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Title: SPRING, SUMMER AND FALL USE BY CATTLE AND BIG GAME ON FOOTHILL RANGELANDS

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Dr. William C. Krueger

The objectives of this study were to evaluate environmental factors influencing use of several plant communities by cattle, elk and deer; determine understory production by plant species and the amount utilized by cattle, elk and deer in certain plant communities; evaluate the interactions of range use between cattle, elk and deer; and look closely at potential and use of seeded clearcut forest communities during the spring, summer and fall on the Hall Ranch of the Northeastern Oregon Experiment Station, in Union County.

Understory production was classified into three significant groups: the bunchgrass, forest, and clearcut groups. Soil depth and tree canopy cover accounted for 96 percent of the variability in understory production. Forested communities had a high potential for producing forage after logging. The Grand fir - pachistima habitat type had the greatest potential for producing quality seeded forage.

The vegetation group most heavily utilized during spring and summer by deer, elk, and cattle was the clearcut. The four logged stands provided 66 percent of the forage consumed by deer and elk, and 63 percent of the forage consumed by cattle. Seeded grasses on the clearcut accounted for 30 percent of the big game diet and 55 percent of the cattle diet. Grass species generally did not have high preference indices for big game or cattle. Shrubs and forbs tended to have a high preference ratings for big game during spring and early summer. Forbs were generally unavailable for cattle by mid-summer. Browse preference indices for cattle were low.

Factors having the greatest effect on pounds and percent of forage removed by big game during spring and early summer were pounds of palatable species produced per acre, soil depth, canopy cover and distance to water. Factors highly correlated with utilization by cattle during summer were distance to salt and water, soil depth and canopy cover.

Big game pellet groups did not correlate with forage use among plant communities. Logged communities provided 66 percent of the total forage consumed by big game while they accounted for only 20 percent of the big game pellet groups.

Cattle and big game animals utilized the study area during different seasons of the year. Big game were primarily present on the pasture during the winter, spring and early summer. By mid-summer

elk and the majority of deer had moved to higher elevations. Cattle were present during mid- and late summer. Utilization measurements during the spring, summer and fall indicated no direct forage competition occurred between cattle and big game. Combined utilization by big game and cattle on forage species did not exceed acceptable levels.

Spring, Summer and Fall Use by Cattle and Big Game on Foothill Rangelands

by

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Redacted for privacy

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INTRODUCTION

The forested foothills of the Wallowa Mountains in northeastern Oregon have been used as summer cattle (Bos taurus) range for many years. The deficiency of research in this area on interactions between animals and their environment in specific plant communities has hindered effective resource management. The understanding of ecological relationships in these areas is essential so land uses can be integrated, enabling the optimum harvest of multiple products. This study was conducted to evaluate the use of several plant communities by cattle, elk (Cervus canadensis nelsoni) and deer (Odocoileus hemionus hemionus) in the foothills of the Wallowa Mountains.

Important products from this area are timber; fish; water; forage for livestock and wildlife; and recreation. Through intensive management, use of these major products can be harmonized with one another to optimize harvest. Research not only brings forth new ideas and methods of management, but also gives us a clearer understanding of the resource we manage. This study examined intra- and interspecific usage of different plant communities by large herbivores.

Forage values of different plants and plant communities vary with such features as plant composition, range condition, season, seral stage, and canopy cover. Range plants provide an important

source of food for both domestic and wild animals. These plants are also important in stabilizing soils essential to watershed management. Resource managers need to know where, what, why and how much forage large herbivores are consuming to effectively manipulate vegetation.

The objectives of this study were as follows:

1. define and measure environmental factors influencing the use of several distinct plant communities by cattle, elk and deer;
2. determine understory production of plant species and the amount utilized by cattle, elk and deer in certain plant communities;
3. evaluate the interactions of range use between cattle, elk and deer; and
4. evaluate potential and use of seeded clearcut forest communities.

STUDY AREA

The study area was located on the northeast side of the Hall Ranch in a 360 acre pasture. The Hall Ranch lies 12 miles southeast of Union, Oregon, in the foothills of the Wallowa Mountains, in Township 5, South, Range 41, east of the Willamette Meridian. The elevation of the study area ranges from 3,300 to 4,000 feet. Catherine Creek runs along the west boundary.

Geology

The Wallowa Mountain fault block or horst is approximately 50 miles long by 15 to 20 miles wide (Root et al., 1960). This batholith was raised to its present heights by diastrophic processes in the late Tertiary - Quaternary time and carved by subsequent erosion (Wagner, 1955). During the Miocene period, repeated lava flows covered most of eastern Oregon to a depth of several thousand feet with basalt. Remnants of the basaltic flows represent, now, almost a completely eroded but once extensive sheet that covered the entire area (Smith et al., 1941). This basaltic lava laid down during the Tertiary period underlies the Hall Ranch.

Soils

Vance et al. (1965) classified four soil series found in the study area: the Tolo, Klicker, Hall Ranch and Chop silt loams. Pumicite, a dacite, silt-size volcanic ash, is the parent material for the Tolo series and is found in varying amounts in the other three series (Strickler, 1965). Most of the moisture available for plant use is due to this glassy ash-like material. The moisture holding capacity of pumicite is approximately 40 percent by volume. Strickler (1965) found that pumicite in the soil profile influenced the kinds and amount of vegetation present. Some of the pumicite is believed to have come from Mount Mazama 6,500 years ago (Williams, 1942).

The Chop silt loam is a shallow, stony, rocky soil. Hard, rock andesite is covered by a thin layer of silt loam. Plant species composition is related to soil depth, aspect, degree of slope and degree of bedrock fracture (Strickler, 1965).

The Klicker series is a silt to stony silt loam, moderately fine textured, commonly found on moderate south slopes. Approximately 12 inches below the surface texture changes to clay loam. Soil depth is highly variable with bedrock exposed at the surface throughout the site. Strickler (1965) found vegetation composition was partially dependent upon the amount of pumicite in the soil, depth to bedrock and slope.

The Hall Ranch soil is similar to Klicker soil except soil depth and pumicite content are greater in the Hall Ranch series. As soil depth and pumicite increased so did the presence of Douglas-fir (Pseudotsuga menziesii) and shinyleaf spiraea (Spiraea betulifolia).

The Tolo soils are well drained silt loams composed of moderate to very fine textured regosols originating from pumicite. These moist soils found on north aspects cover an older buried horizon. This buried horizon is generally a moist, silty-clay approximately one foot thick (Strickler, 1965).

Climate

Most of the moisture falls on the Hall Ranch in the form of snow during November through March. Fall and spring are usually moist while summer is dry. What precipitation does fall during the summer occurs during thunderstorms. A rain gauge was located on an adjacent site approximately 400 yards from the east boundary of the study area.

Temperatures rarely exceed 100 degrees Fahrenheit during summer months. Snow quickly melts off the Hall Ranch on exposed areas in early spring.

Vegetation

Habitat types found within the study area were: Sandberg's bluegrass - kellogg onion (Poa sandbergii - Allium anceps), ponderosa pine - bluebunch wheatgrass (Pinus ponderosa - Agropyron spicatum), ponderosa pine - snowberry (Pinus ponderosa - Symphoricarpos albus), Douglas-fir - snowberry (Pseudotsuga menziesii - Symphoricarpos albus), Douglas-fir - ninebark (Pseudotsuga menziesii - Physocrpus malvaceus), and grand fir - pachistima (Abies grandis - Pachistima myrsinites) (Daubenmire, 1970; Daubenmire and Daubenmire, 1968).

The Sandberg's bluegrass - kellogg onion habitat type was found on very shallow silt loam soils. Bedrock was exposed above the surface throughout the area. Shallow soils underlain by bedrock material and slope not exceeding six degrees resulted in poor drainage. Soils were over-saturated for a short period during the spring and dried by June. Other plant species commonly found in this community were foxtail (Hordeum jubatum), rat tail fescue (Festuca myuros), field woodrush (Luzula campestris), wyeth buckwheat (Eriogonum heracleoides), little flower collinsia (Collinsia parviflora), and autumn willowweed (Epilobium paniculatum). This site supported only a few stunted ponderosa pine. The Sandberg's bluegrass - kellogg onion community most closely resembled Daubenmire's (1910) bluebunch wheatgrass - Sandberg's bluegrass (Agropyron spicatum - Poa sandbergii) habitat type. However, Strickler (1965) suspected that sites

with Rock Creek soils (similar to Chop silt loam) in the Blue Mountains, having a slope of less than five percent would not support bluebunch wheatgrass and should be managed for Sandberg's bluegrass and onespike danthonia (Danthonia unispicata).

The ponderosa pine - bluebunch wheatgrass habitat type was found on south slopes underlain by the Klicker soil series. Many important forage species occurred on these sites. Tree canopy was sparse so light interception was not a limiting factor to understory production. Some of the plant species found in these stands were Idaho fescue (Festuca idahoensis), Sandberg's bluegrass, woodrush pussytoes (Antennaria luzuloides), and western yarrow (Achillea millifolium). The area was seeded to tall oatgrass (Arrhenatherum elatius) after a fire in 1949.

In the ponderosa pine - snowberry habitat type, shade tolerant species were characteristic in the herbaceous composition. These stands, found on the Hall Ranch soil series, also had bedrock exposed above the soil surface throughout the site. Some of the more common plant species were elk sedge (Carex geyeri), pinegrass (Calamagrostis rubescens), heart-leaved arnica (Arnica cordifolia), peavine (Lathyrus nevadensis), woolyweed (Hieracium scouleriana), wild strawberry (Frageria virginiana), snowberry and shinyleaf spiraea.

The Douglas-fir - snowberry habitat type was similar to the ponderosa pine - snowberry habitat type. Two major differences

were, presence of Douglas-fir and greater soil depth in these stands when compared to the ponderosa pine - snowberry stand. Species occurrence of the two understories was similar except snowberry was not as abundant in the Douglas-fir - snowberry stand.

The grand fir - pachistima habitat type was situated on moist north slopes containing Tolo soil series. The grand fir - adenocaulon (Adenocaulon bicolor) community represented this habitat type. The overstory consisted of grand fir, Douglas-fir and western larch (Larix occidentalis). The sparse understory was dominated by northwestern sedge (Carex concinnoides), elk sedge, tall trisetum (Trisetum canescens), heart-leaved arnica, peavine, western meadowrue (Thalictrum occidentale), adenocaulon, and rattlesnake plaintain (Goodyera oblongifolia). Soils were deep volcanic ash with a high potential for growing forage as well as trees (Edgerton, 1972).

A 66 acre clearcut area occurred within the study area. The site was logged in 1969, burned on July 21, 1970, and seeded on September 9, 1970, to tall oatgrass, timothy (Phleum pratense), white Dutch clover (Trifolium repens), Manchar smooth brome (Bromus inermis), orchardgrass (Dactylis glomerata), and blue wildrye (Elymus glaucus). Habitat types contained within the logged area included ponderosa pine - snowberry, Douglas-fir - ninebark, and grand fir - pachistima. The logged ponderosa pine - snowberry habitat type was dominated by Kentucky bluegrass (Poa pratensis),

timothy, cheatgrass (Bromus tectorum), Ross sedge (Carex rossii), white Dutch clover, bull thistle (Cirsium vulgare), and mullein (Verbascum thapsus). In the logged Douglas-fir - ninebark habitat type bull thistle, mullein, timothy, orchardgrass, and Kentucky bluegrass dominated the understory vegetation. In the grand fir - pachistima habitat type timothy and orchardgrass made up the greatest proportion of the understory.

Browse accounted for only five percent of the understory composition. The most common browse species were ninebark, oceanspray (Holodiscus discolor), Scouler's willow (Salix scouleriana), serviceberry (Amelanchier alnifolia), snowberry, shinyleaf spiraea, and redstem ceanothus which occurred in the clearcut.

Land Use History

The Union County area was first settled in the early 1860's (Hug, ed., 1961). With the settlers came horses (Equus caballus), cattle and sheep (Ovis aries). Catherine Creek canyon served as a natural route from the Grand Ronde Valley to high mountain grazing lands in the Wallowa Mountains. The Hall Ranch was primarily used as a spring and fall range for cattle and sheep. Horses were often wintered on the lower meadows. Keniston (1957) reported that most of the Hall Ranch was logged in the 1930's.

Experiment station records showed the Hall Ranch was heavily grazed by both cattle and sheep from 1936 to 1956. A range survey taken in 1956 indicated most of the area was in poor condition. After 1956, cattle were the only domestic herbivores to utilize the study area, except in 1968 when 12 horses were pastured during the summer. Prior to fencing the east side of the Hall Ranch in 1961, the entire area was treated as one pasture. The number of AUM's on the east side (which contained approximately 1,000 acres) averaged 307, ranging from 153 in 1957 to 454 in 1960. In 1961 the east side was fenced, separating the study area as an individual unit. The number of AUM's present on the study area from 1962 to 1972 averaged 116, ranging from 47 in 1969 to 189 in 1970. In February 1972 Sundstrom (1973) observed 81 elk and 150 deer within the Hall Ranch area. He felt there were more animals present, but limited visibility made it difficult to see more animals.

LITERATURE REVIEW

Factors Affecting Habitat Use

Specific conditions of a habitat directly influence utilization of the resources by livestock and big game. Due to the complexity of any habitat, no one factor can be solely responsible for ruminant behavior. Cook (1966) found the most important of 21 variables associated with cattle distribution on mountainous terrain were percent slope, distance from water, thickness of brush and the percent palatable species. Loveless (1967) found availability and abundance of browse species, and the proximity of feeding areas to cover to be important.

Physiognomy has been closely correlated with animal distribution. Hedrick et al. (1968) found it difficult to obtain moderate to heavy use by cattle beneath dense overstory canopies. Julander and Jeffrey (1964) reported that brush range, which was little used by cattle due to its density, provided valuable habitat for deer. Loveless (1967) found high densities of deer on upper slopes having heavy shrub cover. Patton (1969) associated differences in deer use relative to topography with variation in vegetation.

The occurrence of ruminants in different habitat types is often influenced by the amount of slope (Mackie, 1970). Cattle distribution decreased as steepness of slope increased on mountainous range in

southwestern Montana (Mueggler, 1965). Cattle preferred lower and middle slopes (Julander and Jeffrey, 1964). In Utah, steepness of slope limited cattle distribution but had little effect on deer movement (Julander and Robinette, 1950). They found the heaviest deer use on steep slopes of 30 percent or more. Most cattle use was on slopes of less than 30 percent.

Food habits of deer, elk, and cattle changed with relative availability of preferred forage species (Edgerton, 1971; Nellis, 1969). During the spring, deer and elk fed mostly on grasslands and open forests where succulent forbs were available (Edgerton and Smith, 1971). Later, as preferred forbs matured, deer and elk shifted almost entirely to forested habitats for food and cover. Availability of forage species was partially dependent upon weather conditions. Climate directly related to plant composition, availability of different forage species, and nutrient composition (Skovlin, 1965). Population trend counts for deer and elk reflected winter weather conditions on summer ranges (Skovlin et al., 1968). Animals used summer ranges longer under mild weather conditions. Skovlin et al. (1968), and Morris and Schwartz (1957) also found spring or fall drought reduced the amount of grassland use by cattle, elk, and deer during the spring, summer and fall. DeNio (1938) reported cold winds and low temperatures to be more influential on deer and elk foraging movements than snow conditions. Cold winds and low temperatures caused deer and

elk to spend more time in heavy cover.

Factors affecting animal preference or selectivity for forage also play an important role in habitat use by herbivores. Skovlin (1967) found animal forage preference usually followed shifts in nutrient quality. Animal preference for any plant was dependent upon season of use, ecotypic differences, animal function, changes in plant community structure, and many other environmental characteristics (Krueger, 1972).

Livestock and Big Game Interrelationships

A problem concerning land resource managers is the interrelationship between livestock and deer and elk. It is a common belief that livestock grazing is detrimental to deer and elk range. Poor management is probably one of the major causes for this way of thinking.

Julander (1955) defined forage competition between deer and livestock as the conflict for a limited supply of forage which begins with the overuse of important forage species by grazing animals. Four conditions necessary for forage competition to exist are: (1) deer, elk and livestock use the same range; (2) deer, elk and livestock use the same forage plants; (3) forage plants are an important source of forage for either livestock or deer and elk; and (4) forage plants are limited in supply or deteriorating in production

as a result of combined use (Cole, 1958).

Range condition influences the amount of overlap in diets of wild ungulates and livestock (Stoddart and Smith, 1955). On ranges containing insufficient forage, cattle utilize browse for a major portion of their food supply (Theilenus and Hungerford, 1967; Julander, 1958). In the Blue Mountains, Edgerton and Smith (1971) found competition on an overstocked cattle range was most likely to occur in the open forest (Pinus ponderosa, Pseudotsuga menziesii with Calamagrostis rubescens), during summer and fall when both cattle, deer and elk were using the same habitat. On depleted, overstocked range in Utah, plant species making up 92 percent of the cattle diet accounted for 99 percent of the deer diet (Julander, 1955). On a good condition aspen-browse site moderately populated with deer and stocked with cattle, species that made up 100 percent of the cattle diet composed 10 percent of the deer diet.

Competition varied with the environmental factors characterizing a particular habitat. Factors that affected the extent to which deer and livestock utilized the same areas were steepness of slope and roughness of topography, water supply, forage composition, and management practices (Urness, 1966). Mackie (1970) found competition between mule deer and cattle was limited by broad differences in food and range use habits in the Missouri River Breaks, Montana. In Utah deer often utilized large areas inaccessible to cattle due to

topography or lack of water (Julander, 1958).

Different levels of cattle grazing altered patterns of deer and elk use (Skovlin et al., 1968). Elk forage preference was closely related to numbers of plants ungrazed. Increased stocking intensities of cattle had no significant effect on deer use but did decrease elk use (Skovlin and Harris, 1970). It was apparent that cattle management had a decided impact on the availability of forage for elk.

