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Title INFLUENCE OF RANGE IMPROVEMENT PRACTICES ON COMPOSITION, PRODUCTION, AND UTILIZATION OF ARTEMISIA DEER WINTER RANGE IN CENTRAL OREGON

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Recent emphasis on range improvement of sagebrush-bunchgrass types in Oregon has underscored the need for better understanding of their importance to deer winter range management. The objectives of this study were to evaluate the impact of various sagebrush control practices on the composition, production, and utilization of deer forage plants during the critical winter period.

Field studies continued from June, 1963, to August, 1965, at various locations throughout the Fort Rock and Silver Lake deer winter range units in northern Lake County.

Range improvement effort has been directed primarily toward poor condition communities dominated by big sagebrush (*Artemisia*

tridentata). Consequently, sampling was practically restricted to these communities although other types were recognized to be of equal or greater value to deer.

Two basic approaches were followed. The first consisted of establishing three experimental treatment blocks in stands representative of extensive big sagebrush communities. Quantitative plant ecological data were taken prior to treatment as a basis for interpreting later successional changes. Four commonly-accepted range improvement methods--spraying, spray-seeding, rotobeating, and plow-seeding--were initiated on two-acre strips in each block with an additional untreated strip forming a control. Half of each block was fenced to determine differences resulting from livestock exclusion. Periodic resurveys over five to seven years are scheduled.

The second approach entailed a paired-macroplot study of selected existing projects where spraying, rotobeating, burning, and seeding treatments had been used. Similarity of soils and other physical site factors formed the basis for pairing plots and inferring similarity of pretreatment vegetation.

Floristic differences among paired plots were quantified by data on shrub coverage, density, and height; basal area of herbaceous species; and frequency of all species. All treatments reduced shrub cover sharply but rotobeating resulted in the greatest shrub survival. Herbaceous species response was variable but only seeded stands of crested wheatgrass showed marked increases in basal area of desirable forages.

Production data indicated wide fluctuations in shrub herbage available for winter use. Estimated big sagebrush herbage production on untreated stands in oven-dry pounds per acre ranged from 23 to 449 and averaged 234. Winter-active grass herbage was most abundant on crested wheatgrass seedings, particularly those grazed heavily by livestock in the preceding growing season. Estimated production ranged from 37 to 126 and averaged 75 pounds per acre of oven-dry material. Green growth of native grasses was important feed for deer primarily during the latter part of the winter period.

Bitterbrush, the key browse plant for deer on the study area, sustained excessive levels of use at all locations studied. Recent changes in livestock grazing season have effectively minimized use of bitterbrush by this class of grazing animal. Bitterbrush mortality has been high and both vigor and stand regeneration are generally poor. It was concluded that effects of existing improvement programs were usually minor compared with the declining condition of the all-important bitterbrush stands resulting from excessive winter populations of deer.

Species other than bitterbrush were utilized moderately to lightly. Green rabbitbrush showed a consistently higher percent of plants grazed and mean percent utilization than big sagebrush on untreated stands. Seedings and other range improvements tended to create a diversified plant cover and forage resource that appeared to enhance use of the untreated sagebrush.

Green grass material was significantly higher in crude protein percentage than current annual growth of shrubs.

Management emphasis should be directed toward positive programs of vegetational manipulation designed to increase forage values of big sagebrush types for deer as well as livestock.

INFLUENCE OF RANGE IMPROVEMENT PRACTICES ON COMPOSITION, PRODUCTION, AND UTILIZATION OF <u>ARTEMISIA</u> DEER WINTER RANGE IN CENTRAL OREGON

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF APPENDIX TABLES

INFLUENCE OF RANGE IMPROVEMENT PRACTICES ON COMPOSITION, PRODUCTION, AND UTILIZATION OF *ARTEMISIA* DEER WINTER RANGE IN CENTRAL OREGON

INTRODUCTION

The recent emphasis on range improvement as an aid to increasing the production of forage on the semiarid sagebrush-bunchgrass ranges of central Oregon has necessitated a more critical look at the ecology of these areas. The fact that it is possible to increase greatly the volume of many desirable plant species by judicious selection of improvement method has been amply demonstrated. However, the manipulation of vegetation to benefit one type of resource use may be undesirable from the standpoint of another.

For the most part, the extensive sagebrush-bunchgrass types are important to mule deer only on limited, concentration areas of winter range and to livestock as spring range. These ranges form the most critical deficiency in the year-long forage resource for game and livestock.

In Oregon, particularly, much of the semiarid rangeland is in governmental ownership, and the stated policy of the agencies administering these lands is "multiple use." Consequently, a careful appraisal of the desirability of improvements must be based on an ecological understanding of the environmental units, the kinds and requirements of organisms placing demands on the resource and the value of minimizing conflicts between the resource users (Smith, 1958).

The present study was initiated by the Oregon State Game Commission, Research Division, in cooperation with the Department of Range Management, Oregon State University, to gain information on range improvements relative to deer forage values and successional patterns. Little research on these subjects has been done in Oregon or elsewhere despite the frequent statements purporting the deleterious or beneficial influences of range improvements on deer.

The contiguous Silver Lake and Fort Rock deer winter range units in northern Lake County were selected as the study location. Factors involved in the selection include: (1) a large number of different improvements had already been established there, (2) it is the locus of a continuing research program on deer populations and range relationships, and (3) the sagebrush-bunchgrass types found there are similar to those found elsewhere on the "High Desert" (Anderson and Greenfield, 1960) and northern Great Basin.

Evaluation of the impact of range improvements on game range followed two main approaches. The first was an inferential, paired-plot study of treated and adjacent untreated stands. The pretreatment vegetation of both stands was assumed to be the same on the basis of similarity of soils, topography, and management history.

The second approach involved experimental treatments established on three sites representative of sagebrush stands of wide occurrence.

In both approaches, the overall objectives of this study were: (1) to determine the comparative differences in plant composition, production, and utilization resulting from the several improvement methods and (2) to formulate recommendations for vegetational manipulation that complement both game and livestock use.

DESCRIPTION OF THE STUDY AREA

PHYSIOGRAPHY

Silver Lake valley lies at the transition between the High Lava Plains and Basin Range Provinces as defined by Baldwin (1959). The lake itself is typical of the fault-block basin lakes characteristic of south-central Oregon except that it is a freshwater body devoid of the normal alkalinity (Russell, 1883). These lakes are formed by north-south trending, infacing escarpments described by Smith and Greenup (1939).

Both provinces contained extensive lake systems during the Pleistocene epoch that are now either entirely extinct or nearly so. Dry lake beds form a considerable portion of the study area, especially in the Fort Rock unit as shown on the map by Russell (1883). Soils on these lake beds are deep, relatively rock-free and more productive than upland soils and, consequently, offer greater potential for range improvement. It is no accident that most improvement projects occur on these silted basins.

Volcanism in its varied forms is everywhere the outstanding physiographic feature of the entire central Oregon area. Cinder cones, fissure-flow basalt caps, and aeolian deposits of ash and pumice are the pervading elements of the landscape. Most of these formations are of Pliocene or Pleistocene origin but some recent

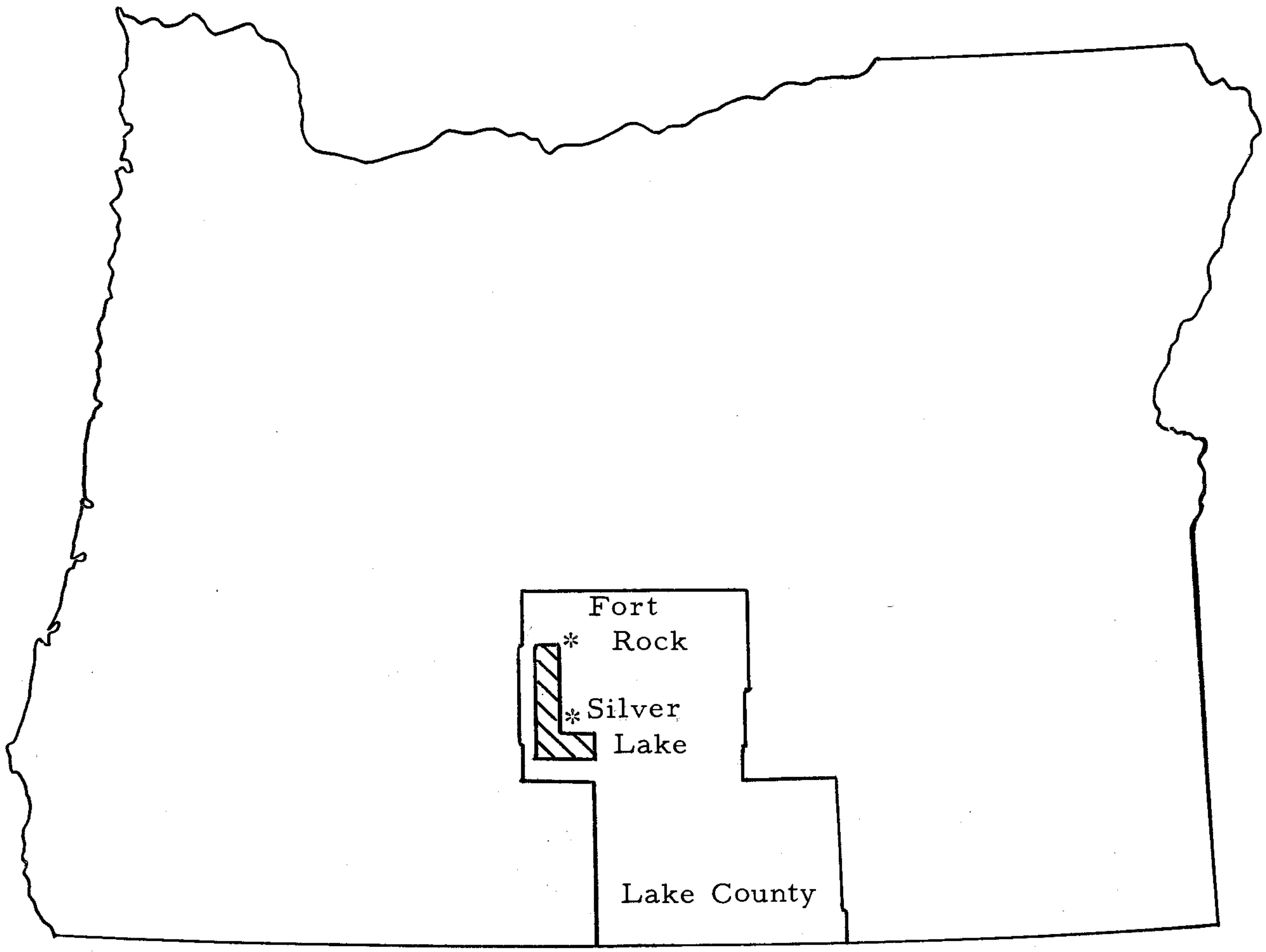

Figure 1. Location of the study area.

lava flows, such as the one near Fort Rock, are only a few hundred years old (Baldwin, 1959).

GEOLOGY AND SOILS

Russell (1905) lists the three important types of rocks found in the general Silver Lake area as (1) basalt, (2) rhyolite, and (3) andesite. Basalt usually occurs as dense lava while rhyolite and andesite occur as lavas, tuffs, or breccias; the latter two being weakly consolidated or loose. Other distinctive volcanic features, such as obsidian flows, pyroclastic bombs, and pumice mantles, are commonly found.

The main pumice deposits at Summer Lake, about twenty miles southeast of Silver Lake, have their origin in the Mount Mazama (Crater Lake) eruptions (Allison, 1945). Somewhat thinner biotitic pumice beds were correlated with Fossil Lake pumice originating from Newberry Crater. Allison (1945) established the age of the climactic Crater Lake explosions at between 10,000 and 14,000 years based on (1) rate of sedimentation, (2) peat profile analyses, and (3) climatic conditions necessary for persistence of pluvial lakes.

Knox (1962) briefly discusses the general soil groups found in the central Oregon area. Regosols of fresh pumice sand and gravel predominate on the forested western edge of the Silver Lake and Fort Rock units. Representative soils here are the Lapine series

(Youngberg and Dyrness, 1959) and the Shanahan series (Volland, 1963).

Soil groups on the nonforested portion of the range include Alluvial soils, Browns, Lithosols, Chestnuts, Solonetz, and Regosols. Detailed soil maps have not been developed for either the Silver Lake or Fort Rock valleys. However, preliminary series descriptions and general soil maps are available and provide some indication of the predominant soil types.[1] Six main series occur in the study area on a tentative basis and are listed below with some general characteristics.

1. Arrow Gap series: shallow, upland Regosols developed from volcanic tuff residuum.
2. Bonnick series: deep, high terrace Regosols developed from Pleistocene lake sediments; gravelly, with low exchangeable sodium and rarely having hardpans. Lime coatings on subsurface gravels are common.
3. Plush series: moderately deep to deep, well-drained, moderately fine-textured Brown soil from basalt and tuff colluvium. The surface and subsoil are very stony; commonly underlaid by tuff.

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1. Cahoon, J. S. Preliminary descriptions of Lake County, Oregon, soils. Unpublished manuscript on file with the Soils Department, Oregon State University. 1961.

4. Hart series: shallow, fine-textured Brown soil developed from tuff. Surface extremely stony. Low sagebrush dominates on these soils.

5. Shanahan series: aeolian pumice Regosols with little gravel. Coarse sandy loam to loamy sand texture. Moderately deep over buried substrata. AC horizon 8-20 inches thick.

6. Lapine series: deep aeolian pumice Regosol with gravel. Coarse loamy sand to sand texture. AC horizon 3-10 inches thick.

Soil profiles from pits dug at each plot location have been described and appear in the appendix. No attempt was made to assign accepted series names although in several cases the affinities of the study site profiles to those of previously described series are emphasized.

CLIMATE

The "High Desert" of central Oregon, lying in the rain shadow cast by the Cascade Range, is characterized by hot, dry summers and cold, dry winters. Aridity is the primary factor in shaping the vegetational patterns. The average annual precipitation of ten inches on the study area is limited even further by highly permeable soils and rapid evaporation rates resulting from high temperatures, low humidity, and frequent strong winds.

Most of the precipitation occurs in winter as snow but the months of May and June usually receive effective amounts of rain. Nocturnal temperatures below freezing occur frequently throughout the summer and a wide diurnal fluctuation in summer temperatures is normal.

Johnsgard (1963) summarizes climatological data from two stations that are pertinent to the study area. The Silver Lake station (elev. 4,486 feet), located in the town of that name, recorded temperature and precipitation data from 1898 until 1925 when it was discontinued. The Fremont Station (elev. 4,300 feet) lies in the northern part of the Fort Rock unit. Data from this station are continuous from 1931 to 1955.

A hythergraph of monthly mean precipitation and monthly mean maximum and minimum temperatures from the two stations is presented in Figure 2. Total annual precipitation and monthly temperatures are similar at both stations. Precipitation fluctuates less from month to month at Silver Lake where the wettest month receives less than four times as much moisture as the driest. At Fremont the wettest month receives more than eight times as much as the driest.

Mean minimum temperatures exceed the freezing level in only three months--June, July, and August--as a result of high

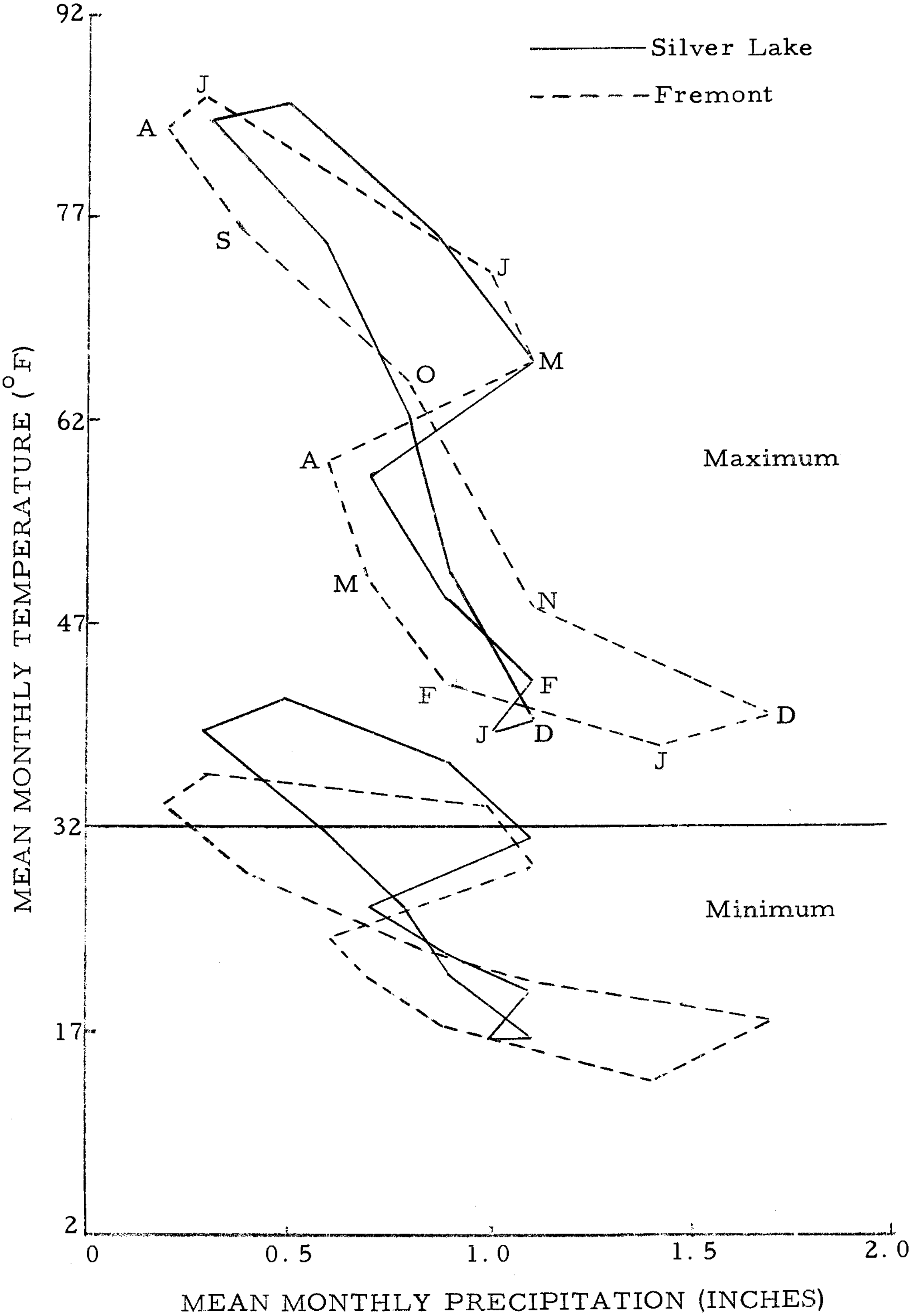

Figure 2. A hythergraph of climatological data from the Fremont and Silver Lake weather stations (from Johnsgard, 1963).

elevation and cold air drainage from the Cascades. No frost-free growing season exists and consequently plants must be cold hardy as well as drought resistant.

VEGETATION

A general list of dominant species is meaningless when discussing an area as diverse in vegetational cover as the study location. Sagebrush country often elicits visions of dreary stretches of monotonous sameness. This is far from the case. The abrupt changes in soil depth, moisture, and development likewise produce sharp ecotones between plant communities; communities that are grossly similar but obviously different to even the casual observer.

The unique combinations, interactions, and compensations of factors that form these different communities tend to repeat with similar relief, soils, and climate. That is, the variation among and within stands of the same environmental unit is usually much less than the variation between units. Sharp ecotones between communities on different units are the rule in this region. Daubenmire (1952, p. 303) calls the collective area of one such environmental unit a "habitat type" which receives its name from the dominant plants in the climax association.

The importance of defining the landscape by individual habitat-types cannot be overemphasized. It offers the best possible means

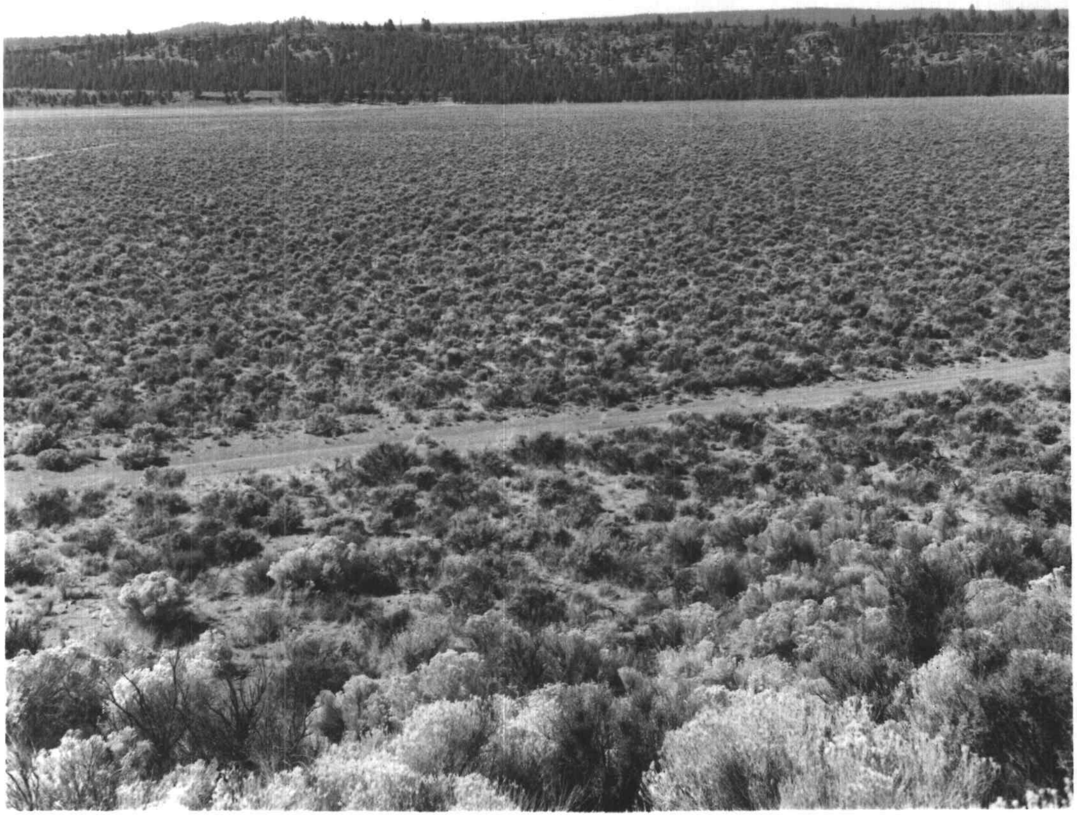

Figure 3. A high-seral community occupying a site with a potential vegetational development leading toward an Artemisia tridentata/Stipa thurberiana association. The homogeneity shown in this stand is typical of the vegetation on deep water-worked pumice sand Regosols in the well-drained portions of basins in the Fort Rock unit.

of stratifying the landscape as a basis for meaningful evaluation of animal behavior, plant production, utilization, composition, condition, etc. Unfortunately, little in the way of an intensive ecological study of plant communities has been done in the Silver Lake area *per se*. Such a study would enhance the value of the information from this project by contributing to a better understanding of the potential vegetation and the distinctive sequence of seral communities on each habitat-type sampled. Near-climax vegetation is rare and most of the area is occupied by seral communities that are extremely important as game range.

Eckert (1957) and Tueller (1962) have characterized some of the important plant associations in northeastern Lake and Harney Counties from Bend south and east to the Squaw Butte Experiment Station. Review of their data indicates that at least three and perhaps more of the associations they recognize occur at Silver Lake. Stands representative of the *Artemisia tridentata*/*Agropyron spicatum* association appear definitely to be present as are stands of the *Artemisia arbuscula*/*Agropyron spicatum* association and *Artemisia arbuscula*/*Festuca idahoensis* association.

There is strong inferential evidence and limited quantitative data to suggest the presence of an association dominated by big sagebrush (*Artemisia tridentata*) and Thurber's needlegrass (*Stipa thurberiana*) on the well-drained pumice Regosols in the

Figure 4. Big sagebrush dominated communities on relatively shallow soils at lower elevations in the Silver Lake unit receive little deer use and offer excellent potential for crested wheatgrass seeding on suitable sites.

Figure 5. Low-seral big sagebrush dominated communities occupy much of the Silver Lake unit. Bitterbrush (*Purshia tridentata*), western juniper (*Juniperus occidentalis*), gray rabbitbrush (*Chrysothamnus nauseosus*), and cheatgrass (*Bromus tectorum*) are common elements in these communities.

Figure 6. A landscape view of big sagebrush-dominated communities on upland Regosol soils in the Fort Rock unit. Note the open, savanna-like distribution of western juniper and the high density of gray rabbitbrush, an indicator of heavy past disturbance.

water-worked basins of the Fort Rock unit. The seasonally ponded, clayey depressions in some of these basins are occupied by communities dominated almost exclusively by silver sagebrush (*Artemisia cana*).

Bitterbrush (*Purshia tridentata*) dominates some shrub communities on upland Brown soils, especially near the forest edge, often with bluebunch wheatgrass (*Agropyron spicatum*) as the understory dominant or with Idaho fescue (*Festuca idahoensis*). Big sagebrush frequently attains codominance with bitterbrush. More ecological information on the bitterbrush types is needed in this area in relation to their seral and climax status. Hubbard and Sanderson (1961) suggest that native perennial grasses on similar sites in northern California are stronger competitors for limited soil moisture. At Silver Lake bitterbrush appears subordinate to the native perennial grasses on the Brown soils and the dense, productive stands that occur are probably the result, in large part, of former heavy grazing pressure on the grasses by livestock.

Bitterbrush-dominated communities also occur on nonforested pumice Regosols, especially in the Fort Rock unit. On the basis of similar understory composition these stands may represent the extension of bitterbrush and associated species farther down a moisture gradient than the forest trees; that is, the bitterbrush ecotype here has a wider ecological amplitude than ponderosa pine (*Pinus*

Figure 7. Extensive low sagebrush (Artemisia arbuscula) communities occupy shallow, rocky upland sites with soils having a heavy clay B horizon. Deer make heavy use of these types in early spring concentrating on low sagebrush and Sandberg's bluegrass (Poa secunda).

Figure 8. Silver sagebrush (Artemisia cana) dominates communities on seasonally-ponded clayey basins in some of the "flats" in the Fort Rock unit. This stand occupies the southern end of Ceres Flat. Although small in total area, these communities sustain considerable deer use.

ponderosa).

The forested types of importance on the winter range units are dominated by ponderosa pine and have understories dominated by bitterbrush and Idaho fescue (Dyrness and Youngberg, 1958; Volland, 1963). Mountain mahogany (Cercocarpus ledifolius) occurs in isolated pockets along the forest border, frequently on the edges of rimrocks but not restricted to them.

Western juniper (Juniperus occidentalis) is typically a widely-spaced overstory component forming a savanna from the lower edge of the pine forest to the upper edge of the more xeric, upland Artemisia types (Driscoll, 1962). The importance of juniper tends to be over-emphasized because of its contrast with the gray desert shrubs but in some stands it is sufficiently dense to dominate on the basis of ground cover. Eckert (1957) discussed the sagebrush-bunchgrass associations at Squaw Butte on the basis of shrub and/or grass dominance since he failed to detect differences in these communities with or without a juniper overstory. The occurrence of juniper in savannas appears to correlate with patterns of increased effective soil moisture resulting from subtle environmental differences that compensate for low precipitation.

Green rabbitbrush (Chrysothamnus viscidiflorus) and gray rabbitbrush (Chrysothamnus nauseosus) are common components of cover types over the entire area but neither attains dominance except in highly disturbed, low-seral stands. On burned and abandoned cultivated lands these species retain a dominant position for long periods. Green rabbitbrush is important in high-seral stands of the Artemisia tridentata/Stipa thurberiana communities in the Fort Rock basins with cover values up to ten percent.

RANGE USE HISTORY

Unlike many other areas in the Great Basin at the time of settlement, central Oregon apparently had abundant game populations of antelope and mule deer. Russell (1883) states: "Game is plentiful; antelope may be seen in bands in the valleys [Silver Lake and Christmas Lake]; deer are abundant amid the foothills . . . . ." Shaver et al. (1905, p. 863) also were impressed by the abundance of deer: ". . . . . the mountains and deserts are alive with them. Bands of fifty have been seen . . . . ." Frémont (1845), however, did not mention deer along the west shore of Summer Lake in late December, an area that winters large numbers today.

The ecological changes favoring greater importance of preferred browse species would seem, logically, to favor an increase in deer. Greater hunting pressure, better access, and improved forage supplies plus continued large harvests and fairly stable populations characterize the Silver Lake and Fort Rock herds at the present time. Combined, these factors form a persuasive argument in support of the contention that deer have been considerably more abundant in recent years than at any earlier period since settlement.

Livestock were trailed through south central Oregon in the 1850's and 1860's but the establishment of ranches did not begin to accelerate until 1870 (U. S. Congress, 1936). The era of the large stock ranches--ZX, Devine, French-Glenn, Brown, Hanley, Miller and Lux, etc.--reached its peak between 1880 and 1900 (Brogan, 1964; Brimlow, 1951). Settlement of the Silver Lake area began in the early 1870's and a tax roll in 1875 listed eighteen individuals representing, presumably, a like number of families (Shaver et al., 1905). A census in 1880 for the Silver Lake precinct revealed a total population of 92; by 1900 this had increased to 229.

Livestock control began with establishment of the U. S. Forest Service in 1905 and passage of the Taylor Grazing Act in 1934. By regulating season of use and numbers of livestock, federal administrators encouraged a trend toward proper grazing of the forage resource that continues today. The concept of "multiple use" as applied to range land management is a recent effort to include livestock and big game in a concerted program that recognizes the desirability of managing the total resource.

METHODS AND SPECIFIC OBJECTIVES

EXPERIMENTAL PHASE

Range improvements on the publicly-owned portions of the Silver Lake and Fort Rock units have been restricted primarily to the big sagebrush types. Bitterbrush has been recognized as a critical part of deer winter diets as well as a valuable forage for livestock. Silver sagebrush and low sagebrush types are either not suitable or offer a low potential for improvement in the area. Consequently, this study was restricted to stands dominated by big sagebrush and most study locations included little or no bitterbrush.

