ECOLOGY AND HERBIVORE USE OF FIVE MOUNTAIN MEADOWS IN THE IDAHO PRIMITIVE AREA

A Dissertation

Presented in Partial Fulfillment of the Requirement for the

DEGREE OF DOCTOR OF PHILOSOPHY

Major in Forest Sciences

in the

UNIVERSITY OF IDAHO GRADUATE SCHOOL

by

LARRY DEAN WING

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ABSTRACT

During a study, extending from 1965 through 1969, the physical characteristics, vegetation, and summer herbivore use of five mountain meadows in the Idaho Primitive Area were described. Resident herds of Rocky Mountain elk *(Cervus canadensis nelsoni)*, pack and saddle animals, and Columbian ground squirrels *(Citellus columbianus)* were the principal herbivores. Vegetation was typed as "wet," "moist," "dry," and "very dry" according to prevailing soil moisture conditions. Soil moisture percentages ranged from 3 to 15 in the dry type, 10 to 60 in the moist type, and 35 to 300 in the wet type. Wet type soils remained saturated with moisture throughout the summer; moist type soils were saturated during early summer, but dried on the surface by mid-July; and dry type soils were well-drained, never saturated, and low in moisture content most of the summer. The percentage of area occupied by the wet, moist, dry, and very dry cover types was 49.6, 38.2, 10.1, and 3.1 respectively. Average canopy coverage of individual plant species was measured on 8 x 18-inch plots along randomly distributed transects. The percentage of ground covered by vegetation, excluding mosses, was 36.0, 48.7, 58.8, and 68.7 for the very dry, dry, moist, and wet cover types respectively. The very dry type was dominated by forbs, the dry and moist types by nearly

equal proportions of grasses and forbs, and the wet type by sedges. Average gross production was measured by clipping and air-drying vegetation from 4 x 4-foot caged plots which excluded grazing animals. Pounds of air-dried forage production per acre was 354, 2,167, 2,076, and 3,237 for the very dry, dry, moist, and wet cover types respectively. Estimates of forage removed by herbivores were made by comparing air-dried weights of vegetation between grazed and ungrazed 4 x 4-foot plots. Average pounds of forage removed per acre varied between meadows from: 46 to 248 for ground squirrels, 62 to 680 for elk, and 117 to 353 for horses. Total forage removed varied between meadows from 1.8 to 30.5 percent. Ground squirrels removed nearly equal amounts of forage from the dry, moist, and wet cover types. Approximately 70 percent of all forage used by elk came from the moist cover type, 26 percent from the dry, and 4 percent from the wet. Horses obtained approximately 40 percent of their forage from each of the wet and moist cover types, and 20 percent from the dry. The percentage of forage removed varied from 17.8 to 55.6 on the dry type, 12.5 to 33.1 on the moist type, and 2.9 to 22.6 on the wet type. Elk use of meadows was highest during June, dropped rapidly during the summer, and was rare by late August. Elk activity was maximum from 5 to 11 p.m. and minimum from 11 a.m. to 5 p.m. The

incidence of elk utilization of plant species was recorded on 1 x 4-foot plots along randomly-located transects. Forbs were the most frequently used plants, sedges second, grasses third, and shrubs last. Heaviest use of sedges occurred early in the summer during their blooming period. Heaviest use of both grasses and forbs occurred between July 7th and 31st. Forb utilization was greatest near the full bloom period of the respective species, but use of grasses occurred well in advance of blooming.

BIOGRAPHICAL SKETCH OF THE AUTHOR

Larry Dean Wing was born in Webster City, Iowa on August 13, 1935. He attended Wheaton High School in Wheaton, Illinois and received a diploma in 1953. He received the degree of Bachelor of Science in Forestry, with a major in Wildlife Management, from the University of Idaho in 1958. From February, 1958 until August, 1960, he was on active military duty as a naval officer. He commenced graduate work at the University of Idaho in September, 1960, and received the degree of Master of Science in Forestry in June, 1963. From September, 1962 until September, 1965 he was employed as a research biologist by Washington State University and served as assistant project leader on an ecological study of the African elephant. In September, 1965, he entered the Graduate School of the University of Idaho and in August, 1969, completed the requirements for the degree of Doctor of Philosophy in Forest Sciences.