Balanced grazing pressure on shrub and understory vegetation is essential if a stable plant community is to be maintained. Competition from the understory can reduce shrub growth and increase mortality of browse seedlings. Removal of perennial grasses and weed understory caused a dramatic increase in the leader length of bitterbrush (Hubbard and Sanderson, 1961). On properly stocked sites, browse was in healthier condition than on areas where livestock were excluded (Smith, 1949). Gibbens and Schultz (1962) studied three similar areas on a burn; one site was totally protected, one protected from just cattle, and one remained open. The mortality rates for browse seedlings were 46 percent in the deer-cattle exclosure, 68 percent in the cattle exclosure, and 36 percent in the open area. Light browsing by cattle in the spring and early summer maintained browse in an available form for deer (Hedrick et al., 1971). The Oregon State Game Commission (1970) found summer cattle grazing an essential tool for maintaining quality elk habitat. Thick

mats of grass unpalatable to elk formed on meadows where summer cattle use was removed. Elk were found to prefer adjacent meadows used for summer cattle range. Meadows utilized by cattle provided higher levels of succulent regrowth in the fall.

Cattle and big game utilized many of the same plant species in the Blue Mountains (Skovlin et al., 1968; Edgerton, 1971). But total use did not reach detrimental levels on any of these forage plants. Competition for grasses between deer and livestock probably was important only when grass species were in a succulent stage during spring and no other forage was available in quantity (McMahan, 1964). Stevens (1966) found bluegrasses were used heavily by both elk and cattle although he did not indicate direct competition between the two. Late in the summer, elk sedge was probably the only species preferred by both cattle and big game in the Blue Mountains (Skovlin and Harris, 1970).

Big Game, Cattle, and Logging

Proper management of logged areas will dramatically increase the quantity and quality of forage since mature forests monopolize sunlight and soil nutrients. In western Oregon, elk and deer populations were in direct proportion to the amount of land logged within the previous 15 years (Harper, 1973). Plant succession can be manipulated to benefit deer by rotation cutting since deer are considered a

seral species (Leopold, 1950). The U.S. Forest Service estimated a four-fold increase in the deer population since the mid-1940's in the national forests of Oregon (Hansen and Smith, 1970). The increase coincides with patch cutting of Douglas-fir stands.

Porter (1959) reported the Fool Creek deer herd in central Colorado decreased for two years after logging. Ten years later, Wallmo (1969) found approximately a two-fold increase in deer use on Fool Creek as on adjacent unlogged watersheds. He reported cut strips received three times as much use as uncut strips. Deer obtained 63.3 percent of their forage from cut strips, 27.4 percent from uncut strips, and 9.3 percent from logging roads (Wallmo et al., 1972). On a clearcut, deer use increased three times and elk use six times to what it was prior to logging (Patton, 1969). Maximum development of deer forage occurred six years after logging in northern Arizona, and declined to original levels in 15 years (Reynolds, 1962a). Forage peaked six to eight years after logging on Vancouver Island, and declined to original levels in 20 to 40 years (Pengelly, 1963). In eastern Oregon, logged areas should provide approximately 20 years of grazing before forage is significantly reduced by cover from maturing forests (Anonymous, 1971). Hooven (1973) reported elk use of clearcuts increased gradually after timber was removed and peaked five to seven years after logging. He found deer used these areas longer than elk since browse continued to increase 15 to 20 years

after logging.

On forested game range, forage diversity was often the key to habitat quality (Lay, 1969; Zeedyk, 1969). Reynolds (1962b, 1966) found the abundance and variety of forage available in a clearcut attracted deer and elk. Edgerton (1972) reported forage was the obvious attraction in clearcuts for deer and elk. He found adjacent unlogged stands provided excellent cover while selectively logged stands lacked volume and variety of forage, and hiding cover to attain much use from deer and elk. Mixed coniferous forest in the Wallowa Mountains producing 100-200 pounds per acre of forage increased production ten-fold after logging and seeding (Hedrick et al., 1971). However, where logging activities exposed subsoil, herbage production was only one-third as much as areas where the soil surface had not been greatly disturbed after logging (Wood, 1972).

An effective method of increasing forage production on newly logged areas was seeding. The benefits of planting forage were erosion control, increasing the aesthetic values of logged areas, improvement of deer and elk habitat, and improvement of livestock grazing opportunities (Sassaman, 1972). Seeded grasses grew in place of low value forage that seed in naturally, such as bull thistle (Pettit, 1968; Sassaman, 1972). Hungerford (1965) reported deer fed heavily on seeded species such as orchardgrass, wheatgrass species, clover, and sweetclover on the Kaibab Plateau. Pettit (1968) found cattle

preferred orchardgrass over other seeded species in northeastern Oregon.

Grazing large ruminants on timber plantations under proper management can benefit tree growth. Clipping understory vegetation increased both tree growth and water-yield (Barret, 1970). Hedrick and Keniston (1966) reported that carefully controlled grazing conserved soil moisture, thereby influencing the growth of planted Douglas-fir. After ten years, trees on grazed plots averaged 25 inches or 27 percent taller than their counter-parts on ungrazed plots. Complete removal of herbaceous competition resulted in increased survival and growth of tree seedlings (Pearson, 1942). Edgerton (1971) concluded that summer grazing by deer, elk, and cattle can be compatible with reforestation practices. He found that generally only the tips of a few needles were lightly browsed, with occasional instances of terminal buds being broken off. Causes of seedling mortality were: trampling, five percent; porcupine girdling, 14 percent; gopher damage to roots, 48 percent; and undetermined, 33 percent. Deer have been reported to consume measurable quantities of conifer seedlings when food supplies were low (Hansen and Smith, 1970; Cliff, 1939). Hansen and Smith (1970) reported browsing damage to Douglas-fir by blacktailed deer coincided with snow cover. Douglas-fir was also browsed heavily during bud burst when certain oxygenated monterpenes such as citronellal, linlool, and citronellol alcohols, which

inhibit rumen micro-organisms, were absent in new growth (Longhurst et al., 1968).

Management objectives should be considered when guidelines are being established for a timber harvest. For the benefit of livestock, timber sale contracts should be written so that trails are left clear, cull logs are positioned properly, and slash or logging debris are removed (Hedrick et al., 1968). Utilization of timothy by cattle varied greatly according to accessibility of forage (Edgerton, 1971). Slash should not cover more than ten percent of the logged area to allow for maximum forage yields (Clary, 1972). Clary and Larson (1971) reported deer were more reluctant to move into clearcuts if slash had been removed on logged ponderosa pine communities in Arizona. However, burning slash did increase the diversity of plant species, and created a more adequate diet for deer and elk (Komarek, 1967). Burning slash also increased essential nutrients: N, Ca, P, and Mg (Hooven, 1973).

The optimum size of a clearcut is difficult to determine. It would vary with management objectives, slope, and habitat characteristics. Hooven (1973) claimed the determining factors relating to animal abundance and tree regeneration were the amount and type of edge. Pellet groups indicated use in natural forest openings was greater 600 feet into the clearing for deer and 800 feet for elk than in bordering forests (Reynolds, 1972). He also reported the largest

desirable opening for deer and elk would be a 24 acre square or a strip no wider than 1, 200 feet. Halls (1970) reported although many wildlife biologists feel 30 to 40 acres would be the optimum size for big game use, 50 to 100 acres would be more practical for multiple use purposes.

Understory - Overstory Vegetation Relationships

Tree overstory strongly affects the ecological characteristics of understory vegetation in forested communities. Overstory canopy directly affected the amount of sunlight and through-fall rain that reached the ground (Jameson, 1967). Overstory density accounted for more variation in herbage yield than either basal area or stems per acre of trees (Hedrick et al., 1968).

Shallow rooted herbs were affected by the amount of precipitation penetrating overstory canopy directly overhead. Anderson et al. (1969) found a decrease in tree canopy density from 84 percent to 74 percent, increased moisture by 50 percent in the organic layers after a light rainfall.

It takes approximately five years for ponderosa pine seedlings to gain dominance over grass cover (Arnold, 1950). In 20 years, density of grasses was reduced by 25 percent. Arnold (1950) reported density of herbaceous vegetation was five times greater under a ten percent tree canopy than under a 100 percent tree canopy. Thompson

and Gartner (1971) found warm season grasses in the Black Hills of South Dakota to be more drastically affected by a change in canopy cover than cool season species. Pase (1958) reported a decline of Kentucky bluegrass from 191 pounds per acre in an open ponderosa pine canopy to one pound per acre in a closed canopy. Sedges (Carex sp.) decreased from 139 pounds per acre in the open pine canopy to 26 pounds per acre in the closed canopy. The relationship of percent canopy to pounds of understory produced varied from one area to the other. Cooper (1960) measured a loss of 21 pounds per acre for every one percent increase of ponderosa pine canopy in Arizona while McConnell and Smith (1965) associated only a six pound to the acre loss for every one percent increase in pine canopy cover in eastern Washington.

Vegetation composition also changed with canopy cover. Only small amounts of grass were found under canopies greater than 75 percent (Cooper, 1960). McConnell and Smith (1965) found forbs dominated the understory when ponderosa pine canopy was greater than 45 percent, while grasses were dominant under a canopy of less than 45 percent.

Large herbivores usually showed a higher preference for forage established in forest openings than vegetation growing beneath a dense tree overstory. Elk preferred open ponderosa pine stands with higher herbage yields and lower tree basal area levels than closed ponderosa

pine stands (Clary and Larson, 1971). Hedrick et al. (1968) reported difficulties obtaining even use by cattle on available forage in forested and non-forested communities. Animals preferred sites with low density tree canopy cover. McEwen and Dietz (1965) attributed heavier grazing on meadow vegetation, in comparison to available forage on forested sites, to the lower palatability of shaded forage. This lower palatability was indicated by lower percentages of nitrogen free extract. Plants grown in shade usually had the following characteristics compared to those same species growing in the sun: lower percentage of nitrogen free extract, lower production, higher percentage of lignin, and higher percentage of protein (Vallentine and Young, 1959; Halls and Epps, 1969).

Food Habits

Although numerous papers have been published concerning big game food habits, the majority of these pertain to winter range. Only a small percentage provide a detailed account of big game food habits on spring, summer, and fall ranges. Information on diet composition for cattle grazing logged and unlogged communities is also limited. Taylor (1956) believed the emphasis placed on woody plants in the winter diet of mule deer often led to underestimating importance of herbaceous species. Kufeld (1973) found little information available on spring use of major forage classes by elk outside of Montana.

The composition of cattle, elk, and deer diets showed distinct seasonal changes. Consumption by deer and elk of shrubs and conifers decreased sharply when grasses greened-up in the spring (DeNio, 1938). During frost-free periods, grasses and forbs provided important sources of deer food (Taylor, 1956). Stevens (1966) reported grasses constituted approximately 80 percent of the diet of elk during spring. During summer, forbs increased in the diet as deer and elk moved from grasslands into forested communities in northern Arizona (Arnold, 1950). Cattle maintained a high level of grass species in their diet throughout the summer. Utilization of browse by big game increased in fall. Edgerton (1971) and Skovlin et al. (1968) reported, elk grazed largely on elk sedge while deer mainly consumed Sandberg's bluegrass in the fall. Lack of fall growth decreased the amount of grass consumed by both deer and elk (Morris and Schwartz, 1957). Lovass (1958) reported grasses made up a minor portion of the fall diet for deer.

Timber Grazing

An important management goal on foothill rangelands is integrating deer, elk, and cattle use to optimize forage resources. Management should harmonize grazing use with such resource values as watershed, recreation, wildlife, and timber. One of the biggest problems in grazing forested areas was obtaining uniform utilization

of forage species across different habitat-types.

Proper season of use was an important consideration in obtaining improved patterns of livestock distribution (Hedrick et al., 1968). In early summer, palatable forbs were at peak production on less preferred forested communities. Studies of seasonal preference and use patterns in the Blue Mountains showed cattle utilized grasslands heaviest during early summer and fall (Harris, 1954; Skovlin, 1968). During mid-summer, they preferred plants in forested areas. Pickford and Reid (1948) reported cattle readily grazed Sandberg's bluegrass in open grasslands during spring and early summer.

Cattle showed distinct preferences toward certain habitat types. Use of local areas was dependent upon forage availability, water supplies, and weather conditions (Mackie, 1970). Cole (1958) reported livestock tended to concentrate on parklands and meadows adjacent to water. Although water distribution was not a significant factor in determining deer and elk distribution, it was closely related with cattle distribution (Mackie, 1970).

It was common to find light or no use on herbaceous vegetation by livestock in heavily shaded areas (Hedrick et al., 1968). They further reported cattle preferred the following areas in descending order: (1) open areas; (2) edges of tree stands where they seek shade; and (3) under dense canopies. Deer, however, consistently preferred the forested areas over grassland openings, while elk showed no

special preference (Skovlin et al., 1968; Mackie, 1970). This variability of preference for different plant communities made it difficult to obtain uniform utilization of forage. Bunchgrass species suffered greater losses within forest openings and under lighter amounts of ponderosa pine canopy than under heavier tree cover (Arnold, 1950). Since cattle preferred open areas, pinegrass and elk sedge ranges were seldom heavily grazed (Pickford and Reid, 1948). They felt that overgrazing on hawkweed (Hieracium Scouleri) and elk sedge, and deterioration of open areas would occur if proper utilization by cattle on these forested sites was to be obtained. Under heavy stocking elk sedge, an important forage species for both cattle and elk, diminished production by 50 percent (Skovlin and Harris, 1970).

Livestock management practices to improve patterns of forage use in these areas of relatively steep topography and dense timber, fall into four main categories: (1) facilitating actions; (2) selection of livestock; (3) methods to improve livestock distribution; and (4) proper season of use (Hedrick et al., 1968). Management tools for improving livestock distribution include fencing, water development, integration of logging and grazing plans, reseeding, rotation grazing, salting, and riding (Hedrick et al., 1968; Arnold, 1950; Harris, 1954). In northeastern Oregon, best gains were obtained at the peak of plant growth when percent dry matter content was maximum. This was the period when steers, which effectively utilize rough and relatively

inaccessible areas, were most effective in grazing the range uniformly (Young et al., 1967). Forested areas were most effectively used by steers, replacement heifers, dry cows, and cows with calves, in decreasing order of efficiency.

METHODS OF STUDY

Vegetation Analysis

A 360 acre pasture on the east side of the Hall Ranch was delineated into ten plant communities. Divisions were partially based on a 1956 classification of vegetation types and soils by Poulton and Anderson (1956). They used the ocular reconnaissance method to describe vegetation types. Soils were sampled with a soil auger.

In the field, vegetation types were further delineated by sampling plant species frequency and canopy cover of the tree overstory. As a result nine stands were delineated for sampling (Figure 1). These stands were: Sandberg's bluegrass - kellogg onion, ponderosa pine - bluebunch wheatgrass, ponderosa pine - snowberry, Douglas-fir - snowberry and grand fir - adenocaulon communities. Three habitat types sampled in the clearcut were: ponderosa pine - snowberry, Douglas-fir - ninebark, and grand fir - pachistima. Two locations on the grand fir - pachistima habitat type were studied.

Seventeen 100 foot transects were placed throughout nine different stands. Three transects were placed in stand 1, two in 2, three in 3, three in 4, one in 5*, one in 6*, one in 3*, two in 6* and one in 7. A 50 foot transect was established perpendicular to each 100 foot transect at the 1, 25, 75 and 100 foot marks. Two transects were established to the left of the 100 foot transect, while the other

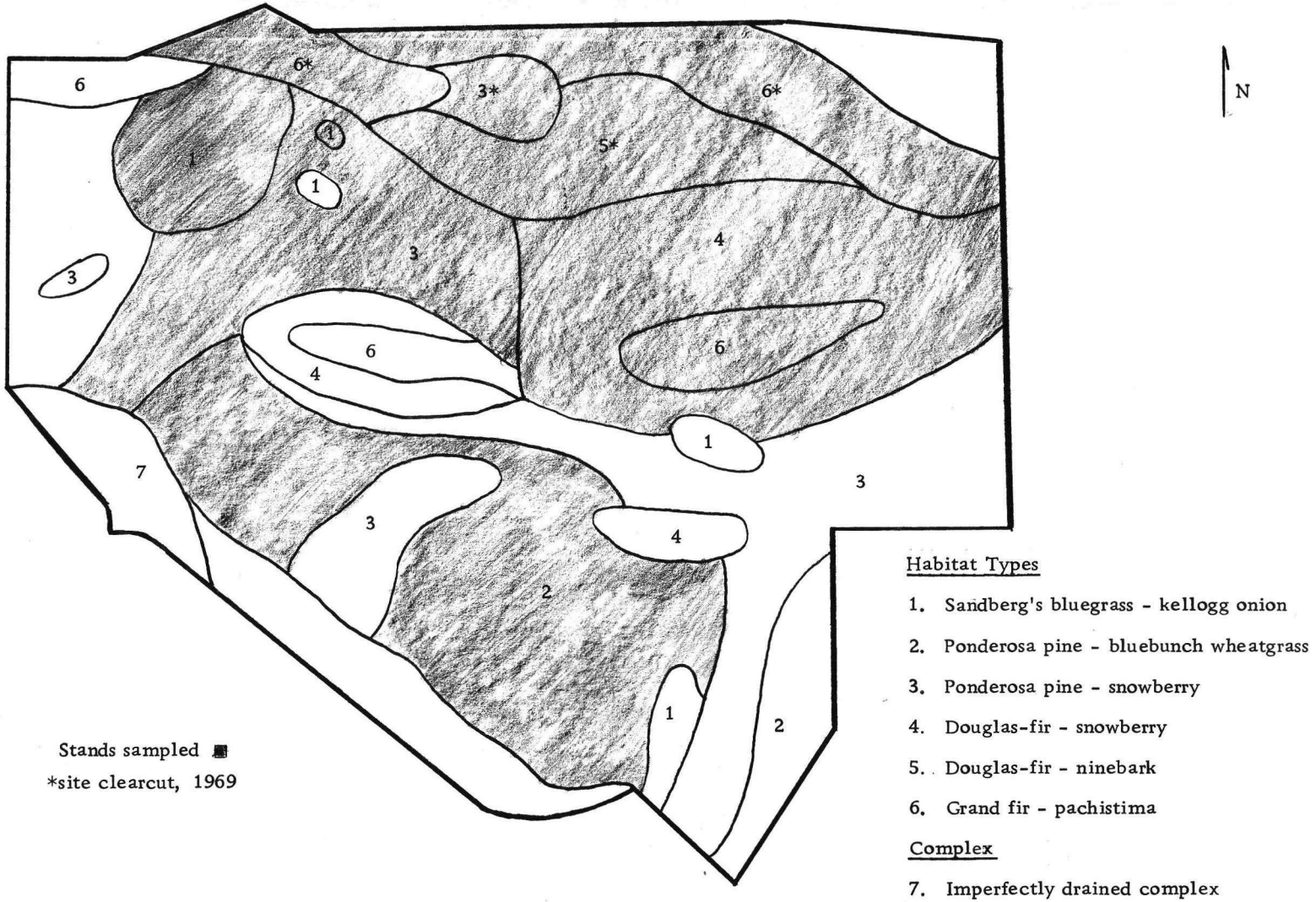

Figure 1. Generalized map of the 360 acre study area on the Hall Ranch.

pair was established to the right. All transects were positioned to avoid crossing ecotones. Frequency of plant species in a 1×2 foot plot were recorded. Samples were taken at intervals of 5 feet on each of the 50 foot transects totaling 40 quadrats per 100 foot transect. All plant species in each vegetation type were listed. Those present in the stand but not occurring in any of the quadrats were recorded as present (P).