Establishment of experimental sagebrush control trials had two primary objectives. The first was to secure quantitative ecological data on the pretreatment vegetation to determine more precisely, through periodic resurveys, differences in successional patterns following treatment. Secondly, use of several locally-accepted improvement practices at each of three locations permits more valid comparisons between methods by eliminating major site variability. Differences in parameters before and after could, then, be reasonably assumed to result from treatment effects.

STAND SELECTION AND TREATMENT: Three main factors were considered in experimental stand selection. The site had to: (1) be representative of types occupying a significant area on the Silver Lake range, (2) present no physical barriers to most treatments, and (3) offer a reasonable assurance of important gains in desirable herbaceous cover. Homogeneity of the study site was determined by examination of soils. A detailed description of one profile at each experimental block was made by a Soil Conservation Service soil scientist. At least two additional profiles were checked against the detailed description for uniformity.

Cost considerations, both financial and time, precluded a complex design or interaction analysis. Four commonly-accepted improvement practices were uniformly established on adjacent strips 100x800 feet with some modifications in method between locations based on inherent vegetational differences. Treatments included (1) chemical control with butyl ester of 2, 4-D applied at the rate of 3, 3 1/2, or 4 pounds acid equivalent per acre with a tractor-pulled ground rig, the variable rate depending upon relative amounts of rabbitbrush (Chrysothamnus sp.) in the stand, (2) chemical control as before with fall seeding of crested wheatgrass, (3) mechanical control with a high speed rotary flail, and (4) mechanical control by an initial, late-summer disc plowing followed by fall seeding to crested wheatgrass. An untreated strip formed a control to detect vegetational changes, if any, resulting from factors other than treatment.

Figure 9 presents a scale model of one of three experimental blocks as it occurs at Roadside Park in the Fort Rock unit. A three-strand barbed-wire fence was constructed around half of each block to exclude livestock but not deer. Permanent macroplots 50x100 feet were systematically placed in the center of each half treatment strip and all ecological sampling was done within them.

SAMPLING METHODS: The macroplot sampling procedures used in this study were adopted with only slight modification from those outlined by Poulton and Tisdale (1961). Their method was developed, as part of Western Regional Project W-25: The Ecology and Improvement of Brush-Infested Ranges, specifically to describe and classify sagebrush-bunchgrass communities. Eckert (1957) and Tueller (1962) used essentially the same approach in northeastern Lake and Harney Counties.

At least two advantages were gained by macroplot sampling in the experimental phase. First, it provided sufficiently precise quantitative statistics to reflect even small changes over time in the existing vegetational cover. Secondly, since the method had been employed by others, the data obtained could be added to a pool of ecological information which, synthesized, could lead to better understanding of the habitat-types occurring in the Silver Lake area.

Community attributes of value in evaluating vegetational

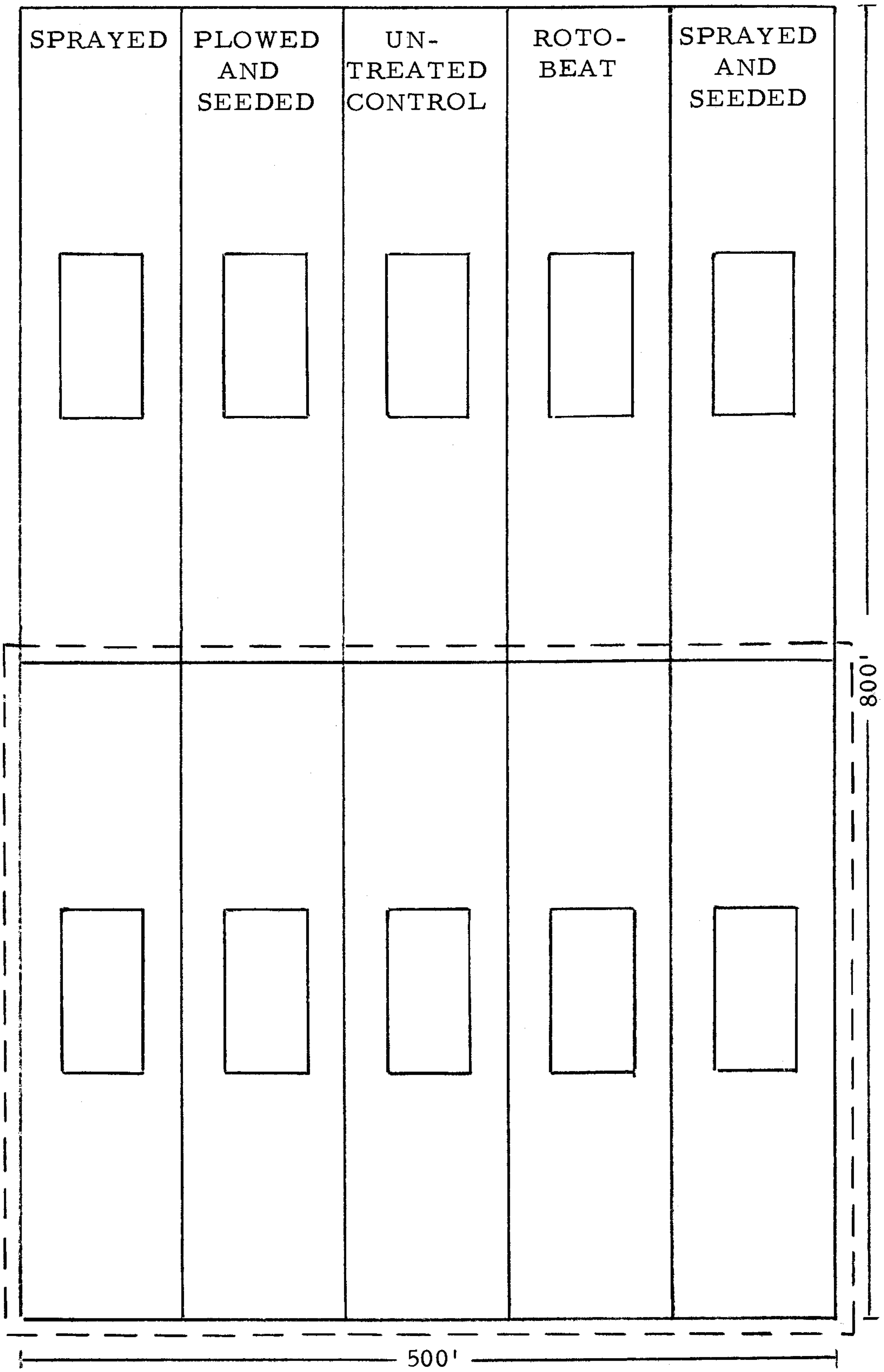

Figure 9. The experimental block as it occurs at Roadside Park illustrates the macroplot location, fenced portion, and kinds of sagebrush control practices evaluated.

change are: (1) relative dominance estimated by average basal area of herbaceous species and crown-spread cover of shrubs, (2) average maximum shrub height as a site index, (3) shrub density (numbers per unit area), and (4) frequency. These statistics were obtained by plot sampling within the macroplot.

Shrub cover, density, and maximum height were sampled with forty microplots (4x5 feet) in four belts of ten contiguous plots parallel to the long-axis of the macroplot and located by a restricted random point of origin. Crown-spread cover of shrubs was estimated in six cover classes described by Daubenmire (1959). In addition, shrub intercept was recorded along the 50-foot baseline of each microplot belt. Shrub density data included only plants with stems lying inside the microplot. Height of the tallest shrub by species was measured in each microplot to derive a mean maximum height for the stand.

Basal area of herbaceous species was estimated directly in percent in an observation plot 1x2 feet located systematically midway along the baseline in each microplot. Two rings representing two and five percent of the observation plot area aided in estimating basal area. Figures 10 and 11 illustrate the position of the observation plots and the placement of microplot transects. Where no grazing of the herbaceous species had occurred, crown-spread cover was estimated in cover classes as additional information on

Figure 10. An example of the 4x5-foot microplot and 1x2-foot observation plot and their relative position along the 50-foot baseline tape.

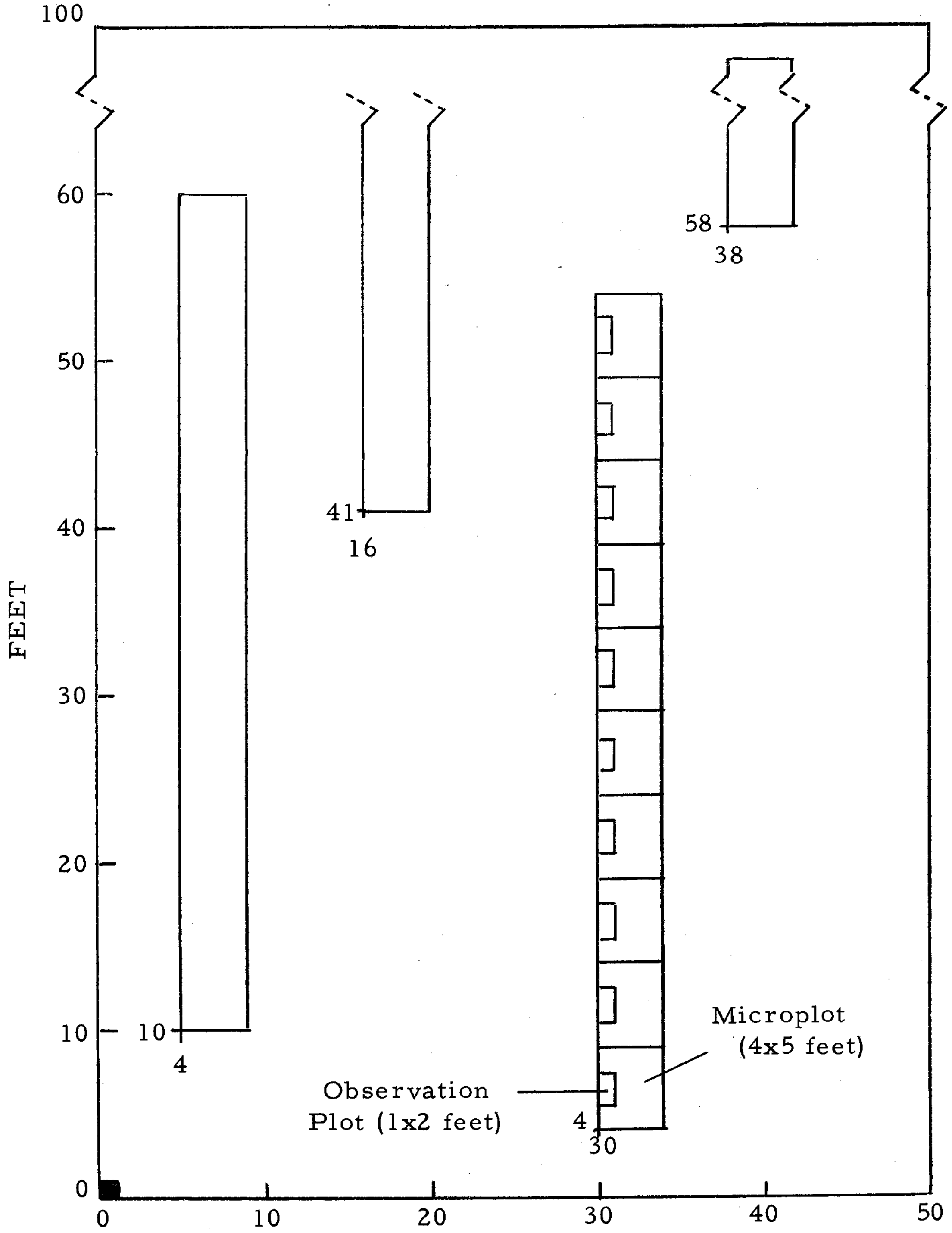

Figure 11. A macroplot drawn to scale illustrating the placement of sampling plots (after Poulton and Tisdale, 1961).

dominance.

Frequency data were obtained with four transects of fifty contiguous 1x1-foot plots located in restricted random fashion along the long-axis baseline of the macroplot and perpendicular to it (Figure 12). Four hundred observations of presence or absence by species were recorded in a manner similar to that of Tueller (1962). Tueller points out the difficulty of interpreting frequency in that it is not synonymous with density nor is it a measure of dominance. Within broad limits, however, frequency provides a rapidly-obtained index of dispersion and density that is useful in evaluating community changes.

Finally, a careful reconnaissance of the macroplot was made to list all species occurring within it. Rare or scattered plants not encountered in the sample plots were noted for constancy data and for their possible indicator value in determining the potential climax association.

TREATMENT SCHEDULE: The sprayed-seeded strips were chemically treated in mid-June, 1964, which normally would be too late, but cool temperatures caused slow plant development that year. The macroplot inventory on these strips had to wait until immediately after spraying, but the survey was completed before effects of the chemical became evident. On all other strips the initial inventory

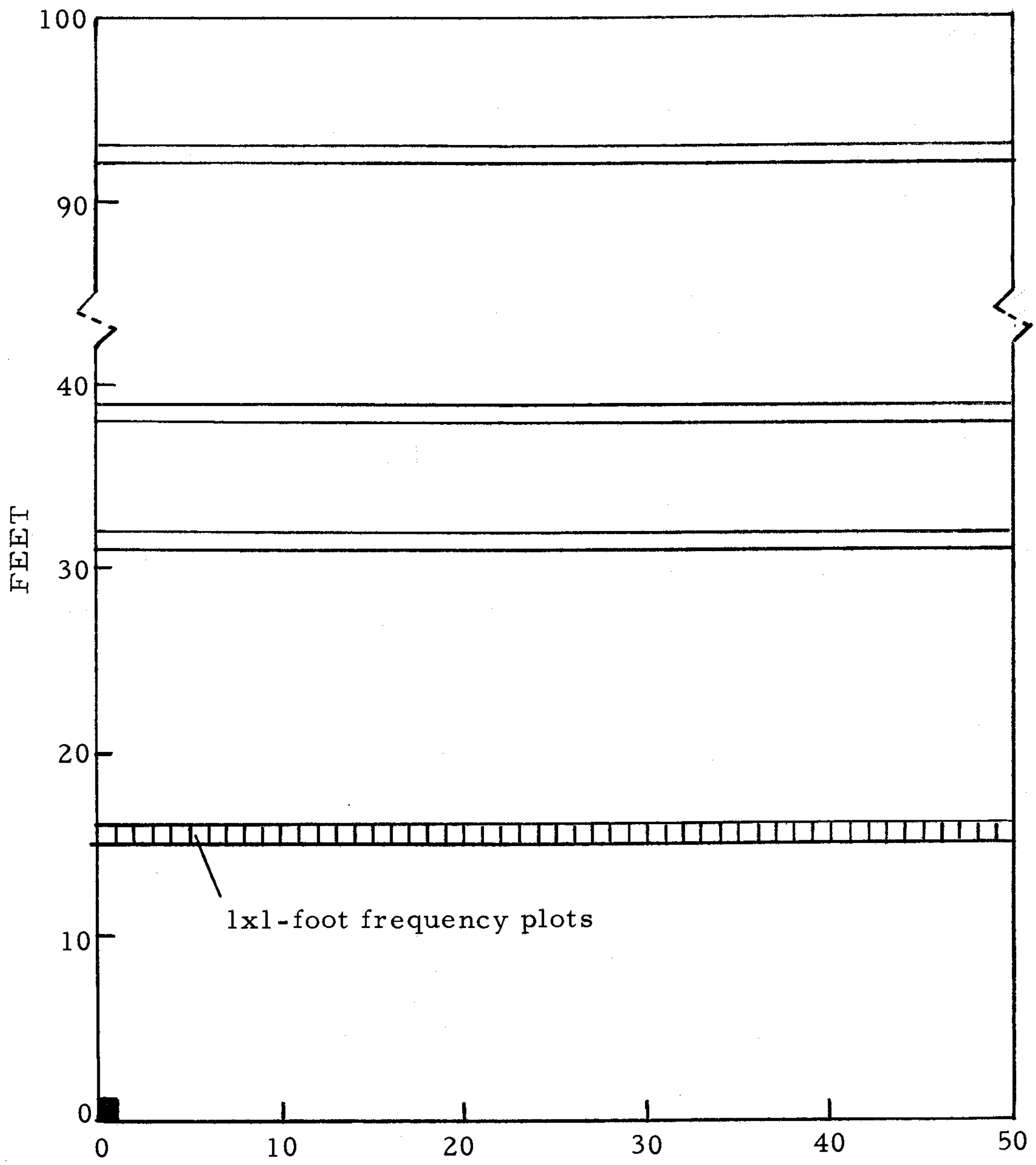

Figure 12. Location of the frequency plot transects was restrictedly randomized along the 100-foot baseline of the macroplot.

was completed before treatment by late July.

A brushland disc plow mechanically removed the shrub cover on the plowed-seeded strips in August, 1964. The plowed-seeded and sprayed-seeded strips were then seeded with a rangeland drill to crested wheatgrass (Agropyron desertorum) in November. Wet ground conditions at one of the experimental blocks caused some problems with plugging of the seed pipes which resulted in a somewhat spotty stand at this location.

Rotobeating was accomplished on July 20, 1964, with a Service Co. rotary flail. The blade was lowered within two inches of the ground surface effecting a heavy reduction in live sagebrush plants.

The last treatment, sprayed-only, was completed on June 10, 1965, with the same ground-rig equipment and chemical rate used the previous year on the sprayed-seeded strip.

Another inventory within the permanent macroplots will be completed in August, 1965, to determine first-year effects of treatment. Also, limited pellet-group count data for an index to activity were obtained on the control and rotobeaten strips in May, 1965. Forty-eight, 96-square-foot circular plots in twelve clusters of four plots systematically located at five-step intervals were examined for pellet-groups in each half of the treatment strips at all three experimental areas.

INFERENCE PHASE

A wide variety of range improvement methods have been tried on the big sagebrush-bunchgrass types in the Silver Lake and Fort Rock units although acreages of any one or total acreage treated is not large. The projects vary by age, site, season of application, degree of success, pretreatment composition, subsequent management, as well as kind of treatment. Paired-plot studies of treated and adjacent untreated stands were initiated to evaluate the changes on a particular site but the extrapolation of results from these studies must be done with caution, giving due consideration to the large number of variables. Despite these limitations there are, of course, characteristic features of the several methods that have rather broad applications to vegetational manipulation.

STAND SELECTION: The objectives of the paired-plot approach were to determine differences in species composition, production, and utilization between treated and adjacent untreated stands. It was inferred that the pretreatment vegetation in the treated stand was the same as the untreated vegetation on the basis that (1) no significant differences existed in respect to soils, (2) topography and aspect were the same, and (3) that both stands had received the same grazing management as evidenced by their inclusion in the same fenced unit. The paired plots in every case were never more than

200 yards apart.

Projects of particular improvements were first delineated on a map and then examined in the field. Plot locations were then selected as representative of the treated and untreated stands after a careful reconnaissance of the entire project area.

Soil profiles were exposed at each plot location and described by standard procedures outlined in the Soil Survey Manual (U. S. Dept. of Agriculture, Soil Survey Staff, 1951). A Soil Conservation Service soil scientist made the description of one profile at each location and checked the paired-plot profile for uniformity. Several macroplots were relocated because of excessive variability.

Permanent macroplots, 50x100 feet, were staked at the origin with steel fence posts and either stone or iron markers at the two corners nearest the origin. At two locations three macroplots were established where different treatments occurred together. More than one pair of plots would have been desirable to gain information on stand variability but time limitations did not permit it.

Fourteen paired-plot comparisons were studied involving five different kinds of treatment. Table 1 lists these by control method, location, and assigned name. The burned-seeded stands in every case resulted from seeding directly into the ashes; no further soil disturbance occurred.

Table 1. A list of sagebrush control projects studied with paired macroplots to compare treated and adjacent untreated stands.

Project Name	Map Location	Sagebrush Control Method	
Dehne Flat	SW¼Sec10T26SR13E	Chemical	aerial, 2,4-D
Hockman Well	SE¼Sec22T26SR13E		aerial, 2,4-D
Ceres Flat	NW¼Sec3T27SR13E	Mechanical	rotobeat
Arbow	NW¼Sec29T28SR14E		plowed & seeded
Airport	SW¼Sec29T28SR14E		plowed & seeded
Silver Creek	NW¼Sec28T28SR14E		plowed & seeded
D. Long	SE¼Sec28T28SR14E		plowed & seeded
L. Iverson	NE¼Sec35T28SR14E		plowed & seeded
North Burn	NW¼Sec1T29SR14E	Fire	burned & seeded
South Burn (E)	NW¼Sec18T29SR15E		burned
Silver Lake Burn	NW¼Sec7T29SR15E		burned
Silver Lake Burn			burned & seeded
West Burn	NE¼Sec4T29SR14E		burned
West Burn			burned & seeded

SAMPLING METHODS:

Composition: Collection of species composition and other ecological data from treated and adjacent untreated stands followed identical procedures outlined in the experimental phase. All sampling was done within the macroplots using the 4x5-foot microplots, 1x2-foot observation plots, and 1x1-foot frequency plots. These data provided a reasonably good picture of the species present in the stand although to evaluate changes in deer forage value resulting from treatment the questions "How much is produced?" and "What is utilized?" needed to be answered.

Production: An estimate of pounds per acre production of grass and shrub herbage was obtained by establishing deer-proof woven-wire cages in temporary macroplots having a common baseline with the permanent macroplots. The cages consisted of ten circular exclosures, one rod in circumference and five feet in height, located in a restricted random fashion within the temporary macroplots by random numbers. Each exclosure protected a 9.6-square-foot production plot from October, 1963, until mid-April, 1964, at which time all herbaceous and shrub material was clipped at ground level, crudely separated by species, and stored for later careful separation.

Protection was continued throughout the winter period to determine the estimated total amount of herbage available to deer

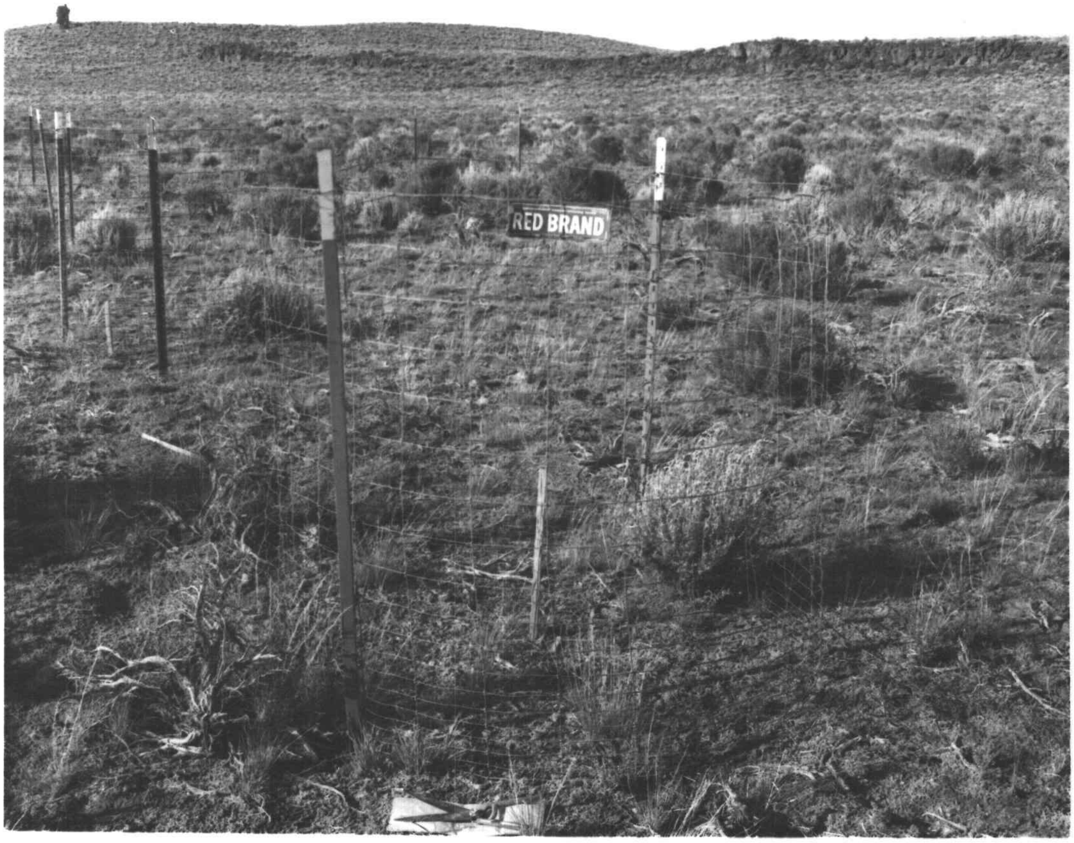

Figure 13. A woven-wire exclosure protecting a 9.6-square-foot circular production plot in the sprayed stand at Dehne Flat. Note the very long leaders on the surviving big sagebrush and vigorous green rabbitbrush.

during that period. Growth of grasses in the fall and early spring could be accounted for in this way. After clipping, the grass material was frozen and then hand separated by species into green and mature components, oven-dried at $105^{\circ}F$ for 24 hours, and weighed to the nearest hundredth of a gram on a Mettler electric balance. Current annual growth of browse species, including leaf spurs, was clipped, oven-dried at $105^{\circ}F$ for 24 hours, and weighed to the nearest gram on a Toledo balance.

Pounds per acre production was then estimated by multiplying the average, per-plot production in grams of a particular species by ten (National Research Council. Subcommittee on Range Research Methods, 1962, p. 58).

Utilization: Reliable estimates of forage removal are difficult to obtain but necessary statistics if the game resource is to be properly balanced with the forage resource. At the present time no "census" method is sufficiently accurate to permit management on the basis of estimated deer numbers alone, nor is one likely to be developed. Important forage species, such as bitterbrush, that receive the heaviest grazing pressure provide phytometers of utilization that are sensitive to changes in production and deer population levels. Plant response, in addition to deer population structure, is then one of the best indexes available to the game manager to gauge the adequacy of a particular type of harvest program.

To determine the level of utilization on bitterbrush, the "key" browse plant on the Silver Lake and Fort Rock winter ranges, twig-length reduction transects were established. A transect consisted of twenty-five tagged branches on as many plants with a minimum of 10-15 twigs per branch depending on average leader length. The observed uniformly-heavy use of bitterbrush indicated that a statistically-sound sample could be derived with twenty-five branches which later proved to be correct. It was desired to estimate utilization within 10 percent of the mean at the .05 level of significance (Smith and Urness, 1962).

An individual branch formed the observation unit with all twigs measured in the fall before deer use and again in the spring after deer migration. The fall-spring difference in total twig length per branch yielded an average utilization index for that location. These data were fitted to the formula $N = \frac{(t.05)^2 \; (s)^2}{(.1 \times \bar{y})^2}$ to determine the adequacy of each sample.

Four transects were established on the Silver Lake unit in the fall of 1963. The same four plus eight additional transects scattered throughout the Silver Lake and Fort Rock units were measured in the winter 1964-65.

Utilization on other species such as big sagebrush, green rabbitbrush and grasses is generally much lower than bitterbrush.

Consequently, in the case of the shrub species a twig-length reduction transect would require astronomical numbers of tagged branches to estimate utilization at the same level of accuracy. For this reason an index based on percentage of plants grazed (Hurd and Kissinger, 1953; Mattox, 1955; Evans and Love, 1957) combined with an ocular estimate of utilization was employed.

One hundred plants of a particular shrub or grass species were sampled near selected macroplot locations with four "step-point" transects of twenty-five plants per transect. The point consisted of a notch in the boot-tip which formed an observation locus on each fifth step. The nearest plant of a species to the point was noted as grazed or ungrazed and if use had occurred an estimate of percent removal was recorded. Crested wheatgrass on seeded stands was sufficiently dense to permit examination of 200 plants.

Although this level of sampling is too low for statistically-accurate estimates of utilization, it does provide a comparative ranking of species when density and production are considered. Such comparisons are strengthened if similar relationships among species are consistent at different locations.

Limited pellet-group count data supply another rough index to animal activity which, although inadequate statistically, was of value in reflecting differential use of treated and adjacent untreated areas (Smith, 1964; Rogers, Julander, and Robinette, 1958). These data were secured in three transects of twenty-five, 96-square-foot circular plots per stand. Ten macroplot locations in the spring of 1964 and eight macroplot locations in 1965 were sampled. It is assumed that pellet-groups are directly related to time spent on an area. There was no evidence to suggest the paired stands were used for other than foraging purposes; the inference being that since neither area was used as cover or bed ground in addition to foraging, the differential-use levels, if any, should be a reflection of varying forage values.

Crude protein analyses of important browse and grass species were run to help explain utilization patterns and to ascertain differences in nutritional content. Einarsen (1946) discusses the value of crude protein in deer forage analyses, particularly browse. At Silver Lake, deer actively seek green grass material in the fall and early spring, as well as in snow-free periods during winter. Few, if any, analyses of this green component have been reported and it was deemed instructive to compare it with crude protein of current annual growth of the common shrubs.

Samples of deer forages were clipped each month from November 30, 1964, until April 26, 1965. Material from at least twenty plants of a species was pooled at each location to include normal variability. Frequently, a much larger number was sampled, especially grasses, to obtain an adequate amount of green material.

The samples were hand separated, oven-dried, ground through a 20 mesh per inch screen, and analyzed with standard Kjeldahl procedures (Association of Official Agricultural Chemists, 1955). The questions of protein quality and digestibility were left largely unanswered.

RESULTS AND DISCUSSION

EXPERIMENTAL PHASE

Ecological data from the initial survey of the experimental sagebrush control strips were summarized by macroplot and appear in Appendix II. A description of a representative soil profile for each of the three experimental areas is presented in Appendix III. Since a resurvey has not been completed, only general differences in pre-treatment communities between locations can be discussed.

Table 2 illustrates the sharp differences in shrub cover that result from past grazing use and site differences. Big sagebrush dominates all three locations but varies in average canopy cover from a low of 16 percent at Roadside Park to a high of 29 percent at North Burn. Data in Tables 2 and 3 indicate that the North Burn and Airport stands are representative of the same habitat-type although North Burn is in lower seral status as a result of heavier past use. Green and gray rabbitbrush exhibit reduced cover, density, and frequency on the Airport site, suggestive of a declining position in a somewhat higher seral community.

The Roadside Park stand is representative of a different habitat-type and is apparently in high-seral condition. Green rabbitbrush has a relatively-high cover value (7 percent) on this type while gray rabbitbrush all but disappears. Hedrick, Hyder and Sneva

Table 2. Mean canopy cover, percent frequency, mean maximum height and density of shrubs representing averages from ten macroplots at each of three locations.