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TABLE OF CONTENTS

PAGE

PAGE

PAGE

LIST OF FIGURES

Figure | Page

LIST OF TABLES

Table | Page

Table | Page

Table | Page

Table | Page

Table | Page

Table | Page

INTRODUCTION

Objectives

In 1965 a research project was initiated for the purpose of studying the ecology of mountain meadows on the Big Creek Ranger District in the Idaho Primitive Area. Specifically, the objective of the project was: to describe the physical characteristics, vegetation, and herbivore use of mountain meadows representative of those found on the Big Creek Ranger District.

Justification

The use of wilderness and primitive resources is an important aspect of land management in Idaho where 3,386,280 acres of public land are classified as Wilderness or Primitive (Outdoor Recreation Resources Review Committee 1962). Ecological research on these lands however has been noticeably lacking. The need for basic ecological facts has become urgent, particularly now that the concept of wilderness has become a popular issue. Opinions vary widely on the subject of wilderness management and use, but the means for resolving differences on the basis of factual data is grossly lacking. Now, as no time in the past, the surge of humanity in search of outdoor recreation is being felt in Idaho and

throughout the nation, as the use of existing facilities and areas, including wilderness, continues to increase each year.

The wildlife resources of our wilderness and primitive areas are integral parts of the unspoiled environments in which they occur and are a major attraction to the ever increasing number of wildland users. These animals as well as the vegetation upon which they depend are dynamic resources and man's lack of interference will not necessarily insure their perpetuation. The vegetation in particular is continually altered by natural succession and disturbance, which may or may not enhance the production of forage used by herbivore populations. Herbivore utilization is in itself a factor capable of influencing the rate and direction of vegetation change.

Because of the relatively small total area occupied by mountain meadows in most regions, the important role they play in providing summer range forage is sometimes overlooked. Mueggler (1962) reports that mountain meadow vegetation in northern Idaho and northeastern Washington provides a disproportionately large amount of forage for the relatively small fraction of total summer range it represents. Reid and Pickford (1946) report that mountain meadows in the eastern portions of Oregon and Washington make up only 1 to 2 percent of the summer range area, but have the potential for producing 20 percent of the summer range forage.

Demands on the forage resource of the mountain meadows in the Idaho Primitive Area by big game and pack and saddle stock have risen markedly during recent years. Simpson and McConnell (1956) estimated that the herd of elk *(Cervus canadensis nelsoni)* in the Idaho Primitive Area grew from essentially nothing at the turn of the century to approximately 4,000 to 5,000 animals in 1956. Although no current census figures are available, annual trend counts of elk on the winter range, made by the Idaho Fish and Game Department, indicate that the population has probably not declined since 1956. Between 1939 and 1964 the number of outfitters and guides working in the Idaho Primitive Area increased from about six to fifty (Douglas 1964). The magnitude of the increase in numbers of outfitters and guides is not known but is undoubtedly considerable and will continue to rise as recreational use increases.

Wilderness and primitive areas have esthetic and recreational values, but also provide opportunities to study the complex aspects of ecological cause and effect under relatively undisturbed conditions. It is anticipated that much of the potential value of this study derives from the description of such conditions. It is hoped that, at the very least, the present study will provide a base of information from which to measure future deviations.

Previous Work

A number of studies of mountain meadows and various herbaceous subalpine communities have been conducted in the western United States and are pertinent to this study. Studies concerning elk utilization of summer range have been conducted in Montana in particular, and throughout the West in general. Very little information has been produced however on the specific topic of elk use of mountain meadows. In Idaho no detailed information on mountain meadow ecology has been produced. With the exception of Hornocker's (1967) study of the mountain lion *(Felis concolor)*, and this study, no ecological research has been conducted on the Big Creek Ranger District. Throughout the remainder of this paper, under the appropriate topical subdivisions, pertinent aspects of previous research are reviewed, discussed, and related to this study.

Procedures

During the summer of 1965 an aerial reconnaissance of mountain meadows on the Big Creek Ranger District was made, followed by a one-week ground survey. These preliminary surveys indicated the suitability of the Cold Meadow Guard Station as a field headquarters, not only because of its

central location among meadows representative of the district, but also because the airstrip, housing facilities, and horse pasture located there greatly reduced the problems normally associated with the logistics of field work in a primitive area.