Production and Utilization of Herbaceous Vegetation

Nine plant communities were sampled using one representative stand of each in the 360 acre pasture. Utilization of herbaceous vegetation was calculated by the ocular weight estimate method (Pechanec and Pickford, 1937). Samples were taken from forty, 4.8 square foot, circular plots randomly located in each plant community. Twenty of these plots were placed in one acre cattle exclosures to determine percent utilization of herbaceous vegetation by big game only. The remaining 20 were situated outside of the exclosures to determine percent utilization by both cattle and big game. Utilization and production plots were randomly located on pellet transects. Percent utilization of current annual growth for each species was estimated separately. Plots were randomly clipped to check for accuracy. Five estimates of utilization were made through

the spring, summer and fall of 1973. The measurements were taken just as the snow was melting in the spring; prior to flowering; before cattle were placed on the range; immediately following removal of cattle; and in fall.

Two methods were used to measure total production of herbaceous vegetation available to ruminant animals. First, total green weight produced was estimated on 20 of the 40 ocular weight estimate plots. Ten of these plots were examined on the area used only by big game and ten on the area used by deer, elk and cattle. These estimates were made concurrently with estimations of utilization. Samples of each plant species were collected in the field, oven dried at 60° C for 48 hours, to convert measurements into dry weight. Second, caged plots were used for determining production of vegetation also available to ruminant animals (Brown, 1954). Ten wire cages protected ten randomly selected 4.8 square foot circular plots from being grazed in each stand. Each species occurring on these plots was estimated for production.

Production and Utilization of Browse Species

Utilization and available production were measured for all browse species in each stand. Eight belt transects, 160 feet by 4.4 feet, were located on the pellet transects established in each plant

community. Another belt transect of the same dimensions was placed inside each one acre cattle exclosure. Shrubs were estimated for utilization and production only within the canopy available for cattle or big game use. Only shrubs with the main stem within the transect were measured.

Forage production was estimated by mentally dividing the plant into quarters or eighths. Current year's growth was measured in centimeters on this portion of the plant. A sample of each shrub was clipped and oven dried at 60° C for 48 hours to convert centimeters into pounds of dry weight.

Utilization was measured within the same transects. The percentage of new growth removed from each plant was estimated. These measurements were converted into pounds dry weight utilized per acre for each species. (% utilization × lbs dry matter produced/ acre = lbs dry wt. utilized/ acre).

Measurements of utilization and available production were collected during three different time periods. These periods were: prior to the stocking of cattle, after cattle removal, and late fall.

Pellet Transects

Pellet group counts were made on nine belt transects 150 feet long and 4.4 feet wide located in each stand (Neff, 1968). Deer pellets, elk pellets, and cow chips were counted. One of the nine

transects was placed inside the cattle exclosure for each stand sampled. This transect measured possible differences in pellet counts from transects on the outside of the exclosure. Counts on all ten transects were accumulative. The difference between the last count and the current count was assumed to represent the number of pellets added between counts. Transects were established parallel to contours. They were distributed equal distance from one another and from one end of the stand to the other.

Pellet transects were established and cleared during mid-August, 1972. Pellet counts were made concurrently with utilization and production estimates in 1973. Pellet counts were correlated with relative deer and elk use in each community.

Canopy Cover

Canopy cover of the tree overstory was measured on each production plot with a Type C forest densiometer (Lemmon, 1956). Effects of shade on vegetation composition, phenology, production, and utilization within and among plant communities were evaluated.

Exclosures

A single one acre cattle exclosure (208×208 feet) was placed on representative areas in seven of nine stands studied. These stands were (1) ponderosa pine - bluebunch wheatgrass; (2) ponderosa

pine - snowberry; (3) Douglas-fir - snowberry; (4) ponderosa pine - snowberry habitat type (clearcut); (5) Douglas-fir - ninebark habitat type (clearcut); and (6) two on the grand fir - pachistima habitat type (clearcut). Exclosures were not placed on the grand fir - adenocaulon stand or the Sandberg's bluegrass - kellogg onion stand because of their limited size. Within the exclosures, 20 plots were used to estimate utilization and 10 plots were used to estimate production. Utilization of forage on the inside of the exclosure was recorded as deer and elk use unless it could be otherwise accounted for. Forage utilized on the outside of the exclosure was recorded as both big game and cattle use.

Soils

Soil surveys conducted on the Hall Ranch in 1956 (Poulton and Anderson, 1956) and again in 1965 (Vance et al., 1965) were used to describe soil characteristics. The characteristics used in this study were soil depth, texture and parent material.

Phenology

Biological periodicity of plant species within each plant community was recorded throughout the spring, summer and fall (West and Wein, 1971). Phenological stages, such as development of new foliage, flowering, pollination, and seed dissemination were recorded

during each sampling period. Phenology data were taken on the 40 utilization plots in each stand. Frequency of use and the amount of plant material removed were compared with the phenological stage or stages within the time period prior to the current measurement for each species.

Slope

The most representative slope in each stand was described with respect to aspect, length, and steepness. Percent slope was measured with a hand level (Mosby, 1971). Aspect and percent slope were measured at the approximate center of each stand. Pellet transects, utilization plots and animal observations were used to evaluate the effects of slope on animal distribution and the amount of vegetation removed.

Weather

Long term climatological records of the northeastern Oregon area can be obtained from Union, Cove and Elgin, Oregon (U. S. Dept. of Commerce, 1909-1973). Only general trends can be implied from these weather records to the study area due to variations in climatic conditions over the mountainous topography. Variations in precipitation were recorded on a monthly basis during 1972 and 1973 in a rain guage adjacent to the study area.

Water and Saltlicks

Effects of water and saltlick locations on animal distribution in relation to each stand were evaluated (Cook, 1966). Distances were measured from the center of each stand to water or salt facilities. Distances were correlated with forage utilization and pellet group densities.

Diet and Relative Preference Index

The percentage of each plant species in the diet and relative preference index (RPI) for each species were calculated for big game (deer and elk) and cattle. Diets were determined from measurements of cattle and big game utilization (Laycock et al., 1972):

$$\% \text{ diet} = 100 \times \frac{\% \text{ utilization} \times \% \text{ composition}}{\Sigma\ (\% \text{ utilization} \times \% \text{ composition})}$$

Animal preference for each plant species was evaluated with a relative preference index (Krueger, 1972):

$$\text{RPI} = \frac{\% \text{ diet}}{\% \text{ comp.}}$$

This was a ratio between percent composition of a plant in the animal's diet to percent composition of the plant on the range.

Statistical Analysis

Four statistical methods were used as tools to aid in interpretation of data. They were simple linear regression, multiple regression (backstep technique), analysis of variance (completely random), and Duncan's test.

Analysis of variance and Duncan's test (Steel and Torrie, 1960) were used to determine differences among sets of data at the 95 percent confidence level. Production during the spring, summer and fall; percentage and pounds of forage utilized by big game; percentage and pounds of forage utilized by cattle; percentage and pounds of specific species utilized by big game; percentage and pounds of specific species utilized by cattle; production of palatable forage for big game; production of palatable forage for cattle; cow chip densities; deer pellet group densities, and elk pellet group densities were examined with analysis of variance (completely random) and Duncan's test.

For simple correlation of two variables, linear regression was used (Draper and Smith, 1966). Canopy cover was correlated with forage production, and percentage and pounds utilized by big game and cattle in each stand. Deer and elk pellet group densities and cow chip density were also correlated with canopy cover. Linear regression was also used to correlate pounds and percentage big

game utilization versus cattle utilization; cow chip densities versus elk pellet group densities; cow chip densities versus deer pellet group densities; and elk pellet group densities versus deer pellet group densities among plant communities.

Multiple regression was used to evaluate the effects of numerous factors in the environment on some dependent variable. The backstep technique or backward elimination procedure was used (Draper and Smith, 1966). Dependent variables analyzed were forage potential, production of preferred species for big game, production of preferred species for cattle, big game forage use, cattle forage use, elk pellet group distribution, deer pellet group distribution and cow chip distribution. Observations input into multiple regression equations were the means for each community due to unequal sample sizes. For example each production observation was the mean from a sample size of 30 plots in each stand. This enabled variables such as soil depth, aspect, slope and distance to water, where only one measurement for each community was recorded, to be evaluated. Limiting the sample size increased the values of correlation coefficients (Draper and Smith, 1966). This was mainly due to removing the variability of samples within communities by using means, and limiting the number of observations.

Throughout the thesis the term significant refers to the 95 percent confidence level unless otherwise stated.

RESULTS AND DISCUSSION

Herbage and Browse Production

Herbage production on foothill rangelands was highly variable among different plant communities. Each plant community existing under a different set of ecological factors was characterized by a certain level of herbage potential and a diverse set of dominant species. For the purpose of a more organized discussion, the nine stands were combined into three groups based on herbage production and physiognomy. These assemblages were the clearcut group, the bunchgrass group and the forested group. Habitat types in the clearcut group were represented by ponderosa pine - snowberry, Douglas-fir - ninebark, and two sites on the grand fir - pachistima habitat type, one at the base and one on top of a slope. The constituents of the bunchgrass group were a Sandberg's bluegrass - kellogg onion stand and a ponderosa pine - bluebunch wheatgrass stand. The forested group, having a canopy cover of 50 percent or greater, was made up of a ponderosa pine - snowberry stand, a Douglas-fir - snowberry stand and a grand fir - adenocaulon stand. Herbage production for the 1973 growing season was represented by an abnormally low level of annual species due to drought conditions (Figure 2).

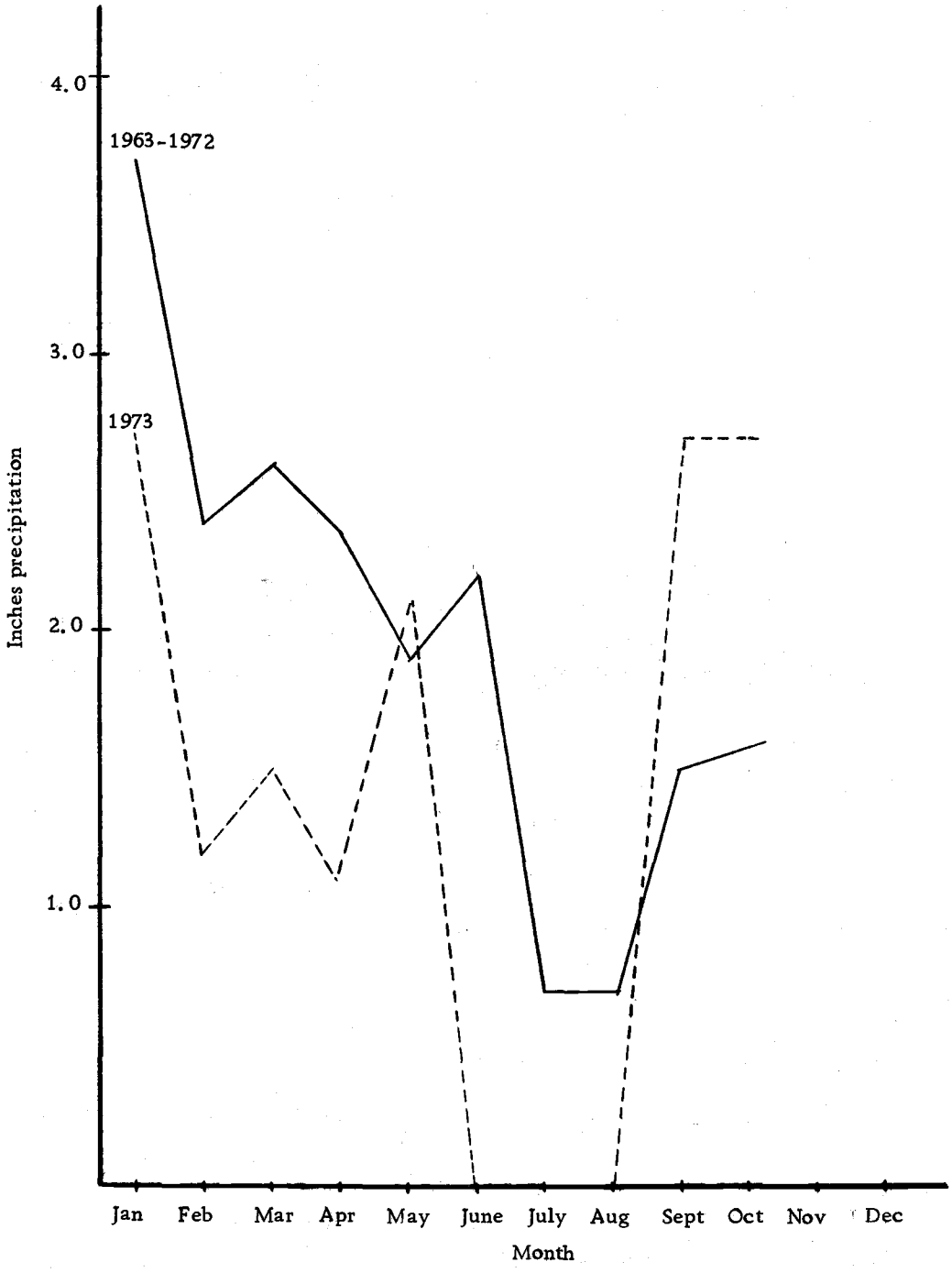

Figure 2. A comparison of precipitation deviation between a 10 year average and 1973 on the Hall Ranch.

Herbage and Browse Production Among Communities

Total production of herbaceous and shrubby species during peak growing season in the nine stands, segregated into three significant groups (Table 1). These were bunchgrass, forest and clearcut groups. Production ranged between 311 to 314 pounds per acre on the bunchgrass stands, 63 to 125 on the forest stands, and 513 to 604 on the clearcut stands.

Production averaged 312 pounds per acre in the bunchgrass communities. Both the Sandberg's bluegrass - kellogg onion and ponderosa pine - bluebunch wheatgrass stands were characterized by shallow rocky soils with south to southwest exposures. Herbage production was high on these sites in relation to forested communities although they were relatively more xeric than other foothill rangeland communities. Canopy cover of the tree overstory was less than five percent so light interception was not a limiting factor to understory growth.

On the Sandberg's bluegrass - kellogg onion stand depth of the Chop silt loam soils averaged only five inches. Hard rock andesite was exposed throughout the community. Herbage production on this xeric site averaged 314 pounds per acre. Fifty percent of this production was Sandberg's bluegrass. Onespike danthonia and field woodrush represented 22 percent of the community. Production of

Table 1. Production of understory vegetation in nine plant communities during spring and early summer, 1973 on the study area.

	Production (lbs/A)		
	March	May	July[1]
Bunchgrass communities			
Sandberg's bluegrass - kellogg onion	10	49	314[a][4]
Ponderosa pine - bluebunch wheatgrass	20	106	311[a]
Forest communities			
Ponderosa pine - snowberry	15	38	125[b]
Douglas-fir - snowberry	16	34	123[b]
Grand fir - adenocaulon	11	25	63[b]
Clearcut habitat types			
Ponderosa pine - snowberry	11	156	513[c]
Douglas-fir - ninebark	9	117	564[c]
Grand fir - pachistima[2]	8	167	525[c]
Grand fir - pachistima[3]	16	249	604[c]

[1] The only period which includes production of browse.

[2] Stand at the top of the slope.

[3] Stand at the bottom of the slope.

[4] Pounds of production followed by the same letter were not significantly different at the $P < 0.05$ level.

forbs and annuals was probably below normal due to a dry spring. The two most conspicuous forbs were kellogg onion and yarrow constituting six percent of the herbaceous layer. This community was first to initiate growth in spring and first to cease growth in summer.

Tree canopy cover in the ponderosa pine - bluebunch wheatgrass stand averaged four percent. After a fire in 1949, tall oatgrass was seeded to the area. Established for 24 years, this species constituted eight percent of the community. Bluebunch wheatgrass, Idaho fescue, Sandberg's bluegrass and Kentucky bluegrass dominated the herbaceous layer constituting 70 percent of the total production. Conspicuous non-grass species were yarrow, cusick peavine and snowberry. This community is probably in an upward trend as inferred from frequent occurrence of young bluebunch wheatgrass plants.

The driest of the three forested communities was the ponderosa pine - snowberry stand. This community produced 125 pounds of understory vegetation beneath a 57 percent tree canopy cover. The most important understory species was elk sedge which represented 34 percent of the total production. Other important species were cusick peavine, shinyleaf spiraea and snowberry making up 39 percent of the understory. Soils were 16 to 20 inches deep with bedrock exposed throughout the stand.