Statistic	Location	Artr	Chvi	Chna	Lepu 2	Putr
Mean percent canopy cover (4x5 ft. micro-plots)	North Burn	29	2	2	-	-
	Airport	23	t	1	-	t
	Roadside Park	16	7	t	3	1
Percent fre-quency from 1x1-foot plot transects	North Burn	55	5	7	-	-
	Airport	53	1	2	-	t
	Roadside Park	36	24	t	10	4
Mean maximum height (inches)	North Burn	20	11	18	-	-
	Airport	16	11	16	-	28
	Roadside Park	15	13	8	8	9
Numbers per 800 sq. feet (density)	North Burn	141	15	12	-	-
	Airport	147	1	7	-	t
	Roadside Park	103	100	t	34	6

Table 3. Average percent basal area and coverage of herbaceous species (1x2-foot observation plot) from ten macroplots at each of three locations excluding species with minor cover value or no indicator significance.

Species	Roadside Park		Airport		North Burn	
	Mean	Range	Mean	Range	Mean	Range
SITANION HYSTRIX	2.39	1.09-3.38	2.08	0.55-3.63	0.44	0.16-0.94
STIPA THURBERIANA	2.15	1.54-2.78	0.36	0.00-1.10	0.07	0.00-0.38
CAREX ROSSII	2.12	1.00-3.45	0.14	0.00-0.88	--	-- --
LUPINUS ARIDUS	0.56	0.21-1.15	--	-- --	--	-- --
ELYMUS TRITICOIDES	0.30	0.00-1.25	--	-- --	--	-- --
ERIOGONUM SPHAEROCEPHALUM	0.16	0.00-0.42	0.01	0.00-0.08	t	-- --
FESTUCA IDAHOENSIS	0.01	0.00-0.13	0.10	0.00-0.43	0.03	0.00-0.30
ASTRAGALUS LENTIGINOSUS	--	-- --	0.09	0.00-0.29	0.04	0.00-0.11
AGROPYRON SPICATUM	--	-- --	0.16	0.00-0.58	0.06	0.00-0.23
POA SECUNDA	--	-- --	0.03	0.00-0.25	0.01	0.00-0.06
BROMUS TECTORUM	--	-- --	0.13	0.00-0.35	0.46	0.16-0.95
Bare Ground	56.87	48.13-62.75	65.81	55.75-74.50	60.75	53.88-78.75
Litter	33.93	28.00-42.08	27.41	18.95-35.25	33.32	16.60-41.50
Cryptogams	0.55	0.13-1.00	1.87	0.30-3.88	4.17	1.25-7.68
Gravel >1" Diameter	t	0.00-0.03	1.37	0.00-4.38	0.29	0.00-0.85

(1964) found both rabbitbrushes abundant on seedings of crested wheatgrass but gray rabbitbrush was most abundant where density of the grass was low. Gray rabbitbrush, then, appears to be a low-seral community component on both sites while green rabbitbrush is an important component of near-climax big sagebrush communities only on the deep, water-worked pumice soils in the Fort Rock unit. Tentatively, the North Burn and Airport stands are seral representatives of the *Artemisia tridentata/Agropyron spicatum* habitat-type while the Roadside Park stand represents a proposed *Artemisia tridentata/Stipa thurberiana* habitat-type. Additional stands must be examined before the latter habitat-type designation can be accepted.

Herbaceous cover at Roadside Park is more varied and occupies much greater area than at North Burn or Airport. Three species--squirreltail, Thurber's needlegrass, and Ross' sedge--have average basal areas above two percent. Only one species, squirreltail, attains two percent basal area at Airport and none do at North Burn. Bluebunch wheatgrass and Sandberg's bluegrass occur in only small amounts at North Burn and Airport, but are important indicators of their presence in climax on these sites. Both species are notable by their absence at Roadside Park.

Some preliminary comments on appropriate improvement methods for these areas can be made, but a more comprehensive evaluation must await results of this testing of improvement practices over time. Deer and other game animals along with livestock should be allocated a share of the forage resources on federal ranges based on physical relationships, institutional, economic, and social considerations (Smith, 1958) so long as they are kept within proper numerical limits imposed by the resource. Consequently, the seasonal forage needs of these animals must be considered in any improvement program on federal lands in the Silver Lake and Fort Rock units. Modifications, where needed, of presently-accepted practices could conceivably augment the seasonal deer forage supply, a subject that will be pursued in greater detail in a later section.

Hyder and Sneva (1956, p. 37) have suggested as a general rule that improvement methods designed to favor native perennial bunchgrasses require an initial stand of these species sufficiently dense to permit stepping from plant to plant. With this in mind, rotobeating or sprayed treatments that affect only the shrub layer would have greatest value at Roadside Park or Airport sites. North Burn, in contrast, with a very poor perennial grass cover should show greatest improvement with seeding. Unopened stands of big sagebrush in all three areas tend to become stagnant and yield low amounts of current annual growth. When the density of shrubs is reduced, animal preference (Heady, 1964) and production per plant increase.

Pellet-group count data as an index to deer activity illustrate the importance of pinpointing the specific areas of deer concentration within the winter range unit. Table 4 shows the relative use of the three experimental areas by deer. The North Burn and Airport areas are on the lower half of the winter range and neither receives more than minor deer pressure but Roadside Park lies in the heart of a concentration area in the Fort Rock unit. The impact of any vegetational manipulation would be of slight adverse influence on deer at the first two locations but could profoundly affect carrying capacity at Roadside Park.

Table 4. Pellet-group count data as a first-year index to deer activity on experimental sagebrush control strips at three locations.

Location	Treatment			
	Control Fenced	Control Unfenced	Rotobeat Fenced	Rotobeat Unfenced
North Burn	0	0	0	0
Airport	1	3	0	0
Roadside Park	58	46	2	2

The marked differences in numbers of pellet groups between the control and rotobeaten strips at Roadside Park reflect the reduction of shrub cover since little or no change in herbaceous cover occurred. These data support the idea that pellet groups are directly related to forage value since the parallel transects were only 100 feet apart. Initial sharp reductions in forage value on rotobeaten stands have been shown to be largely offset in a few years by the rapid recovery of the surviving big sagebrush and other browse plants.

Periodic resurveys employing identical sampling methods plus an annual series of photographs should provide an excellent ecological basis for making recommendations for improvements on game winter range in the sagebrush-bunchgrass types of south central Oregon. Comparative analyses of from five to seven years' data are to be published as a cooperative bulletin of the Oregon State University Agricultural Experiment Station in collaboration with the Department of Range Management, the Bureau of Land Management and the Oregon State Game Commission, Research Division. Responsibility for all future sampling has been assumed by the Range Management Department, Oregon State University.

INFERENCE PHASE

Knowledge of what constitutes the winter range forage resource is essential to evaluate changes resulting from vegetational manipulation. Only limited data are available concerning the winter diets of deer in the Silver Lake area either by species or volume consumed. The present study was an effort to expand this information by determining (1) the species composition of selected treated and adjacent untreated stands, (2) estimated weight production by species, and (3) estimated utilization of preferred species in these stands.

COMPOSITION: Ecological data from fourteen paired-plot comparisons at twelve locations are summarized in Tables 5 through 9. These data include frequency of all species; mean percent basal area of herbaceous species; mean percent shrub canopy cover, mean maximum height, and density; and percentage of ground surface unoccupied or covered with litter, coarse gravel and cryptogams. Soil data from the twelve study locations are summarized in detail in Appendix IV.

Pretreatment differences in composition resulting from a multiplicity of factors tends to favor discussion of individual project locations. It is, however, the similarity of effects of a particular treatment that is of main interest. Consequently, discussion will emphasize the various types of range improvement with location differences in species response underscored whenever pertinent.

Influence of Herbicides: The sprayed stands at Dehne Flat and Hockman Well were part of the same project completed June 10, 1958. Although the stands are on separate "flats," the physical site factors are similar. Both are seral communities on deep pumice Regosols having a probable potential plant association of *Artemisia*

Table 5. Ecological data from paired macroplots on the Dehne Flat and Hockman Well sagebrush spraying projects in the Fort Rock winter range unit. Frequency data were obtained in July, 1964. All other data were recorded from June through July, 1963.

Location: Dehne Flat Treatment: Sprayed 6/10/58

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U*	T**	U	T	U	T	U	T		U	T
Artr	11	1	18	11	87	9			Stth	71	65
Chvi	4	2	11	10	76	21			Sihy	23	35
Lepu 2	-	t	-	8	-	1			Chvi	23	15
Stth							2.1	1.0	Artr	22	1
Caro							1.4	1.4	Caro	19	19
Sihy							0.8	1.3	Erla	7	1
Migr							0.3	0.3	Vipu	6	6
Lemo							0.1	t	Lemo	3	4
Erla							0.1	0.1	Erov	3	-
Tofl							0.1	-	Aspu	3	5
Erov							t	-	Lile	2	-
Aspu							t	0.1	Tofl	2	1
Mina							t	-	Phle	1	-
Lile							t	-	Acmi	1	-
Vipu							t	t	Gara	1	6
Copa							t	t	Asca	1	-
Depi							t	t	Mina	1	-
Luar 2							-	0.1	Depi	-	7
Meal 2							-	0.1	Migr	-	8

Table 5. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Chdo							-	0.1	Eltr	-	8
Gara							-	t	Arsp 2	-	1
Eltr							-	t			
Bare Ground							81.9	66.3			
Litter							10.5	25.9			
Cryptogams							-	1.4			

* Untreated macroplot
** Treated macroplot

Table 5. Continued.

Location: Hockman Well   Treatment: Sprayed 6/10/58

Species	Mean Percent Canopy Cover U	Mean Percent Canopy Cover T	Mean Maximum Height (Inches) U	Mean Maximum Height (Inches) T	Number/800 Sq. Feet (Density) U	Number/800 Sq. Feet (Density) T	Mean Percent Basal Area and Ground Cover U	Mean Percent Basal Area and Ground Cover T	Species	Percent Frequency U	Percent Frequency T
Artr	25	-	14	-	197	-			Artr	50	1
Chna	2	-	15	-	17	-			Sihy	42	65
Chvi	2	-	8	-	49	-			Luar 2	14	1
Luar 2							1.3	t	Chvi	11	-
Sihy							1.2	2.0	Chna	10	-
Aspu							0.2	t	Aspu	8	5
Gara							0.1	0.3	Asca	6	-
Chdo							0.1	-	Stth	5	35
Migr							0.1	0.1	Phle	2	1
Erla							t	t	Vipu	2	7
Cram							t	t	Migr	1	30
Meal 2							t	0.1	Tofl	1	1
Lemo							t	-	Arsp 2	1	2
Stth							-	1.3	Putr	1	-
Depi							-	0.1	Chdo	1	-
Brte							-	t	Caro	1	3
Copa							-	t	Depi	-	1
									Gara	-	7
Bare Ground							81.5	67.3	Erla	-	1
Litter							12.1	27.2			

tridentata/*Stipa thurberiana*. Butyl ester of 2, 4-D was aerially applied at the rate of 3 pounds acid equivalent in 5 gallons of water and 1/2 gallon diesel oil per acre.

The untreated stand at Dehne Flat contains less than half the canopy cover and density of big sagebrush found at Hockman Well. The lower basal area of grasses and greater abundance of gray rabbitbrush indicate a more recent and heavy disturbance, presumably from cultivation, of the Hockman Well site.

Response to chemical control was not uniform between sites indicating the influence of variable pretreatment composition and difficulty of attaining uniform spray distribution. Survival of big sagebrush and green rabbitbrush at Dehne Flat was about 10 percent and 30 percent, respectively. All shrubs were effectively removed at Hockman Well although an occasional seedling can be found that became established after treatment. Thurber's needlegrass declined somewhat in frequency and basal area at Dehne Flat but increased sharply at Hockman Well. Squirreltail increased at both locations but especially at Hockman Well.

Herbaceous species other than grasses exhibited changes generally favoring annuals. Since forbs comprise neither a very large part of total ground cover nor contribute much to winter diets of deer, the observed changes have only minor influence on deer forage production.

In summary, successful sprayed treatments on these sites can be expected to effect a heavy to complete reduction in shrub cover. The opening created in the community is closed by Thurber's needlegrass and squirreltail with some increase in total forb cover. Green rabbitbrush as indicated by the Dehne Flat stand may recover rapidly.

Influence of Rotobeating: The only example of rotobeating on the entire study area was found at Ceres Flat. This site has the same potential vegetation as Dehne Flat and Hockman Well although it is more mesic because of a finer-textured subsoil. A high-speed rotary cutter was used in late September, 1960, to control big sagebrush and green rabbitbrush.

Perusal of Table 6 shows that rotobeating is much less effective in reducing shrub density and cover than chemical treatment which is the opposite of results obtained by Mueggler and Blaisdell (1958) in Idaho. Density of big sagebrush and green rabbitbrush on the treated stand was between 60 and 70 percent of the untreated stand density. Coverage of green rabbitbrush, as expected, increased because of greater vigor of the remaining plants (McKell and Chilcote, 1957; Robertson and Cords, 1957). Mean cover of big sagebrush was only about 30 percent of the untreated stand after three growing seasons but can be expected to increase rapidly as the

Table 6. Ecological data from paired macroplots on the Ceres Flat sagebrush control project in the Fort Rock winter range unit. Frequency data were obtained in July, 1964. All other data were recorded from June through July, 1963.

Location: Ceres Flat Treatment: Rotobeat 9/25/60

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	14	4	15	7	115	76			Caro	45	66
Chvi	2	3	8	10	75	50			Sihy	44	37
Chna	t	-	12	-	3	-			Artr	42	19
Lepu 2	t	-	12	-	2	-			Muri	34	54
Arca	t	-	9	-	1	-			Luar 2	21	-
Caro							2.8	2.3	Stth	21	38
Muri							2.0	1.8	Chvi	17	12
Sihy							1.7	0.8	Aspu	8	3
Luar 2							1.3	2.6	Eltr	7	35
Stth							1.2	1.0	Gara	6	1
Aspu							0.1	t	Lemo	4	-
Erov							0.1	0.3	Erla	2	-
Eltr							0.1	0.7	Erov	2	1
Gara							0.1	0.1	Ersp 3	1	-
Migr							t	0.1	Orte	1	-
Vipu							t	-	Arsp 2	1	-
Erla							t	-	Asca	-	1
Arsp 2							t	-	Vipu	-	1

Table 6. Continued.

Species	Mean Percent Canopy Cover U	Mean Percent Canopy Cover T	Mean Maximum Height (Inches) U	Mean Maximum Height (Inches) T	Number/800 Sq. Feet (Density) U	Number/800 Sq. Feet (Density) T	Mean Percent Basal Area and Ground Cover U	Mean Percent Basal Area and Ground Cover T	Species	Percent Frequency U	Percent Frequency T
Copa							t	t			
Lemo							t	t			
Phle							-	0.1			
Bare Ground							73.3	60.6			
Litter							14.1	27.5			

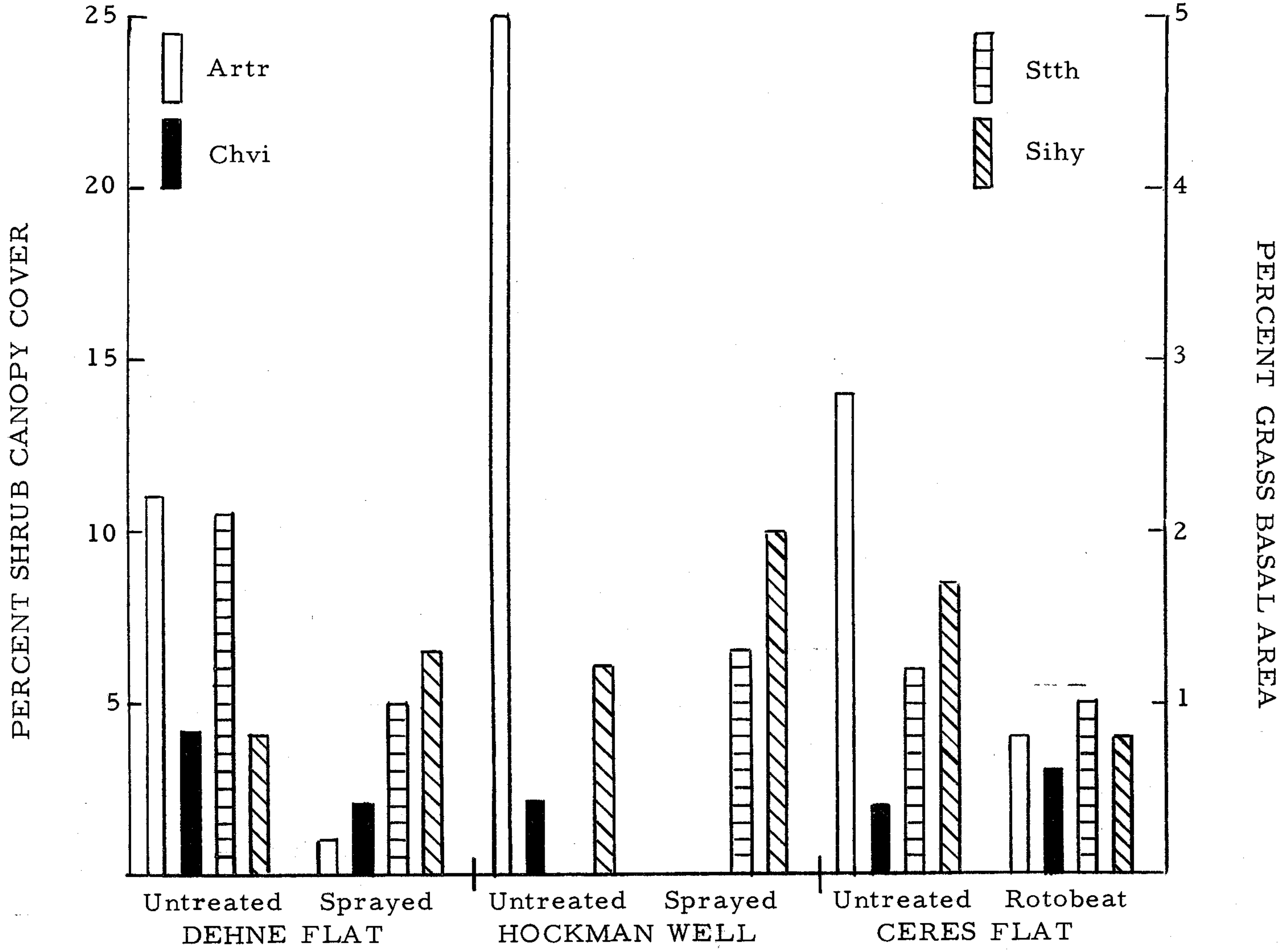

Figure 14. Changes in shrub canopy cover and grass basal area in four important species resulting from chemical and rotobeating treatments.

individual plants attain greater size.

Basal area of grasses showed a generally small decline, possibly as a result of greater accessibility for cattle use. Rotobeating would not be likely to damage grasses. Frequency data during the 1964 growing season indicated increases in all grasses except squirreltail.

Forbs, particularly lupine, gained slightly in basal area on the treated stand in 1963 but frequency of forbs in 1964 was lower than in the untreated stand. Changes in the competitive relationship between grasses and forbs resulting from shrub reduction partially explain these differences.

A silver sagebrush community at Ceres Flat on seasonally-ponded, clayey soil was rotobeaten as part of the same project. No plot data were recorded but the ineffectiveness of this treatment to control silver sagebrush was obvious. The treated stand presented almost the same aspect as the untreated stand after only three growing seasons.

Influence of Plow-Seeding: All plowed and seeded stands studied, with the exception of Silver Creek, occurred on Brown soils of variable depth at lower elevations in the Silver Lake unit (Table 7). The Silver Creek soil is a deep, sandy loam Regosol formed by lucustrine deposits. Untreated plant communities in every case are

Table 7. Ecological data from paired macroplots on the L. Iverson, D. Long, Arbow, Airport, and Silver Creek seedings in the Silver Lake unit. Frequency data were obtained in July, 1964. All other data were recorded from June through July, 1963.

Location: L. Iverson   Treatment: Plow-seeded (1958)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	24	t	18	13	131	1			Artr	54	1
Chvi	4	-	12	-	28	-			Brte	16	-
Chna	2	t	16	10	7	1			Sihy	14	1
Sihy							0.6	-	Chvi	11	-
Brte							0.2	0.2	Chna	4	3
Copa							0.1	-	Aspu	1	-
Asst							0.1	-	Agsp	1	-
Gara							0.1	t	Gara	1	-
Migr							t	-	Agde	-	92
Aspu							t	-			
Depi							t	-			
Ersp 4							t	-			
Agde							-	6.4			
Bare Ground							81.5	81.8			
Litter							15.7	11.0			
Cryptogams							0.3	-			
Gravel >1" Diameter							0.1	0.2			

Table 7. Continued

Location: D. Long Treatment: Plowed-seeded (1959)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	21	-	28	-	64	-			Brte	78	-
Brte							3.8	0.1	Artr	30	-
Sihy							2.1	0.1	Sihy	28	1
Eltr							0.3	0.1	Eltr	10	1
Ascu 2							0.2	t	Ascu 2	5	1
Gara							t	-	Chna	1	-
Migr							t	-	Chvi	1	-
Chdo							t	-	Kocr	1	-
Depi							t	-	Gara	1	-
Ersp 4							t	t	Agde	-	90
Agde							-	7.8			
Bare Ground							74.5	86.8			
Litter							18.1	4.7			
Cryptogams							0.2	-			

Table 7. Continued.

Location: Arbow Treatment: Plow-seeded (1954)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	28.1	2.7	23	13	100	17			Brte	68	-
Chna	1.3	-	20	-	7	-			Eltr	57	8
Brte	9.6	2.6					1.4	0.2	Artr	27	7
Eltr	4.8	1.2					0.6	0.1	Chna	15	-
Stth	3.1	-					0.5	-	Ascu 2	4	2
Depi	0.5	0.3					t	t	Stth	4	-
Ascu 2	0.6	0.4					t	-	Cram	2	-
Sihy	0.1	-					t	-	Gara	2	-
Gara	0.4	-					t	-	Sihy	1	1
Cram	0.3	0.1					t	t	Agde	-	91
Ersp 4	0.1	-					t	-			
Copa	0.1	0.1					t	t			
Agde	-	30.3					-	5.8			
Migr	-	0.4					-	t			
Meal 2	-	0.2					-	t			
Bare Ground							81.1	83.0			
Litter							15.1	10.0			

Table 7. Continued.

Location: Silver Creek Treatment: Plowed-seeded (1961)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	15	-	16	-	76	-			Eltr	48	7
Chvi	9	-	13	-	84	-			Chvi	34	-
Chna	4	1	26	8	9	5			Artr	29	-
Lepu 2	t	-	7	-	2	-			Brte	28	52
Eltr							1.1	0.3	Sihy	14	-
Brte							0.8	2.2	Chna	10	2
Sihy							0.5	-	Lepu 2	5	-
Feid							0.1	-	Orhy	3	-
Orhy							0.1	-	Gara	2	-
Chdo							t	-	Stco 2	2	-
Depi							t	0.1	Phle	1	-
Gara							t	-	Chdo	1	-
Agde							-	3.0	Ascu 2	1	-
Migr							-	t	Luco 2	1	-
									Agde	-	59
									Depi	-	3
Bare Ground							73.9	88.5			
Litter							21.7	5.5			
Cryptogams							0.1	-			

Table 7. Continued.

Location: Airport   Treatment: Plowed-seeded (1957)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	28.1	1.1	17	9	133	9			Artr	53	4
Chvi	0.1	-	9	-	1	-			Sihy	37	-
Sihy	6.7	1.2					1.1	0.2	Brte	8	1
Brte	2.8	3.1					0.3	0.6	Stth	4	1
Stth	1.3	-					0.2	-	Feid	1	-
Migr	2.0	2.4					0.1	0.3	Brin	-	69
Copa	1.5	1.1					0.1	0.1	Agde	-	48
Feid	0.9	-					0.1	-	Chna	-	2
Pose	0.1	-					0.1	-	Ascu 2	-	1
Agsp	0.1	-					t	-			
Gara	0.1	-					t	-			
Cram	0.1	0.2					t	t			
Lemo	0.1	-					t	-			
Aspu	0.1	0.3					t	0.1			
Brin	-	15.8					-	3.0			
Agde	-	14.8					-	2.7			
Ersp	-	0.3					-	t			
Depi	-	0.1					-	t			
Meal 2	-	0.1					-	t			

Table 7. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Bare Ground							81.0	87.4			
Litter							14.0	5.1			
Cryptogams							1.4	-			
Gravel>1" Diameter							0.4	-			

in low seral status but the potential climax association is likely Artemisia tridentata/Agropyron spicatum on the Brown soils.

Late summer plowing usually removes most of the native cover including shrubs and perennial grasses (Bleak and Miller, 1955). Pretreatment densities of big sagebrush ranged from 64 to 133 per 800 square feet while treated stands contained none to 17 plants in a like area. Gray rabbitbrush was least affected but occurred as a minor element on all sites, treated or not. Cheatgrass (Bromus tectorum) benefits from initial soil disturbance after plowing but becomes less abundant with seeded grass establishment.

Established seedings of crested wheatgrass (Agropyron desertorum) at the L. Iverson, D. Long, and Arbow locations exhibited a consistently-high basal area and frequency (Figure 15). Basal area ranged from 6 to 8 percent with percent frequency near 90. The Silver Creek seeding was only two years old at the time of sampling and, in addition, the initial seed distribution was poor. Basal area of crested wheatgrass at this site was only 3 percent and frequency 60 percent. Several additional growing seasons should increase the seeded grass density and the present high cover of cheatgrass will most likely decline.

Smooth brome (Bromus inermis) and crested wheatgrass were seeded at the Airport in 1957. A codominant stand of these grasses has developed that favors smooth brome in years of greater

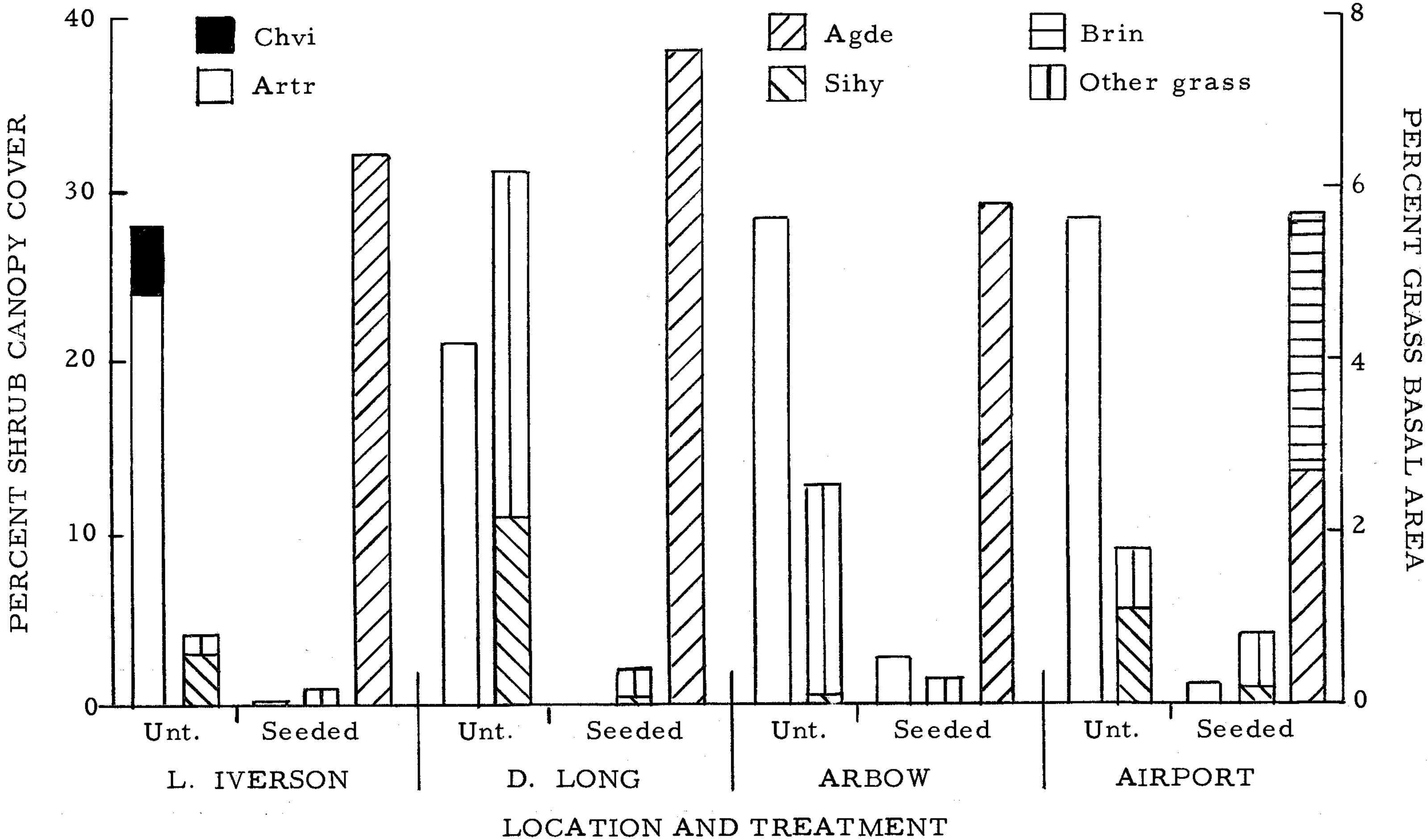

Figure 15. Composition changes following plowing and seeding at four locations in the Silver Lake unit.

precipitation and crested wheatgrass in drier years. Combined, these species display about the same basal area and frequency as crested wheatgrass does alone. Livestock grazing has been totally excluded from the Airport seeding which probably accounts for the continued vigor of smooth brome on this dry, shallow site.

Successful seedings on Brown soils are notable for the general lack of forb and shrub elements. Establishment of almost pure stands of seeded grasses forms a strong competitive barrier against shrub reestablishment. Proper grazing management can maintain a closed community rather effectively on these sites in contrast to the rapid shrub reestablishment, especially rabbitbrushes, that can and often does occur on Regosol soils.

A discussion of the effects of plowed and seeded treatments on deer forage production will be deferred to a later section, but deer use was light on the treated and untreated stands examined. Creation of a more diversified forage supply through seeding probably compensates for the loss of shrubs only lightly utilized, particularly since physical site factors limit the areas suitable for seeding to relatively small tracts.

