dry mountain meadow on the lower part of an eight per cent colluvial slope. The series is moderately well-drained, moist, and non-stoney, with deep ground water.

<u>SOIL PROFILE</u>

A1	0-5"	10YR 2/1 moist black silty clay loam; moderate very fine angular blocky breaking to moderate very fine granular, friable, plastic, sticky. Roots common.
B_{21}	5-12"	10YR 2/2 moist very dark brown silty clay; moderate medium prismatic to moderate very fine subangular blocky to weak very fine granular, friable, very plastic, very sticky. Roots common, common thin clay flows.
B_{22}		10YR 3/2 moist very dark gray brown silty clay; weak medium prismatic to moderate very fine, subangular, blocky to weak very fine granular, friable, plastic, and very sticky, common very friepous, roots common common clay flows.
C	22-29"	10YR 4/2 moist dark gray brown clay loam; massive, friable, plastic, and sticky. Common fine to very fine pores.
D	29-35"	25Y 4/2 moist dark gray brown clay; weak coarse prismatic, very plastic and very sticky.

1 mm. of sandy A2 like material on top.
10YR 7/2 dry light gray
10YR 6/2 moist light brownish gray

APPENDIX XII

SCIENTIFIC AND COMMON NAMES OF THE PLANTS FOUND ON THE THREE STUDY SITES

COMMON NAME	SCIENTIFIC NAME
Trees	
Douglas fir	Pseudotsuga menziesii (Mirb) Franco.
Ponderosa pine	Pinus ponderosa Dougl.
Western larch	Larix occidentalis Hook.
Grand fir	Abies grandis Lindl.
Willow	Salix sp.
Shrubs	
Gray rabbitbrush	Chrysothamnus nauseosus (Pall.) Britt.
Huckleberry	Vaccinium membranaceum Dougl.
Ninebark	Physocarpos capitatatus (Pursh) Kuntze.
Oceanspray	Holodiscus discolor (Pursh) Maxim.
Oregon grape	Berberis repens Lindl.
Prince's pine	Chimaphila menziesii Spring.
Rose	Rosa gymnocarpa Nutt.
Serviceberry	Amelanchier sp.
Snowberry	Symphoricarpos albus (L.) Blake.
Snowbrush	Ceanothus velutinus Dougl.
Spirea	Spiraea lucida Dougl.
Grass and Grass-like	
Annual hairgrass	Deschampsin danthonioides (Trin.) Munro.
Blue wildrye	Elymus glaucus Buckl.
Canadian bluegrass	Poa compressa L.
Cheatgrass	Bromus tectorum L.
Columbia needlegrass	Stipa columbianna Macoun.
Crested wheatgrass	Agropyron cristatum (l.) Gaertn.
Elk sedge	Carex geyeri Boott.
Kentucky bluegrass	Poa pratensis L.
Mountain bromegrass	Bromus marginatur Nees.
Oniongrass	Melica bulbosa Geyer.
Pinegrass	Calamagrostis rubescens Buckl.
Praire Junegrass	Koelaria cristata (L.) Pers.

(Grass and Grass-like) con't.

Rattlesnake bromegrass	Bromus brizaeformis Fisch. and Mey.
Spiked trisetum	Trisetum spicatum (L.) Richt.
Timothy	Phleum pratene L.
Woodrush	Luzula sp.