The understory in the Douglas-fir - snowberry stand was very similar to that of the ponderosa pine - snowberry stand. Production averaged 123 pounds per acre and tree canopy 73 percent. Elk sedge constituted 43 percent of the understory. Other important species collectively comprising 38 percent of the understory were western fescue (Festuca occidentalis), onion grass (Melica bulbosa), pine-grass, cusick peavine and shinyleaf spiraea. Snowberry sharply dropped in importance as compared with the ponderosa pine - snowberry stand.

Understory production in the grand fir - adenocaulon stand averaged 63 pounds per acre. Heavily shaded by a 91 percent tree canopy, this stand produced the lowest level of understory vegetation in the study area. The grand fir - adenocaulon stand was located on a north facing slope and growing in deep Tolo soils. The presence of adenocaulon, western meadowrue, rattlesnake plantain, twinflower (Linnaea borealis) and big huckleberry (Vaccinium membranaceum) indicated a high soil-water potential. The three species of greatest importance were elk sedge, adenocaulon and shiny-leaf spiraea. They made up 55 percent of the understory.

Production in the clearcut communities was significantly higher than any of the other stands measured in the study area. Combined production of herbaceous and woody species averaged 542 pounds per acre. Timothy, orchardgrass, blue wildrye, smooth brome,

tall oatgrass and white Dutch clover were seeded after slash was burned in 1970. Seeded species provided an abundant source of forage to large herbivores, and accounted for 45 percent of the total vegetation produced on the clearcut.

The ponderosa pine - snowberry habitat type in the clearcut produced a lower level of forage than the other logged sites. Situated on a south exposure, this site was relatively more xeric than the other three stands in the logged area. Timothy was the only planted species that germinated with some amount of success, constituting 10 percent of the herbaceous layer. Low germination was attributed to relatively lower moisture availability and heavier competition from Kentucky bluegrass than on other logged sites. Kentucky bluegrass was established prior to clearcutting and made up approximately 27 percent of the understory. Bull thistle, a biennial, mainly present in the rosette stage, comprised about 20 percent of the understory (and produced 103 pounds of forage per acre).

Germination of seeded grasses was better on the moister Douglas-fir - ninebark habitat type than the ponderosa pine - snowberry habitat type, although competition from Kentucky bluegrass was still high. Both timothy and orchardgrass made up 28 percent of the herbaceous layer while Kentucky bluegrass represented 24 percent of the layer. Both mullein and bull thistle collectively constituted 31 percent of the herbaceous vegetation.

Seeded species established themselves successfully in the grand fir - pachistima habitat type where they were exposed to adequate moisture and little competition from previously established species. Plant species established on these sites prior to logging were low in density due to light interception by a dense tree overstory. Most species occurring in these communities such as adenocaulon, twinflower, and western meadowrue are adapted to dense shade. With the removal of the tree overstory they were unable to compete against seeded grasses. Production peaked at 604 pounds per acre on the lower site and 525 pounds per acre on the upper site. Orchardgrass, timothy, blue wildrye, tall oatgrass and smooth brome constituted 74 percent of the herbaceous layer on the upper site and 56 percent on the lower site. Bull thistle made up 16 percent of the herbaceous vegetation on the upper site and 27 percent on the lower site.

Browse accounted for only a small percentage of total understory production throughout the study area. The Douglas-fir - ninebark habitat type in the clearcut was the only stand that contained substantial amounts of browse. This site produced 21 pounds of new growth annually per acre, significantly more than any other stand (Table 2). Ninety five percent of this production was ninebark. The three remaining logged communities and the grand fir - adenocaulon stand averaged between three and six pounds of browse

Table 2. Pounds per acre of woody species produced annually in each stand on the study area in 1973).

	Production (lbs/A)
Bunchgrass communities	
Sandberg's bluegrass - kellogg onion	0[a][1]
Ponderosa pine - bluebunch wheatgrass	1[a]
Forest communities	
Ponderosa pine - snowberry	0[a]
Douglas-fir - snowberry	2[ab]
Grand fir - adenocaulon	4[c]
Clearcut habitat types	
Ponderosa pine - snowberry	5[c]
Douglas-fir - ninebark	21[d]
Grand fir - pachistima[2]	3[bc]
Grand fir - pachistima[3]	6[c]

[1]Production followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

production per acre. The most important browse species were ninebark, redstem ceanothus (Ceanothus sanquineus), and oceanspray. Browse occurred in trace amounts on the two bunchgrass stands, and the ponderosa pine - snowberry stand and Douglas-fir - snowberry stand. Hedrick et al. (1968) reported that approximately 100 pounds of browse will produce one pound of new growth annually.

Factors Affecting Herbage and Browse Production

Two environmental factors correlating highly with understory production were canopy cover and soil depth (Table 3). Soil depth appeared directly related to soil water-potential in each plant community. As soil depth increased plant species requiring a moist environment increased. Soil depth was positively correlated with tree canopy cover. The shallowest soils, Chop silt loam series supported bunchgrasses and a few stunted ponderosa pines. In deep Tolo soils, moisture dependent species such as grand fir, adenocaulon, western meadowrue and twinflower were found. In the unlogged communities, tree overstory had a linear correlation coefficient of -0.99 with understory production. In these foothill rangeland communities, trees increasingly dominated the physiognomy as soil depth increased. Since deeper soils provided more suitable conditions for tree growth, low availability of sunlight was a major limiting factor to forage production in forested communities. When canopy cover was

removed forage production increased with soil depth. Stands with deeper soils had the greatest potential for forage production. Soil depth and canopy cover together accounted for 96 percent of the variability in understory production in both logged and unlogged stands. Potential of forage production can be estimated by knowing soil depth and tree canopy cover in foothill rangeland communities.

Table 3. Variables correlated with pounds of understory vegetation produced in each plant community with corresponding accumulated R^2 values.

	R^2
Canopy cover	0.77
Soil depth	0.96

Aspect and steepness of slope had no direct significant effect on the variability of understory production in the study area. However these two factors affect water drainage and soil depth, thereby indirectly influencing production and species composition. South slopes contained relatively shallower stony soils while north slopes were covered with volcanic soils. A good example of how slopes affected the vegetation composition was in the Sandberg's bluegrass - kellogg onion stand where slope did not exceed five percent. Species dominating the herbaceous layer were Sandberg's bluegrass, onespike danthonia, and field woodrush. Strickler (1965) reported that certain shallow soils with less than five percent slope cannot support

bluebunch wheatgrass and should be managed for Sandberg's bluegrass and onespike danthonia. Poor soil drainage probably was the limiting factor in this case. Although Chop silt loams were typified by their xeric nature, they become supersaturated for a short period during the spring. This over-saturated condition may be the limiting factor for bluebunch wheatgrass.

Fall Regrowth

Personnel of Oregon State Game Commission in La Grande feel that regrowth of herbaceous species in the fall is essential to big game (Michael Kemp, 1973, personal communication). Fall growth provides animals with a high quality diet for a short period prior to winter. When, and how much, new-growth herbaceous forage is provided is dependent on weather conditions.

Communities with the highest levels of fall regrowth had little if any canopy cover (Table 4). The clearcut averaged 27 pounds of fall growth per acre. This was almost twice as high as any other community in the bunchgrass or forested groups. Production in the clearcut ranged from 13 pounds per acre in the grand fir - pachistima habitat type at the top of the slope to 44 pounds in the grand fir - pachistima habitat type at the bottom of the slope. Forty-four pounds of fall growth on this lower site was significantly higher than fall growth for any other stand. The most important species generating

Table 4. Fall production by understory vegetation in each stand on the study area in 1973.

	Production (lbs/A) October
Bunchgrass communities	
Sandberg's bluegrass - kellogg onion	17[cd][1]
Ponderosa pine - bluebunch wheatgrass	7[ab]
Forest communities	
Ponderosa pine - snowberry	3[a]
Douglas-fir - snowberry	1[a]
Grand fir - adenocaulon	1[a]
Clearcut habitat types	
Ponderosa pine - snowberry	30[e]
Douglas-fir - ninebark	24[de]
Grand fir - pachistima[2]	13[bc]
Grand fir - pachistima[3]	44[f]

[1]Production followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

fall growth on this site were timothy, orchardgrass and bull thistle. The logged ponderosa pine - snowberry habitat type produced 30 pounds of forage per acre, the second highest level. Kentucky bluegrass made up the greatest percentage of this production. Kentucky bluegrass was also important on the logged Douglas-fir - ninebark habitat type along with timothy and bull thistle.

Bunchgrass sites were also relatively productive, averaging 12 pounds per acre. Sandberg's bluegrass was the main species producing new growth late in the season. The forest sites were very low producers, ranging from less than one pound of fall growth per acre in either the grand fir - adenocaulon stand and Douglas-fir - snowberry stand to three pounds per acre on the ponderosa pine - snowberry stand. Only trace amounts of several species like yarrow and California strawberry (Fragaria vesca) showed any signs of new growth.

The combined effects of percent canopy cover and soil depth explained 62 percent of the variability in fall growth from one community to the other (Table 5). Aspect and steepness of slope apparently had little effect.

Table 5. Variables correlated with pounds of understory vegetation produced in the fall in each plant community with corresponding accumulated R^2 values.

	R^2
Canopy cover	0.51
Soil depth	0.62

Fall growth is highly variable from one year to the next depending on moisture availability and temperature. Adequate moisture from fall rains initiates fall growth. However if precipitation comes to late or cold weather strikes early, little or no fall growth will occur.

Production of Preferred Forage for Big Game

Relative preference of big game for specific plant species was determined during the spring and early summer from a ratio of dietary composition to availability. A preferred species was defined as a plant with a relative preference index rating of two or more. This meant percent composition of a preferred species was at least twice as high in the diet as on the study area. Percent composition of plant species on the area and diet were based over the entire study unit.

The clearcut produced a significantly greater amount of palatable species for big game animals in the spring and early summer than unlogged stands (Table 6). Both the upper and lower sites in the grand fir - pachistima habitat type produced approximately 175 pounds of preferred herbaceous and woody forage per acre. This was significantly higher than any of the unlogged stands. The most important species growing on both logged sites of the grand fir - pachistima habitat type were timothy and smooth brome. Prickly lettuce (Lactuca serriola) was also preferred but availability was

Table 6. Pounds and percent preferred species available for big game in each stand on the study area (March - July, 1973).

	Preferred Forage	
	(lbs/A)	(%)
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	2[a][1]	1
Ponderosa pine - bluebunch wheatgrass	56[ab]	18
Forest communities		
Ponderosa pine - snowberry	22[a]	18
Douglas-fir - snowberry	8[a]	6
Grand fir - adenocaulon	20[a]	32
Clearcut habitat types		
Ponderosa pine - snowberry	156[c]	30
Douglas-fir - ninebark	104[bc]	18
Grand fir - pachistima[2]	169[c]	32
Grand fir - pachistima[3]	186[c]	31

[1]Pounds of preferred forage followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

low throughout the clearcut. Both sites produced only about five pounds of preferable browse per acre.

The logged ponderosa pine - snowberry habitat type produced 156 pounds of preferred herbaceous forage per acre. The most important species to big game on this site was goatsbeard (Tragopogon dubius). Approximately 80 pounds of goatsbeard were produced per acre. This was the only stand where goatsbeard was produced in significant amounts. Timothy, sheep sorrel, and prickly lettuce also occurred in this community. Only a negligible amount of preferred browse was produced on this site.

Although the logged Douglas-fir - ninebark habitat type produced the lowest level of preferred herbaceous species on the logged area, production was higher than in the bunchgrass and forested communities. Production of preferred herbaceous forage averaged 104 pounds per acre. The logged Douglas-fir - ninebark habitat type produced significantly more preferred browse than any other community in the study area. Preferred species of importance occurring on this site were timothy, tall oatgrass, sheep sorrel, and ninebark.

The ponderosa pine - bluebunch wheatgrass stand produced the highest levels of preferred forage on the unharvested stands. Production averaged 56 pounds of preferred forage per acre. Although production was more than twice as high as any other undisturbed stand, differences were not significant. Preferred species on this

site were tall oatgrass, snowberry, junegrass, kellogg onion and orange arnica (Arnica fulgens).

The ponderosa pine - snowberry and grand fir - adenocaulon stands produced about 20 pounds of preferred forage for big game. Snowberry was the only preferred species produced in significant amounts in the ponderosa pine - snowberry stand. Important preferred species in the grand fir - adenocaulon stand were adenocaulon, ninebark and oceanspray. Although this stand only produced 20 pounds of preferred forage per acre this represented 32 percent of the understory. The Douglas-fir - snowberry communities produced only eight pounds of preferred forage per acre.

Factors Affecting Availability of Preferred Forage for Big Game

Relationships between eight independent variables with availability of preferred forage during spring and summer in each community for big game were evaluated. Availability was based on pounds produced per acre and the relative proportion present in the stand. The eight independent variables evaluated for each community were pounds of forage produced per acre, percent tree canopy, soil depth, aspect, distance to water, pounds per acre of forage removed by big game, percent utilized by big game, and density of big game pellet groups.

Pounds of preferred forage produced was strongly correlated with forage production, soil depth, and percent utilized by big game. These three variables accounted for 94 percent of the variability in pounds of palatable species produced in each community (Table 7). As forage production, soil depth and percent forage utilized by big game increased in a community, pounds of preferred available forage increased. Soil depth probably indirectly affected preferred forage by influencing understory production. It is difficult to separate percent forage utilized by big game and availability of preferred forage since they are not totally independent from one another. However the availability of preferred forage species would be expected to influence percent utilization. Communities with higher levels of forage production provided more preferred species than less productive sites.

Table 7. Variables correlated with pounds of palatable species produced for big game in each plant community with corresponding accumulated R^2 values.

	R^2
Pounds of understory produced per acre	0.78
Soil depth	0.89
Percent big game forage utilized	0.94

The same eight variables were correlated with percent palatable species present in a community. Percent forage use by big game, soil depth, distance to water, pounds forage removed by big game,

and forage production correlated highly with percent palatable species present in each community (Table 8). Both percent utilization and pounds utilization by big game were not completely independent from percent palatable species so interpretation was difficult. Availability of preferred forage increased as soil depth and understory production increased. On deep soils in the logged grand fir - pachistima habitat type and unlogged grand fir - adenocaulon stand, palatable species made up 30 percent of the understory composition. However on the unlogged grand fir - adenocaulon stand 30 percent was from a less productive understory. For this reason pounds palatable species per acre in a community was probably a better index to availability of preferred forage.

Table 8. Variables correlated with percent palatable species for big game occurring in each plant community with corresponding accumulated R^2 values.

	R^2
Percent forage used by big game	0.47
Soil depth	0.80
Distance to water	0.83
Pounds removed by big game	0.90
Pounds produced per acre	0.95

Production of Preferred Forage for Cattle

Only a limited number of plant species were rated as being preferred by cattle during late summer. The majority of relative

preference indices ranged from 0.7 to 1.8. The only relatively palatable species in the study area were orchardgrass, blue wildrye, and field woodrush. Of these three, orchardgrass was the most important making up 12 percent of the total forage composition.

The highest level of production of palatable species for cattle was on the two sites on the grand fir - pachistima habitat type in the clearcut (Table 9). These two stands averaged about 260 pounds of palatable forage per acre which consisted of orchardgrass and blue wildrye. The logged Douglas-fir - ninebark habitat type was the next most productive stand for preferred species. Production of preferred forage was 124 pounds per acre. The logged ponderosa pine - snowberry habitat type produced 100 pounds of palatable forage per acre.

The only stand outside the clearcut which produced palatable forage during late summer was the Sandberg's bluegrass - kellogg onion community. Approximately 27 pounds per acre of field woodrush were produced on this site.

Factors Affecting the Availability of Preferred Forage for Cattle

Availability of preferred species for cattle was influenced by numerous environmental variables interacting with one another. On the foothill rangelands studied, only a few variables appeared to

Table 9. Pounds and percent preferred species available for cattle in each stand on the study area (July 31 - Sept. 12, 1973).

	Preferred Forage (lbs/A)	(%)
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	27[a][1]	9
Ponderosa pine - bluebunch wheatgrass	0[a]	0
Forest communities		
Ponderosa pine - snowberry	0[a]	0
Douglas-fir - snowberry	0[a]	0
Grand fir - adenocaulon	0[a]	0
Clearcut habitat types		
Ponderosa pine - snowberry	95[ab]	17
Douglas-fir - ninebark	124[b]	15
Grand fir - pachistima[1]	237[b]	40
Grand fir - pachistima[2]	282[b]	32

[1]Pounds of preferred forage followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

determine the availability of palatable forage.

The importance of eight variables in determining palatable species availability was evaluated. These were forage production, percent canopy cover, soil depth, aspect, distance to water, distance to salt, pounds of forage utilized per acre by cattle, and percent use by cattle. Variables that correlated with production of palatable species were canopy cover, soil depth, distance to water and distance to salt (Table 10). Variables correlated with percent palatable species present within a community were percent forage use by cattle, soil depth and canopy cover (Table 11). Palatable species for cattle, only occurred on stands where no tree canopy existed. Percent palatable species increased as soil depth increased on these open stands.

Table 10. Variables correlated with pounds palatable species available for cattle in each plant community with corresponding accumulated R^2 values.

	R^2
Canopy cover	0.34
Soil depth	0.87
Distance to water	0.96
Distance to salt	0.99

Table 11. Variables correlated with percent palatable species available for cattle in each plant community with corresponding accumulated R^2 values.

	R^2
Percent forage use by cattle	0.66
Soil depth	0.85
Canopy cover	0.95

Big Game

Forage utilization and pellet groups were measured to evaluate the importance of several plant communities to big game animals. These measurements were used to define how animals utilized different plant communities occurring on foothill rangelands.

Forage Use Among Communities by Big Game

Utilization by deer and elk throughout the study area was light averaging 1.5 percent, or 6.3 pounds per acre. The amount of forage removed by big game varied between the nine stands studied. Utilization ranged between trace on the Douglas-fir - snowberry stand to 24 pounds per acre on the logged ponderosa pine - snowberry site (Table 12). Percent utilization did not exceed five percent in any community.