Commencing in 1966, three summers were spent in the field collecting detailed information on five meadows within a 10-mile radius of the Cold Meadow Headquarters. Additional general information was obtained through visits to twelve other major meadows scattered throughout the district. Periods of time spent in the field were as follows:

1966: June 22 - September 5

1967: June 26 - September 7

1968: June 10 - September 13

During the course of the three field seasons project objectives were fulfilled as follows:

1. General meadow characteristics and vegetation were described in terms of:
   a. Plant species composition of four cover types, expressed as percent ground coverage.
   b. General soil characteristics (predominant soil types and percent moisture).
   c. Air-dried weight of forage produced per acre, by cover type.

d. Phenology of major plant species.

e. Total acreage and elevation of each meadow.

2. Herbivore use of the meadows was described in terms of:

a. Air-dried weight of forage removed per acre by big game, livestock, and ground squirrels, by cover type.

b. Forage species preferences of elk.

c. Animal days use by elk and livestock.

d. Migratory patterns of elk which summer on the meadows.

e. Daily and seasonal patterns of meadow use by elk.

f. Nature and extent of differences in ground squirrel activities between meadows and major cover types.

3. Weather records were maintained at Cold Meadow throughout the study period.

STUDY AREA

Location and Definition

The meadows which were studied intensively are located in the northeastern portion of the Big Creek Ranger District in central Idaho (Figure 1). This 1,280-square-mile district is a part of the Payette National Forest and most of it (85 percent) falls within the boundaries of the Idaho Primitive Area. The locations of the five intensively-studied meadows in relation to major landmarks, as well as the location of the study area within Idaho, are illustrated in Figure 2.

The study area, in its strictest sense, encompasses only the five mountain meadows for which detailed field data were collected. However, since these meadows are typical of those scattered throughout the northern portion of the Big Creek Ranger District, and since general information was collected from other meadows throughout the northern portion of the district, the study area in its broadest sense encompasses the northern two-thirds of the Big Creek Ranger District.