Influence of Burn-Seeding: A controlled-burn project in the summer of 1960 escaped fire lanes and burned over several thousand acres at mid-elevations on the Silver Lake winter range. Big sagebrush and low sagebrush-dominated communities were burned in addition to some sites codominated by big sagebrush and bitterbrush. Three stands were selected for study that were seeded to crested wheatgrass by drilling directly into the ashes shortly after the fire (Table 8). All three locations--North Burn, West Burn, and Silver Lake Burn--are old lake terraces with shallow, gravelly Chestnut soils derived from volcanic tuff or lucustrine sediments.

The unburned sagebrush stands were similar with crown cover ranging from 24 to 30 percent, density per 800 square feet ranging from 126 to 141, and percent frequency between 40 and 45. Green rabbitbrush was practically absent at West Burn but formed 8 percent cover at Silver Lake Burn with a density of 61 plants in an 800-square-foot area.

Perennial grasses were minor elements in all three low-seral communities, but the presence of relatively dense stands of bluebunch wheatgrass (Agropyron spicatum) in some areas indicates that this species with big sagebrush dominates in the climax association. Cheatgrass and small amounts of squirreltail make up the bulk of the grass components in retrogression.

Bitterbrush occurred in small but important amounts at North Burn and Silver Lake Burn but only widely scattered plants were found at West Burn. Severe overuse by deer, especially, and livestock has caused some mortality and seriously reduced bitterbrush

Table 8. Ecological data from paired macroplots on the North Burn, Silver Lake Burn, and West Burn sites in the Silver Lake unit. Frequency data were obtained in July, 1964. All other data were recorded from June through July, 1963.

Location: North Burn   Treatment: Burned-seeded 12/29/60

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Artr	24.4	0.1	16	3	134	2			Brte	75	24
Chvi	4.0	1.7	10	11	30	9			Artr	44	1
Chna	3.1	-	17	-	16	-			Chvi	16	3
Putr	1.9	-	29	-	3	-			Ersp 4	14	2
Teca	1.5	2.1	15	9	5	22			Gara	10	-
Brte	14.3	15.9					1.5	2.0	Sihy	6	-
Ersp 4	0.8	1.2					0.6	0.1	Chna	5	-
Gara	0.6	-					0.4	-	Agsp	2	5
Sihy	2.6	-					0.3	-	Putr	2	-
Stth	1.3	-					0.2	-	Pose	1	-
Copa	2.3	1.8					0.2	0.1	Blsc	1	-
Migr	2.0	0.8					0.2	0.1	Agde	-	73
Agsp	0.8	1.5					0.1	0.1	Stth	-	3
Kocr	0.9	-					0.1	-			
Pose	0.1	0.1					t	t			
Depi	0.3	0.9					t	t			
Cram	0.2	1.1					t	0.1			
Phli	0.1	0.6					t	t			
Aspu	0.1	-					t	-			

Table 8. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Agde	-	25.6					-	3.7			
Cama	-	0.3					-	t			
Bare Ground							64.1	89.0			
Litter							29.3	4.7			
Cryptogams							2.2	-			
Gravel>1" Diameter							0.2	-			

Table 8. Continued.

Location: Silver Lake Burn

Treatments: T_1 Burned (1960)
T_2 Burned-seeded (12/29/60)

Species	Mean Percent Canopy Cover			Mean Maximum Height (Inches)			Number/800 Sq. Feet (Density)			Mean Percent Basal Area and Ground Cover			Species	Frequency		
	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2		U	T_1	T_2
Artr	26.8	0.9	0.5	21	5	3	126	23	13				Brte	65	80	4
Chvi	7.9	4.8	2.5	14	12	13	61	33	20				Artr	39	5	1
Putr	2.4	0.5	-	19	10	-	8	3	-				Caro	16	1	5
Juoc	0.1	-	-	13	-	-	1	-	-				Chvi	15	14	9
Chna	-	0.1	-	-	9	-	-	2	-				Gara	11	18	-
Brte	30.2	42.1	18.4							5.6	7.9	2.1	Sihy	8	7	3
Sihy	3.9	0.8	0.1							0.4	t	t	Stth	6	8	2
Stth	0.9	0.5	0.4							0.2	0.1	0.1	Ascu 2	2	-	1
Caro	2.6	-	1.9							0.2	-	0.1	Putr	2	1	-
Copa	2.9	1.2	1.6							0.2	0.1	0.1	Depi	1	1	-
Migr	1.1	12.1	0.3							0.1	0.5	t	Mina	1	-	-
Cram	0.8	0.8	1.1							0.1	0.1	0.1	Ersp 4	1	3	-
Gara	1.4	-	-							0.1	-	-	Agde	-	1	84
Ersp 4	0.3	1.6	0.2							t	0.1	t	Feid	-	-	1
Depi	0.3	-	0.1							t	-	t	Pose	-	-	1
Eppa	0.2	-	-							t	-	-	Eppa	-	48	-
Lysp	-	0.8	-							-	0.1	-	Migr	-	10	-
Pose	-	0.4	-							-	0.1	t	Lysp	-	2	-
Lemo	-	0.2	-							-	t	-	Chna	-	1	-

Table 8. Continued.

Species	Mean Percent Canopy Cover			Mean Maximum Height (Inches)			Number/800 Sq. Feet (Density)			Mean Percent Basal Area and Ground Cover			Species	Percent Frequency		
	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2		U	T_1	T_2
Agde	-	-	35.5							-	-	6.1	Meal 2	-	1	-
Pobu	-	-	0.1							-	-	t	Aspu	-	1	-
Bare Ground										65.9	66.1	78.9				
Litter										21.1	17.5	11.2				
Cryptogams										3.1	-	-				
Gravel > 1" Diameter										0.3	4.8	0.3				

Table 8. Continued.

<u>Location:</u> West Burn   <u>Treatments:</u> T_1 Burned (1960)
T_2 Burned-seeded (12/29/60)

Species	Mean Percent Canopy Cover U	T_1	T_2	Mean Maximum Height (Inches) U	T_1	T_2	Number/800 Sq. Feet (Density) U	T_1	T_2	Mean Percent Basal Area and Ground Cover U	T_1	T_2
Artr	30	t	t	21	3	3	141	1	1			
Chna	1	t	t	17	12	8	4	2	2			
Chvi	t	-	t	13	-	11	1	-	1			
Brte										2.2	4.3	0.9
Sihy										1.6	0.3	0.1
Pose										0.4	0.1	0.1
Copa										0.2	0.1	0.2
Migr										0.1	0.3	0.3
Gara										t	t	-
Cram										t	0.2	0.1
Agde										t	0.1*	3.9
Agsp										t	-	-
Eppa										t	t	t
Blsc										t	0.1	-
Aspu										t	t	-
Ersp 4										-	0.1	t
Stth										-	t	-
Depi										-	t	t
Brbr										-	-	t

Species	Percent Frequency U	T_1	T_2
Brte	65	94	33
Artr	44	1	1
Sihy	19	41	7
Chna	7	-	1
Pose	6	1	6
Gara	5	12	6
Agsp	2	-	-
Cram	1	2	-
Migr	1	6	5
Erba	1	-	-
Blsc	1	15	6
Feid	1	-	-
Eppa	-	44	-
Agde	-	11*	94
Depi	-	10	-
Chvi	-	2	-
Ersp 4	-	2	3
Stth	-	1	-
Asst	-	1	-

Table 8. Continued.

Species	Mean Percent Canopy Cover			Mean Maximum Height (Inches)			Number/800 Sq. Feet (Density)			Mean Percent Basal Area and Ground Cover			Species	Percent Frequency		
	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2	U	T_1	T_2		U	T_1	T_2
Bare Ground										59.6	86.0	87.3				
Litter										31.8	3.8	4.9				
Cryptogams										1.8	-	-				
Gravel>1" Diameter										0.6	4.2	2.1				

* Few scattered plants resulting from aerial seeding.

vigor on these marginal sites.

The burned and seeded stands are strongly dominated by crested wheatgrass with frequency of 75 to 95 percent and basal area of 4 to 6 percent. The originally low perennial grass cover increased slightly while cheatgrass was significantly reduced, particularly in 1964, as shown by frequency data. Deer use of seedings located in or near concentration areas was extensive.

Big sagebrush was effectively removed and the low cover and density on treated plots was comprised entirely of seedlings that became established soon after the fire. Green rabbitbrush was only partially reduced. Coverage of this species on seeded plots was one-half while density was one-third of that found in the unburned stands at North Burn and Silver Lake Burn.

The main differences between burning vs. plowing before seeding are better retention of native perennial grasses and greater survival of green rabbitbrush in the burned treatments. Except where bitterbrush is more than a rare component, the same benefits of diversification of forage resources are derived from burned-seeded as plowed-seeded stands. Fire is at best a hazardous tool and every precaution needs to be taken to contain it in the desired area. Otherwise, whether natural or accidental, uncontrolled fires remove plant cover on some areas that do not have fire resistant perennial grasses nor can they be artificially revegetated. The result is a weedy mixture of small value to deer or livestock.

Influence of Burning: Two burned stands at Silver Lake Burn and West Burn had the same potential as the drilled sites but were too small for seeding. These were studied in a three-way comparison with the unburned and seeded stands.

An additional burned site on Chestnut soils--South Burn (E)--had an initial shrub cover codominated by bitterbrush and big sagebrush (Table 9). Such communities form the single most valuable vegetation type on the entire winter range in terms of deer forage production and use. The complexity of the low-seral understory in the unburned plot makes an elucidation of the climax potential difficult. Idaho fescue (Festuca idahoensis) was found in greater abundance than bluebunch wheatgrass or Sandberg's bluegrass (Poa secunda), yet in this area fescue is not a decreaser with grazing abuse as is bluebunch wheatgrass. The present composition favoring fescue does not of necessity imply dominance in climax.

Burning alone on all three locations increased cheatgrass, in particular, and many annual forbs (Figure 16). The post-fire aspect is, indeed, a cheatgrass grassland. Perennial grasses showed a fairly consistent decline on burned plots compared to adjacent unburned plots. Idaho fescue appeared especially fire sensitive at South Burn (E).

Table 9. Ecological data from paired macroplots on the South Burn (E) site in the Silver Lake unit. Frequency data were obtained in July, 1964. All other data were recorded from June through July, 1963.

Location: South Burn (E) Treatment: Burned (1960)

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T				U	T
Artr	27.9	0.1	21	6	165	2			Brte	70	100
Putr	3.7	0.4	17	9	16	2			Artr	52	1
Chvi	0.4	0.8	13	14	2	3			Feid	28	2
Teca	-	0.4	-	15	-	1			Sihy	20	1
Feid	16.5	-					2.5	-	Putr	12	-
Brte	10.3	36.9					1.3	4.7	Stth	12	6
Pose	2.3	1.1					0.6	0.3	Pose	12	9
Sihy	2.9	0.1					0.5	-	Agsp	8	3
Kocr	2.9	-					0.5	-	Kocr	6	1
Stth	2.1	2.4					0.3	0.3	Erba	3	1
Agsp	1.6	0.4					0.2	0.1	Chvi	3	2
Copa	1.8	2.1					t	0.2	Gara	2	3
Erba	0.7	-					0.1	-	Asst	1	1
Cram	0.3	0.7					t	-	Eppa	-	29
Depi	0.1	2.3					t	0.1	Depi	1	26
Phli	0.1	-					t	-	Cogr	-	5
Migr	0.4	1.8					t	0.2	Migr	-	3
Eppa	0.1	0.4					t	t	Luco 2	-	1
Cogr 2	0.1	0.1					t	t	Cama	-	1

Table 9. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	U	T	U	T	U	T	U	T		U	T
Ersp 4	-	0.3					-	t	Meal 2	-	1
Ersp 3	-	0.1					-	t	Liru	-	1
Swmo	-	0.1					-	t			
Chna 2	-	0.1					-	t			
Bare Ground							78.0	87.8			
Litter							14.3	6.1			
Cryptogams							0.5	-			
Gravel>1" Diameter							-	0.1			

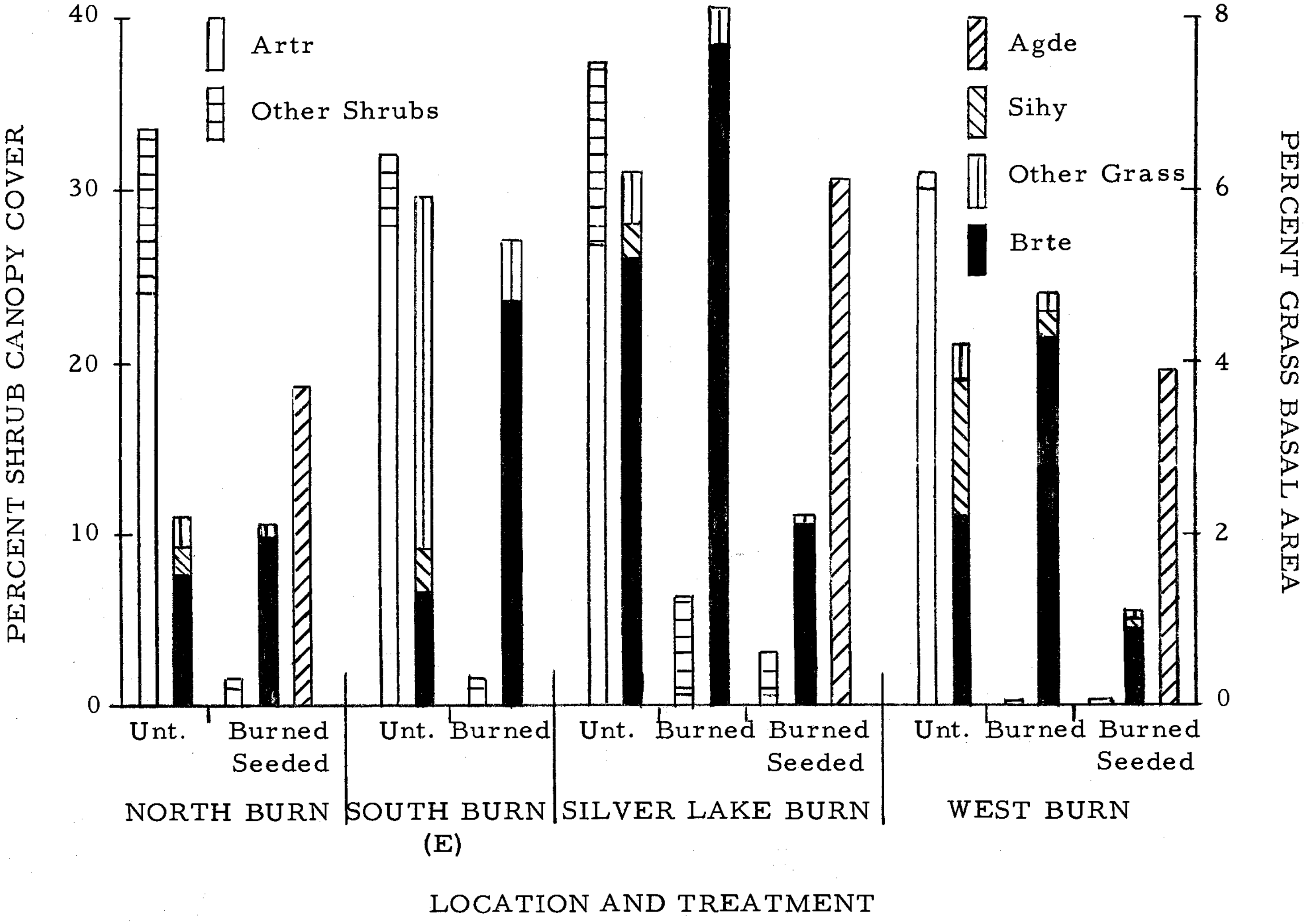

Figure 16. Composition changes following burning or burning and seeding treatments at four locations in the Silver Lake unit.

Big sagebrush was completely removed at all three locations with the present low cover and density composed entirely of seedlings established since the fire. Green rabbitbrush at Silver Lake Burn was more vigorous and had a greater density on the burned macroplot than in the seeded stand. On many burned areas that were not sampled, green rabbitbrush and cheatgrass increased greatly and dominate the stand.

Aerial portions of bitterbrush were completely killed by fire at South Burn (E) and Silver Lake Burn. The few surviving plants initiated sprouts from adventitious buds below the soil surface. Incidence of sprouting was low throughout the burned areas probably because of the very hot, mid-summer fire on a dry site (Driscoll, 1963; Blaisdell, 1950).

In summary, fire produced a poor, low-value stand of cheatgrass and weeds, reduced perennial grasses and removed shrub cover except for green rabbitbrush. Countryman and Cornelius (1957) found essentially the same response on a burned-over bitterbrush type in northern California using nearly identical sampling procedures.

Critique: Evaluation of the sampling procedure used in this study for possible future determinations of species composition changes tends to favor adoption of frequency sampling alone (Hyder *et al.*,

1963) or in combination with a reconnaissance level of species dominance classification (Culver, 1964; Volland, 1963). Frequency data appear to be a fairly sensitive index to composition changes and are much more rapidly obtained than plot estimates of cover and basal area. Consequently, stand variability can be more adequately sampled in the same or less time, an important consideration in studies of large areas with complex vegetational mosaics.

PRODUCTION: Production estimates are necessary to approximate carrying capacity and forage value of different vegetation types. Few quantitative data are available on pounds of grass or shrub forage available for winter use. Consequently, all shrub and grass species were recorded from production plots clipped in late April, 1964, and green grass was separated from dead material.

A sample size of ten, 9.6-square-foot plots per macroplot location was too small for accurate estimates of production except for species with uniform ground cover. Grass production in general and seeded crested wheatgrass in particular were estimated reasonably well but shrub production estimates were only crudely indexed. Confidence intervals at the .05 level of significance were determined for species producing more than 10 pounds of herbage per acre and occurring in five or more of the ten plots. Weight estimates and confidence intervals for species occurring within production plots at twelve locations appear in Table 10.

Grass production in the fall, 1963, and spring, 1964, was excellent because of timely fall precipitation and mild temperatures. Consequently, weight estimates of green grass reflect availability of this material in a good year. The dry fall of 1964, in contrast, resulted in minimal regrowth. Garrison (1953a) states that shrub production is as much or more variable than grasses during the growing season, but this relationship appears to be reversed during winter when green regrowth is compared with browse forage.

Sagebrush production data from the same plots are low for two reasons: (1) Plot size and number were too small to sample some open stands, and (2) a defoliating moth (*Aroga websteri*) infestation the preceding summer (Gates, 1964) greatly reduced current annual growth. In some stands such as Dehne Flat and D. Long, production was predominately secondary growth of leaves and twigs after heavy loss of initial foliage. Since severe drains on stored nutrient reserves accompany early spring growth and recovery of defoliated plants is slow, secondary production can be expected to be much less than on unaffected plants.

Influence of Herbicides: Spraying at Dehne Flat did not significantly increase grass production because a slight increase in squirreltail was offset by a decline in Thurber's needlegrass. Heavier use by

Table 10. Mean oven-dry herbage production in pounds per acre of shrub and grass species at each macroplot location.

		Estimated Pounds Per Acre															Total		
					Ersp	Lepu	Caro		Eltr		Muri		Sihy		Stth		Shrub	Grass	
Location	Treatment	Arca	Artr	Chvi	3	2	D	G*	D	G	D	G*	D	G	D	G	CAG**	D	G
Dehne Flat	Sprayed	-	-	16	-	1	2	2	t	t	-	-	13	16	t	t	17	15	18
														(±9)					
	Untreated	-	23	62	-	-	1	1	-	-	-	-	60	12	6	2	85	67	15
			(±86)	(±61)										(±14)					
Hockman Well	Sprayed	-	-	-	-	-	-	-	-	-	-	-	399	101	33	2	-	432	103
														(±45)					
	Untreated	-	233	9	-	-	-	-	-	-	-	-	79	12	2	1	242	81	13
			(±23)											(±9)					
Ceres Flat	Rotobeat	-	-	8	9	-	46	19	4	1	8	66	117	65	-	-	17	175	151
								(±14)				(±32)		(±36)					
	Untreated	1	240	17	-	-	20	12	9	1	27	77	157	22	26	t	258	239	112
			(±244)	(±14)				(±7)				(±54)		(±11)					

* Green material of Caro and Muri is actually matured growth from the preceding growing season that retains some green color in the cured state. Dry is accumulated material from previous years. Green material of other grasses includes only living tissue.

** CAG = current annual growth.

t Less than 1 pound per acre.

± Confidence limits at the .05 level on species yielding more than 10 pounds per acre and occurring in five or more plots out of a sample size of 10.

Table 10 (Cont.)

Location	Treatment	Estimated Pounds Per Acre																			Total		
		Artr	Chna	Chvi	Agde		Agsp		Brin ***		Brte		Eltr		Feid		Sihy		Stth		Shrub	Grass	
					D*	G*	D	G	D	G	D	G	D	G	D	G	D	G	D	G		D	G
L. Iverson	Plow seeded	-	-	6	323	90 (±16)	-	-	-	-	t	-	-	-	-	-	2	t	-	-	6	325	90
	Untr. **	449 (±276)	t	40 (±79)	-	-	130	5	-	-	17	-	-	-	-	-	12	3	-	-	489	159	8
D. Long	Plow seeded	-	-	-	331	124 (±18)	-	-	-	-	11	-	6	t	-	-	1	1	-	-	-	349	125
	Untr.	321 (±285)	-	-	-	-	-	-	-	-	121	1	-	-	-	-	58	25 (±20)	-	-	321	179	26
Silver Creek	Plow seeded	-	15	-	98	70 (±41)	-	-	-	-	119	1	23	6	-	-	-	-	-	-	15	240	77
	Untr.	143 (±140)	13	86 (±63)	-	-	-	-	-	-	43	t	21	13 (±9)	-	-	17	8	3	1	242	84	22
Airport	Plow seeded	-	-	-	150	20 (±7)	53	1	163	17 (±7)	-	-	-	-	-	-	30	4	1	t	-	397	42
	Untr.	137 (±104)	-	-	-	-	-	-	-	-	29	-	-	-	100	5	42	2	-	-	137	171	7
Arbow	Plow seeded	-	-	-	387	67 (±18)	-	-	-	-	2	-	3	1	-	-	4	1	-	-	-	396	69
	Untr.	221 (±170)	35	-	-	-	-	-	-	-	75	-	33	3	4	1	t	1	4	t	256	116	5

* D = Dry; G = Green

** Untreated

*** Bromus inermis seeded in combination with crested wheatgrass.

Table 10 (Cont.)

Location	Treatment	Estimated Pounds Per Acre																		Total		
		Artr	Chvi	Putr	Teca	Agde		Agsp		Brte		Feid		Pose		Sihy		Stth		Shrub	Grass	
						D	G	D	G	D	G	D	G	D	G	D	G	D	G		D	G
North Burn	Burn seeded	-	-	-	-	594	49 (±9)	-	-	104	-	8	t	-	-	12	1	-	-	-	718	50
	Untr.	179 (+158)	17	-	-	-	-	1	t	26	-	9	1	5	t	12	1	-	-	196	53	2
South Burn (E)	Burned	-	-	-	-	-	-	68	3	591	3	21	1	2	2	1	1	20	1	-	703	11
	Untr.	408 (±204)	-	160 (±215)	-	-	-	7	-	80	t	113	2	-	-	2	t	1	t	568	203	2
Silver Lake Burn	Burned	4	100 (±113)	13	-	-	-	-	-	164	-	10	t	-	-	16	2	-	-	117	190	2
	Burn seeded	4	35 (±38)	-	-	618	40 (±9)	-	-	43	t	-	-	-	-	13	1	4	-	39	678	41
	Untr.	180 (±274)	104 (±81)	6	-	-	-	-	-	53	t	-	-	-	-	t	t	-	-	290	53	t
West Burn	Burned	-	-	-	-	22	14 (±20)*	-	-	78	4	-	-	1	3	3	1	-	-	-	104	22
	Burn seeded	-	-	-	-	209	126 (±36)	-	-	28	t	-	-	t	2	-	-	-	-	-	237	128
	Untr.	273 (±181)	-	-	1	-	-	-	-	27	t	-	-	-	-	19	3	-	-	274	46	3

* Few scattered plants resulting from aerial seeding.

cattle of the more available grass on the treated area was indicated by a lower amount of cured grass material in the treated plots. The reverse occurred at Hockman Well where grass production in the sprayed stand exceeded by many times that of the untreated area. Livestock use of the Hockman Well site has been light since treatment. Production of grasses in the untreated stands at both locations was similar.

The low estimate of big sagebrush production at Dehne Flat was primarily a result of heavy infestations of the *Aroga* moth although the small number of plots failed to sample adequately this low-density stand. Production of big sagebrush at Hockman Well was higher because of greater plant density, more uniform cover, and only light defoliation.

Chemical control of shrubs at Dehne Flat reduced game forage values since no increase in grass production occurred to compensate for the loss. Although total production of shrubs was sharply reduced, the rapid recovery of green rabbitbrush and slow reestablishment of big sagebrush will result in future increases in forage value. Widely-spaced, vigorously-growing young plants produce greater amounts of current annual growth that are more heavily utilized than mature plants in dense stands.

Shrub removal at Hockman Well was largely compensated for by increased green grass production. Although not equaling by weight the shrub herbage lost, green grass at this site supplies considerable early spring deer forage which is higher in crude protein than browse during this critical period of deer nutrition.

Influence of Rotobeating: Browse production estimates from the Ceres Flat rotobeaten stand were low because of inadequate sample size. Density and coverage data in Table 6 provide a better indication of browse values. For example, no sagebrush plants happened, by chance, to occur within the ten randomly located 9.6-square-foot plots, yet density counts showed 76 small plants per 800 square feet. Green rabbitbrush density on the rotobeaten area was two-thirds that of the untreated stand, yet cover increased because of greater size of remaining plants. Reduced density, however, influenced production sampling which falsely indicates a lower herbage weight on the treated stand.

Green grass production was increased somewhat by rotobeating. Most of the increase consisted of squirreltail and this is significant because it is the only grass species of importance to deer at this location. The other grass species are either cured forages low in crude protein or they begin growth too late in spring to be of value. Growing season production of grasses may be somewhat greater and certainly availability is better but the small increases do not appear to justify the cost of treatment at this site.[2]

On the other hand, use of rotobeating as a tool in manipulation of big sagebrush types on deer winter ranges shows considerable promise. Alternate strip treatments of various widths and adjustments in height of cut above ground surface need further research to determine if overall production and utilization can be increased. Robertson and Pearse (1945) found a 70 percent increase in sagebrush leader length five feet into the untreated stand from the edge of grubbed strips.

Hedrick et al.[3] recorded greater sagebrush survival from rotobeating than sprayed treatments on poor condition ranges and, in addition, a much faster reestablishment of seedlings. Density of sagebrush on rotobeaten plots was higher than pretreatment levels after eight years. During the same period, the sprayed stand density increased but slightly from the initial low following treatment. They concluded that rotobeating would be a safer method of increasing herbaceous species production on deer winter ranges because it retained good shrub cover and encouraged vigorous shrub growth.

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2. Costs of rotobeating vary from $5 to $8 per acre.

3. Hedrick, D. W., D. N. Hyder, F. A. Sneva and C. E. Poulton. Ecological response of sagebrush-grass range in central Oregon to mechanical and chemical control practices. Unpublished manuscript on file with the Range Management Department, Oregon State University. 1963.

Influence of Plow-Seeding: Stands that were plowed and seeded invariably had initially high shrub cover, predominantly of big sagebrush, and very poor herbaceous understories. Seeding reversed this relationship so that two very different types were produced; both of which are of value to wintering deer populations.

Crested wheatgrass produces practically all of the green grass material on seeded stands except at the Airport location where smooth brome was seeded with it. This material is actively sought by deer on winter range and is, when available, important in fall, spring, and snow-free periods in winter. It supplies a highly nutritious forage that appears to form a buffer against early exhaustion of key browse species such as bitterbrush. Considerable fall regrowth of crested wheatgrass in 1963 was accompanied by moderate, early use of bitterbrush in the proximity of seedings whereas, in the fall of 1964, observations showed no crested wheatgrass regrowth and bitterbrush was heavily used by the end of December.

The value of crested wheatgrass seedings for deer is influenced by livestock use during the preceding spring and early summer. Moderate to heavy livestock use of seedings more than doubles the expected amount of fall regrowth with favorable conditions. Table 11 demonstrates this difference and includes both plow-seeded and burn-seeded stands since the same principle applies.

Public land administrators and private landowners are

Table 11. Oven-dried weight of green and dry crested wheatgrass clipped April 20, 1964, from production plots on seeded stands grazed moderately to heavily the preceding growing season contrasted with stands receiving light or no livestock use.

		Pounds per Acre			
		Light Use		Heavy Use	
Location	Treatment	Dry	Green	Dry	Green
Silver Creek	Plow-seed*			98	70
L. Iverson	Plow-seed			323	90
D. Long	Plow-seed			331	124
West Burn	Burn-seed			209	126
Airport	Plow-seed	313**	37**		
Silver Lake Burn	Burn-seed	618	40		
North Burn	Burn-seed	594	49		
Arbow	Plow-seed	387	67		
Mean		478	48	240	103

* Silver Creek seeding was only two years old and had not become fully established.

**Includes both crested wheatgrass and smooth brome seeded in mixture and contributing about equally to production.

anxious to recover the cost of range improvements from increased livestock production, and it is fortunate that heavy growing-season use of crested wheatgrass is also beneficial to game. The characteristic of crested wheatgrass to withstand heavy grazing has been one of the factors in its selection for semiarid range improvement (Hyder and Sneva, 1963).

All of the plowed and seeded projects studied occurred on privately-owned land at lower elevations in the Silver Lake unit.

Deer use of these seedings as well as the surrounding sagebrush stands was light. It appears that these seeding improvements have been beneficial to deer. Lower elevation seedings have created a seasonally important herbaceous forage that was largely unavailable prior to improvement. Figure 17 illustrates the greater amount of green grass forage available to deer on seedings compared with untreated stands.

Only minor amounts of green grass material are supplied by other species either on seeded or untreated stands. Squirreltail is second in importance to crested wheatgrass but it produced only twenty-five pounds of oven-dried green forage per acre on the untreated site at the D. Long seeding and never exceeded ten pounds at the other locations.