The clearcut received the heaviest utilization of forage by big game in the study area. Big game utilized between two and three percent of the herbage in the logged sites during spring and early summer. The clearcut provided 66 percent of the forage consumed by big game although it made up less than one third of the area studied (Table 13). Approximately half of the diet was composed of seeded grasses. Significantly more browse was utilized by deer and elk in the logged Douglas-fir - ninebark habitat type where

Table 12. Pounds and percent utilization of forage by big game in each stand on the study area (March - July, 1973).

	Utililization	
	(lbs/A)	(%)
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	2[ab][1]	1
Ponderosa pine - bluebunch wheatgrass	7[ab]	2
Forest communities		
Ponderosa pine - snowberry	1[a]	1
Douglas-fir - snowberry	t[a]	t
Grand fir - adenocaulon	1[a]	2
Clearcut habitat types		
Ponderosa pine - snowberry	24[b]	5
Douglas-fir - ninebark	4[ab]	1
Grand fir - pachistima[2]	4[ab]	1
Grand fir - pachistima[3]	13[b]	2

[1]Pounds of forage removed followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

Table 13. Percent forage consumed by big game from each stand on the study area (March-July, 1973).

	Percent Forage Consumed			
	Grasses	Forbs	Browse	Total
Bunchgrass communities				
Sandberg's bluegrass - kellogg onion	3	4	0	7
Ponderosa pine - bluebunch wheatgrass	16	1	0	17
Forest communities				
Ponderosa pine - snowberry	t	3	t	3
Douglas-fir - snowberry	3	0	1	4
Grand fir - adenocaulon	1	2	t	3
Clearcut habitat types				
Ponderosa pine - snowberry	3	25	3	31
Douglas-fir - ninebark	2	1	4	7
Grand fir - pachistima[1]	14	1	2	17
Grand fir - pachistima[2]	10	1	t	11
Total	52	38	10	100

[1]Stand at the top of the slope.

[2]Stand at the bottom of the slope.

pounds per acre of browse removed exceeded one.

The two bunchgrass stands provided 25 percent of the forage consumed by big game. Grasses were the main forage selected in the ponderosa pine - bluebunch wheatgrass stand. Only a small percentage of forbs were utilized. The ponderosa pine - bluebunch wheatgrass stand provided 17 percent of the forage removed by big game. Forage use averaged seven pounds per acre or two percent. The Sandberg's bluegrass - kellogg onion stand was important in providing both grasses and forbs early in the spring. This community was one of the first to initiate growth in spring. Although forage use averaged two pounds per acre or one percent over spring and early summer, the majority of plant material was consumed during early spring.

Although the three forested communities accounted for 41 percent of the area studied they only provided eight percent of the forage removed by big game. Browse made up the largest percentage of plant material consumed in these communities.

Factors Affecting Big Game Use

Forage consumed by deer and elk was regulated by a complex network of interactions between the animal and its environment. To evaluate the effects of some of these interactions on animal use, eight habitat characteristics were correlated with forage utilization by big game in each community. These factors were percent tree

canopy cover, soil depth, aspect, slope, pounds per acre palatable species, percent palatable species, production and distance to water.

The four factors having the greatest effect on pounds and percent forage removed during spring and early summer in a plant community were pounds of palatable species produced per acre, percent tree canopy cover, soil depth and distance to water (Tables 14 and 15).

Table 14. Variables correlated with pounds forage removed by big game in each plant community with corresponding accumulated R^2 values.

	R^2
Palatable species (lbs/A)	0.48
Soil depth	0.62
Canopy cover	0.83
Distance to water	0.96

Table 15. Variables correlated with percent utilization by big game in each plant community with corresponding accumulated R^2 values.

	R^2
Palatable species (lbs/A)	0.26
Soil depth	0.37
Canopy cover	0.71
Distance to water	0.93

Soil depth and canopy cover probably indirectly influenced big game use by determining production of palatable forage in each community. In a simple linear regression percent canopy cover accounted for 53 percent of the variability in percent forage use and 61 percent of the variability in pounds per acre removed by big game.

Diet Composition

Big game diet was determined from forage utilization measurements across the nine plant communities (Table 16). Although measurements were taken throughout spring, summer and fall, measurable use by deer and elk only occurred during spring and early summer. Pellet group densities indicated deer and elk were present during winter, spring and early summer, but not late summer and fall.

Grasses made up 52 percent of the big game diet. The ponderosa pine - bluebunch wheatgrass stand and the two sites on the grand fir - pachistima habitat types in the clearcut had the highest levels of grass consumption among stands studied (Table 13). Grasses were generally moderate in preference values. Timothy, junegrass, tall oatgrass and smooth brome were the most palatable grass species with RPI exceeding two. Timothy accounted for 18 percent of the diet.

Tabl 16. Percent composition of selected plant species in the diet of deer and elk, and their relative preference index, RPI (March - July, 1973).

Species	Percent Diet	RPI
Grasses and sedges		
timothy	18	2.4
tall oatgrass	8	2.3
Sandberg's bluegrass	6	1.1
orchardgrass	6	0.7
bluebunch wheatgrass	3	0.8
blue wildrye	2	1.3
Idaho fescue	2	0.6
smooth brome	2	2.3
junegrass[1]	2	3.3
Kentucky bluegrass	1	0.1
elk sedge	1	0.2
Ross sedge	1	0.6
Forbs		
goatsbeard	25	273.3
tailcup lupine[2]	2	6.0
prickly lettuce	2	35.0
big-flowered agoseris[3]	2	17.0
adenocaulon	2	20.0
sheep sorrel[4]	1	1.7
western hawksbeard[5]	1	80.0
orange arnica	1	8.3
autumn willowweed	1	2.2
common camas[6]	1	25.0
Browse		
snowberry	4	2.5
ninebark	3	5.4
oceanspray	2	11.0
redstem ceanothus[7]	1	4.2

[1] Koelaria cristata

[2] Lupinus caudatus

[3] Agoseris grandiflora

[4] Rumex acetocella

[5] Crepis occidentalis

[6] Camassia quamash

[7] Ceanothus sanguineus

Thirty-eight percent of the diet was made up of forbs. The majority of forbs was consumed from the logged ponderosa pine - snowberry habitat type. Goatsbeard, the most preferred forb, made up 25 percent of the diet. Most forbs consumed by deer and elk had palatability ratings of two or better. Some of the most preferred species besides goatsbeard were western hawksbeard, prickly lettuce, big flowered agoseris (Agoseris grandiflora), and common camas (Camassia quamash). Of these, goatsbeard and possibly prickly lettuce were the only plants abundant enough to be of importance.

Browse accounted for 10 percent of the diet although it only made up five percent of the understory composition. Ninebark, oceanspray, redstem ceanothus and snowberry had high preference ratings.

Availability appeared to be an important determining factor in forage intake by big game. During March, Sandberg's bluegrass was grazed more heavily than any other grass species. Sandberg's bluegrass initiated growth prior to most other herbaceous species, providing tender leaf sprouts in late February. Use on Sandberg's bluegrass dropped by 50 percent from 29 pounds within the study area in May and to only a trace by early summer. Sandberg's bluegrass, bluebunch wheatgrass, Idaho fescue, Kentucky bluegrass and timothy accounted for over 90 percent of the herbaceous plants in the diet in March. Few forbs were consumed due to their low availability

at this time. The two bunchgrass stands and the logged ponderosa pine - snowberry habitat type supplied most of the forage during early spring. Only very light use was recorded on forested communities and the other logged communities. Limited use on browse was observed at this time.

By mid-May, forbs represented almost half of the forage consumed on the unlogged communities. Clearcut communities received the heaviest use during this period. Forage removed from logged communities consisted almost solely of grasses. Important plant species in the big game diet during the latter part of spring were Sandberg's bluegrass, timothy, orchardgrass, blue wildrye, Ross sedge, common camas, kellogg onion, and western hawksbeard (Crepis occidentalis).

By early summer, use on the clearcut increased, with both grasses and forbs being utilized. The two most important herbaceous species during this time were timothy and goatsbeard. Almost 10 pounds of timothy per acre were harvested by big game on the lower stand in the logged grand fir - pachistima habitat type. On the logged ponderosa pine - snowberry habitat type big game removed almost 21 pounds of goatsbeard per acre.

When utilization was measured in late fall the majority of deer and elk were still at higher elevations. However, a small number of deer were observed on the study area during late fall. Although no

utilization was recorded for big game during late fall, heavy utilization on fleshy fungi was observed. The majority of mushrooms occurred on disturbed soils. They were most commonly found on skid trails in the clearcut. Miller and Halls (1969) reported nutritive values on some common mushrooms occurring in the southern forests. These species averaged 30 percent crude protein, 17 percent crude fiber, and 0.68 percent phosphorus. Fresh mushrooms had a moisture content ranging from 75 to 90 percent, so large volumes must be consumed to provide adequate total intake of protein and phosphorus.

In January, elk were observed using the study area. They were mainly concentrated on the clearcut (Vavra, 1974, personal communication). Elk were observed digging through snow to obtain forage on the harvested communities. Dry, seeded grasses probably provided the majority of forage consumed. Deer were also present on the area at this time. They were frequently observed on south slopes. Snow depths averaged 18 to 20 inches on the south slopes.

Pellet Group Densities

Pellet group densities were measured for all plant communities in an attempt to evaluate big game distribution. Despite its inadequacies this technique has been commonly used to measure relative use among plant communities. Inaccuracies may have occurred in

this study from possible variability in defecation rates on different plant communities, difficulty in identifying a single pellet group, similarities between elk calf pellets and deer pellets, and missed groups in stands with dense ground cover.

No pellet groups occurred in samples from mid-summer to fall (July - October). By mid - July, elk and most deer had moved to summer ranges at higher elevations. What few deer resided on the area year around moved to adjacent pastures when cattle were present in August and the first half of September. By fall, due to mild weather conditions, big game species had not been moved down to lower elevations. Use of the few resident animals on the study area was not measurable during late summer.

Elk Pellet Group Distribution

Elk showed no significant preference for any of the nine plant communities based on pellet group distribution. The small size of plant communities in the study area may have lowered the importance or effective level of habitat characteristics affecting pellet group distribution. Evans (1960) reported effectiveness of distributional forces influencing the distribution of a population decreases as an area's size decreases.

Pellet group densities increased from winter to spring, peaking in May, then declining to winter levels by July. No elk or deer pellet

groups occurred in the transects during late summer and fall.

The four clearcut communities accounted for 25 percent of the total elk pellet group yield. Pellet densities steadily declined on the grand fir - pachistima habitat type and Douglas-fir - ninebark habitat type in the clearcut from September, 1972 to July, 1973 (Figure 3).

In the bunchgrass communities elk pellet groups rose to relatively high levels in May, especially in the Sandberg's bluegrass - kellogg onion stand. Yields of pellet groups began to decrease in the summer on both bunchgrass communities, dropping to zero after July.

In the grand fir - adenocaulon stand elk pellet group numbers were at their highest levels during winter, steadily declining to zero by July. Elk pellet groups, peaked in May on the ponderosa pine - snowberry and Douglas-fir - snowberry communities. The highest level of elk pellet groups in the forested stands during spring occurred on the Douglas-fir - snowberry community.

The highest densities of elk pellet groups occurred on the Sandberg's bluegrass - kellogg onion and grand fir -adenocaulon stands (Figure 4). However densities were only significantly greater than densities in the ponderosa pine - snowberry stand, the logged grand fir - pachistima habitat type and logged ponderosa pine - snowberry habitat type.

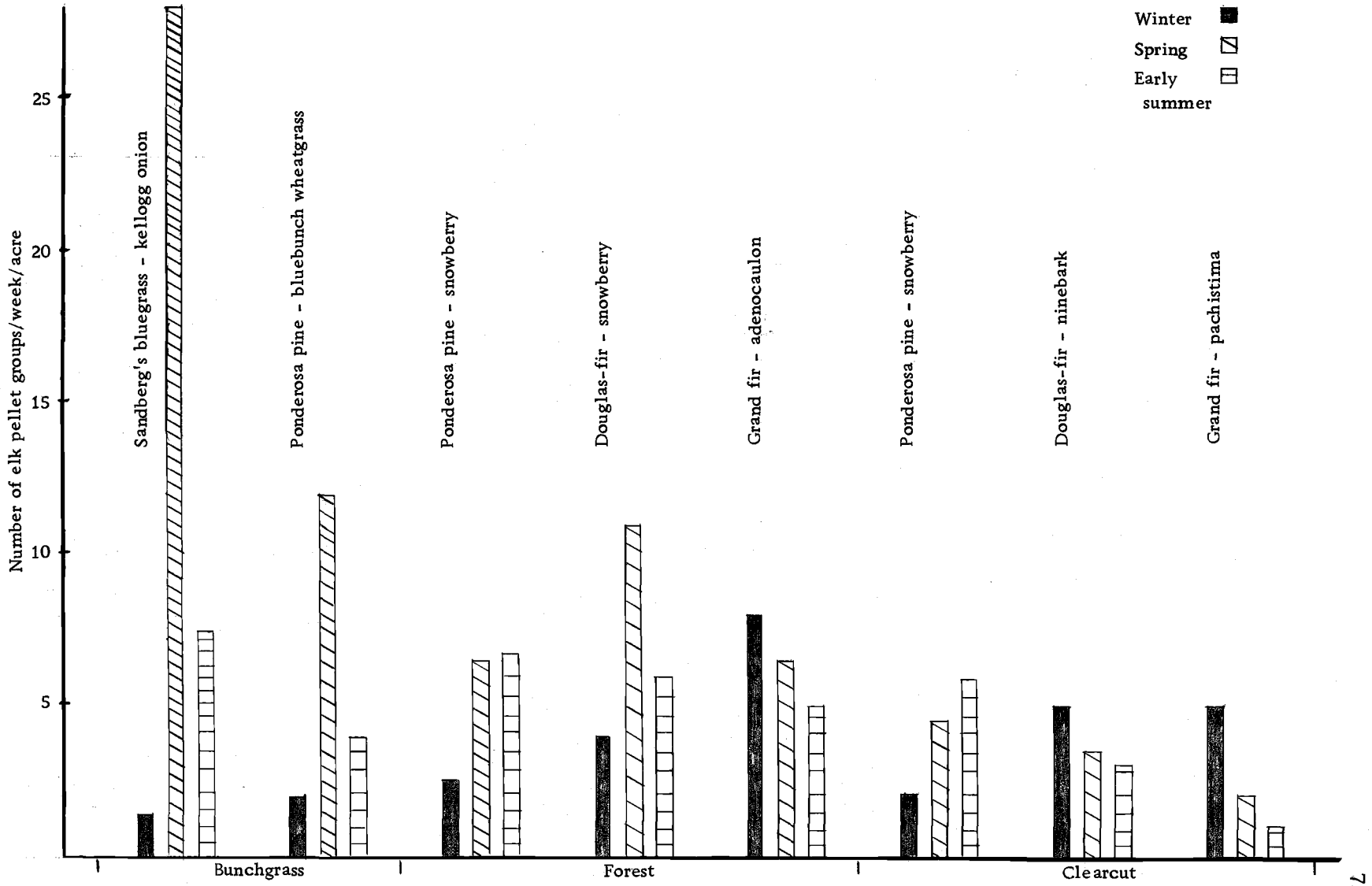

Figure 3. Elk pellet groups per weeks per acre in each stand during winter, spring and early summer on the study area (Sept, 1972 - July, 1973)

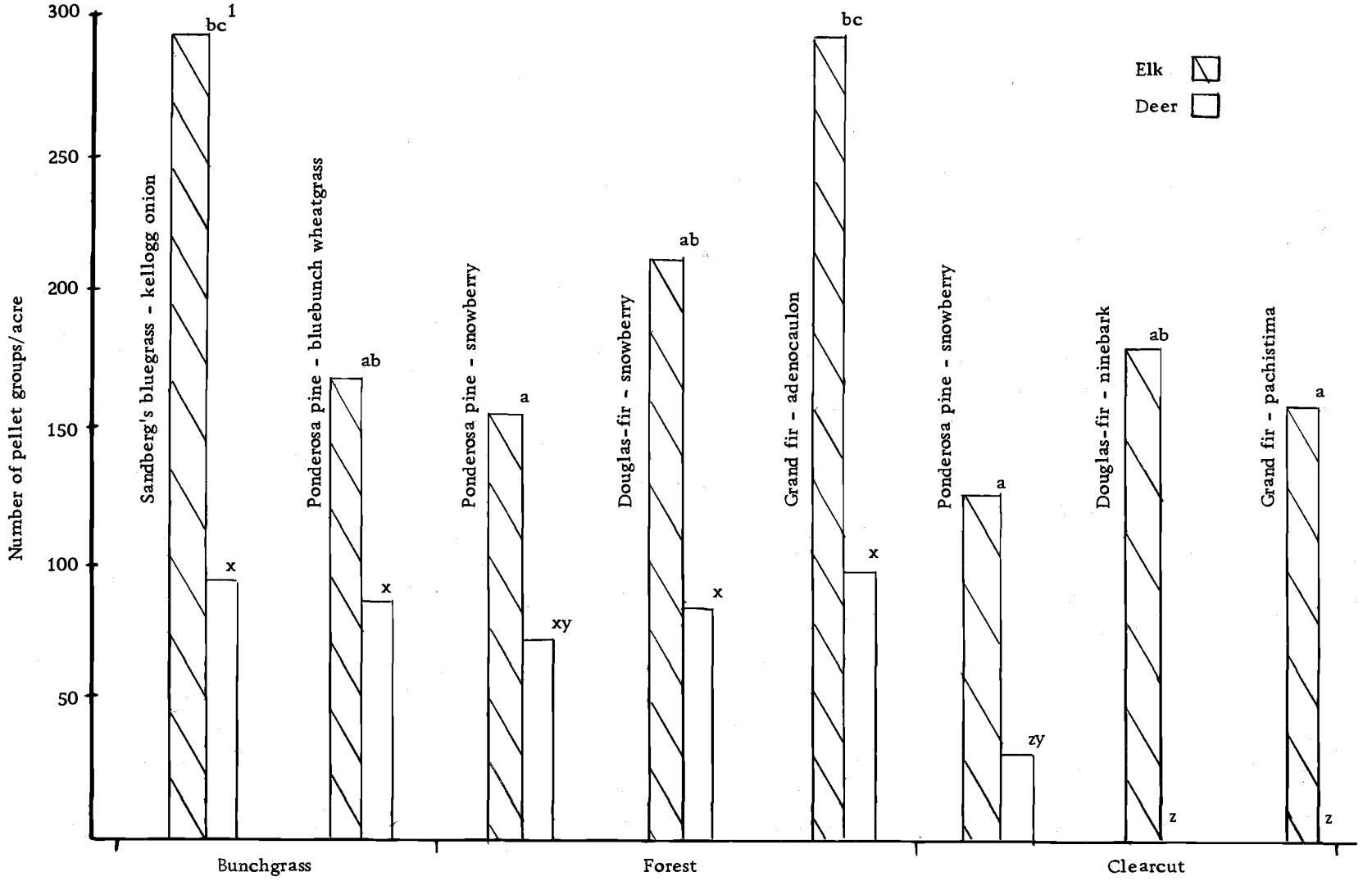

Figure 4. Deer and elk pellet groups per acre; total for eight stands on the study area (Sept., 1972 - July, 1973).
1 - Pellet groups followed by the same letter were not significantly different at $P < 0.05$.