Forbs

Aster	Aster conspicuus Lindl.
Burnett	Sanguiscorba annua Nutt.
Canadian thistle	Cirsium arvense Scop.
Clintonia	Clintonia uniflora (Schult.) Kunth.
Cherchermallow	Sidalcea sp.
Dandelion	Taraxacum officinale L.
Fairy bells	Disporum oreganum
False Solomon's seal	Smilacina stellata (L.) Desf.
Fireweed	Epilobium paniculatum Nutt.
Fivefingers	Potentilla glandulosa Lindl.
Geranium	Geranium sp.
Groundsel	Senecio canus Hook.
Heartleaf arnica	Arnica cordifolia Hook.
Iris	Iris missouriensis Nutt.
Little red elephant	Pedicularis groenlandica Retz.
Meadowrue	Thalictrum sp.
Mullein	Verbascum thapsus L.
Pearly everlasting	Antennaria sp.
Rattlesnake plantain	Goodyera oblongifolia Raf.
Sheep sorrel	Rumex acetocella L.
Silene	Silene sp.
Silvery lupine	Lupinus leucophyllus Dougl.
Strawberry	Frageria cuneifolia Nutt.
Sweet cicely	Osmorhiza sp.
Tarweed	Madia glomerata Hook
Tiarella	Tiarella unifoliata Nutt.
Trail plant	Adenocaulon bicolor Hook
Twinflower	Linnaea borealis L.
Violet	Viola sp.
White clover	Trifolium sp.
Wild pea	Lathyrus sp.
Wooly weed (1)	Hieracium albiflorum Hook
Wooly weed (2)	Hieracium scouleri Hook
Yarrow	Achillea lanulosa Nutt.

APPENDIX XIII

VEGETATION DESCRIPTION OF THE 214 PONDEROSA PINE DOUGLAS FIR/PINEGRASS SITE

(Species listed in descending order of dominance by growth form.)

Common Name	Estimated Per Cent Cover Trees and Shrubs	Age Class of Trees
Trees	Per Cent	
Ponderosa pine	45	All age classes present dominated by pole and young and vigorous trees.
Douglas fir	25	(Same as above)
Western larch	10	Poles present with a dominance of young and vigorous trees.
Shrubs		
Oceanspray	15	
Snowberry	10	
Ninebark	10	
Snowbrush	2	
Gray rabbitbrush	2	
Grass and grass-like		
Kentucky bluegrass		
Elk sedge		
Pinegrass (around trees only)		
Cheatgrass		
Mountain bromegrass		
Prairie Junegrass		
Spiked Trisetum		
Timothy		

(Vegetation Description, con't.)

Forb

Yarrow
Strawberry
Wooly weed
Mullein
Fivefingers
Sheep sorrel
Fire weed
White clover
Canadian thistle
Groundsel
Dandelion
Pearly everlasting
Silene

APPENDIX XIV

VEGETATION DESCRIPTION OF THE 315 MIXED FIR FOREST SITE

(Listed in order of descending dominance by growth form)

Common Name	Per Cent Cover of Trees and Shrubs	Age Class for Trees
Douglas fir	30	Seedlings, dominance of poles and young, vigorous trees.
Grand fir	40	All age classes present, dominance of poles.
Western larch	15	Poles and a dominance of young and vigorous trees.
Willow	2	Mature.
Shrubs		
Ninebark	55	
Oceanspray	5	
Spirea	6	
Snowberry	1	
Rose	1	
Huckleberry	1	
Oregon grape	1	
Serviceberry	1	
Prince's pine	-	
Grass and Grass-like		
Pinegrass		
Elk sedge		
Spiked Trisetum		
Sedge		
Onion grass		
Blue wild rye		

(Vegetation Description, Con't.)

Forbs

Wild pea (broad leaf and narrow leaf)
Twin flower
Meadowrue
Heartleaf arnica
Strawberry
Wooly weed
Violet
Aster
Silene
Sweet cicely
Tiarella
False Solomon's seal
Little red elephant
Rattlesnake plantain
Trail plant
Clintonia
Fairy bells

APPENDIX XV

VEGETATION DESCRIPTION OF THE 424 DRY MOUNTAIN MEADOW SITE

(Listed in descending order of dominance by growth form)

Common Name

Grass and Grass-like

Kentucky bluegrass
Canadian bluegrass
Cheatgrass
Timothy
Woodrush
Rattlesnake brome
Annual hairgrass
Crested wheatgrass

Forbs

Silvery lupine
Tarweed
Fivefingers
Canadian thistle
Strawberry
Yarrow
Geranium
Fireweed
Aster
Burnett
Iris
Checkermallow