Sagebrush did not occur in any production plots on plowed and seeded sites indicating the almost complete removal of this shrub with plowing. Estimated production of sagebrush on untreated plots varied from 137 to 449 pounds per acre and reflect subnormal amounts resulting from moderately defoliated plants attacked by the Aroga moth in the 1963 epidemic. Green rabbitbrush was found in minor amounts at all sites yet occurred in production plots only at the Silver Creek and L. Iverson locations. Likewise, gray rabbitbrush was recorded in production plots only at Silver Creek and Arbow.

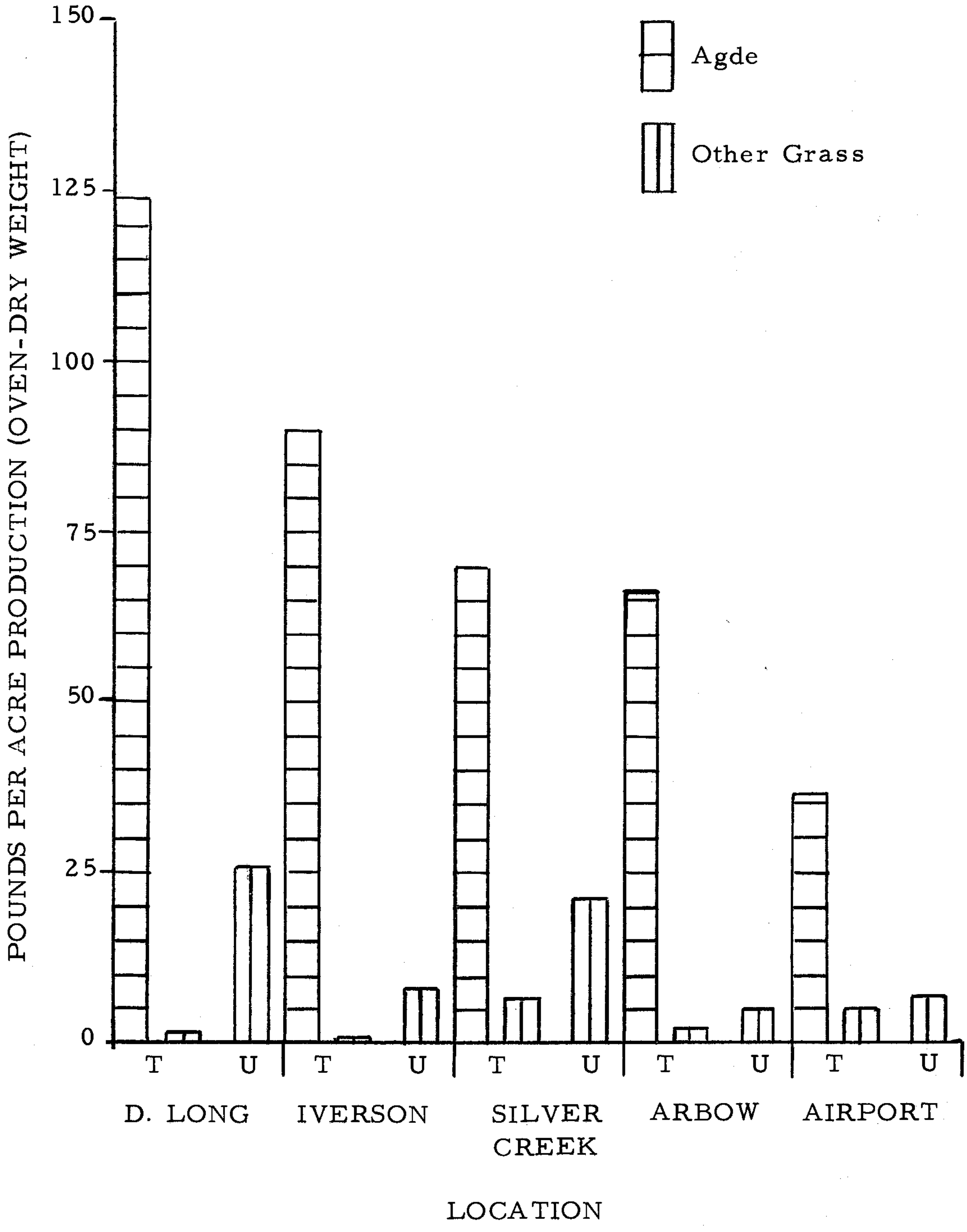

Figure 17. Green grass production in plowed and seeded stands compared with adjacent untreated sites. Both crested wheatgrass and smooth brome (Bromus inermis) are included at the Airport site. (T = treated, U = untreated)

Influence of Burn-Seeding: Burned and seeded stands were examined at three locations--North Burn, West Burn, and Silver Lake Burn--and only slight differences were detected between these and the plowed-seeded projects. Establishment of crested wheatgrass was excellent in every case. All burned-seeded treatments occurred on Chestnut soils and drilling was done directly into the ashes soon after the fire in 1960 without further seed-bed preparation.

Shrub cover is reduced about equally by plowing or burning except where green rabbitbrush occurs. At Silver Lake Burn green rabbitbrush on seeded plots was one-third that on unburned plots showing the rapid recovery this species is capable of since it sprouts readily. Small amounts of sagebrush at the same site consisted of three-year old seedlings that established the first growing season after the fire.

Cheatgrass tends to be favored in seedings on burned sites over plowed treatments as shown by weight of dry material in Table 10. No fall germination and only slight spring germination of cheatgrass had occurred by the time production plots were clipped in late April, 1964, on either plowed or burned and seeded sites. Only small amounts of green grass material were produced by grasses other than crested wheatgrass although squirreltail and Sandberg's bluegrass supply some late winter-early spring forage to deer on restricted areas of greater abundance. Figure 18 shows the

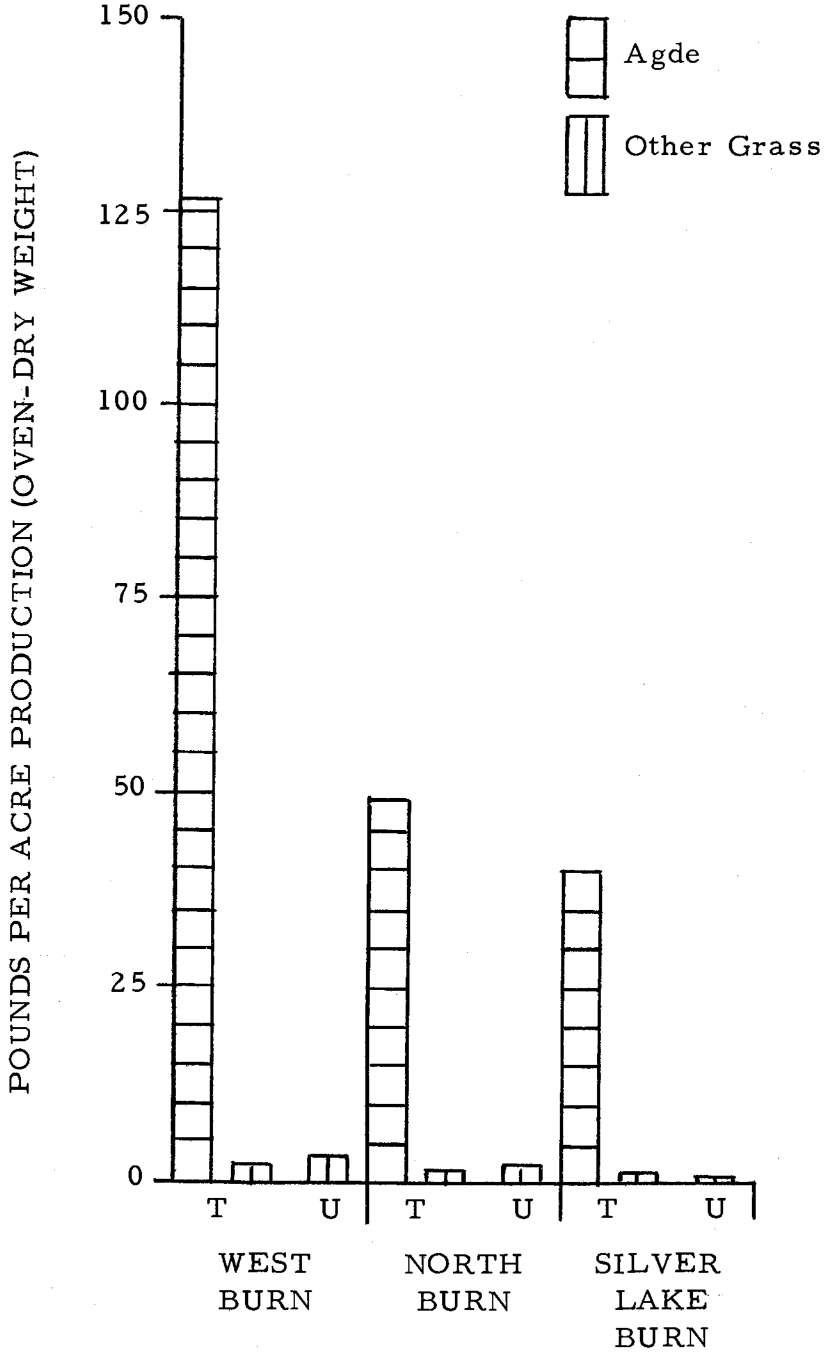

Figure 18. Comparison of pounds per acre production of green grass forage on burned and seeded sites vs. unburned stands. (T = treated, U = untreated)

difference in green grass forage available to deer on seeded and unburned stands. As discussed earlier, heavier livestock use of the North Burn and Silver Lake Burn seedings would increase production of green crested wheatgrass in winter to more nearly approximate the West Burn condition. Deer have made extensive use of these higher elevation seedings.

Influence of Burning: Production data from burned stands were taken at West Burn, Silver Lake Burn, and South Burn (E) locations. Differences in pretreatment stand composition result in few consistent changes following fire. Shrub production was eliminated at West Burn and South Burn (E), but green rabbitbrush showed no change from the unburned stand at Silver Lake Burn. Seedlings of big sagebrush, as in the seeded plots at this location, made up all of the small production recorded. A dense stand of bitterbrush at South Burn (E) was almost completely removed by fire and none of the few resprouting plants occurred within the production plots.

Burning alone increases production of green grass forage in winter only slightly above that on unburned stands. Increases in one species were often negated by a decline in another as with bluebunch wheatgrass and Idaho fescue at South Burn (E). Squirreltail increased at one location, declined at another, and remained the same at the third. Cheatgrass was greatly increased during late spring on burned plots as shown by weight of dry material but lack of early spring growth limits its value in comparison with crested wheatgrass (Hull, 1949).

Shift to an aspect of cheatgrass and weeds is the main effect of fire and although temporary, its influence on forage values for game and livestock may be maintained for many years. No alternative forage sources are produced on burned sites comparable to crested wheatgrass on seeded stands. Consequently, whenever fires occur, all suitable sites should be drill seeded. Aerial seedings have generally proven unsuccessful in this area although scattered plants have been established by this means on burned sites such as West Burn. These scattered plants receive heavy use by deer in winter.

Critique: Production data in Table 10 are believed to be reasonably representative of the relative importance of grasses on treated and untreated stands studied. Shrub data at this level of sampling frequently fail to reflect actual forage values, and estimates of shrub production on untreated stands provide at best a rough approximation as shown by the broad confidence intervals.

Since clipping and hand-separation are so time consuming, increasing sample sizes is not a satisfactory alternative. Perhaps future sampling of shrub production would be better served by ocular weight estimates of many plots preceded by an intensive training period and followed by frequent checks to compare estimates with actual weight (Pechanec and Pickford, 1937). Density counts and regression techniques on average weight and size are other possibilities of arriving at reasonably accurate indexes to production of shrubs.

UTILIZATION: One approach to game herd management is through the response of important plant species to utilization by game and livestock. This concept is based on the fact that game animals as consumer-herbivores are dependent upon producer organisms in the form of preferred plant species. If these plants are maintained in a vigorous, competitive position with other community components, then the game animal will also derive the greatest long-term benefit. Refinements of herd management such as determinations of population structure, increase rates, distribution, and proper harvest levels should all be focused on the objective of enhancing the forage resource. Resource conflicts among forage, game, recreation and aesthetic uses can be resolved only with such a management philosophy.

Utilization indexes are less difficult to obtain than production data but, alone, they reflect only the pressure exerted on a unit of range and not relative population levels or total amount of forage taken (Smith and Urness, 1962, p. 24). Stated another way, utilization can be used at the end of the grazing season only to determine whether the herd in a particular winter did or did not exceed proper use levels imposed by production for that year.

Utilization data have limited value in predicting the forage available and what game harvest is needed to properly use it. But yearly production and herd trends are the kinds of information required by game managers to avoid wasting game and declining range condition. Therefore, a combination of: (1) some kind of production index in late summer prior to setting harvests, (2) utilization checks after deer use on limiting winter ranges, and (3) population trend data would seem to offer the best alternative to the difficulties of starvation losses and range abuse still common on many herd units.

Development of such indexes based on the "key species" concept would provide an initial starting point that is compatible with the conditions under which most game agents operate (Smith, 1965). The assumption being, within Smith's definition of a "key species," that when this species receives proper utilization, the remaining components of the forage resource will be, with few exceptions, managed correctly. This approach necessitates a more dynamic emphasis on removing herd surpluses through flexible hunter harvest within the framework of the management unit system than has been exhibited in the past by many game agencies. Greater investment in public education is necessary to gain understanding and acceptance of this kind of management.

Bitterbrush Utilization: Bitterbrush in the Silver Lake and Fort Rock units is the logical choice as the "key species." It supplies a large amount of forage, it is preferred over other important shrubs, and these other forages would not replace it in equal proportions were it removed. Because of its critical importance, four utilization transects in different bitterbrush stands were established in 1963 and at eight additional locations in 1964. These data are presented in Table 12 and illustrate excessive use on every area both years.

Garrison (1953b) found 50-60 percent removal of current annual growth maximal for sustained production on dry sites in central Oregon. Observations on the Silver Lake winter range support Garrison's conclusions in that bitterbrush mortality has been high, many plants have partially dead crowns, and stand regeneration is poor. Data show that use has exceeded 60 percent in at least 13 of the past 21 years and that most of this use in recent years is attributable to deer.[4] Shifts in the livestock grazing season to spring and early summer have practically eliminated nongame use on bitterbrush in the past seven years.

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4. Oregon Game Commission. The Silver Lake Show-me trip, April 6-7, 1963. In cooperation with the Pacific Northwest Forest and Range Experiment Station; U. S. Forest Service; Bureau of Land Management. On file with the Oregon State Game Commission, Research Division, Oregon State University. 1963.

Table 12. Percent utilization of bitterbrush by deer based on reduction-of-twig-length measurements in fall and spring.

Transect	Location	Jan. 2 1964	Mar. 26 1964	April 25 1965
South Burn (W)	SE¼Sec12T29SR14E	55	77	82
South Burn (E)	NW¼Sec18T29SR15E	53	76	83
Silver Lake Burn	NW¼Sec7T29SR15E	39	80	84
West Burn	SE¼Sec4T29SR14E	60	77	77
Herder Spring	NE¼Sec14T29SR14E			83
Mt. Mahogany Butte	NW¼Sec15T29SR14E			76
Penington Spraying	SE¼Sec36T28SR13E			72
FS Cattleguard	SW¼Sec18T29SR14E			74
Middle 9-mile Ridge (E)	NW¼Sec12T27SR13E			89
Lower 9-mile Ridge	NE¼Sec24T27SR13E			92
Middle 9-mile Ridge (W)	SE¼Sec3T27SR13E			91
Upper 9-mile Ridge	NW¼Sec27T26SR13E			85
Mean		52	78	82

Generally declining condition of the key species on the Silver Lake and Fort Rock units can lead only to reduced deer carrying capacity. The value of big sagebrush in over-wintering of deer has been recognized (Smith, 1950, 1959) but this is limited by the amounts of more preferred browse and herbaceous forages available. Experimental feeding of big sagebrush alone resulted in low intakes and weight losses although nutritionally it appeared better than bitterbrush (Dietz, Udall, and Yeager, 1962). Alfalfa had to be mixed with big sagebrush to get minimal intakes, yet bitterbrush rations were completely consumed and resulted in small weight gains. The assumption that declining production of bitterbrush can be compensated for by increased consumption of big sagebrush or other less preferred shrubs is not supported by the experimental evidence. Consequently, if productivity of these ranges and the deer herds using them is to be maintained, every possible means should be employed to retain and improve the condition of these bitterbrush stands rather than depend upon costly rehabilitation measures later.

Step-Point Utilization Indexes: Utilization estimates for species other than bitterbrush are difficult to obtain because use levels are generally low and, consequently, large sample sizes are required. Therefore, examination of one hundred plants, and in the case of seeded crested wheatgrass, two hundred plants, represents a minimal sample for indexing utilization. These data provide an indication of use levels on some species for which no estimates were previously available and it is recommended that further information be obtained to determine seasonal utilization patterns. Only species showing observable use were examined.

Table 13 shows the mean percentage of plants grazed and mean percent utilization of all plants from step-point transects at eight locations. Some unexpected results were evident, particularly in reference to green rabbitbrush use. On untreated stands, percent of plants grazed and mean percent use were higher on green rabbitbrush than big sagebrush. This is graphically illustrated on Figure 19. The lack of normal fall regrowth of grasses and early heavy utilization of bitterbrush may have influenced the relatively heavy use of green rabbitbrush, a species believed by some (Stanton, 1962) to be rarely used by deer. Additional observations need to be taken to ascertain the value of this species to deer in terms of its use from year to year. Dasmann (1949) found rabbitbrush utilized up to 7 percent on pine-bitterbrush types in northern California.

On the sprayed stand at Dehne Flat and the rotobeaten one at Ceres Flat, use of big sagebrush exceeded that on green rabbitbrush. This fact indicates that deer have a greater preference for the more succulent, leafy growth of young, big sagebrush plants. In contrast, use levels on green rabbitbrush in treated and untreated

Table 13. A summary of utilization data from step-point transects at eight locations showing percent of plants grazed and mean percent use based on ocular estimates.

Location	Area	Species	Numbers of Plants Sampled	Percent of Plants Grazed	Mean Percent Use (All Plants)
Iverson	Seeded	Agde	200	27	3.4
	Untreated	Zipa	100	52	19.3
		Chvi	100	35	11.9*
		Feid	100	33	6.9
		Chna	100	16	2.9*
		Artr	100	6	1.1
		Sihy	100	0	0.0
North Burn	Seeded	Agde	200	16	1.8
	Untreated	Chvi	100	25	5.2
		Artr	100	8	1.5
		Chna	100	4	0.6
Silver Lake Burn	Seeded	Agde	200	70	7.6
		Chvi	100	70	22.6
	Untreated	Chvi	100	52	15.4
		Artr	100	42	7.2
West Burn	Seeded	Agde	200	64	4.3
	Untreated	Arar	100	74	12.1
		Artr	100	5	0.7
South Burn (E)	Burned	Agde**	100	65	15.3
		Chvi	100	55	13.2*
		Pose	100	28	5.4
		Sihy	100	21	3.2
		Agsp	100	6	0.5
		Feid	100	4	0.7

Table 13. Continued.

Location	Area	Species	Numbers of Plants Sampled	Percent of Plants Grazed	Mean Percent Use (All Plants)
South Burn (E) (Continued)	Untreated	Chvi	100	78	26.0*
		Artr	100	47	7.2
		Sihy	100	9	1.5
		Pose	100	5	0.7
		Feid	100	4	0.9
Hockman Well	Sprayed	Sihy	100	26	4.3
		Stth	100	2	t
	Untreated	Chvi	100	73	30.1
		Artr	100	56	14.4
		Sihy	100	8	0.9
Dehne Flat	Sprayed	Artr	100	75	20.1
		Chvi	100	43	13.9
	Untreated	Chvi	100	40	13.7
		Artr	100	33	6.2
Ceres Flat	Rotobeaten	Artr	100	69	23.5
		Chvi	100	56	18.4
	Untreated	Chvi	100	46	15.1
		Artr	100	23	4.5

* Some rabbit use involved.
** Few scattered plants resulting from unsuccessful aerial seeding.

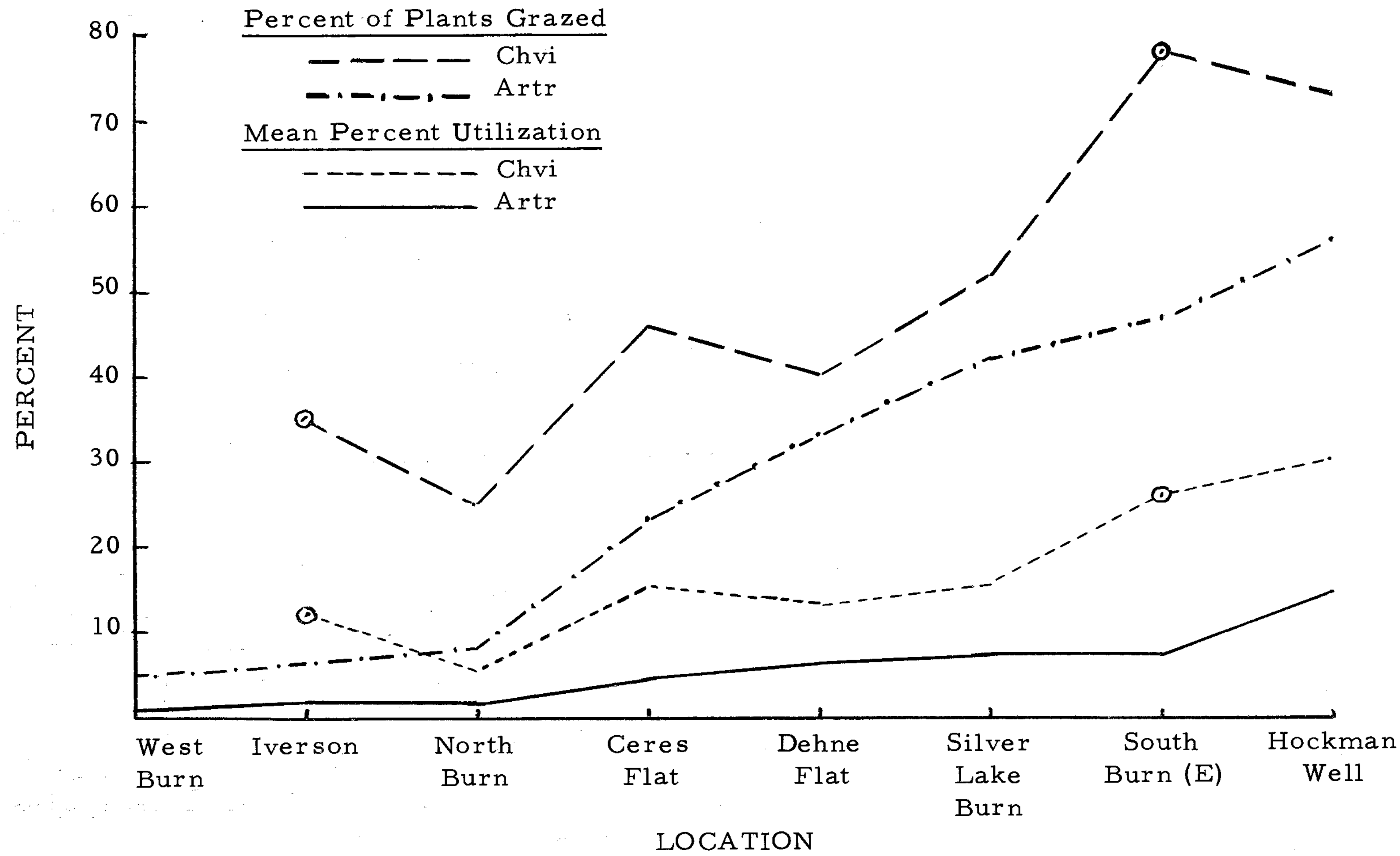

Figure 19. Percent of plants grazed and mean percent utilization of big sagebrush and green rabbitbrush on untreated stands. Circled points indicate the occurrence of some use by rabbits at these locations.

stands at the two locations were similar, indicating that no increased preference occurred in this species with treatment.

Deer use of green crested wheatgrass compared to untreated big sagebrush showed a consistently higher percentage of plants grazed and mean percent utilization on the grass (Figure 20). This does not mean that more pounds of forage per unit area are supplied by the seeded grass. Big sagebrush far exceeds production of green grasses so that percentage utilization is meaningful only when production is taken into account. To illustrate this relationship, mean percent utilization of crested wheatgrass, green rabbitbrush, and big sagebrush was multiplied by the production estimates for each from Table 10 in order to derive an estimation of pounds per acre removal of oven-dried forage. These data were plotted as a histogram and appear in Figure 21. Crested wheatgrass exceeded big sagebrush in estimated weight of forage removed only at the West Burn location but was only slightly less important at North Burn and Iverson sites. Considerably more sagebrush than crested wheatgrass was removed at the Silver Lake Burn location.

Similarly, green rabbitbrush exceeded estimated total use of big sagebrush at Iverson, Silver Lake Burn, and Dehne Flat. The reverse was true for North Burn, Hockman Well, and Ceres Flat, but production of green rabbitbrush is much lower at these sites.

When production of bitterbrush at South Burn (E) is multiplied

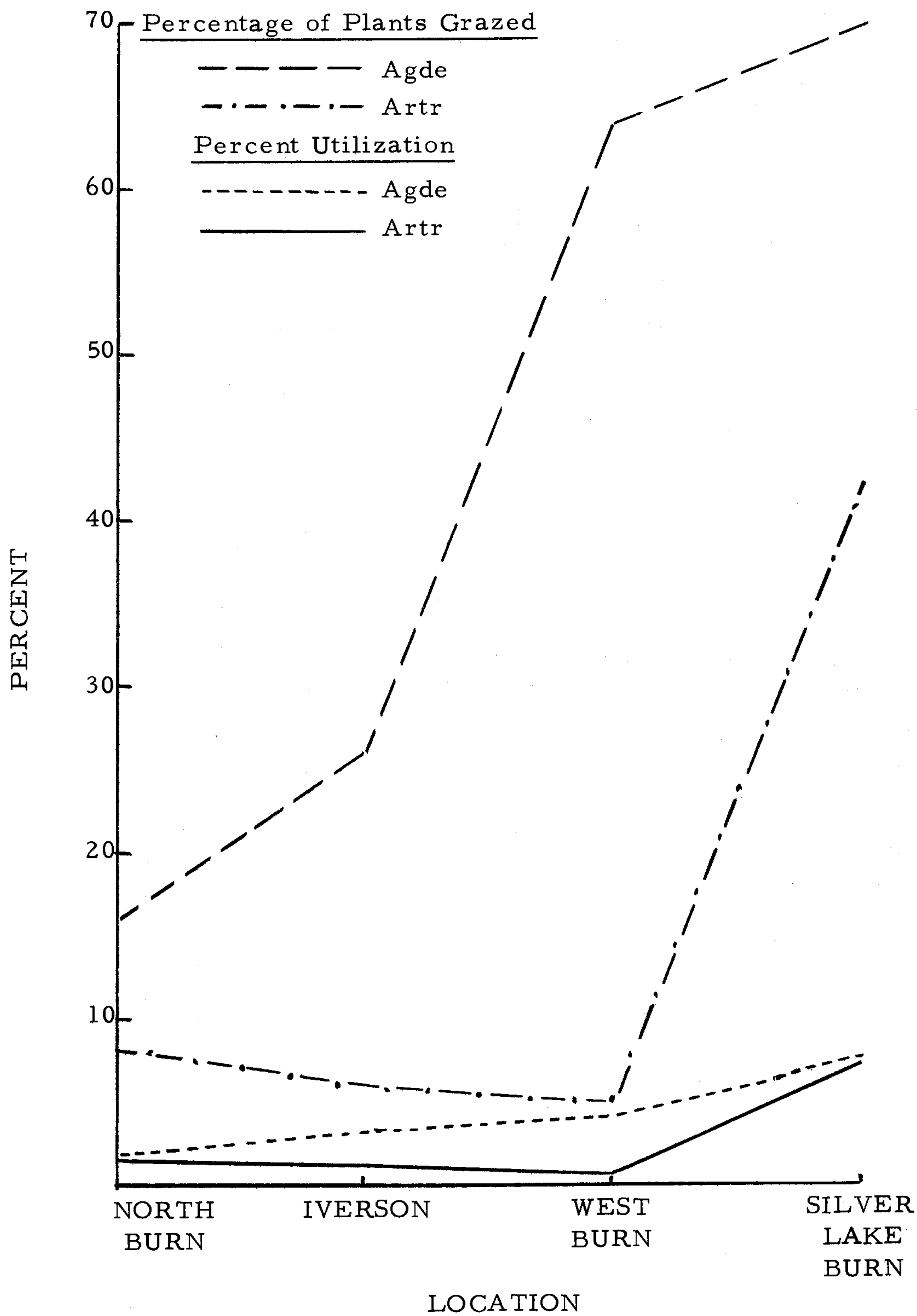

Figure 20. A comparison of percentage of plants grazed and mean percent utilization of seeded crested wheatgrass and untreated big sagebrush.