Factors Affecting Elk Pellet Group Distribution

Eleven environmental variables were evaluated for their importance in influencing elk pellet group distribution. These were forage production, percent tree canopy cover, soil depth, aspect, pounds per acre utilized by big game, percent utilization by big game, percent palatable species, pounds palatable species, distance to water, deer pellet group density, and steepness of slope.

Factors most important in accounting for the variability in elk pellet group distribution were availability of palatable forage, aspect, percent canopy cover and pounds of forage removed (Table 17). Communities with high forage values tended to have lower densities of pellet groups than stands with low forage values. Aspect may have indirectly affected pellet group densities by influencing vegetation. Elk had no special preference for the clearcut based on pellet group densities.

Table 17. Variables correlated with elk pellet group densities in each plant community with corresponding accumulated R^2 values.

	R^2
Palatable forage (lbs/A)	0.49
Aspect	0.71
Tree canopy cover	0.80
Forage use (lbs/A)	0.94

Deer Pellet Group Distribution

Clearcut communities had a significant effect on deer pellet group distribution. Deer pellet group densities were significantly lower in the clearcut than in the bunchgrass and forest communities (except for the ponderosa pine - snowberry stand) throughout spring and summer (Figure 4). Deer pellet groups only occurred in the clearcut on the ponderosa pine - snowberry habitat type. The entire logged area accounted for only 4.2 percent of the deer pellet groups in the area studied.

During winter, deer pellet groups were highest in the forested communities (Figure 5). In May, pellet group densities sharply increased on both bunchgrass communities and on the grand fir - adenocaulon community. During June and July, deer pellet group yields increased to relatively high densities on the Sandberg's bluegrass - kellogg onion community. This level was significantly higher than any other stand on the study area during this period.

Deer pellet groups steadily increased from winter to summer declining in July.

Factors Affecting Deer Pellet Group Distributions

Deer pellet group distribution was analyzed using the same set of factors as elk pellets. Factors correlated with pellet group

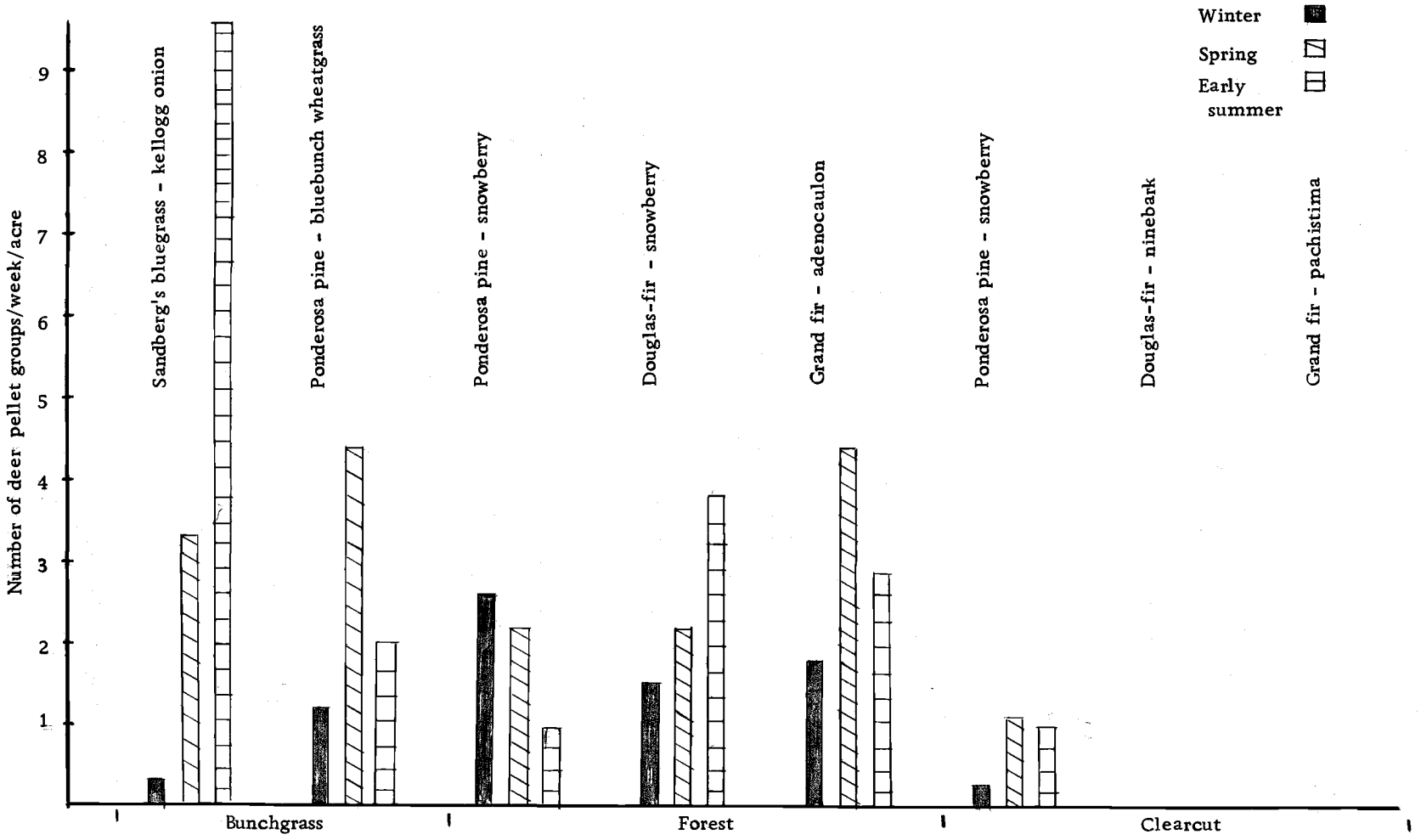

Figure 5. Deer pellet groups per week per acre in each stand during winter, spring and early summer on the study area (Sept., 1972 - July, 1973).

distribution during spring and summer were pounds forage utilized per acre by big game, percent forage utilization by big game, percent palatable species and percent canopy cover (Table 18). Where forage potentials tended to be high, pellet groups were low.

Table 18. Variables correlated with deer pellet group densities in each plant community with corresponding accumulated R^2 values.

	R^2
Forage use (lbs/A)	0.26
Forage use (%)	0.65
Palatable species (%)	0.93
Canopy cover (%)	0.96

Distribution of Deer and Elk Pellet Groups

Fluctuation of elk pellet group densities paralleled those of deer on non-logged communities (Figure 4). The correlation of deer pellet group densities and elk pellet group densities on these stands was highly significant with a coefficient of determination (R^2) equaling 0.76. However the occurrence of pellet groups on the clearcut was different for both species. The clearcut had a significant effect on deer pellet groups but little effect on elk pellet groups.

Forage Utilization and Pellet Group Densities

In spite of inadequacies, pellet group densities have been extensively used to determine relative game use among different areas. The value of plant communities to deer and elk habitat is often based on the number of pellet groups occurring within a stand (Neff, 1968). Although this technique may estimate time spent by animals in each community, it can easily underestimate the importance of some plant communities' forage values.

In the foothill ranges of the Wallowa Mountains, deer and elk pellet group densities did not correlate with forage utilization. The ability of plant communities in the study area to fit the needs of big game based on pellet group densities underestimated forage values in the clearcut. Logged communities provided 65 percent of the total forage consumed by big game while they accounted for only 20 percent of the big game pellet groups (Table 19). Measurements of both forage use and pellet group densities were closer on the two bunchgrass communities. These communities provided 25 percent of the forage removed by big game and accounted for 33 percent of the big game pellets. Pellet group densities overestimated the value of forested communities to big game. These stands provided 10 percent of the forage consumed while accounting for 47 percent of the total big game pellet groups across the study area. The pellet group counting technique was not an adequate indicator

Table 19. Percent forage consumed and percent big game pellet groups yielded in each stand on the study area (March - July 1973).

	Percent Forage Consumed	Percent Pellet Groups Yielded
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	7.0	12.0
Ponderosa pine - bluebunch wheatgrass	18.0	21.0
Total	25.0	33.0
Forest communities		
Ponderosa pine - snowberry	3.0	13.0
Douglas-fir - snowberry	4.0	29.0
Grand fir - adenocaulon	3.0	5.0
Total	10.0	47.0
Clearcut habitat types		
Ponderosa pine - snowberry	30.0	5.0
Douglas-fir - ninebark	6.0	7.0
Grand fir - pachistima	29.0	8.0
Total	65.0	20.0

of forage potential in plant communities.

Environmental factors correlating with big game forage utilization did not correlate with big game defecation. Deer pellet group densities tended to be high on areas dense in cover or situated on south exposures. Deer pellet group distribution on the clearcut was very low. Elk pellet group densities tended to occur randomly throughout the entire area.

Both forage use and pellet groups were important for evaluating a plant communities' relative value to big game species. Forage utilization measures a plant communities' relative ability to fulfill the food needs of big game. It may not evaluate other important requirements such as cover. Pellet group densities on the other hand were not sensitive to forage use in the nine stands measured. Pellet groups probably measured the relative time animals spent in plant communities affected by certain favorable habitat characteristics. Measuring both forage utilization and pellet groups gives a more complete picture of animal activities within plant communities than if just one of these techniques was used.

Cattle

Cattle were stocked on the 360 acre study area July 31, 1973. The herd was composed of 94 cows and 90 calves. Cattle were removed from the pasture August 21 to wean the calves. On August 27,

88 cows were returned to the pasture until September 12. The pasture was grazed for 21 days by cows with their calves and 16 days by cows alone. Understory vegetation was mature by July 31. The majority of forbs were not available by this time. Cattle use in 1973 was less than usual because of the dry conditions.

Forage Use Among Communities by Cattle

Utilization of forage by cattle was highly variable among communities. Utilization ranged from four pounds per acre in the grand fir - adenocaulon stand to 268 pounds per acre on the lower site on the logged grand fir - pachistima habitat type (Table 20). Grasses and grass-like species made up 95 percent; forbs, one percent; and browse, four percent of the forage consumed by cattle (Table 21).

The logged communities as a whole received the heaviest use by cattle. Sixty-three percent of all forage consumed by livestock in the study area was accounted for by these four sites. Significantly more forage was removed from the two logged sites on the grand fir - pachistima habitat type than any other plant community. Cattle utilized 268 pounds of forage per acre in the site at the bottom of the slope. This was 32 percent of the understory vegetation. Cattle utilized 27 percent of the understory which was equivalent to 149 pounds per acre in the logged grand fir habitat type at the top of the slope. Both the logged ponderosa pine - snowberry and

Table 20. Pounds and percent utilization by cattle in each stand on the study area (July 31 - Sept. 12, 1973).

	Utilization (lbs/A)	Utilization (%)
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	63[c][1]	25
Ponderosa pine - bluebunch wheatgrass	41[bc]	8
Forest communities		
Ponderosa pine - snowberry	20[ab]	9
Douglas-fir - snowberry	8[a]	5
Grand fir - adenocaulon	4[a]	4
Clearcut habitat types		
Ponderosa pine - snowberry	56[c]	17
Douglas-fir - ninebark	62[c]	7
Grand fir - pachistima[2]	149[d]	27
Grand fir - pachistima[3]	268[e]	32

[1]Pounds of forage utilized followed by the same letter were not significantly different at $P < 0.05$.

[2]Stand at the top of the slope.

[3]Stand at the bottom of the slope.

Table 21. Percent forage consumed by cattle from each stand on the study area (July 31-Sept. 12, 1973).

	Percent Forage Consumed			
	Grasses	Forbs	Browse	Total
Bunchgrass communities				
Sandberg's bluegrass - kellogg onion	10	0	0	10
Ponderosa pine - bluebunch wheatgrass	18	0	1	19
Forest communities				
Ponderosa pine - snowberry	3	0	1	4
Douglas-fir - snowberry	3	0	1	4
Grand fir - adenocaulon	0	0	0	0
Clearcut habitat types				
Ponderosa pine - snowberry	9	0	0	9
Douglas-fir - ninebark	18	0	1	19
Grand fir - pachistima[1]	19	0	0	19
Grand fir - pachistima[2]	15	1	0	16
Total	95	1	4	

[1] Stand at the top of the slope.

[2] Stand at the bottom of the slope.

Douglas-fir - ninebark habitat types received significantly lower use, averaging 59 pounds of forage per acre. Pounds of forage utilized on these two stands were comparable to both bunchgrass stands. The Douglas-fir - ninebark habitat type however accounted for most of the browse in the cattle's diet. Seeded grass species comprised 80 percent of forage removed by cattle in the clearcut. These seeded species made up 56 percent of the cow and calf's diet.

Cattle utilized about 50 pounds of herbaceous forage per acre on the bunchgrass communities. This was higher than consumption on the forested communities. The two bunchgrass stands provided 29 percent of the forage consumed by cattle. The Sandberg's bluegrass - kellogg onion stand received the heaviest use with the exception of the grand fir - pachistima habitat type on the clearcut. However its small size somewhat limited its importance. Approximately 25 percent of the forage was utilized. Sandberg's bluegrass constituted 95 percent of the 63 pounds per acre of forage utilized in this community. Cattle harvested eight percent of the forage on the ponderosa pine - bluebunch wheatgrass site. Bluebunch wheatgrass provided 72 percent of the forage consumed from this stand. Browse production on the bunchgrass communities was insignificant.

The three forest communities received light use. Forage utilization ranged from three to 20 pounds per acre and averaged about 10 percent. Elk sedge was the most important forage species

throughout the three stands with the exception of shinyleaf spiraea on the grand fir - adenocaulon stand. Most forbs were no longer available on the ponderosa pine - snowberry stand and Douglas-fir - snowberrty stand when cattle were present.

Factors Affecting Forage Utilization

Effects of eight habitat characteristics on forage use by cattle were evaluated; They were production, canopy cover, soil depth, aspect, distance to water, distance to salt, production of palatable forage and percent palatable species. Those accounting for most of the variability in pounds of forage removed were distance to water, distance to salt, soil depth and canopy cover (Table 22).

Table 22. Variables correlated with forage use (lbs/A) in each plant community with corresponding accumulated R^2 values.

	R^2
Distance to salt	0.59
Distance to water	0.79
Soil depth	0.90
Canopy cover	0.99

Distance to salt and water facilities influenced the amount of forage used in plant communites by cattle. Three watering areas were located on the 360 acre pasture. Maximum distance to water was a quarter mile. The average distance between water and the

center of a plant community was 1627 feet. Salting distances averaged 1204 feet.

Canopy cover and soil depth appeared to relate indirectly with pounds of forage utilized by cattle. These two environmental factors strongly correlated with forage production in each community. The coefficient of determination in a simple linear regression between production and pounds utilization by cattle in each community equaled 0. 74.

Distances to water, percent palatable species, aspect and canopy cover correlated with the variability in percent use (Table 23). Percent forage use appeared to be highly dependent on distance to water (correlation coefficient equaling 0. 88). Distance to water facilities on the two logged sites in the grand fir - pachistima habitat type were only 635 and 785 feet.

Table 23. Variables correlated with forage use (%) in each plant community with corresponding accumulated R^2 values.

	R^2
Distance to water	0. 77
Percent palatable species	0. 83
Aspect	0. 89
Soil depth	0. 96

Diet Composition

To evaluate forage values of vegetation in plant communities we must know what animals are eating and how much. Plant composition of livestock diets on foothill rangelands was determined from forage utilization measurements on nine communities (Table 24). Cattle forage preferences were evaluated through a relative preference index.

Cattle were stocked onto the study area July 31. Grass species made up almost the entire diet. However at this time availability of forbs was very low and browse accounted for only a small portion of the total vegetation.

Only three plant species during August and the first half of September had preference indices greater than 2.0. These were orchardgrass, blue wildrye, and field woodrush. None of these exceeded a relative preference index rating of three.

Canada milkvetch (Astragalus canadensis) and prickly lettuce were highly palatable forbs but both made up only minute amounts of the vegetation composition. Forbs were most important in the vegetation composition during spring and early summer on these foothill rangelands. Very few remained by late summer.

Table 24. Percent composition of selected plant species in the diet of cattle and their relative preference index, RPI (July 31 - Sept. 12, 1973).

Species	Percent Diet	RPI
Grasses and sedges		
orchardgrass	28	2.4
timothy	16	1.7
Kentucky bluegrass	11	1.5
Sandberg's bluegrass	7	1.2
tall oatgrass	6	1.5
elk sedge	6	0.5
Idaho fescue	6	1.3
blue wildrye	5	2.3
bluebunch wheatgrass	4	1.8
field woodrush	2	2.6
Ross sedge	2	0.8
foxtail	1	0.6
smooth brome	1	0.7
Browse		
shinyleaf spiraea	1	0.7
snowberry	1	1.6
ninebark	1	1.2

Cow Chips

Cow chips were counted in each plant community to get an estimate of distribution. Transects did not occur through bedding grounds or near water and salt facilities where cow chip densities were highest. Transects had been cleared of all cow chips before cattle were stocked in the pasture for the summer.