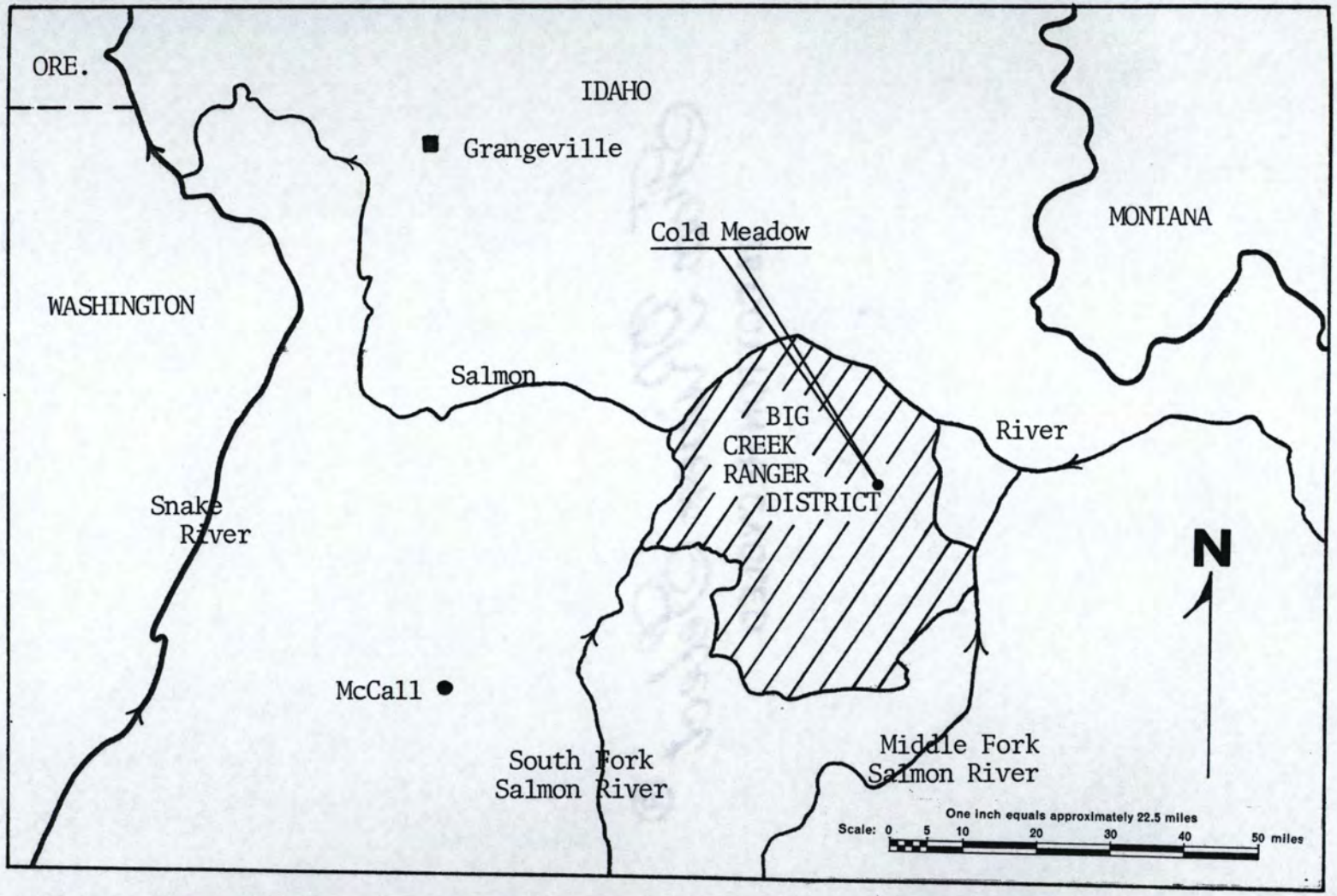

Figure 1. Area map of central Idaho showing the location of Cold Meadow within the Big Creek Ranger District and the relationship of the Big Creek Ranger District to prominent features in central Idaho.