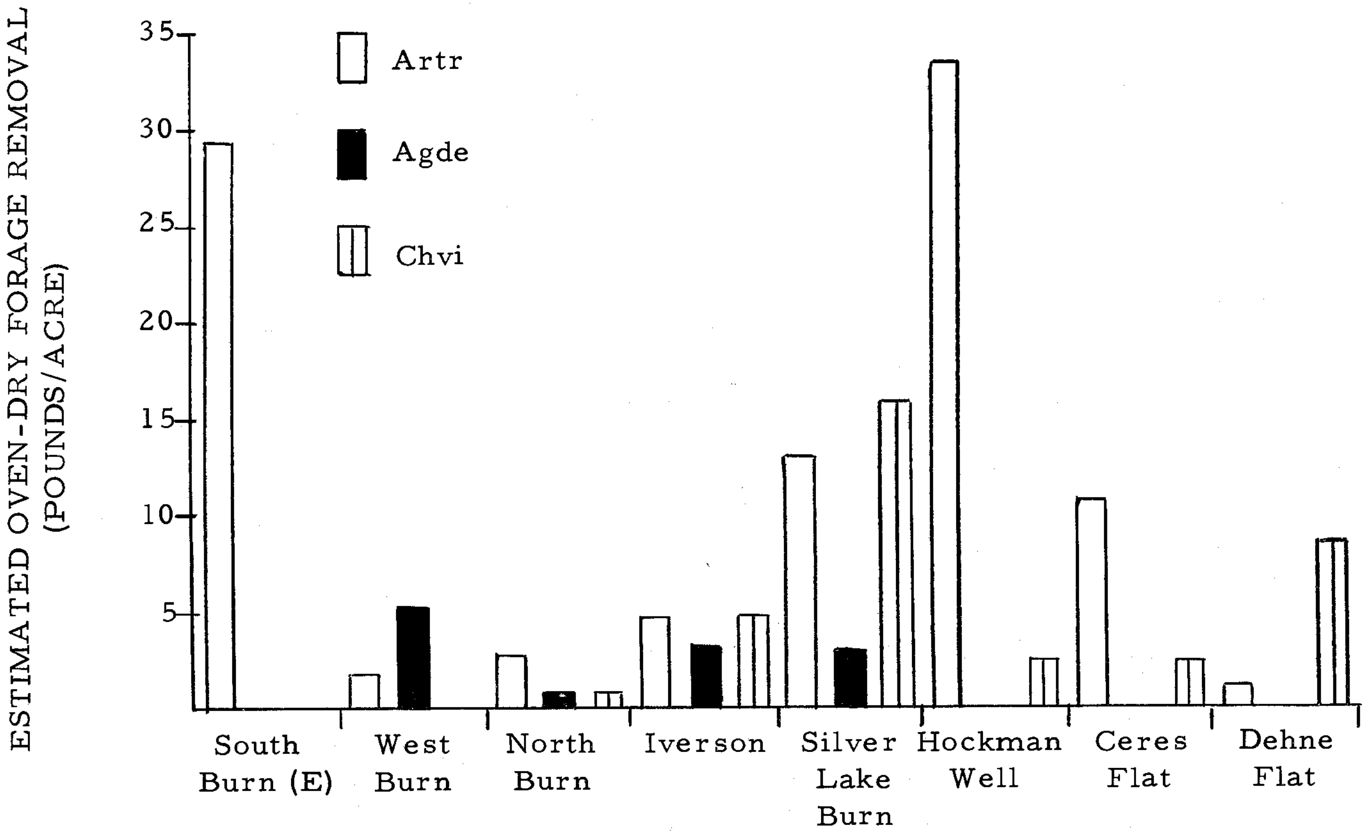

Figure 21. Estimated forage removal as a product of percentage utilization x production plot estimates. Artr and Chvi data are from untreated stands only.

by the utilization figure from Table 12, an estimated total weight removal of about 130 pounds of oven-dry forage per acre is derived. Big sagebrush exceeds bitterbrush production at this site, yet only about 30 pounds of big sagebrush were used, indicating the relative importance of bitterbrush in these codominated stands.

Step-point data from a single location suggested the possibility of much greater preference by deer for low sagebrush than big sagebrush. At West Burn an intergrade of both species showed seventy percent of low sagebrush plants grazed for a mean utilization of twelve percent while big sagebrush had only five percent of plants grazed for less than one percent mean utilization. Game agents have noted a heavy use of low sagebrush communities by deer, especially in spring when green Sandberg's bluegrass is abundant and available. Utilization data from West Burn indicate the need for more information on the importance of low sagebrush types to over-wintering of deer in the Silver Lake and other areas.

These data show a low percentage use on both native and seeded grasses and do not support the contention that use by deer in early spring inhibits later production or extends the date of range readiness for livestock. An attempt was made to evaluate the role of deer in this resource conflict on a seeding used extensively by deer in the Silver Lake unit. Cages were placed around ten, 9.6-square-foot plots and compared with ten unprotected plots to determine differences in amount of new growth at the time of livestock turnout. The results were inconclusive because of livestock use before the plots were clipped. A better-controlled experiment should be initiated to obtain information on this and other important relationships between deer and livestock use patterns.

Forbs supplied only minor amounts of winter range forage to deer in the study area. Low shrubs, such as the eriogonums (*Eriogonum* spp.), that exhibit more of a forb aspect were used to a limited extent. Death camas (*Zigadenus paniculatus*), only locally abundant and usually scattered, was used heavily in April as shown in Table 13 at the Iverson location. Apparently, it is not poisonous to deer.

The variable behavior that deer exhibit when grazing different plant species is illustrated by Figure 22 which plots percent of plants grazed against mean percent utilization. When feeding on big sagebrush, deer removed small amounts on many individual plants with forty percent of plants grazed corresponding to only about eight percent utilization. In comparison, use on individual green rabbitbrush plants was heavier with forty percent of plants grazed at a level of about fifteen percent utilization. The few samples on crested wheatgrass indicate uniformly light use even where a high percentage of plants was grazed.

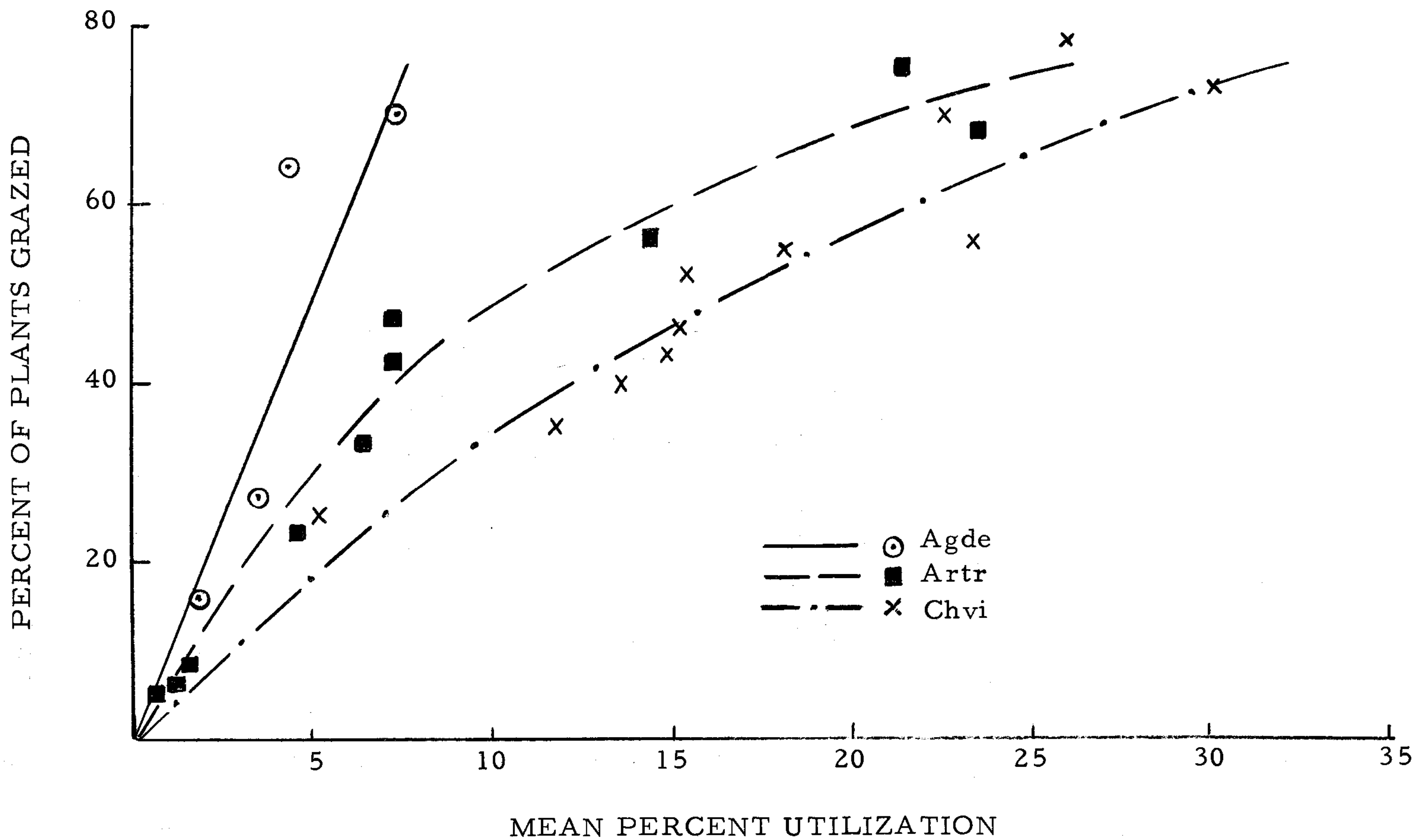

Figure 22. Species differences between percent of plants grazed and mean percent utilization by deer. The curves were ocularly fitted to the points.

Pellet-Group Count Data: Limited pellet-group count data provide a rough index to differential use by deer of treated and untreated adjacent stands. The minimal sampling intensity of about 500 plots indicated by Rogers, Julander, and Robinette (1958) was not feasible in the time available. The plot size of 96 square feet was based solely on the availability of a plot frame. Smith (1964) suggests grouping four, 108.9-square-foot plots as a sample unit for ease in computing deer days use per acre and to gain the efficiency of the larger area. He also indicates a large minimal sample size at low intensities of use to estimate adequately population levels and range use.

Table 14 shows a general trend toward reduced use of treated stands, although seedings are only slightly lower than untreated big sagebrush communities. At North Burn, the seeding received slightly greater use. The greatest differences occurred at South Burn (E) where the loss of dense bitterbrush and other shrubs and replacement mainly by cheatgrass and weeds sharply reduced use on the burned site. At all locations, except Dehne Flat and Ceres Flat, the use on treated stands was predominantly on grasses. The generally small differences in pellet-group counts, then, underscore the seasonal importance of grass forages for deer.

Low densities of pellet groups on treated and untreated stands at Iverson, Arbow, Airport, and North Burn reflect the light grazing pressure deer exert on the lower elevations of the Silver Lake unit.

Table 14. Pellet-group count data from selected paired-macroplot locations using 96-square-foot circular plots.

Location	Treatment	Number of Groups per 75 Plots 1964	Number of Groups per 150 Plots 1964	Number of Groups per 75 Plots 1965
Dehne Flat	Sprayed	24		10
	Untreated	37		14
Hockman Well	Sprayed	39		24
	Untreated	78		24
Ceres Flat	Rotobeaten	15		2
	Untreated	33		9
L. Iverson	Seeded	8		16
	Untreated	10		26
Arbow	Seeded	0		-
	Untreated	3		-
Airport	Seeded	1		-
	Untreated	6		-
West Burn	Seeded	22		11
	Burned	13		7
	Untreated	23		14
North Burn	Seeded	8	15	3
	Untreated	5	7	2
Silver Lake Burn	Seeded	14	22	21*
	Untreated	15	32	20
South Burn (E)	Burned	12	23	12
	Untreated	38	64	58

* Some possible sheep use involved.

Statistically sound pellet-group count data could be used to delineate the areas of concentrated use that require careful consideration before vegetational manipulation is undertaken.

Crude Protein Analyses: Although there are numerous references to the use by deer of green grass forage on winter ranges (Edwards, 1942; Dasmann, 1949; Morris and Schwartz, 1957) no published chemical analyses of this material were found. Cook and Harris (1950) state that desert shrubs in the intermountain area in winter are higher in crude protein and phosphorus while cured grasses supplied constituents with high energy values. They concluded that diversified plant cover would provide a better balanced diet to ruminants. Although dry grasses frequently appear in appreciable amounts in winter diets of deer (Interstate Deer Herd Committee, 1947, 1954), it is the amount and quality of green grass that is critically important on game winter ranges in terms of nutritional balance with preferred browse forages (Leach, 1956).

The National Research Council Subcommittee on Range Research Methods (1962) points out that "A chemical analysis of plant material for a particular constituent merely indicates that the plant is comparatively high or low in that particular constituent," but Sullivan (1962) states that the Kjeldahl method of crude protein analysis is within limits an acceptable criterion of the nutritional value of forages. Proximate analyses and other nutritional determinations were too costly for this study. Consequently, the results presented in Table 15 form an important but incomplete picture of the value of winter range forages examined.

In general, actively growing grass material supplies a forage higher in crude protein than most browses (Figures 23 and 24). Shrub current annual growth, with few exceptions, had a crude protein content at or below ten percent until late April when spring growth started. Crude protein of green grass was well above ten percent, particularly in the critical period beginning in February. High protein feeds are particularly valuable to pregnant females at this time to promote healthy development of fetuses as shown in sheep (Clanton, Harris, and Butcher, 1959; Whitcomb et al., 1951).

Crested wheatgrass (Agropyron desertorum) was consistently above twenty percent crude protein throughout the winter period. It was particularly high during March. Whitman et al. (1951) found crude protein levels of 21 to 22 percent in green crested wheatgrass (Agropyron cristatum) in April and May. Crested wheatgrass appears superior to native grasses as a deer winter forage from the standpoint of weight production and crude protein content.

Junegrass (Koeleria cristata) and Idaho fescue began growth in the fall and there was a gradual increase in crude protein throughout the winter, but levels were well below those in crested

Table 15. Percent crude protein determinations of green grass and current annual growth of shrubs collected during the late fall and winter, 1964-65.

		Date of Collection					
Location	Species	11/30	1/2	2/5	3/1	4/2	4/26
South Burn (E)	Agde	22.2	-	24.4	31.6	27.6	21.2
	Agsp	-	-	-	-	21.0	-
	Brte	22.6	-	17.4	14.4	18.6	-
	Feid	8.2	-	9.7	13.9	19.0	-
	Kocr	9.0	-	12.5	15.0	20.8	-
	Pose	-	-	-	-	21.8	21.6
	Sihy	14.9	-	17.9	21.3	23.6	22.5
	Chna	6.7	8.9	6.1	9.2	8.9	-
	Chvi	7.5	6.6	7.1	8.3	9.6	8.5
	Juoc	-	-	-	-	6.6	-
	Putr	8.3	9.3	7.9	8.4	9.0	10.2
	Rivi	-	-	-	-	10.1	-
Roadside Park	Caro*	9.1	-	7.9	9.0	9.8	-
	Muri*	4.2	-	4.5	4.5	4.7	-
	Sihy	11.7	-	-	19.0	23.0	-
	Artr	7.8	8.5	8.0	8.0	8.3	9.3
	Cele	-	-	-	-	10.5	-
	Chna	9.0	8.4	8.0	9.1	8.2	-
	Chvi	6.6	6.8	6.9	7.0	8.3	12.8
	Ersp 3	7.2	-	7.5	-	9.9	-
	Putr	8.5	9.7	8.7	8.9	9.8	12.2
	Rivi	-	-	-	-	9.7	-
North Burn	Arar	-	-	9.4	9.7	8.3	12.6
Ceres Flat	Pose	-	-	-	-	25.4	-
	Arar	-	10.1	9.9	9.2	11.0	12.9
	Arca	-	10.0	10.5	10.1	10.6	-
	Juoc	-	-	-	-	6.3	-
Cooperative Seeding	Agde	22.1	-	22.9	24.1	25.3	21.8

*Actually cured material retaining green color and eaten to a limited extent by deer.

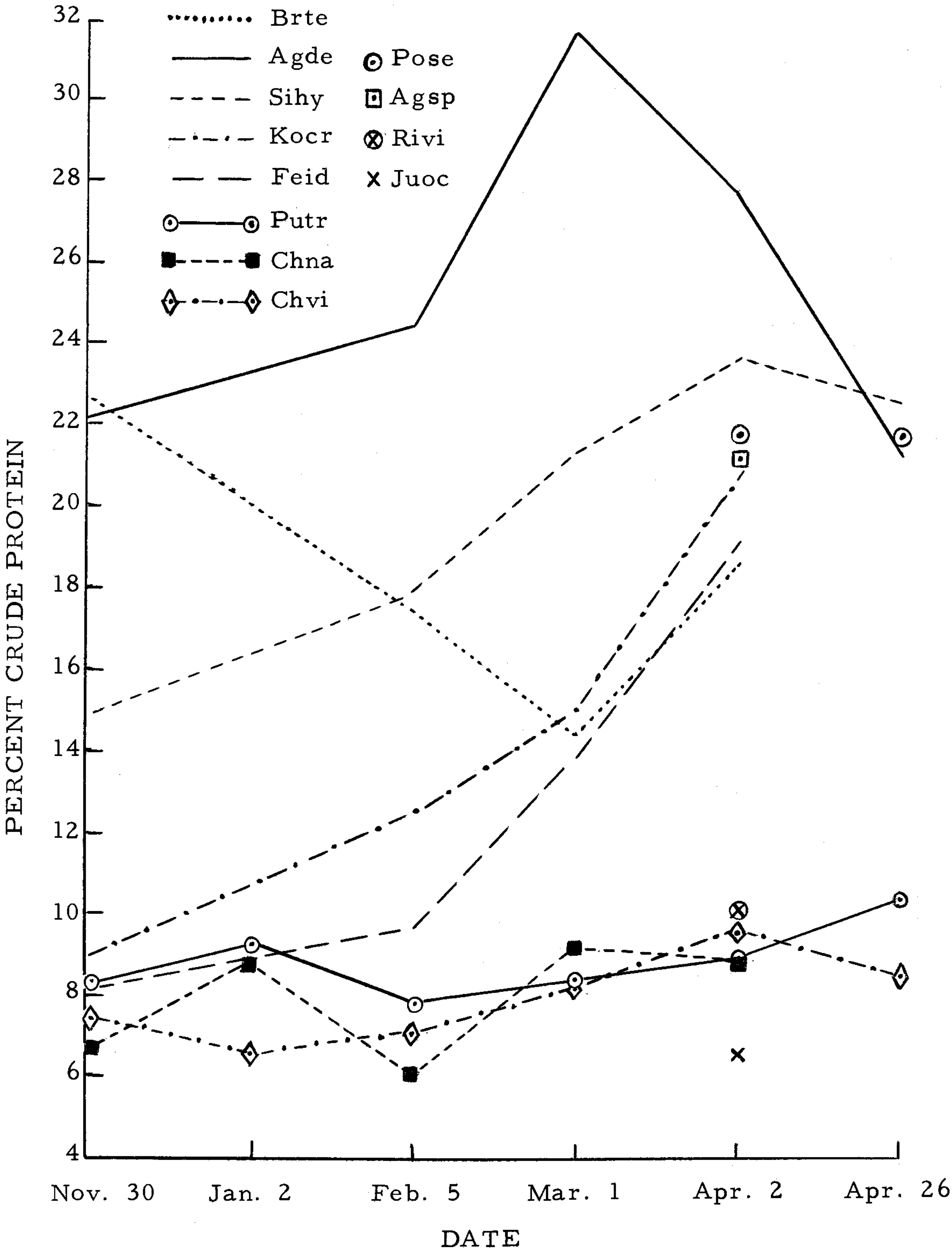

Figure 23. Crude protein changes in monthly samples of green grass and shrub current annual growth from the South Burn (E) site in the Silver Lake unit, 1964-65.

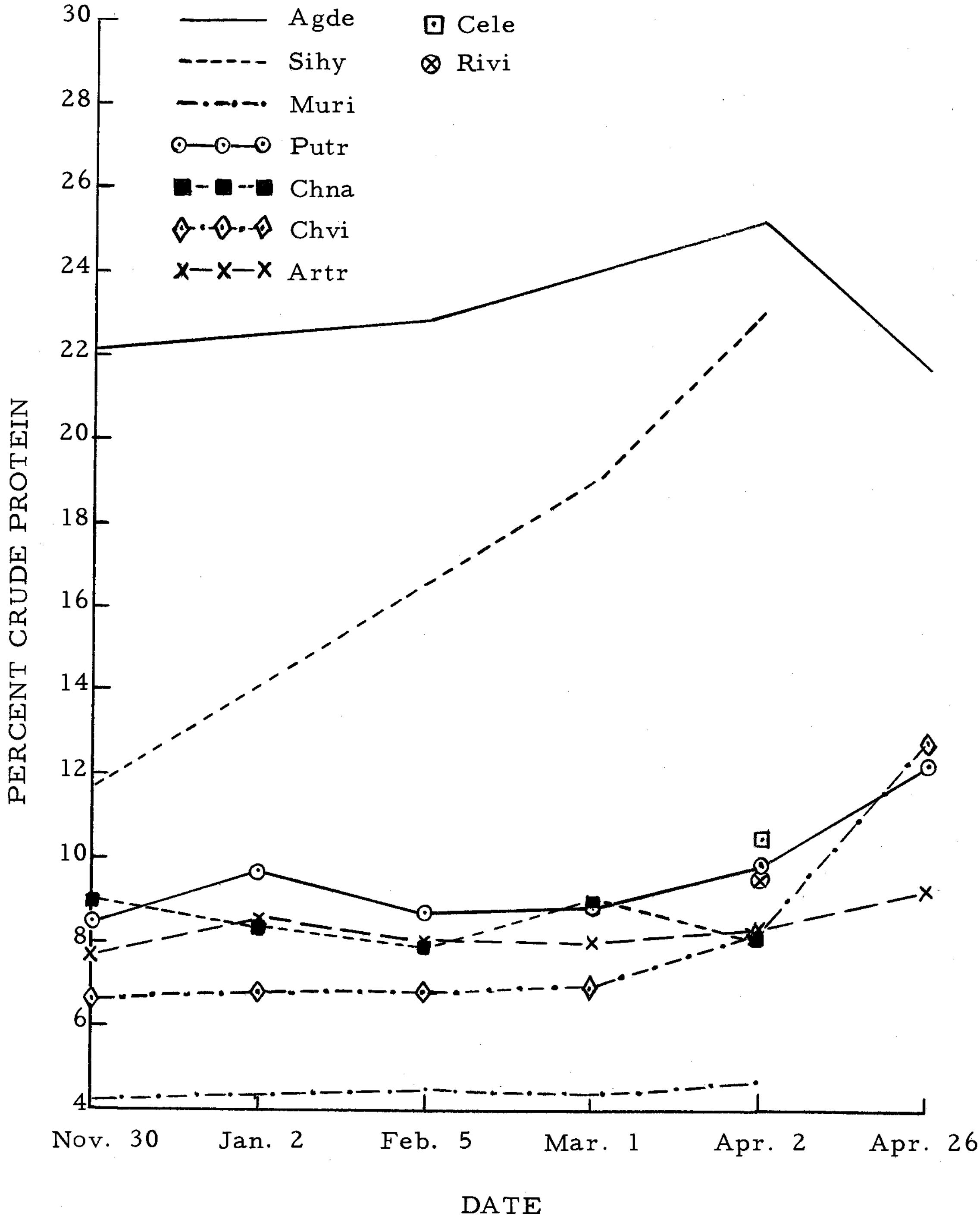

Figure 24. Crude protein analyses of green grass and shrub current annual growth from monthly samples at the Roadside Park site in the Fort Rock unit, 1964-65. Crested wheatgrass data came from the Coop. seeding near Roadside Park.

wheatgrass until early April. Neither of these native species supplied large amounts of forage. Cheatgrass growth was so poor during the sampling period that difficulty was encountered in obtaining sufficient green material for analysis. Crude protein levels in this species were high, indicating its value in years of favorable climatic conditions that permit germination and appreciable growth.

Squirreltail was second only to crested wheatgrass in fall regrowth production but followed the same pattern of crude protein as Junegrass and Idaho fescue. It is higher in protein than either of these species initially. Sandberg's bluegrass probably supplies more total forage than squirreltail but it starts growth in late March and is important in spring only.

Mat muhly (*Muhlenbergia richardsonis*) and Ross' sedge (*Carex rossii*) were sampled at Roadside Park because they retained green color in the cured state and were utilized to some extent by deer. Mat muhly showed a consistent crude protein content between four and five percent, which is about average for cured grasses in winter (Cook and Harris, 1950). Ross' sedge contained twice as much crude protein as mat muhly.

Shrubs were less variable in crude protein content and ranged from six to ten percent until spring growth started in late April. Big sagebrush at Roadside Park on deep pumice Regosol soil contained about the same crude protein (8 to 8.5 percent) as found by Smith

(1963) on developed soils in the Silver Lake unit.

Bitterbrush was slightly but consistently higher in crude protein than big sagebrush which is the reverse of analyses reported by Dietz, Udall, and Yeager (1962) from Colorado. The latter study showed bitterbrush with seven to nine percent and big sagebrush with 8 to 12 percent crude protein. Smith (1952) likewise found bitterbrush low in crude protein (7.4 percent). Aldous (1945) analyzed various portions of bitterbrush twigs with and without leaves in Nevada and found considerable variation. Twigs four to seven inches in length with leaves intact contained about 8.5 percent crude protein and this is in close agreement with similar material at Silver Lake.

Silver sagebrush and low sagebrush exceeded big sagebrush in percent crude protein. The apparently greater nutritive value of and preference by deer for low sagebrush suggest that it should be rated higher as a winter forage.

Green and gray rabbitbrush showed considerable fluctuation in crude protein between six and nine percent. Green rabbitbrush was consistently below gray rabbitbrush at Roadside Park until April when it began growth earlier. No such consistent pattern occurred at South Burn (E). Only slight differences in crude protein exist between the rabbitbrushes and big sagebrush in this area.

Three species--western juniper, curlleaf mountain mahogany

(Cercocarpus ledifolius) and sticky currant (Ribes viscosissimum)--were analyzed only on April 2. Juniper normally receives light use although in severe winters and years of poor production of preferred species it can be heavily hedged (Figure 25). Analyses showed it to contain the lowest percentage of crude protein (6.3 to 6.6) of any shrub at that date. Similarly, Smith (1952, 1957) found Utah juniper (Juniperus utahensis) to contain 6.2 percent crude protein and concluded that it provides a very poor feed because of low protein and high fat content.

Curlleaf mahogany is a highly preferred forage of limited production that receives extremely heavy grazing pressure from deer. Crude protein content of the single sample at Roadside Park was 10.5 percent which is identical with that determined by Smith (1952). Although preference paralleled nutritional value for curlleaf mahogany, the reverse was true for sticky currant. Crude protein of sticky currant was about 10 percent, yet it was practically unused.

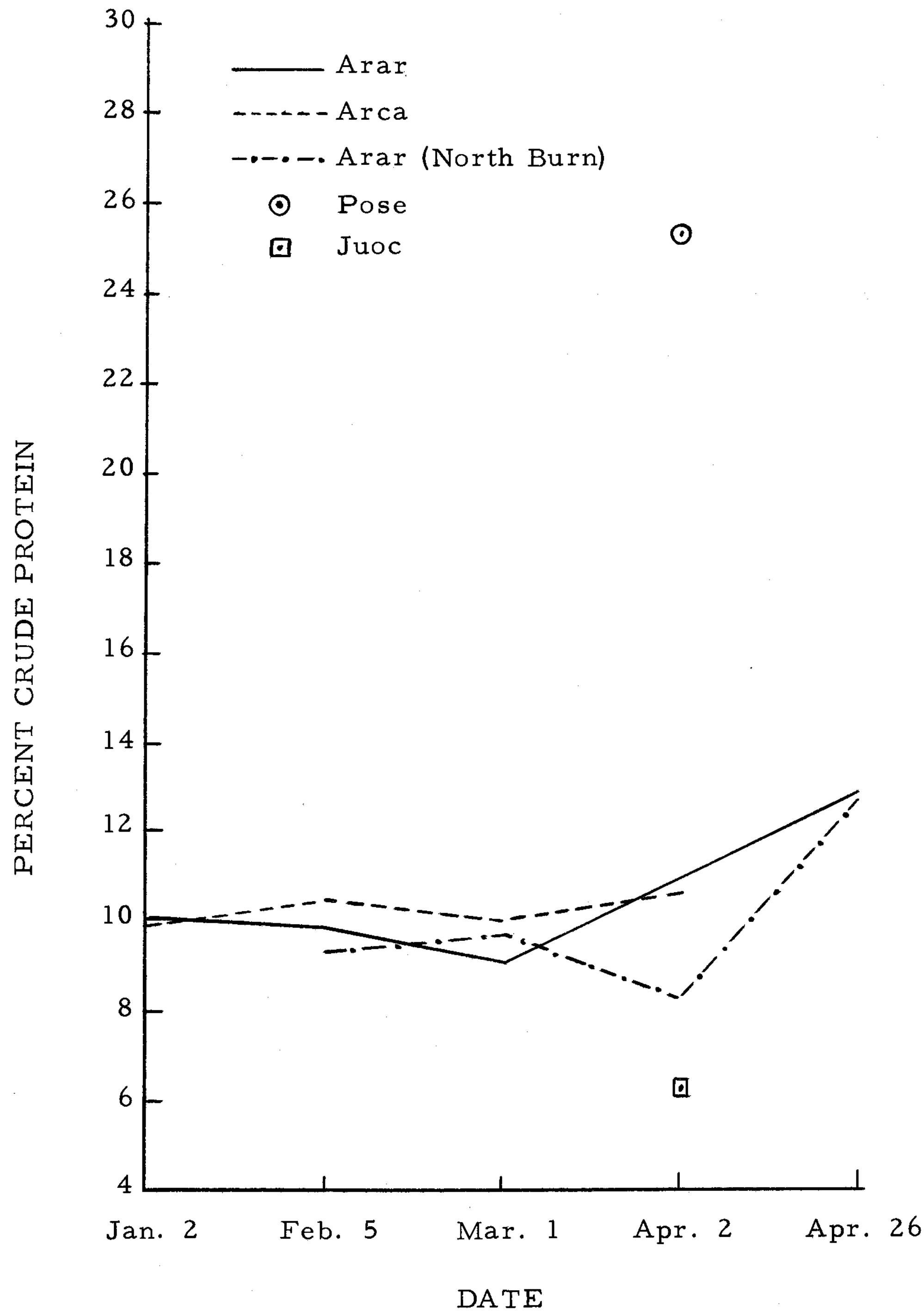

Figure 25. Crude protein content of low sagebrush, silver sagebrush, western juniper, and Sandberg's bluegrass from Ceres Flat and low sagebrush from North Burn, 1964-65.

MANAGEMENT APPLICATIONS

It would be gratifying, as an outgrowth of this study, to be able to state that a certain percentage of untreated sagebrush must remain intact to supply the winter needs of deer. No such yardstick to optimum size and dispersion of untreated blocks can be formulated because of the multiplicity of factors involved.

Guidelines for proper range improvement outlined by published research strongly restrict the possibilities for large, uniform tracts of a particular treatment on many central Oregon deer winter ranges. Surface stoniness, poor herbaceous understory, and inability of livestock operators to effectively use large tracts of seasonal forage place definite limits, both physical and economical, on the acreage suitable for improvement. For example, the Vale project in Malheur County, often cited as an example of range improvement on a grand scale, accounts for only 20-25 percent of the land within the project area and this is composed of many noncontiguous blocks (Bureau of Land Management, 1962).