Cow chip densities gave some indication of cattle distribution throughout the study area. Cow chip occurrence was high where forage use was high. The Sandberg's bluegrass - kellogg onion community had the highest level of cow chips (Figure 6). This community was grazed heavily and served as a trailway between the stream bottom and clearcut. Clearcut communities also had relatively high levels of cow chips.

Environmental factors that had some effect on cow chip distribution were canopy cover, percent forage use by cattle, pounds forage consumed by cattle, production, aspect and percent palatable species (Table 25). Forage use and availability of highly preferred forage appeared positively related to cow chip densities. Densities were low where tree canopies were high. Both tree canopy and aspect probably indirectly related to cow chip density through their influence on vegetation. However heavily shaded areas with few ground obstructions occurring near open areas, were frequently

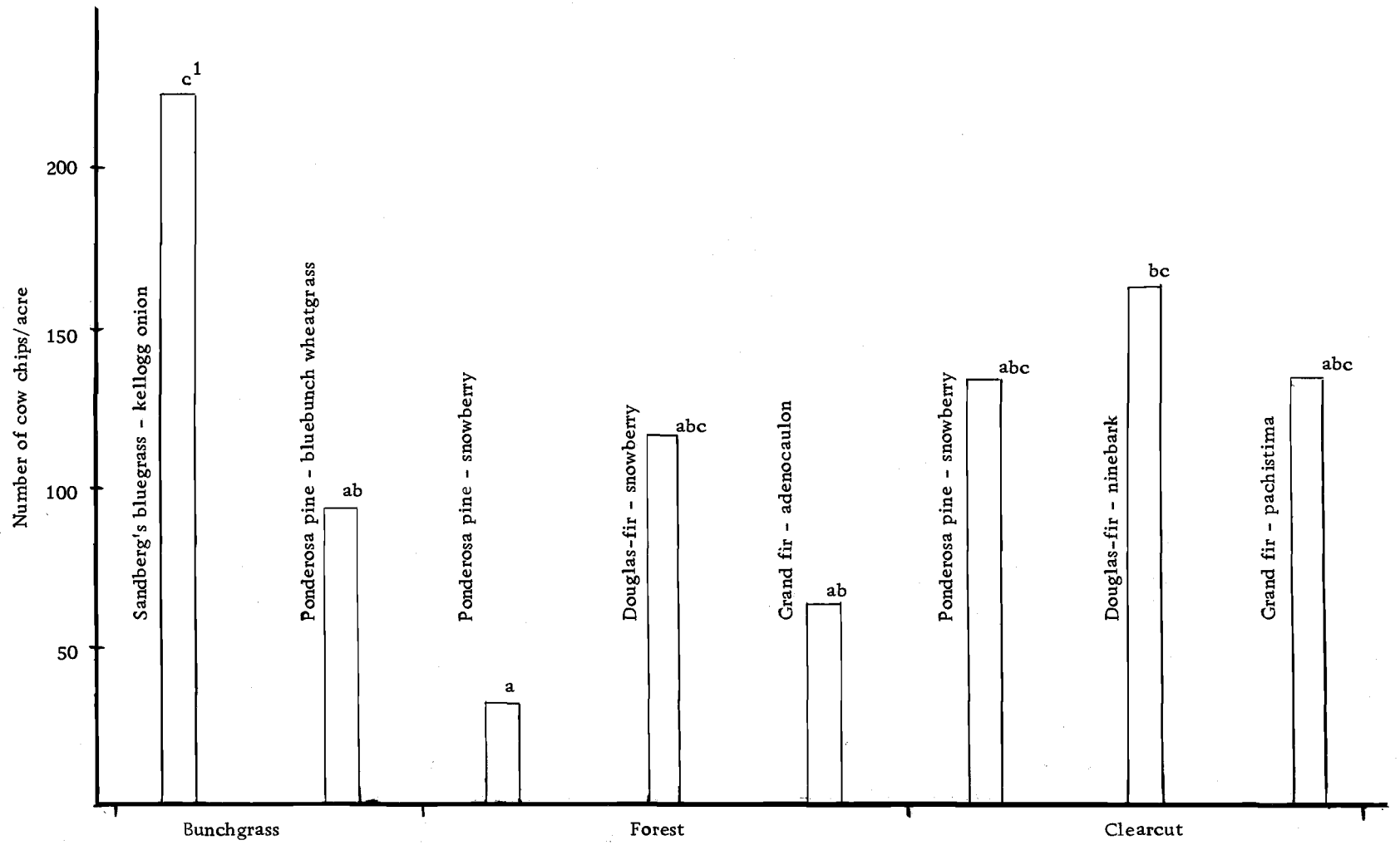

Figure 6. Cow chips per acre; total for eight stands on the study area (July 31 - Sept. 12).
1 - Cow chips followed by the same letter were not significantly different at $P < 0.05$.

used for bedding ground. This was not shown in the sampling since plots did not occur near a plant community's edge.

Table 25. Variables correlated with cow chip distribution in each plant community with corresponding accumulated R^2 values.

	R^2
Canopy cover	0.41
Forage use (%)	0.43
Forage use (lbs/A)	0.52
Production	0.67
Aspect	0.74
Palatable species (%)	0.94
Palatable species (lbs/A)	0.99

Interrelationships Between Cattle and Big Game

Forage Utilization

Big game animals were present on the study area during winter, spring and early summer. By mid-summer, both elk and the majority of deer had moved to high elevation summer ranges. Only a few deer were present when cattle were stocked in the pasture July 31. Although the presence of cattle and big game did not coincide, potential competition could occur from combined use on important forage species. Due to a seasonal difference in use between domestic and wild ruminants, plant species composition and therefore available forage was different. Forb availability was very low by mid-summer.

Grasses and grass-like plants accounted for 95 percent of the cow and calf's diet and 52 percent of the big game diet. Many plant species overlapped in the diets of both cattle and big game (Table 26). Ninety-one percent of grasses and sedges making up the diet of cattle accounted for 47 percent of the big game diet. The most important grass species found in both the diets of cattle and big game were orchardgrass, timothy, Sandberg's bluegrass, and tall oatgrass. Although there was substantial overlap in diet composition between domestic and wild ruminants, overuse on forage species did not occur during the period of initial growth in the spring until fall. The most heavily grazed species was timothy. Utilization averaged 50 percent on this species in the lower logged site of the grand fir - pachistima habitat type. Over 45 percent of the plant was used after dissemination of seeds. Most of the herbaceous forage was consumed while in a mature phenological stage.

Browse was not over-utilized by the combined use of cattle and big game during the spring, summer and fall. Redstem ceanothus was the most heavily used shrub, although it was relatively unimportant in the diet of both cattle and big game. Utilization on this species ranged from 30 to 54 percent on the two logged sites in the grand fir - pachistima habitat type.

No direct forage competition occurred between livestock and big game during the growing season on these foothill rangelands.

Table 26. Percent diet of important plant species for cattle and big game, and combined minimum and maximum levels of utilization in the study area.

Species	Percent Diet Cattle	Percent Diet Big Game	Combined Use (%) Minimum	Combined Use (%) Maximum
Grasses				
orchardgrass	28	6	7	48
timothy	16	18	12	50
Kentucky bluegrass	11	1	6	33
Sandberg's bluegrass	7	6	t	31
tall oatgrass	6	8	t	6
elk sedge	6	1	8	17
Idaho fescue	6	2	5	3
blue wildrye	5	2	4	19
Ross sedge	2	1	1	30
Forbs				
goatsbeard	0	25	t	28
tailcup lupine	0	2	t	10
prickly lettuce	t	2	t	3
Browse				
snowberry	1	4	0	4
ninebark	1	3	9	24
oceanspray	t	2	14	38
redstem ceanothus	t	1	30	54

This applied when cattle were present on the pasture during the last half of summer. The impact that cattle and big game had on each other's forage resource may have been minimized by different seasons of use. Interrelationships between big game and livestock were not evaluated during the winter.

Pellet Groups and Cow Chips

There was no relationship between the distribution of cow chips with deer or elk pellet groups (Figure 7). Differences in defecation for livestock and big game were greatest in forested stands. Cow chips correlated closely with forage use and forage potential in a plant community, whereas big game pellet groups did not. Generally, effects of the clearcut on distribution of feces were positive for cattle and negative for deer. Elk fecal distribution was not affected by the clearcut. Forested communities correlated with big game fecal distribution positively, and cattle fecal distribution negatively. Distribution on the bunchgrass stands was similar for livestock and big game. The few mule deer that resided in the area year-long moved to adjacent areas while cattle were present on the study unit.

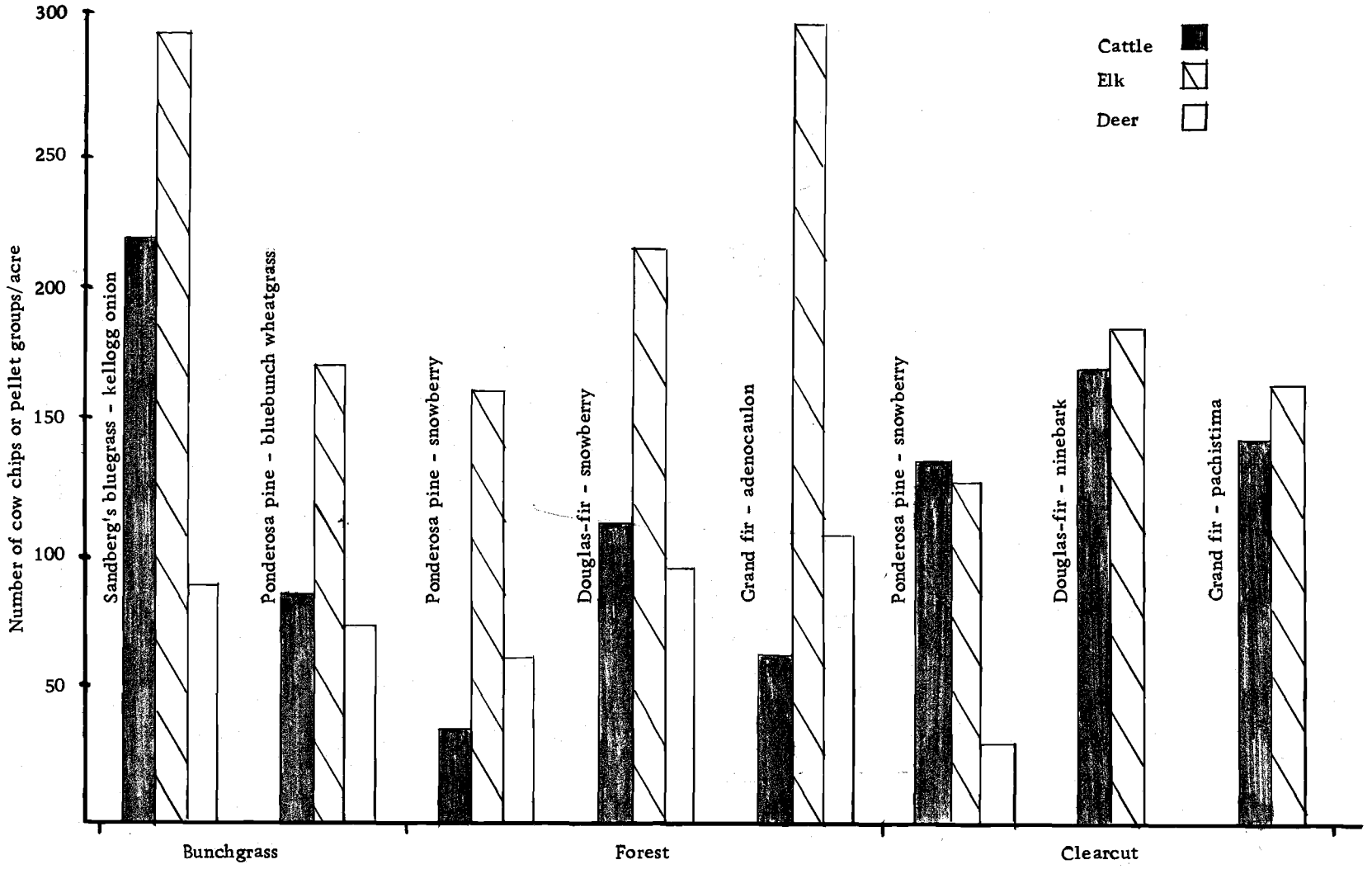

Figure 7. Total deer pellet and elk pellet groups per acrea and cow chips per acre occurring in eight stands on the study area.

SUMMARY AND CONCLUSIONS

The objectives of this study were to evaluate environmental factors influencing use of several plant communities by cattle, elk and deer; determine forage production of plant species and the amount utilized by cattle, elk and deer in certain plant communities; evaluate interactions of range use between cattle, elk and deer; and look closely at potential and use of seeded clearcut forest communities.

The study area was located in a 360 acre pasture on the Eastern Oregon Experiment Station Hall Ranch, 12 miles southeast of Union, Oregon. Nine plant communities were studied on this pasture. These communities were: Sandberg's bluegrass - kellogg onion, ponderosa pine - bluebunch wheatgrass, ponderosa pine - snowberry, Douglas-fir - snowberry, grand fir - adenocaulon, and three habitat types in the 1969 clearcut which included ponderosa pine - snowberry, Douglas-fir - ninebark and grand fir - pachistima, the latter being studied on two locations. Frequency transects and aerial photos were used to delineate plant communities.

Pellet transects were established to measure deer and elk distribution within different communities. Cow chips were also counted on these transects. The weight estimate method was used to measure production and utilization by cattle and big game in each plant community. Shrub leader lengths were measured to determine

both production and utilization. Cattle exclosures were set up to separate big game utilization from cattle utilization. Cages were set up to measure annual production of herbaceous species. Diet composition and relative preference indices were obtained from utilization and production measurements for cattle and big game.

Plant community characteristics were also measured. Canopy cover of the tree overstory was measured on each production plot with a type C forest densiometer. Soil information was available for each plant community from past soil surveys. Distance to water and salt, and slope steepness and aspect were also measured in each stand.

All data were statistically analyzed. Factors affecting understory production, production of palatable species, utilization and defecation distribution by big game and cattle were evaluated with multiple regression. Analysis of variance with a completely random design and Duncan's Test were used to measure differences between plant communities for production, forage use by cattle and big game, and fecal distribution. Linear regressions were conducted for simple correlations between environmental factors with production, and forage use by cattle and big game. Linear regression was also used to correlate fecal distribution and forage use between cattle and big game.

Total production in the nine stands during the 1973 growing

season was separated into three significant groups. The group with the highest understory production was the clearcut where production averaged 542 pounds per acre. The bunchgrass stands produced the most understory vegetation on the undisturbed sites averaging 310 pounds per acre. Production on forested sites ranged from 63 to 125 pounds per acre.

Moisture and light were inferred to be dominant environmental factors determining understory production on the study area. These two variables accounted for 96 percent of the variability in understory production. Soil depth was assumed to be an indirect measure of soil water potential. Production was lowest on forest communities where moisture availability was adequate but direct solar radiation limited. Herbage production increased on the drier bunchgrass sites where direct solar radiation was not limited by a dense tree overstory. Herbage production was greatest on the clearcut where both moisture and solar radiation were readily available. During fall when moisture was adequate for herbage growth in all nine stands, differences of regrowth among communities appeared dependent on direct solar radiation.

Forested sites on these foothill rangelands had a high potential for forage production after logging. The grand fir - pachistima habitat type had the greatest potential for producing seeded forage. Moisture availability was relatively higher on these sites than other forest and

and bunchgrass habitat types. Competition from established species was also lower. Production of timothy and orchardgrass was significantly higher than for any other seeded species.

The clearcut produced the highest quantities of palatable forage for both big game and cattle. Availability of preferred species in a plant community appeared to be dependent on environmental factors related to forage production. The most pertinent factors relating to availability of preferred forage for big game were percent forage utilized by big game, pounds of forage produced per acre depth. Factors relating to availability of preferred forage for cattle were canopy cover and soil depth.

The clearcut was most heavily utilized by big game and cattle. These four logged stands provided 66 percent of the forage consumed by big game and 63 percent of the forage consumed by cattle. The most important food source on these communities consisted of seeded grass species. These plants accounted for 30 percent of the big game diet and 55 percent of the cattle diet. The most important single species for deer and elk was goatsbeard which made up 25 percent of their diet. Grass species generally did not reflect high palatability for big game or cattle. Browse and forbs tended to have high preference ratings for big game. Most forbs were unavailable for cattle by late summer. Browse preference indices for cattle were near one.

The four factors having the greatest effect on pounds and

percent forage removed by big game during spring and early summer were pounds of palatable species produced per acre, soil depth, canopy cover and distance to water. Factors highly correlated with utilization by cattle during the summer were distance to salt and water, soil depth and canopy cover.

Big game pellet groups showed deer and elk were present during the winter and spring. Pellet densities began decreasing in early summer, dropping to almost zero by mid and late summer. Pellet group densities were highest on the Sandberg's bluegrass - kellogg onion stand and grand fir - adenocaulon stand. The clearcut had a negative effect on deer pellet group densities but no effect on elk.

Big game pellet groups did not correlate with forage utilization among plant communities. The value of a plant community to big game habitat as inferred from pellet group densities, underestimated forage values in the clearcut. Logged communities provided 65 percent of the total forage consumed by big game while it accounted for only 20 percent of the big game pellet groups.

Cow chip densities were generally high where forage utilization by cattle was high. Densities of cow chips were highest on the Sandberg's bluegrass - kellogg onion stand and clearcut sites as compared to the remaining four stands. Cow chips were positively correlated with forage use and potential.