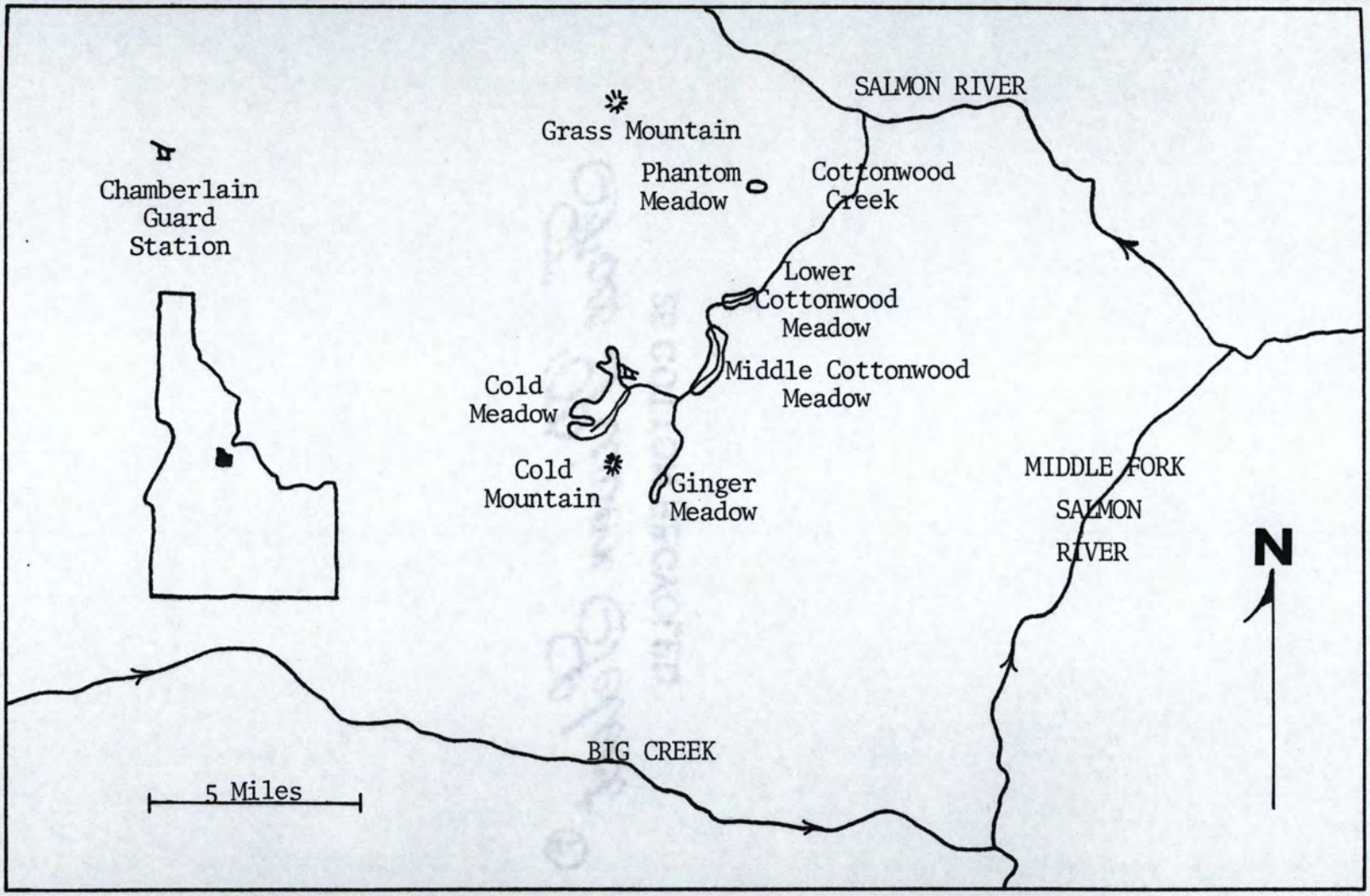

Figure 2. Vicinity map illustrating the positions of the five intensively-studied meadows in relation to major land marks. Inset depicts the location of the study area within Idaho.

Topography - Physiography

The northern two-thirds of the Big Creek Ranger District forms a high mountainous plateau bordered by Big Creek on the south, the Middle Fork of the Salmon River on the east, the Salmon River on the north, and the South Fork of the Salmon River on the west. This plateau extends over approximately 800 square miles and varies in elevation from about 5,500 feet in the lowest creek bottoms to 9,000 feet at the tops of the most prominent peaks. Topography is generally moderate, except for a few granite outcrops, and on the periphery of the plateau, where it drops very abruptly into the bordering drainages.

Vegetation and Soils

Coniferous forest vegetation predominates with species composition varying primarily according to elevation and history of disturbance by fire. According to the classification of Daubenmire (1943) the following forest zones are represented: (1) Ponderosa pine *(Pinus ponderosa)*, (2) Douglas fir *(Pseudotsuga menzesii)*, and (3) Spruce-Fir *(Picea engelmanni/Abies lasiocarpa)*. Large areas in the Douglas fir and Spruce-Fir zones are dominated by lodgepole pine *(Pinus contorta)* and represent seral stages created by past wild fires.

Mountain meadows of varying size are interspersed with the timber and occur primarily between 5,500 and 8,000 feet elevation. Thirty named-meadows occur on the northern two-thirds of the district and small unnamed meadows are common. All of the meadows occur along stream courses or in bog or seep areas. Meadow soils are moist to wet and exhibit a predominance of sedges with a wide variety of grasses and forbs and a scattering of shrubs. A cross-sectional profile of a typical meadow is illustrated in Figure 3. Physiognomy and species composition of meadow vegetation are closely related to soil moisture levels and generally present a distinct stratification from the wettest central portions to the drier outer edges. Hydromorphic and alluvial soils predominate, but sandy loams, derived from residual granite, occur along the outer edges in some areas.

As Reid and Pickford (1946) reported for mountain meadows in the eastern portions of Oregon and Washington, most of the meadows in this study appear to have developed on the sites of former lakes and ponds. Present day meadow vegetation appears to have developed through the normal processes of hydrarch succession, accelerated by the accumulation of finely-textured alluvial materials from surrounding slopes. Meadow soils are maintained in a saturated or near saturated condition by the normal gravitation of surface and subsurface runoff from the adjacent hillsides. As a number of authors