The generally low productivity and limited deer use of dense big sagebrush stands lacking bitterbrush in the Silver Lake area suggest some advantages of taking a positive look at range improvement to enhance the value of these communities for both deer and livestock.

Excessive use on bitterbrush resulting from undesirably large deer populations on winter range is the outstanding problem in game range management in the study area. A reasonable course of action should emphasize: (1) moderate reductions in winter herd aimed at increasing productivity of fewer individuals through better nutrition (Buechner and Swanson, 1955) and (2) attempting to improve distribution through vegetational manipulation in lightly utilized big sagebrush types. Such a program offers the best chance of retaining and improving poor condition bitterbrush stands short of expensive rehabilitation efforts required when the natural seed-source is lost. This does not mean that rehabilitation effort should not be attempted on stands already depleted, only that such work offers little hope for success unless herd density is controlled concomitantly.

Distribution patterns of deer on the Silver Lake unit (Zalunardo, 1965) show that deer definitely occupy restricted home ranges in winter. This fact suggests the possibility of securing local reductions on critically-overused areas of perhaps no more than a few square miles by limited winter range hunts.

Major emphasis in deer management is correctly placed on high-quality, recreational hunting on summer range if such hunts at the same time limit herd densities on specific winter range areas to proper levels. That this cannot be attained by summer range hunts alone was demonstrated amply by Zalunardo's work. His observations indicate that deer from each trapping site on winter range did not likewise occupy restricted areas of summer range; on the contrary, they distributed randomly throughout its extent. Therefore, summer range hunts cannot influence winter range distribution in more than a general way.

Wilbert (1963) noted increased elk use of sprayed sagebrush stands in Wyoming. Deming[5] observed definite attraction of antelope to limited seeded, burned, and sprayed sagebrush stands at Hart Mountain Refuge in south-central Oregon despite predictions of adverse effects by subjective observers (Douglas, 1960). Extensive use of seedings and other improvements by deer at Silver Lake indicate a real possibility of developing procedures of vegetational manipulation that are designed to get better distribution of deer.

One method that offers particular promise is rotobeating in strips or small blocks to alter the density and growth of unproductive sagebrush. Additional field work needs to be done to determine optimum height of cut and width of untreated strips that maximize growth of current annual twigs. Such treatments would not have to increase total sagebrush production necessarily, only increase its acceptability by deer. Data from the rotobeaten project at Ceres Flat indicate that this occurs.

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5. Deming, Oscar. Address to the Oregon Game Biologists Meeting. Oregon State University, Corvallis, Oregon. February 26. 1965.

Other improvements, especially crested wheatgrass seedings, contribute significantly to deer winter diets. When seeded blocks of moderate size are interspersed throughout untreated stands the use of sagebrush appears to be enhanced. Sprayed treatments result in similar patterns but there is a tendency because of low cost and ease of application to treat larger blocks which sometimes include areas with poor herbaceous cover. Such areas cannot respond effectively to reduced competition and deer forage values decline. Intelligent mapping and ground control of aerial spray application or resorting in some instances to ground application can alleviate this problem.

Improvement projects in the study area at present have seldom exceeded 200-500 acre blocks with the exception of an uncontrolled fire. The value to deer in dispersal of diverse types and developmental stages of vegetation is no more than an extension of the "edge-effect" concept recognized early in the science and art of wildlife management. It is, however, essential to plan, establish, and manage improvements on the basis of ecological units of uniform potential to gain maximum benefits for game and livestock. Advocating as policy no manipulative activity for unproductive, poorly-utilized land is a failure to accept resource management responsibility. There is no intrinsic merit in being satisfied with second-rate deer forage values which many stagnant big sagebrush stands represent if a practical action program can increase these values.

In conclusion, there are commendations and recommendations appropriate to existing and future range improvement programs, especially as they influence movement toward purposeful action for effecting better game range management. Four main activities merit special attention.

The Bureau of Land Management in recognition of the importance of bitterbrush types has initiated a survey to determine their location, condition, and utilization. These data should form a better basis for future rehabilitation and management decisions as more ecological data are accumulated.

Another commendable program with benefits for timber production and game is the stand improvement work by the Silver Lake Ranger District of the Fremont National Forest. Dense thickets of ponderosa pine regeneration are opened artificially and result in increased tree and browse growth.

A cooperative study at Silver Lake between the Oregon Game Commission and Pacific Northwest Forest and Range Experiment Station should contribute substantially to grazing management of bitterbrush types. Known levels of deer and cattle use are being tested alone and in combination in exclosures.

Better understanding of the ecology of bitterbrush types is needed and future emphasis in Oregon will be directed to this end through Western Regional Research Project W-25, according to

Poulton.[6]

Recommendations for improvement on the Silver Lake and Fort Rock deer winter range units should consider current game use patterns. As in the past, priority must favor poor condition big sagebrush stands lacking bitterbrush. These can be delineated as heavily or lightly used by deer with emphasis on enhancing deer forage values on the former and livestock forage values on the latter. Exclusive use by game or livestock is not desirable in either area. Dual use has the advantages of (1) balancing grazing pressure on shrub and understory vegetation for better community stability, (2) generally maximizing forage yields, and (3) justifying some game use of permittee base property.

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6. Personal communication. Dr. C. E. Poulton, Department of Range Management, Oregon State University, Corvallis.

SUMMARY

The objectives of this study were to determine changes in species composition, production, and utilization resulting from range improvement practices primarily directed toward control of big sagebrush.

Field studies began in June, 1963, and terminated in August, 1965, at various locations throughout the Fort Rock and Silver Lake deer winter range units in northern Lake County.

Silver Lake lies in the transition between the High Lava Plains and Basin Range physiographic provinces. The area is characterized by geologic formations of volcanic origin. Soils are formed from water-worked sediments, usually high in pumice, or from volcanic tuff-breccia on gravelly lake terraces. Three great soil groups predominate--Chestnuts, Browns, and Regosols.

Aridity is the major influence on plant community development. Precipitation averages slightly more than ten inches, most of which occurs as snow and early summer rains. Summers are hot and dry; winters are cold and dry.

Three general shrub types dominate the aspect of the complex mosaic of seral communities making up the winter range units. These are--low sagebrush (*Artemisia arbuscula*) communities, big sagebrush (*A. tridentata*) communities, and bitterbrush communities.

Range improvement has been focused on big sagebrush dominated stands in fair to poor condition. With few exceptions, sampling in this study was restricted to such stands.

Two main approaches were followed in evaluating the influence of range improvements on game winter range. One consisted of establishing experimental treatment blocks at three locations in stands representative of extensive big sagebrush communities. The central purpose of the experimental phase was to reduce site differences as variables in vegetational response. Quantitative plant ecological data were taken prior to treatment in permanent 50x100-foot macroplots as a basis for interpreting later successional changes.

Four commonly-accepted improvement methods--spraying (2,4-D), rotobeating, spray-seeding, and plow-seeding--were initiated on two-acre strips in each block with an additional untreated strip forming a control. Half of each block was fenced to determine differences resulting from livestock exclusion. The entire block was accessible to deer. Periodic resurveys over five to seven years are scheduled.

The second approach entailed a paired-macroplot study of treated and adjacent untreated stands at twelve existing projects including chemical, rotobeating, burning, and seeding treatments. Plots were paired by similarity of soils and other physical site factors. It was inferred on this basis that pretreatment vegetation was the same on both plots. Soil profile descriptions were made by a Soil Conservation Service soil scientist.

Floristic differences among paired plots were quantified by plot samples within the macroplots. Shrub cover, height, and density were determined in forty restrictedly-randomized transects of ten microplots 4x5 feet in size. Basal area of herbaceous species and ground surface characteristics were recorded in forty, 1x2-foot observation plots systematically located along the baseline of the microplot transects. Percent frequency of all species was estimated using four transects of fifty contiguous 1x1-foot plots randomized laterally across the width of the macroplot.

Production differences in shrub and grass herbage available for winter use were estimated by protecting ten, 9.6-square-foot circular plots with woven-wire cages throughout the winter (1963-64) and clipping all vegetation in mid-April. The plots were randomized within a temporary macroplot having a common baseline with each permanent macroplot. Shrub current annual growth was clipped, separated by species, oven-dried, and weighed. Grass was hand separated by species into cured and green components, oven-dried, and weighed.

Utilization of bitterbrush, the key browse species for deer, was indexed by measuring current annual growth on marked branches in transects of twenty-five plants before deer use in fall and after deer migration in spring. Four such transects were established in 1963 and eight additional transects were added in 1964.

Step-point transects at selected macroplot locations provided indexes to utilization on species other than bitterbrush. One hundred plants, 200 in the case of seeded crested wheatgrass, of a species were examined for evidence of deer use. If use had occurred, an ocular estimate of percent removal was recorded. Sample units consisted of the nearest plant of a species encountered from the point (boot-tip) on paced transects. Percent of plants grazed and mean percent utilization of all plants were calculated.

Limited pellet-group count data provided a crude index of differential use of treated and adjacent untreated stands. Seventy-five, 96-square-foot plots in transects of twenty-five were examined in late spring in 1964 and 1965.

Crude protein content of shrub current annual growth and winter-active green grass material was determined by standard Kjeldahl analyses of samples collected at monthly intervals throughout the winter.

All improvement methods markedly reduced shrub cover and changed the aspect of treated stands from predominantly shrub to herbaceous cover. Rotobeating resulted in the greatest survival of shrubs and stimulated rapid and abundant growth of foliaceous leaders on big sagebrush.

Only seeded stands of crested wheatgrass resulted in consistent, significant increases in basal area of desirable herbaceous species. Established seedings on Brown or Chestnut soils appeared to form stronger competitive barriers against shrub reestablishment than those on coarse sandy Regosols. Cheatgrass and weedy forbs were favored on unseeded burned areas that had poor perennial grass cover prior to burning. These areas now offer very low forage values to either deer or livestock.

Green rabbitbrush showed generally high survival or even increased cover on all but plowed and seeded stands. Big sagebrush was practically eliminated on burned and plowed sites although scattered seedlings became established soon after fire. Bitterbrush types were especially damaged by fire.

Production estimates of shrubs were extremely variable because of low sample size, defoliating insect infestations, and distributional patterns of the stands sampled. Herbage production of big sagebrush ranged from 23 to 449 and averaged 234 pounds of oven-dry material per acre on untreated stands.

Crested wheatgrass provided greater amounts of green forage in winter than native species because of its characteristic fall regrowth with favorable climatic conditions. Deer actively sought this material throughout the winter period. Production of green crested wheatgrass ranged from 37 to 126 and averaged 75 pounds of oven-dry material per acre. Higher production was directly related to heavy use of seedings by cattle the preceding growing season.

Only squirreltail initiated sufficient fall regrowth to be of value to deer in early winter on untreated stands. Other native grasses such as Junegrass and Sandberg's bluegrass were important in early spring only. Cheatgrass was of little value during the study period because of poor germination and growth in both winters of 1963-64 and 1964-65.

Utilization of bitterbrush based on reduction-of-twig-length measurements was uniform and excessive at all locations studied. Percent utilization ranged from 72 to 92 on twelve transects scattered throughout the Fort Rock and Silver Lake units in winter (1964-65). Four transects in 1963-64 showed a range in percent utilization from 76 to 80. Maximum use of 65 percent has been recommended for sustained production on the basis of clipping studies. Bitterbrush condition appears to be declining as evidenced by high mortality, many partially dead crowns, and poor regeneration. In terms of overall effects on herd productivity and range use it was concluded that declining bitterbrush vigor has more serious implications than existing improvement programs on usually lightly used big sagebrush stands.

Step-point transect data indicated light to moderate use of shrub species other than bitterbrush in all stands studied. Green rabbitbrush showed a consistently higher percent of plants grazed and mean percent utilization than big sagebrush on untreated sites.

Data at one location suggest that low sagebrush is more highly preferred by deer than big sagebrush.

Utilization of green grass, including crested wheatgrass, was light on all species sustaining use. The use pattern on grasses indicated uniform removal of small amounts from many plants rather than larger amounts from a low percentage of plants as in big sagebrush and green rabbitbrush.

Production and utilization data were combined to compare estimated percent removal with forage availability on big sagebrush and green rabbitbrush on untreated sites and crested wheatgrass on seeded sites. Relative importance shifted at different locations but big sagebrush supplied the most total forage considering all stands. The differences are not related to availability directly since big sagebrush production usually far exceeds the others.

Forbs contribute only minor amounts of forage to deer winter diets. Death camas is used heavily in spring but growth of other forbs usually starts after deer migration.

Limited pellet-group count data suggest a reduced overall use of treated stands although the crested wheatgrass seedings are only slightly lower in numbers of groups than the adjacent untreated big sagebrush. Low intensities of use were noted on both treated and untreated sites at lower elevations in the Silver Lake unit.

Winter-active grass material contained significantly greater crude protein percentages than current annual growth of shrubs. Shrubs contained between seven and ten percent crude protein while green grasses were usually well above ten percent, particularly in early spring.

Crested wheatgrass green growth exceeded twenty percent crude protein at every samping date. Native grasses such as June-grass, squirreltail, and Idaho fescue exhibited a pattern of slowly increasing protein as the winter progressed.

Bitterbrush slightly but consistently surpassed big sagebrush in crude protein as did both silver sagebrush and low sagebrush. Green rabbitbrush was lower in crude protein than big sagebrush until April when growth started.

It is not known to what extent sagebrush control can proceed without restricting game forage supplies, but physical site factors alone limit the size of areas suitable for treatment on most deer winter ranges. Dense stands of big sagebrush lacking bitterbrush usually receive light deer use and produce small amounts of usable forage. Range improvements on such areas, although specifically designed to increase livestock forage, have slight influence on over-all deer carrying capacity except that they provide deer a more diversified diet.

Some big sagebrush communities, especially those in proximity to bitterbrush stands, are used relatively heavily by deer. Such stands demonstrate the advantages of developing positive programs of range improvement to enhance their value for deer and to improve deer distribution.

Excessive use of bitterbrush has resulted from undesirably large populations of deer in winter, and it was concluded that this problem is far more serious than limited sagebrush control at present. Moderate reductions in herd size are needed to halt the downward trend in bitterbrush condition. Harvests on summer range alone cannot adequately control winter range concentrations as shown by seasonal distributional patterns. Limited either-sex hunts on problem areas on winter range are recommended to improve distribution, reduce deer winter losses, and improve herd productivity.

Rotobeating stagnant big sagebrush stands appears promising as another means of improving deer distribution. Adjustments in height of cut, size, and shape of treatment blocks could increase growth and palatability of big sagebrush. Other improvements on moderate-sized blocks, interspersed throughout untreated stands also appear to increase sagebrush use.

Future range improvement programs on deer winter range should consider game use patterns and continue to place priority on poor condition big sagebrush types. Statistically sound pellet-group count data could delineate areas heavily or lightly used by deer to determine whether improvement should emphasize deer or livestock forage production. In either case, exclusive use by one or the other class of grazing animal is not desirable.

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APPENDIX

Appendix I: A list of plants with scientific names from Peck (1961) and Hitchcock et al. (1955, 1959, 1961). Symbolization is in agreement with Garrison, Skovlin and Poulton.[7]

Abbre-viation	Common Name	Scientific Name
Woody Plants		
Arar	low sagebrush	ARTEMISIA ARBUSCULA Nutt.
Arca	silver sagebrush	ARTEMISIA CANA Pursh
Artr	big sagebrush	ARTEMISIA TRIDENTATA Nutt.
Cele	mountain mahogany	CERCOCARPUS LEDIFOLIUS Nutt.
Chna	gray rabbitbrush	CHRYSOTHAMNUS NAUSEOSUS (Pall.) Britt.
Chvi	green rabbitbrush	CHRYSOTHAMNUS VISCIDIFLORUS (Hook.) Nutt.
Juoc	western juniper	JUNIPERUS OCCIDENTALIS Hook.
Lepu 2	granite gilia	LEPTODACTYLON PUNGENS (Torr.) Nutt.
Pipo	western yellow pine	PINUS PONDEROSA Dougl.
Putr	bitterbrush	PURSHIA TRIDENTATA (Pursh) DC.
Rivi	sticky currant	RIBES VISCOSISSIMUM Pursh
Teca	gray horsebrush	TETRADYMIA CANESCENS DC.
Tegl	smooth horsebrush	TETRADYMIA GLABRATA Gray
Forbs		
Acmi	yarrow	ACHILLEA MILLIFOLIUM L.
Arsp 2	sickle pod rock cress	ARABIS SPARSIFOLIUM Nutt.
Asca	hoary aster	ASTER CANESCENS Pursh
Aspu		ASTRAGALUS PURSHII Dougl. ex Hook.
Asle	mottled milk vetch	ASTRAGALUS LENTIGINOSUS Dougl.
Asst	hanging-pod milk vetch	ASTRAGALUS STENOPHYLLUS T. & G.

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Appendix I: Continued.

Abbre-viation	Common Name	Scientific Name
Forbs (Continued)		
Ascu 2		ASTRAGALUS CURVICARPUS (Sheld.) Macbr.
Blsc		BLEPHARIPAPPUS SCABER Hook.
Cama	green-banded mariposa lily	CALOCHORTUS MACROCARPUS Dougl.
Chdo	hoary chaenactis	CHAENACTIS DOUGLASII (Hook.) H. & A.
Chna 2	dwarf chamaesaracha	CHAMAESARACHA NANA Gray
Cogr 2	large-flowered collomia	COLLOMIA GRANDIFLORA Dougl.
Copa	small-flowered collinsia	COLLINSIA PARVIFLORA Dougl.
Cram	obscure cryptantha	CRYPTANTHA AMBIGUA (Gray) Greene
Dean	desert larkspur	DELPHINIUM ANDERSONII Gray
Depi	tansy-mustard	DESCURAINIA PINNATA (Walt.) Britt.
Eppa	tall annual willow-herb	EPILOBIUM PANICULATUM Nutt.
Ersp 4	few-flowered eriastrum	ERIASTRUM SPARSIFLORUM (Eastw.) Mason
*Erbl	scabland erigeron	ERIGERON BLOOMERI Gray
Erfi	thread-leaved erigeron	ERIGERON FILIFOLIUS Nutt.
Erba	Bailey's eriogonum	ERIOGONUM BAILEYI Wats.
*Erov	oval-leafed eriogonum	ERIOGONUM OVALIFOLIUM Nutt.
*Ersp 3	round-headed eriogonum	ERIOGONUM SPHAEROCEPHALUM Dougl.
Erla	wooly sunflower	ERIOPHYLLUM LANATUM (Pursh) Forbes
Gara	hair-stemmed gayophytum	GAYOPHYTUM RAMOSISSIMUM T. & G.
Getr		GEUM TRIFLORUM Pursh
Hepe		HELIANTHUS PETIOLARIS Nutt.
Lagl	white layia	LAYIA GLANDULOSA (Hook.) H. & A.

Appendix I: Continued.

Abbreviation	Common Name	Scientific Name
Forbs (Continued)		
Lemo	mountain lily	LEUCOCRINUM MONTANUM Nutt.
Lile	western blue flax	LINUM LEWISII Pursh
Liru	western gromwell	LITHOSPERMUM RUDERALE Dougl.
Luar 2	dry-ground lupine	LUPINUS ARIDUS Dougl.
Luco 2	corymbed lupine	LUPINUS CORYMBOSUS Hel.
Lysp	spiny lygodesmia	LYGODESMIA SPINOSA Nutt.
Meal 2	white-stemmed mentzelia	MENTZELIA ALBICAULIS Dougl. ex Hook.
Migr		MICROSTERIS GRACILIS (Hook.) Greene
Mina	dwarf monkey-flower	MIMULUS NANUS H. & A.
Niat	coyote tobacco	NICOTIANA ATTENUATA Torr.
Oeta	tansy-leaved evening primrose	OENOTHERA TANACETIFOLIA T. & G.
Orte	thin-leaved orthocarpus	ORTHOCARPUS TENUIFOLIUS (Pursh) Benth.
Phle	white-leaved phacelia	PHACELIA LEUCOPHYLLA Torr.
Phli	narrow-leaved phacelia	PHACELIA LINEARIS (Pursh) Holz.
*Phlo	long-leaved phlox	PHLOX LONGIFOLIA Nutt.
Pone 3	Newberry's cinguefoil	POTENTILIA NEWBERRYI Gray
Scna	dwarf skullcap	SCUTELLARIA NANA Gray
Seca	gray senecio	SENECIO CANUS Hook.
Stex	small stephanomeria	STEPHANOMERIA EXIGUA Nutt.
Swmo	modoc swertia	SWERTIA MODOCENSIS St. John
Tofl	showy townsendia	TOWNSENDIA FLORIFER (Hook.) Gray
Vipu	purple-tinged violet	VIOLA PURPUREA Kell.
Zipa	death camas	ZIGADENUS PANICULATUS (Nutt.) Wats.

* Plants with woody bases but not exhibiting a shrub appearance.

Appendix I: Continued.

Abbre-viation	Common Name	Scientific Name
Grasses and Sedges		
Agde	crested wheatgrass	AGROPYRON DESERTORUM (Fisch.) Schult
Agsp	bluebunch wheat-grass	AGROPYRON SPICATUM (Pursh) Scribn. & Sm.
Brbr	rattlesnake grass	BROMUS BRIZAEFORMIS F. & M.
Brin	smooth brome	BROMUS INERMIS Leyss.
Brte	cheatgrass	BROMUS TECTORUM L.
Carex	sedge	CAREX SP.
Caro	Ross' sedge	CAREX ROSSII Boott.
Eltr	alkali ryegrass	ELYMUS TRITICOIDES Buckl.
Feid	Idaho fescue	FESTUCA IDAHOENSIS Elm.
Kocr	Junegrass	KOELERIA CRISTATA (L.) Pers.
Muri	mat muhly	MUHLENBERGIA RICHARDSONIS (Trin.) Rydb.
Orhy	indian rice grass	ORYZOPSIS HYMENOIDES (R. & S.) Ricker
Pobu	bulbous bluegrass	POA BULBOSA L.
Pose	Sandberg's bluegrass	POA SECUNDA Presl.
Sihy	bottle-brush squirreltail	SITANION HYSTRIX J. G. Sm.
Stco 2	needle and thread	STIPA COMATA Trin. & Rupr.
Stth	Thurber's stipa	STIPA THURBERIANA Piper

Appendix II. Ecological data from the initial, pretreatment survey of three experimental sagebrush control blocks in the Silver Lake and Fort Rock units.

Location: Roadside Park Treatment: Sprayed

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F*	U**	F	U	F	U	F	U		F	U
Artr	15	11	15	13	93	87			Sihy	51	25
Chvi	8	11	15	15	124	145			Stth	40	47
Lepu 2	3	5	9	9	31	65			Caro	31	33
Putr	2	1	14	8	8	5			Artr	28	26
Sihy							2.8	1.5	Chvi	22	38
Caro							1.7	1.0	Lepu 2	16	9
Stth							1.5	2.2	Luar 2	12	6
Luar 2							0.2	0.4	Putr	5	8
Ersp 3							0.1	0.3	Ersp 3	5	2
Seca							0.1	-	Erla	2	2
Erla							t	0.1	Aspu	2	1
Gara							t	-	Seca	2	1
Orte							t	-	Feid	2	-
Asca							-	0.1	Asca	-	4
Eltr							-	0.1	Eltr	-	3
Vipu							-	t	Orte	-	2
Lemo							-	t	Gara	-	1
Arsp 2							-	t			
Scna							-	t			

Appendix II. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Bare Ground							57.0	62.8			
Litter							35.6	31.4			
Cryptogams							0.5	0.3			

* Fenced
** Unfenced

Appendix II. Continued.

Location: Roadside Park Treatment: Spray-seeded

Species	Mean Percent Canopy Cover F	Mean Percent Canopy Cover U	Mean Maximum Height (Inches) F	Mean Maximum Height (Inches) U	Number/800 Sq. Feet (Density) F	Number/800 Sq. Feet (Density) U	Mean Percent Basal Area and Ground Cover F	Mean Percent Basal Area and Ground Cover U	Species	Percent Frequency F	Percent Frequency U
Artr	16	17	13	13	109	127			Stth	66	69
Chvi	5	5	11	11	109	79			Sihy	41	35
Lepu 2	2	3	5	6	23	43			Artr	34	40
Putr	t	1	3	7	1	9			Caro	30	22
Caro							3.4	2.3	Eltr	30	3
Sihy							3.0	3.4	Luar 2	26	23
Stth							2.6	2.8	Chvi	19	23
Eltr							1.3	-	Lemo	4	7
Luar 2							0.7	0.9	Ersp 3	4	2
Ersp 3							0.4	-	Aspu	4	3
Erfi							0.1	t	Erfi	2	1
Vipu							0.1	0.1	Vipu	2	3
Lemo							-	0.1	Phle	2	-
Gara							-	t	Putr	2	3
									Orte	1	1
Bare Ground							48.1	58.8	Arsp 2	1	-
Litter							37.5	29.6	Dean	1	-
Cryptogams							0.8	1.0	Lepu 2	-	3

Appendix II. Continued.

Location: Roadside Park   Treatment: Rotobeat

Species	Mean Percent Canopy Cover F	Mean Percent Canopy Cover U	Mean Maximum Height (Inches) F	Mean Maximum Height (Inches) U	Number/800 Sq. Feet (Density) F	Number/800 Sq. Feet (Density) U	Mean Percent Basal Area and Ground Cover F	Mean Percent Basal Area and Ground Cover U	Species	Percent Frequency F	Percent Frequency U
Artr	14	12	14	14	90	94			Sihy	46	37
Chvi	3	6	11	13	53	93			Stth	45	50
Lepu 2	2	2	7	8	23	25			Artr	43	36
Putr	1	t	7	14	4	2			Caro	30	36
Stth							2.8	1.7	Luar 2	29	15
Sihy							2.5	2.2	Chvi	19	23
Caro							1.9	1.5	Eltr	13	4
Luar 2							1.2	0.3	Lepu 2	12	11
Eltr							1.0	0.1	Ersp 3	6	10
Ersp 3							0.1	0.4	Lemo	3	1
Lemo							0.1	t	Erfi	2	1
Aspu							t	t	Aspu	2	-
Gara							t	t	Orte	2	2
Erfi							t	t	Vipu	2	4
Asca							t	t	Asca	2	-
Feid							-	0.1	Feid	2	-
Vipu							-	0.1	Putr	1	3
Arsp 2							-	0.1	Erov	-	4
Migr							-	t	Gara	-	4
Orte							-	t	Tofl	-	1
Erov							-	t	Phle	-	1
									Arsp 2	-	1

Appendix II. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Bare Ground							60.8	59.1			
Litter							28.0	33.4			
Cryptogams							0.4	0.1			

Appendix II. Continued.

Location: Roadside Park Treatment: Plow-seeded

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	23	19	17	17	116	123			Artr	44	34
Chvi	8	6	15	15	112	82			Stth	41	53
Lepu 2	2	4	9	8	19	51			Sihy	31	40
Putr	3	1	10	10	8	5			Caro	22	22
Sihy							2.5	2.5	Chvi	20	26
Caro							2.3	1.0	Lepu 2	10	9
Stth							2.1	2.6	Luar 2	9	27
Luar 2							0.3	0.8	Eltr	7	1
Eltr							0.2	-	Ersp 3	6	6
Ersp 3							0.1	t	Putr	5	1
Erla							0.1	t	Aspu	1	1
Seca							t	t	Seca	1	1
Aspu							t	t	Erla	1	-
Lemo							t	t	Orte	-	2
Chdo							-	t	Gara	-	2
Gara							-	t	Chna	-	1
									Vipu	-	1
Bare Ground							60.3	51.1			
Litter							30.9	41.5			
Cryptogams							0.8	0.3			

Appendix II. Continued.

Location: Roadside Park   Treatment: Check Strip

Species	Mean Percent Canopy Cover F	Mean Percent Canopy Cover U	Mean Maximum Height (Inches) F	Mean Maximum Height (Inches) U	Number/800 Sq. Feet (Density) F	Number/800 Sq. Feet (Density) U	Mean Percent Basal Area and Ground Cover F	Mean Percent Basal Area and Ground Cover U	Species	Percent Frequency F	Percent Frequency U
Artr	16	19	14	14	96	94			Stth	45	31
Chvi	7	10	12	15	90	117			Artr	42	33
Lepu 2	1	4	9	9	10	51			Sihy	28	40
Putr	1	2	8	6	4	17			Caro	24	35
Chna	-	t	-	8	-	1			Chvi	21	30
Caro							2.8	3.5	Eltr	15	3
Sihy							2.6	1.1	Lepu 2	9	21
Stth							1.6	1.7	Luar 2	6	18
Eltr							0.4	0.1	Putr	5	4
Luar 2							0.4	0.6	Aspu	5	1
Seca							0.2	0.2	Ersp 3	3	5
Asla							0.1	0.1	Gara	2	4
Ersp 3							0.1	0.1	Erla	2	-
Erla							0.1	-	Seca	1	2
Vipu							t	0.1	Asca	1	2
Arsp 2							t	-	Lemo	1	-
Orte							t	t	Vipu	-	4
Migr							t	t	Erfi	-	2
Lemo							-	t	Tofl	-	1
Gara							-	t	Orte	-	1
Asca							-	0.1			

Appendix II. Continued.

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Bare Ground							48.6	62.1			
Litter							42.1	29.3			
Cryptogams							0.6	0.8			

Appendix II. Continued.

Location: Airport Treatment: Sprayed

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	22	20	17	15	182	132			Artr	48	48
Chna	2	2	22	17	9	13			Sihy	25	36
Chvi	t	-	10	-	2	-			Ascu 2	8	2
Sihy							1.8	1.7	Stth	7	3
Agsp							0.2	0.4	Brte	6	16
Brte							0.2	0.3	Aspu	2	3
Stth							0.1	t	Chvi	2	-
Ascu 2							0.1	-	Agsp	1	-
Asle							t	-	Feid	1	-
Aspu							t	0.1	Chna	1	7
Pose							-	0.3	Caro	1	1
Lemo							-	0.1	Gara	1	-
Gara							-	t	Pose	1	1
									Lemo	-	1
Bare Ground							63.6	74.5	Arsp 2	-	1
Litter							30.4	19.0			
Cryptogams							2.6	1.2			
Gravel >1" Diameter							1.0	2.6			

Appendix II. Continued.