There appeared to be no direct forage competition between big

game and cattle during spring, summer and fall when livestock were present during the last half of summer. Elk and most deer had moved to high elevation summer ranges by July. Variation of forb availability on spring range and late summer range created a substantial difference in understory composition between the two seasons. However many plant species overlapped in the diets of both cattle and big game. Ninety one percent of the forage species making up the diet of cattle accounted for 47 percent of the big game diet. Although there was substantial overlap in diet composition between domestic and wild ruminants overuse on forage species did not occur during the 1973 growing season.

One of the biggest problems that occurs with grazing domestic animals on timbered rangeland is lack of even distribution. To minimize this problem a manager needs to maximize environmental factors stimulating distribution and lessen those that inhibit distribution. For example preference may be increased in a less utilized plant community by nearby water and salt facilities. The land manager needs to select those factors he can manipulate and adjust them to fit his objectives. The overall objectives of a livestock manager on foothill rangelands should be to optimize the forage resource by manipulating vegetation, strategically locating salt and water facilities, and minimizing obstructions such as dense undergrowth, slash and fallen trees.

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APPENDICES

APPENDIX A

Soil description for the six habitat types occurring in the study area.

Soil Profile		Sandberg's bluegrass - kellogg onion
Chop silt loam		Shallow, stony and rocky area 5% west slope. Many cobbles at surface, most of area as described, some with clay B.
A11	0-2"	Very dark brown (10YR2/2) silt loam; weak fine granular.
A12	2-5"	Very dark brown (10YR2/2) gritty silt loam; weak medium subangular blocky; friable, slightly sticky and slightly plastic; abrupt wavy boundary.
IIR	5"+	Hard rock, andesite.
		Note: a variation was observed with 7.5 YR5/2 clay among the fractured rock fragments below 5" and extending to 10" or more with 75% angular rock fragments.

Soil Profile		Ponderosa pine - bluebunch wheatgrass
Klicker		
01	1-0"	Partly decayed needles and twigs, etc.
A1	0-2"	Very dark brown (10YR2/2) gritty silt loam; moderate very fine granular; soft, clear smooth boundary.
B1	2-6"	Dark brown (YR3/4), gritty silt loam; moderate fine subangular blocky; slightly plastic; 5% cobbles and gravel; clear boundary.
B2t	6-12"	Dark brown (7.5YR3/3), clay loam, light; moderate medium subangular blocky; hard, slightly firm, sticky and plastic; 10% rounded gravel and cobbles; thin patchy clay films.
B3	12-16"	Brown (7.5YR5/3) clay loam, light; 20% rounded gravel and cobble; slightly hard, friable, sticky and plastic; few clay films; abrupt irregular boundary.
R	16"+	Fractured hard bedrock.

Soil Profile		Ponderosa pine - snowberry
Hall Ranch		
01	1-0"	Partly decayed needles and twigs.
A11	0-1 1/2"	Very dark brown (10YR2/2) silt loam; moderate very fine granular; soft, very friable, nonsticky and nonplastic; some charcoal at surface; clear smooth boundary.
A12	1 1/2-4"	Very dark grayish brown (10YR2. 6/2. 4) gritty silt loam; very weak coarse platy, breaking to weak medium subangular blocky; soft, friable, slightly sticky and slightly plastic; clear smooth boundary.
B1	4-10"	Dark brown (7. 5YR3. 4/3) silt loam; very weak medium prismatic breaking to weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; clear smooth boundary.
B2	10-16"	Dark brown (7. 5YR3. 4/3. 6) gritty silt loam; structure as above; consistence as above; clear smooth boundary.
IIC&R	16-22"	Reddish brown (5YR4/3) loam; massive; friable, sticky and plastic; gradual boundary.
IIR&C	22-36"	Reddish brown (5YR4/3) loam and silty clay loam, weathered bedrock with 60% hard rock cores, hard rock could be mostly at upper part of layer.

Soil Profile		Douglas-fir - snowberry and Douglas-fir - ninebark
Hall Ranch		
A1	0-3"	Very dark brown (10YR2/2) moist, silt loam, moderate very fine granular; very friable slightly plastic, slightly sticky; clear boundary; 30% coarse fragments.
B1	3-12"	Dark brown (10YR3/3) moist, silt loam, weak very fine subangular blocky; slightly hard (almost soft), slightly plastic, slightly sticky; 30% coarse fragments; clear boundary.
B2	12-22"+	Dark brown (7. 5YR3/2) moist, silty clay loam; moderate medium subangular blocky; slightly hard, plastic sticky; many very fine tubular pores; 60% coarse fragments.

Soil Profile		Grand fir - pachistima
Tolo		
A0	1/2-0"	Duff and conifer litter.
A1	0-3"	Dark grayish brown (10YR4/2) moist, silt loam; weak, thin, platy, breaking to granular structure; very friable, slightly sticky, slightly plastic; abundant roots; few fine continuous pores; pH 6.2; clear, smooth lower boundary. 2-6 inches.
AC	3-10"	Dark brown (10YR3.5/3) moist, silt loam; weak, fine subangular blocky structure; very friable, slightly sticky, slightly plastic; abundant roots, few fine continuous pores; pH 6.2 to 6.6; clear smooth boundary. 7-24 inches.
C	10-20"	Dark yellowish brown (10YR4/4) moist, silt loam; weak subangular blocky structure; very friable, slightly sticky, slightly sticky plastic; abundant roots; few fine continuous pores; pH 5.8; clear smooth boundary. 4.24 inches.
B21b	20-26"	Dark brown (10YR3/3) moist, silky, clay; moderate fine, subangular blocky structure; firm, slightly sticky, slightly plastic; plentiful roots; common fine continuous pores; thick continuous clay films and siliceous ash coatings on peds; pH 6.6; clear smooth boundary. 1-14 inches.
B22b	26-32"	Dark to grayish brown (YR4/2.5) moist, silt loam; weak fine subangular blocky structure; friable slightly plastic, slightly sticky; plentiful roots; few fine continuous pores; pH 6.3; wavy, smooth boundary. 2-12 inches.
Dr	32"	Basalt and basaltic andesite.

APPENDIX B

Relative size and acreage of each stand in the study area

	Composition (%)	(Acres)
Bunchgrass communities		
Sandberg's bluegrass - kellogg onion	7.9	16.6
Ponderosa pine - bluebunch wheatgrass	19.7	41.4
Forest communities		
Ponderosa pine - snowberry	13.8	29.0
Douglas-fir - snowberry	23.8	50.0
Grand fir - adenocaulon	3.3	7.0
Clearcut habitat types		
Ponderosa pine - snowberry	8.0	17.0
Douglas-fir - ninebark	9.9	20.7
Grand fir - pachistima[1]	9.5	20.0
Grand fir - pachistima[2]	3.8	8.0

[1] Stand at the top of the slope.

[2] Stand at the bottom of the slope.

Species	Percent Diet	RPI
Browse		
Symphoricarpos albus	4	2.5
Physocarpus malvaceus	3	5.4
Holodiscus discolor	2	11.0
Ceanothus sanguineus	1	4.2
Spiraea betulifolia	t	
Salix scouleriana	t	
Rosa woodsii	t	
Amelanchier alnifolia	t	

APPENDIX C

Precipitation on the Hall Ranch from 1963 to 1973

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Jan		3.9	6.8	2.5	4.2	2.5	2.8	6.2	3.6	3.6	2.7
Feb		2.1	2.3	3.0	1.4	2.9	2.7	1.9	2.7	2.2	1.2
Mar		2.5	0.5	2.7	3.3	2.8	1.5	3.2	4.2	3.6	1.5
Apr		1.4	2.0	1.0	3.6	1.2	3.7	1.9	2.3	1.5	1.1
May		0.7	1.9	1.1	2.2	2.5	2.0	2.1	2.7	2.2	2.1
June	0.65	4.2	1.7	1.8	0.9	1.8	3.7	3.2	2.3	2.6	0.0
July	0.30	2.0	0.9	0.3	0.6	0.5	0.3	1.7	0.4	0.0	0.0
Aug	1.20	0.7	2.0	0.3	0.0	2.2	0.0	0.0	0.8	0.0	0.0
Sept	1.40	0.6	1.4	0.9	1.4	2.7	1.1	2.3	1.5	0.7	2.7
Oct	0.45	0.9	0.0	1.9	2.2	1.8	2.2	3.5	2.0	1.2	2.7
Nov	?	2.3	2.2	3.3	1.9	4.7	0.8	4.6	3.7	3.6	6.8
Dec	1.8	7.6	0.5	4.9	5.0	4.3	4.5	3.4	5.7	3.9	4.1
Total		28.9	22.2	23.7	26.7	29.9	25.3	34.0	31.8	25.1	24.9

APPENDIX D

Percent composition of plant species in the diet of deer and elk, and their relative preference indices (March - July, 1973)

Species	Percent Diet	RPI
Grasses and sedges		
Phleum pratense	18	2.4
Arrhenatherum elatius	8	2.3
Poa Sandbergii	6	1.1
Dactylis glomerata	6	0.7
Agropyron spicatum	3	0.8
Elymus glaucus	2	1.3
Festuca idahoensis	2	0.6
Bromus inermis	2	2.3
Koeleria cristata	2	3.3
Poa pratensis	1	0.1
Carex geyeri	1	0.2
Carex rossii	1	0.6
Hordeum jubatum	t	
Carex concinnoides	t	
Bromus mollis	t	
Bromus marginatus	t	
Danthonia californica	t	
Forbs		
Tragopogon dubius	25	273.3
Lupinus caudatus	2	6.0
Lactuca serriola	2	35.0
Agoseris grandiflora	2	17.0
Adenocaulon bicolor	2	20.0
Rumex acetocella	1	1.7
Crepis occidentalis	1	80.0
Arnica fulgens	1	8.3
Epilobium paniculatum	1	2.2
Camassia quamash	1	25.0
Allium anceps	t	
Arnica cordifolia	t	
Collinsia parviflora	t	
Sidalcea oregana	t	
Lithophragma parviflora	t	
Ranuculus glaberrimus	t	
Collomia linearis	t	

APPENDIX E

Percent composition of plant species in the diet
of cattle and their relative palatability ratings
(August - Sept. 12, 1973)

Species	Percent Diet	RPI
Grasses and sedges		
Dactylis glomerata	28	2.4
Phleum pratense	16	1.7
Poa pratensis	11	1.5
Poa sandbergii	7	1.2
Arrhenatherum elatius	6	1.5
Carex geyeri	6	0.5
Festuca idahoensis	6	1.3
Elymus glaucus	5	2.3
Agropyron spicatum	4	1.8
Luzula campestris	2	2.6
Carex rossii	2	0.8
Hordeum jubatum	1	0.6
Bromus inermis	1	
Carex concinnoides	t	
Festuca myuros	t	
Bromus tectorum	t	
Trisetum canescens	t	
Forbs		
Polygonum douglasii	t	
Cirsium vulgare	t	
Lactuca serriola	t	
Achillea millefolium	t	
Eriogonum heracleoides	t	
Solidago missouriensis	t	
Rumex acetocella	t	
Astragalus canadensis	t	
Browse		
Spiraea betulifolia	1	0.7
Symphoricarpos albus	1	1.6
Physocarpus malvaceus	1	1.2
Ceanothus sanguineus	t	
Holodiscus discolor	t	
Salix scouleriana	t	
Vaccinium membranaceum	t	

APPENDIX F

Pounds of each species removed from each stand by big game.

Species	Stands[a]									
	1	2	3	4	5	6	7	8	9	Total
Grasses and sedges										
Phleum pratense						14	10	96	20	140
Arrhenatherum elatius		61								61
Poa sandbergii	21	22								43
Dactylis glomerata							16	2	27	45
Agropyron spicatum		22								22
Elymus glaucus								4	16	20
Festuca idahoensis		19								19
Bromus inermis								4	12	16
Koeleria cristata					14					14
Carex geyeri			5		5					10
Poa pratensis						6				6
Carex rossii								5		5
Hordeum jubatum	t									t
Carex concinnoides					t					t
Bromus mollis	t									t
Bromus marginatus							t			t
Danthonia californica		t								t
Total	21	124	5	0	19	20	26	107	75	407
Forbs										
Tragopogon dubius	25					163				188
Lupinus caudatus			19							19
Lactuca serriola						12	1	3		16
Agoseris grandiflora						14				14
Adenocaulon bicolor					13					13
Rumex acetocella							2		6	8
Crepis occidentalis		6								6
Arnica fulgens		4								4

APPENDIX F (continued)

Species	Stands[a] 1	2	3	4	5	6	7	8	9	Total
Epilobium paniculatum								4		4
Camassia quamash	4									4
Allium anceps	3	t								3
Arnica cordifolia			1							1
Collinsia parviflora							1			1
Sidalcea oregana										t
Lithophragma parviflora	t	t								t
Ranuculus glaberrimus	t	t								t
Collomia linearis						t				t
Total	32	10	20	0	13	189	4	7	6	279
Browse										
Symphoricarpos albus			2			8		17		27
Physocarpus malvaceus					t	t	25			26
Holodiscus discolor					1	14	2			17
Ceanothus sanguineus				5				t	3	8
Spiraea betulifolia					2					2
Salix scouleriana						t				t
Rosa gymnocarpa			t							t
Amelanchier alnifolia			t							t
Total	0	0	2	5	3	22	27	17	3	80
Total	53	134	27	5	35	231	57	131	84	

a Stands

1. Sandberg's bluegrass - kellogg onion
2. Ponderosa pine - bluebunch wheatgrass
3. Ponderosa pine - snowberry
4. Douglas-fir - snowberry
5. Grand fir - adenocaulon

Clearcut habitat types

6. Ponderosa pine - snowberry
7. Douglas-fir - ninebark
8. Grand fir - pachistima (upper slope)
9. Grand fir - pachistima (lower slope)

APPENDIX G

Pounds of each species removed from each stand by cattle

Species	Stands[a]									
	1	2	3	4	5	6	7	8	9	Total
Grasses and sedges										
Dactylis glomerata						491	1486	2748	802	5528
Phleum pratense						4	896	774	1522	3196
Poa pratensis		153		5		843	1116			2117
Poa sandbergii	1174	112								1286
Arrhenatherum elatius		1221								1221
Carex geyeri		87	568	465	8					1128
Festuca idahoensis		1080								1080
Elymus glaucus						391	14	212	380	997
Agropyron spicatum		886								886
Luzula campestris	443									443
Carex rossii						24	50	34	183	291
Hordeum jubatum	251									251
Bromus inermis									91	91
Carex concinnoides				60						60
Festuca myuros	5									5
Bromus tectorum						6				6
Trisetum canescens				10	1					11
Total	1873	3539	568	540	9	1759	3562	3768	2978	18,596
Forbs										
Polygonum douglasii									t	t
Cirsium vulgare									90	90
Lactuca serriola						24				24
Achillea millefolium	5									5
Eriogonum heracleoides	t									t
Solidago missouriensis			t							t
Rumex acetocella						2				2
Astragalus canadensis								t		t
Total	5	0	t	0	0	26	0	t	90	121

APPENDIX G (continued)

Species	Stands[a] 1	2	3	4	5	6	7	8	9	Total
Browse										
Spiraea betulifolia		17	72	175						264
Symphoricarpos albus		141	75			t				216
Physocarpus malvaceus					3	2	122			127
Ceanothus sanguineus				20				21	26	67
Holodiscus discolor				5	1	27	2			35
Salix scouleriana						6				6
Vaccinium membranaceum					8					8
Total	0	158	147	200	12	35	124	21	26	723
Total	1878	3697	715	740	21	1820	3686	3789	3094	

a Stands

1. Sandberg's bluegrass - kellogg onion
2. Ponderosa pine - bluebunch wheatgrass
3. Ponderosa pine - snowberry
4. Douglas-fir - snowberry
5. Grand fir - adenocaulon

Clearcut habitat types

6. Ponderosa pine - snowberry
7. Douglas-fir - ninebark
8. Grand fir - pachistima (upper slope)
9. Grand fir - pachistima (lower slope)

APPENDIX H

Percent deer pellet group yields from each stand during each measuring period

	Percent Pellet Groups					
	March	May	July	Sept.	Oct.	Total
Bunchgrass communities						
Sandberg's bluegrass - kellogg onion	1.0	2.0	9.0	0.0	0.0	12.0
Ponderosa pine - bluebunch wheatgrass	12.5	10.0	5.0	0.0	0.0	27.5
Forest communities						
Ponderosa pine - snowberry	12.2	3.5	1.7	0.0	0.0	17.4
Douglas-fir - snowberry	1.0	1.0	1.0	0.0	0.0	3.0
Grand fir - adenocaulon	15.1	6.0	12.1	0.0	0.0	33.2
Clearcut habitat types						
Ponderosa pine - snowberry	0.0	0.0	0.0	1.2	0.0	1.2
Douglas-fir - ninebark	2.5	1.3	1.7	0.0	0.0	5.5
Grand fir - pachistima[1]	0.0	0.0	0.0	0.0	0.0	0.0
Total	44.3	23.8	30.5	1.2	0.0	99.8

[1]Stand at the top of the slope.

APPENDIX I

Percent elk pellet group yield from each stand during each measuring period

	Percent Pellet Groups					
	March	May	July	Sept.	Oct.	Total
Bunchgrass communities						
Sandberg's bluegrass - kellogg onion	1.7	7.9	2.6	0.0	0.0	12.2
Ponderosa pine - bluebunch wheatgrass	5.8	9.1	3.3	0.0	0.0	18.2
Forest communities						
Ponderosa pine - snowberry	4.6	2.3	4.6	0.0	0.0	11.5
Douglas-fir - snowberry	2.0	1.4	2.0	0.0	0.0	5.4
Grand fir - adenocaulon	11.9	10.0	6.0	0.0	0.0	27.9
Clearcut habitat types						
Ponderosa pine - snowberry	7.0	1.2	1.2	0.0	0.0	9.4
Douglas-fir - ninebark	3.8	0.8	0.7	0.0	0.0	5.3
Grand fir - pachistima[1]	8.2	1.1	0.7	0.0	0.0	10.0
Total	45.0	33.8	21.1	0.0	0.0	99.9

[1] Stand at the top of the slope.