Location: Airport Treatment: Spray-seeded

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	23	25	14	18	157	123			Artr	60	52
Chna	1	1	13	13	7	8			Sihy	60	19
Chvi	t	t	3	13	1	1			Asle	14	8
Sihy							2.3	1.3	Stth	5	18
Feid							0.1	0.1	Caro	3	-
Stth							0.1	0.9	Chna	3	2
Pose							0.1	-	Feid	1	1
Caro							0.1	-	Pose	1	-
Asle							0.1	0.2	Chvi	1	-
Aspu							0.1	-	Agsp	-	3
Brte							t	-	Brte	-	1
Ersp 3							-	0.1			
Agsp							-	0.1			
Bare Ground							69.1	71.8			
Litter							24.1	23.9			
Cryptogams							2.8	0.8			
Gravel>1" Diameter							0.4	0.5			

Appendix II. Continued.

Location: Airport Treatment: Rotobeat

Species	Mean Percent Canopy Cover F	Mean Percent Canopy Cover U	Mean Maximum Height (Inches) F	Mean Maximum Height (Inches) U	Number/800 Sq. Feet (Density) F	Number/800 Sq. Feet (Density) U	Mean Percent Basal Area and Ground Cover F	Mean Percent Basal Area and Ground Cover U	Species	Percent Frequency F	Percent Frequency U
Artr	20	27	14	15	120	145			Artr	50	50
Chna	2	t	17	11	8	4			Sihy	45	37
Chvi	1	-	15	-	4	-			Asle	12	4
Sihy							2.1	1.7	Stth	5	13
Stth							1.1	0.2	Brte	4	7
Caro							0.9	-	Caro	3	-
Agsp							0.6	-	Chvi	2	-
Feid							0.3	0.4	Chna	2	3
Asle							0.1	-	Agsp	2	1
Aspu							0.1	0.1	Aspu	2	-
Brte							0.1	0.1	Migr	1	-
Chdo							t	-	Lemo	-	2
Migr							t	-	Gara	-	1
Cram							-	t	Feid	-	1
Lemo							-	t	Orte	-	1
Gara							-	t			
Bare Ground							65.9	69.6			
Litter							27.0	25.1			
Cryptogams							0.8	0.3			
Gravel>1" Diameter							-	1.7			

Appendix II. Continued.

Location: Airport Treatment: Plow-seeded

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	23	21	16	16	130	153			Artr	53	55
Chna	2	1	18	13	11	7			Sihy	50	37
Chvi	t	t	5	17	1	1			Caro	17	-
Sihy							3.6	3.3	Asle	11	3
Asle							0.3	0.1	Chna	4	3
Caro							0.3	-	Stth	3	8
Brte							0.2	0.4	Aspu	2	-
Aspu							t	-	Pose	1	1
Stth							-	0.1	Feid	1	2
Cram							-	t	Migr	1	-
									Brte	-	5
Bare Ground							60.5	55.8	Gara	-	2
Litter							32.5	35.3	Lemo	-	1
Cryptogams							1.9	3.9	Cram	-	1
Gravel>1" Diameter							0.8	1.1			

Appendix II. Continued

Location: Airport   Treatment: Check Strip

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	20	27	15	22	180	148			Artr	59	54
Chna	t	1	18	18	2	4			Sihy	42	10
Putr	t	-	28	-	2	-			Asle	7	6
Sihy							2.5	0.6	Stth	6	19
Asle							0.1	t	Caro	4	-
Brte							0.1	t	Agsp	2	1
Aspu							0.1	-	Feid	1	2
Caro							t	-	Aspu	1	-
Stth							-	1.0	Pose	-	1
Agsp							-	0.3	Brte	-	1
Feid							-	0.1			
Bare Ground							64.4	63.0			
Litter							25.6	31.3			
Cryptogams							2.3	2.3			
Gravel>1" Diameter							4.4	1.2			

Appendix II. Continued.

Location: North Burn   Treatment: Sprayed

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	20	30	20	19	117	175			Artr	40	66
Chna	3	t	24	19	19	2			Brte	19	12
Chvi	2	1	11	9	27	11			Chna	9	5
Brte							0.6	0.2	Chvi	6	5
Sihy							0.4	0.3	Sihy	4	4
Asle							t	t	Asle	3	3
									Ersp 4	1	-
Bare Ground							59.3	64.0	Zipa	1	-
Litter							31.3	31.0	Aspu	-	1
Cryptogams							7.7	4.6	Pose	-	1
Gravel >1" Diameter							0.9	0.1			

Appendix II. Continued.

Location: North Burn Treatment: Spray-seeded

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	32	32	20	20	148	137			Artr	65	57
Chna	3	4	17	17	16	11			Brte	33	24
Chvi	2	4	10	14	11	26			Sihy	14	21
Brte							0.5	0.4	Chvi	10	2
Sihy							0.5	0.9	Agsp	9	2
Agsp							0.2	0.2	Asle	4	2
Asle							0.1	t	Gara	3	-
Stth							0.1	0.4	Chna	3	11
Gara							t	t	Stth	1	18
Cram							t	t	Stco 2	-	6
Feid							-	0.3	Pose	-	1
Kocr							-	0.1			
Ersp 4							-	t			
Bare Ground							59.6	59.9			
Litter							34.8	35.2			
Cryptogams							3.5	1.3			
Gravel>1" Diameter							0.1	0.4			

Appendix II. Continued.

Location: North Burn   Treatment: Rotobeat

Species	Mean Percent Canopy Cover F	Mean Percent Canopy Cover U	Mean Maximum Height (Inches) F	Mean Maximum Height (Inches) U	Number/800 Sq. Feet (Density) F	Number/800 Sq. Feet (Density) U	Mean Percent Basal Area and Ground Cover F	Mean Percent Basal Area and Ground Cover U	Species	Percent Frequency F	Percent Frequency U
Artr	31	39	20	23	151	173			Artr	56	53
Chna	3	2	16	21	21	11			Brte	46	23
Chvi	1	t	11	13	19	3			Sihy	16	14
Sihy							0.6	0.7	Chna	9	9
Brte							0.4	0.2	Asle	5	6
Agsp							0.2	-	Chvi	4	2
Asle							0.1	0.1	Agsp	1	4
Stth							-	0.2	Stth	-	1
									Ersp 4	-	1
Bare Ground							53.9	58.9			
Litter							41.5	37.6			
Cryptogams							2.6	1.3			

Appendix II. Continued.

Location: North Burn   Treatment: Plow-seeded

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	24	30	20	21	104	160			Artr	35	66
Chna	2	t	15	22	17	2			Brte	31	15
Chvi	2	t	11	11	20	1			Chvi	9	-
Brte							0.9	0.2	Chna	8	1
Sihy							0.3	0.3	Sihy	5	4
Agsp							0.1	-	Ersp 4	2	-
Asle							t	t	Asle	1	3
Ersp 4							t	-	Gara	1	-
Pose							-	t			
Bare Ground							57.3	61.5			
Litter							33.4	34.6			
Cryptogams							7.7	3.4			
Gravel>1" Diameter							0.5	-			

Appendix II. Continued

Location: North Burn   Treatment: Check Strip

Species	Mean Percent Canopy Cover		Mean Maximum Height (Inches)		Number/800 Sq. Feet (Density)		Mean Percent Basal Area and Ground Cover		Species	Percent Frequency	
	F	U	F	U	F	U	F	U		F	U
Artr	25	22	21	17	109	136			Artr	55	61
Chna	3	1	17	14	16	8			Brte	27	20
Chvi	2	2	12	10	15	18			Chna	8	2
Brte							1.0	0.3	Chvi	6	3
Sihy							0.2	0.2	Asle	5	5
Asle							0.1	t	Sihy	5	7
Stth							t	-	Aspu	1	1
Cram							t	-	Agsp	1	1
Ersp 4							t	-			
Pose							-	0.1			
Bare Ground							54.5	78.8			
Litter							37.3	16.6			
Cryptogams							6.6	3.3			
Gravel>1" Diameter							0.4	0.6			

Appendix III: Soil profile descriptions from each of three experimental sagebrush control areas.

The soil at North Burn (NW¼Sec1T29SR14E) is an uncorrelated shallow Medial Brown having a B_{2t} horizon with medium subangular blocky structure. Aspect is northwest with 3-4% slope at an elevation of 4600 feet. The vegetation is low-seral big sagebrush-bunchgrass with presumably _Agropyron spicatum_ and _Poa secunda_ the climax dominant grasses. Surface stoniness varies from 0-2% of basalt but parent material is laminated tuff.

A_{11}	0-3"	Light gray (10YR6/1) dry, very dark grayish brown (10YR3/2) moist; loam; weak thin platy structure with many large vesicular pores; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; pH 6.6; plentiful fine roots; abrupt slightly wavy boundary.
A_{12}	3-7"	Gray (10YR5/1) dry, very dark grayish brown (10YR3/2) moist; + loam; weak thin platy with common fine tubular pores; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; pH 6.7; plentiful moderate and fine roots; clear smooth lower boundary.
B_{2t}	7-10"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; clay loam; weak medium subangular blocky with many fine tubular pores; hard dry, friable moist, sticky and plastic wet; pH 6.7; plentiful moderate and fine roots; abrupt smooth lower boundary.
R	10-17"+	Pale brown and light yellowish brown (10YR6/3 and 10YR6/4) dry; laminated tuff; extremely hard dry; silica coatings on tuff surfaces.

The profile at Airport (SE¼Sec30T28SR14E) is a Maximal Brown similar in number and kinds of horizons to the Plush series but less than 20 inches in depth. Structure of the B_{2t} horizon is medium to fine prismatic. Elevation is 4550 feet on gently undulating tableland (2% slope). Surface stoniness is 2%. As at North Burn the vegetation is in low-seral status with _Agropyron spicatum_ and _Poa secunda_ the likely climax dominants along with big sagebrush.

A_{11}	0-2"	Light gray (10YR6/1) dry, very dark grayish brown (10YR3/2) moist; loam; weak very thin platy with moderate medium vesicular pores; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; pH 6.6; clear smooth lower boundary; roots throughout.
A_{12}	2-6"	Light gray (10YR6/1) dry, very dark grayish brown (10YR3/2) moist; + loam; weak medium platy breaking to weak fine granular; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; pH 6.8; lower boundary clear and smooth; roots throughout.
B_1	6-9"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; clay loam; weak medium subangular blocky breaking to weak fine granular with many fine tubular pores; slightly hard dry, friable moist, sticky and plastic wet; pH 6.8; abrupt smooth lower boundary; roots throughout.
B_{2t}	9-13"	Dark grayish brown to brown (10YR4/2.5) dry, dark yellowish brown (10YR3/4) moist; - clay; moderate fine prismatic with moderately thick continuous clay skins on prism surfaces; very hard dry, very firm moist, very sticky and very plastic wet; pH 6.8; abrupt smooth lower boundary; roots throughout.
R	13-16"+	Yellowish brown (10YR5/4 and 10YR5/6) dry; laminated tuff; extremely hard dry, extremely firm moist.

The soil at Roadside Park is a deep, water-worked, uncorrelated Regosol with high estimated pumice content--45% in the A_1 horizon, 70% in C_1, 15% in IIC_2 and 35% in $IIIC_3$. Elevation is 4800 feet and the aspect is a flat basin. Vegetation is dominated by *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Stipa thurberiana*, and *Sitanion hystrix* and is believed to be near-climax. There is no surface stoniness but a few small stones occur in the lower horizons.

A_1	0-2"	Grayish brown (10YR5/2) dry, very dark grayish brown (10YR3/2) moist; loamy sand; weak fine granular with mainly interstitial pores; soft dry, very friable moist, nonsticky and nonplastic wet; pH 6.6; boundary clear and smooth.

C_1	2-18"	Grayish brown (10YR5/2) dry, dark brown (10YR3/3) moist; loamy sand; massive with mainly interstitial pores; soft dry, very friable moist, nonsticky and nonplastic wet; pH 6. 7; abrupt smooth lower boundary.
IIC_2	18-30"	Grayish brown (10YR5/2) dry, dark brown (10YR3/3) moist; - loam; massive with many medium and fine pores; hard dry, friable moist, slightly sticky and slightly plastic wet; pH 6. 8; abrupt smooth lower boundary.
$IIIC_3$	30-33"+	Brown to dark brown (10YR4/3) dry, dark brown (7. 5YR3/3) moist; gravelly clay loam; moderate fine blocky with common fine tubular pores; hard dry, firm moist, sticky and plastic wet; pH 6. 6; many thin clay films on ped and gravel surfaces.

Appendix IV: Soil profile descriptions from each of twelve paired-macroplot locations in the Silver Lake and Fort Rock units.

Dehne Flat Profile (SW¼Sec10T26SR13E)

This profile is a deep uncorrelated Regosol soil with high percentage of coarse pumice sand in the upper horizons. It is located on an old lake bed at 4600 feet elevation. The potential plant association on this site is likely Artemisia tridentata/Stipa thurberiana with important amounts of green rabbitbrush (Chrysothamnus viscidiflorus).

A_1	0-2"	Grayish brown (10YR5/2) dry, very dark grayish brown (10YR3/2) moist; loamy sand; weak thin platy with mainly interstitial pores; very soft, very friable, nonsticky and nonplastic; many fine roots; pH 6.4; clear and smooth lower boundary.
C_1	2-19"	Grayish brown to brown (10YR5/2.5) dry, dark brown (10YR3/3) moist; loamy sand with more than 50 percent pumice; massive; very soft, very friable, nonsticky and nonplastic; many fine roots; pH 6.6; abrupt and smooth lower boundary.
IIC_2	19-27"	Brown (10YR5/3) dry, dark brown (10YR3/3) moist; loam; massive with few large, common fine tubular pores; friable, slightly sticky and slightly plastic; many fine roots; pH 6.8; clear and wavy lower boundary.
$IIIC_3$	27-34"	Brown (10YR5/3) dry, dark brown (7.5YR3/3) moist; heavy loam; moderately strong medium blocky with common fine and medium tubular pores and many moderately thick clay films on ped and pore surfaces; firm to very firm with slightly brittle durinodes; sticky and slightly plastic; few fine roots; pH 6.8; clear and smooth lower boundary.
IVC_4	34-40"+	Dark brown (7.5YR3/3) moist; sandy loam; weak medium subangular blocky with many fine tubular pores; friable to firm, slightly sticky and non-plastic; few fine roots; pH 6.8.

Hockman Well Profile (SE$\frac{1}{4}$Sec22T26SR13E)

Only minor differences exist between this and the Dehne Flat location although they occupy separate basins and Hockman Well is slightly lower in elevation at 4550 feet.

A_1	0-2"	Gray to grayish brown (10YR5/1.5) dry, very dark grayish brown (10YR3/2) moist; loamy sand; very weak thin platy with few vesicular pores; very soft, very friable, nonsticky and nonplastic; many fine roots; pH 6.4; clear and smooth lower boundary.
C_1	2-25"	Gray (10YR5/1) dry pumice and light grayish brown (10YR6/2) dry matrix, brown (10YR5/3) moist pumice, very dark grayish brown (10YR3/2) moist matrix; fine gravelly sand; massive with few large and medium pores; very soft, very friable, nonsticky and nonplastic; many fine roots to 13", few large to 20"; pH 6.6; abrupt and smooth lower boundary.
IIC_2	25-34"	Grayish brown (10YR5/2) dry, dark brown (10YR3/3) moist; loamy sand; massive with mainly interstitial pores; soft, friable, nonsticky and nonplastic; few fine roots; pH 6.6; abrupt and smooth lower boundary.
$IIIC_3$	34"+	Dark brown (10YR3/3) moist; heavy sandy loam; massive with common medium and fine pores; firm, slightly bittle with very firm durinodes, slightly sticky and nonplastic; pH 6.6; an apparent stone-line was found at 37".

Ceres Flat Profile (NW$\frac{1}{4}$Sec3T27SR13E)

The Ceres Flat location lies near the transition between big sagebrush and silver sagebrush communities. Greater mesism resulting from somewhat finer-textured subsoil produces minor floristic differences, but the potential vegetation is believed to be the same as Dehne Flat and Hockman Well. Elevation is 4660 feet with 1 percent slope to the south.

A_1	0-3"	Gray (10YR5/1) dry, very dark grayish brown (10YR3/2) moist; loamy sand; weak thin platy with mainly interstitial pores; very soft, very friable, nonsticky and nonplastic; abundant very fine roots; pH 6.8; clear and smooth lower boundary.
AC	3-13"	Light grayish brown (10YR6/2) dry, very dark grayish brown (10YR3/2) moist; loamy sand; massive with common large tubular pores; very soft, very friable, nonsticky and nonplastic; abundant very fine and fine roots; pH 6.6; gradual and smooth boundary.
C_1	13-22"	Light grayish brown (10YR6/2) dry, dark gray to dark grayish brown (10YR4/1.5) moist; sandy loam; massive with common medium and large tubular pores, slightly hard, very friable, slightly sticky and nonplastic; plentiful fine roots; pH 6.6; abrupt and smooth lower boundary.
IIC_2	22-28"	Grayish brown (10YR5/2) dry, dark grayish brown (10YR4/2) moist; loam; massive with common medium and fine tubular pores; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; pH 6.6; abrupt and smooth lower boundary.
$IIIC_3$	28-42"	Grayish brown (2.5YR5/2) dry, dark brown (10YR3/3) moist; silty clay; strong fine prismatic breaking to fine blocky with few fine tubular pores and thick continuous clay films; very hard, very firm, very sticky and very plastic; few very fine roots; pH 6.6.
IVC_4	42-60"+	Brown to dark brown (10YR4/3) moist; fine gravelly clay loam.

Silver Creek Profile (NW$\frac{1}{4}$Sec28T28SR14E)

This profile is a deep uncorrelated Regosol soil but differs from the preceding three profiles by originating from alluvial deposits and containing much less raw pumice. Elevation is 4380 feet, relief is smooth, and slope is 2 percent north. No evidence of potential vegetation was found.

A_1	0-4"	Grayish brown (10YR5/2) dry, very dark grayish brown (10YR3/2) moist; heavy fine sandy loam; thin platy; soft, very friable, slightly sticky and nonplastic; roots plentiful; pH 6. 6; clear smooth lower boundary.
AC	4-15"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; loam; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6. 6; gradual and smooth lower boundary.
C_1	15-21"	Brown to dark brown (10YR4/3) dry, dark yellowish brown (10YR3/4) moist; loam; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6. 6; gradual smooth lower boundary.
IIC_2	21-50"+	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; loamy fine sand; massive; soft, very friable, nonsticky and nonplastic; plentiful fine roots to 45", few below; pH 6. 6.

L. Iverson Profile (NW¼Sec35T28SR14E)

An uncorrelated Brown soil was found at this location formed from gravelly lucustrine sediments and mixed extrusive igneous rock. It occurs on an old lake terrace at 4450 feet elevation with 2-3 percent slope to the northwest. The potential plant association for this site is likely Artemisia tridentata/Agropyron spicatum but retrogression resulting from excessive grazing has produced a stand dominated by big sagebrush and squirreltail.

A_{11}	0-2"	Gray (10YR5/1) dry, very dark grayish brown (10YR3/2) moist; sandy loam; very weak very thin platy; soft, very friable, nonsticky and nonplastic; plentiful medium and fine roots; pH 6. 5; abrupt and wavy lower boundary.
A_{12}	2-9"	Gray (10YR5/1) dry, dark brown (10YR3/3) moist; sandy loam; weak medium subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; plentiful medium and fine roots; pH 6. 7; clear and smooth lower boundary.

B_1 9-18" Grayish brown (10YR5/2) dry, dark brown (10YR3/3) moist; sandy clay loam; weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; plentiful medium and fine roots; pH 6.7; clear and smooth lower boundary.

B_{2t} 18-27" Brown (10YR5/3) dry, brown to dark brown (10YR4/3) moist; light clay loam; moderately strong medium and fine blocky with 60 percent medium and fine gravel and common thin clay films on ped surfaces; hard, friable, sticky and plastic; few fine roots; pH 6.8; clear and wavy lower boundary.

C 27-39"+ Pale brown (10YR6/3) dry, brown to dark brown (10YR4/3) moist; gravelly sandy loam; massive with 80 percent well graded gravel; slightly hard to hard, very friable, nonsticky and nonplastic; few roots; pH 7.4 with common seam and threads of effervescent lime.

D. Long Profile (SE$\frac{1}{4}$Sec28T28SR14E)

The Brown soil at this location is somewhat like the Hager series and is formed from lucustrine deposits on an old lake terrace. Elevation is 4390 feet with 0-2 percent slope to the east. The potential plant association appears to be Artemisia tridentata/Agropyron spicatum but the present low-seral community is dominated by big sagebrush, squirreltail and cheatgrass.

A_1 0-3" Gray (10YR5/1) dry, very dark grayish brown (10YR3/2) moist; loam; weak thin platy; soft, very friable, slightly sticky and slightly plastic; few large, plentiful fine roots; pH 6.4; abrupt and wavy lower boundary.

B_1 3-5" Dark gray (10YR4/1) dry, very dark grayish brown (10YR3/2) moist; light clay loam; weak medium blocky; soft, friable, slightly sticky and plastic; few large, plentiful fine roots; pH 6.6; clear and wavy lower boundary.

B_{2t}	5-16"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; clay loam; moderately strong medium and fine blocky; hard, firm, sticky and plastic; few large, plentiful fine roots; pH 6.6; abrupt and wavy lower boundary.
IIC_{1m}	16-31"	White (10YR8/2) dry, light gray (10YR7/1) moist; has the appearance of diatomite; extremely hard, extremely firm; abrupt and smooth lower boundary.
$IIIC_2$	31-34"	Stone line; abrupt and smooth lower boundary.
IVC_3	34-39"	Grayish brown (2.5YR5/2) dry, very dark grayish brown (10YR3/2) moist; sand; massive; loose, very friable, nonsticky and nonplastic; pH 7.6+.
VC_4	39"+	Dark grayish brown (10YR4/2) moist; clay loam; massive; firm, sticky and plastic; pH 7.6+.

Arbow Profile (NW$\frac{1}{4}$Sec29T28SR14E)

This profile is also an uncorrelated Brown soil with similarities to the Hager series. Parent material is cemented lucustrine deposits with a geologic rather than pedogenic cemented pan. Elevation is 4425 feet with slope 3-5 percent to the northeast. *Artemisia tridentata/Agropyron spicatum* is again the probable potential association.

A_1	0-2"	Light brownish gray (10YR6/2) dry, very dark grayish brown (10YR3/2) moist; loam; weak thin platy; soft, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6.6; clear and smooth lower boundary.
A_3	2-8"	Grayish brown (10YR5/2) dry, very dark grayish brown (10YR3/2) moist; loam; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6.6; clear wavy lower boundary.
B_{2t}	8-11"	Dark grayish brown (10YR4/2) dry, dark yellowish brown (10YR3/4) moist; sandy clay loam; weak fine blocky; slightly hard, friable, sticky

and slightly plastic; plentiful roots; pH 6.8; abrupt and smooth lower boundary.

IIC_m	11"+	Light gray (10YR7/1) dry, brown (10YR5/3) moist; platy cemented lucustrine material, fractured to 24", solid below; extremely hard.

<u>Airport Profile (SE$\frac{1}{4}$Sec30T28SR14E)</u>

The Airport profile is a maximal Brown soil developed similarly in number and kind of horizons to the Plush series but less than 20" deep. Parent material is tuff and surface stoniness is class two. The site is on gently rolling tableland at 4550 feet elevation and 2 percent slope to the north. Potential plant development likely favors an *Artemisia tridentata*/*Agropyron spicatum* plant association.

A_{11}	0-2"	Light gray (10YR6/1) dry, very dark grayish brown (10YR3/2) moist; loam; weak very thin platy with common medium vesicular pores; slightly hard, very friable, slightly sticky and slightly plastic; abundant roots; pH 6.6; clear and smooth lower boundary.
A_{12}	2-6"	Light gray (10YR6/1) dry, very dark grayish brown (10YR3/2) moist; heavy loam; weak medium platy breaking to weak fine granular with interstitial pores; slightly hard, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6.8; clear and smooth lower boundary.
B_1	6-9"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; clay loam; weak medium subangular blocky breaking to weak fine granular with many fine tubular pores; slightly hard, friable, sticky and plastic; plentiful roots; pH 6.8; abrupt and smooth lower boundary.
B_{2t}	9-13"	Dark grayish brown to brown (10YR4/2.5) dry, dark yellowish brown (10YR3/4) moist; light clay; medium to fine prismatic with moderately thick nearly continuous clay films on prism surfaces; very hard, very firm, very sticky and very plastic; plentiful roots; pH 6.8; abrupt and smooth lower boundary.

R	13-16"+	Yellowish brown (10YR5/4) and 10YR5/6) dry; laminated tuff; extremely hard and extremely firm.

North Burn Profile (NW$\frac{1}{4}$Sec1T29SR14E)

An uncorrelated Chestnut (Durustoll) soil was found at this location having a silica rather than a lime cemented pan. The site occupies a smooth bench on an old lake terrace at 4560 feet elevation with 2-3 percent slope to the north. The potential plant association is likely *Artemisia tridentata/Agropyron spicatum* but has degraded to big sagebrush and cheatgrass dominance through excessive grazing.

A_1	0-6"	Gray (10YR5/1) dry, very dark brown (10YR2/2) moist; loam; very weak thin platy breaking to weak very fine granular with 10 percent gravel; soft, very friable, slightly sticky and slightly plastic; abundant medium and fine roots; pH 6.6; clear and smooth lower boundary.
A_3	6-10"	Gray (10YR5/1) dry, very dark brown (10YR2/2) moist; loam; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; abundant medium and fine roots; pH 7.0; clear and smooth lower boundary.
B_1	10-12"	Grayish brown (10YR5/2) dry, dark brown (7.5YR3/2) moist; clay loam; weak medium and fine blocky with over 30 percent gravel; slightly hard, friable, sticky and plastic; plentiful fine roots; pH 6.9; clear and smooth lower boundary.
B_{21t}	12-18"	Reddish brown (5YR4/4) dry, dark reddish brown (5YR3/3) moist; gravelly clay; moderately strong fine blocky with over 50 percent gravel and thick, nearly continuous clay films on ped and gravel surfaces; hard, firm to very firm, very sticky and very plastic; plentiful fine roots; pH 6.9; abrupt and smooth lower boundary.
B_{22tm}	18"+	Pan extremely hard dry and extremely firm moist.

West Burn Profile (NE$\frac{1}{4}$Sec4T29SR14E)

Another uncorrelated Chestnut soil was found at the West Burn location. Relief is smooth with 3-5 percent north slope on an old lake terrace at 4590 feet elevation. Surface stoniness is class two and parent material is volcanic tuff-breccia.

A_1	0-5"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; loam; weak thin platy; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; pH 6. 5; abrupt and smooth lower boundary.
B_1	5-8"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; clay loam; moderately strong subangular blocky; slightly hard, friable, sticky and slightly plastic; abundant fine roots; pH 6. 7; clear and smooth lower boundary.
B_{2t}	8-16"	Brown (7. 5YR5/2) dry, brown to dark brown (7. 5YR4/2) moist; clay; moderately strong medium and fine blocky with 40 percent stone and gravel fragments and thick, continuous clay films on ped and pore surfaces; hard, firm, very sticky and very plastic; few roots; pH 6. 6; abrupt and smooth lower boundary.
R	16"+	Tuff-breccia; extremely hard; few roots to 18".

Silver Lake Burn Profile (NW$\frac{1}{4}$Sec7T29SR15E)

This profile is a shallow uncorrelated Chestnut (Durustoll) soil with a thin white silica cap on the upper pan surface. Parent material is gravelly lucustrine deposits on an old lake terrace at 4720 feet elevation. Slope is 0-2 percent northwest on a bench with with smooth relief. An association of Artemisia tridentata/Agropyron spicatum is the likely potential plant development although big sagebrush and cheatgrass dominate the aspect now and bitterbrush is present in low but important amounts.

A_1	0-4"	Gray (10YR5/1) dry, very dark brown (10YR2/2) moist; loam; very weak thin platy with many fine vesicular pores and 5-10 percent gravel; slightly

hard, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6.4; clear and smooth lower boundary.

A_3	4-8"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; loam; weak medium subangular blocky breaking to weak fine granular with 5-10 percent gravel; slightly hard, very friable, slightly sticky and slightly plastic; plentiful roots; pH 6.7; clear and smooth lower boundary.
B_{2t}	8-14"	Brown to dark brown (7.5YR4/2) dry, strong brown (7.5YR3/3) moist; gravelly light clay; moderately strong fine block with 50 percent fine gravel; hard, firm, very sticky and plastic; few roots; pH 6.6; abrupt smooth lower boundary.
C_m	14-23"+	Brown (7.5YR5/4) dry, brown to dark brown (7.5YR4/4) moist; very coarsely platy with high percentage of fine gravel; extremely hard and extremely firm.

South Burn (E) Profile (NW$\frac{1}{4}$Sec18T29SR15E)

A fourth and final uncorrelated Chestnut soil was found at this location. It occurs on possibly the highest terrace formed by the Pleistocene lake whose remnant is the present Silver Lake. Parent material is gravelly lucustrine deposits. Elevation is about 4770 feet and relief slopes to the north at 5 percent. Potential plant community development is not known but the present stand is codominated by big sagebrush and bitterbrush. Idaho fescue is by far the most abundant grass at present although it is much less a decreaser in this area than bluebunch wheatgrass.

A_{11}	0-4"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; loam; very weak thin platy breaking to weak fine granular; soft, very friable, slightly sticky and slightly plastic; abundant very fine roots; pH 6.7; gradual and smooth lower boundary.
A_{12}	4-9"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; gravelly heavy loam; weak

		medium subangular blocky breaking to weak fine granular; soft, very friable, slightly sticky and slightly plastic; plentiful very fine roots to 8"; pH 6.9; gradual and smooth lower boundary.
A_3	9-12"	Dark gray (10YR4/1) dry, very dark brown (10YR2/2) moist; gravelly light clay loam; weak medium subangular blocky; slightly hard, friable, sticky and slightly plastic; plentiful very fine roots; pH 6.9; clear and wavy lower boundary.
B_{2t}	12-18"	Dark grayish brown (10YR4/2) dry, dark brown (10YR3/3) moist; gravelly heavy clay loam or gravelly clay with many moderately thick clay films on gravel and ped surfaces; moderately strong fine block; hard, firm, sticky and plastic; abrupt and smooth lower boundary.
C_m	18"+	Yellowish brown (10YR5/4) dry, dark yellowish brown (10YR4/4) moist; massive; extremely hard dry and extremely firm moist.