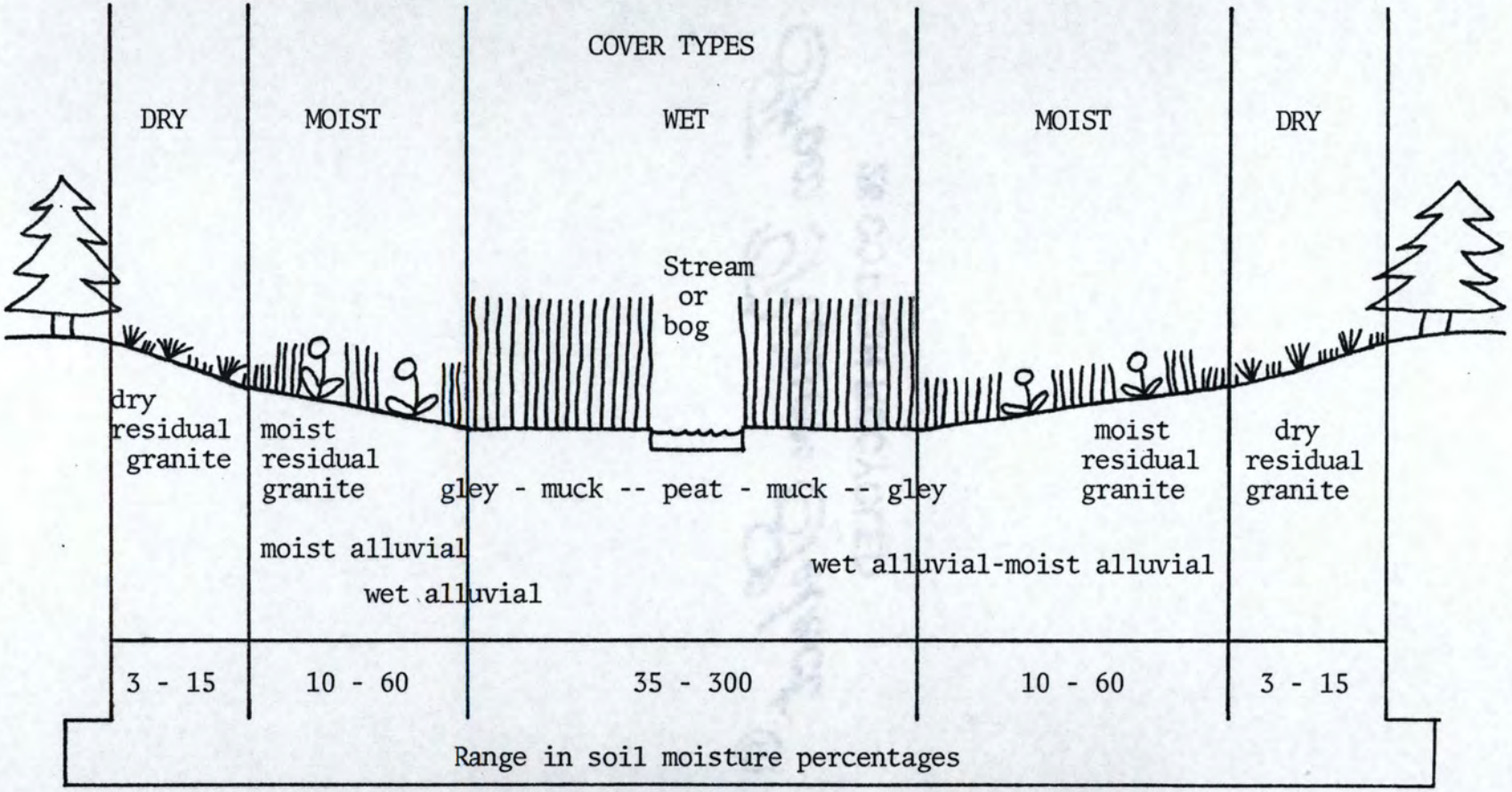

Figure 3. Cross-sectional profile of a typical mountain meadow, illustrating major cover types, soils, and ranges in soil moisture percentages.

have reported, trees are not usually able to survive on such poorly-aerated, fine-textured soils (Daubenmire 1943, Ellison 1954, Patten 1963). The transition from forest to meadow vegetation is usually abrupt, and is probably due to equally abrupt changes in soil texture and moisture conditions. Daubenmire (1943) in describing comparable transitions stated:

> Since the alluvial and loessal soils of the basal plains are commonly finer-textured than the residual covering of the mountain slopes which have lost much of their finer material through natural erosion, the lower limits of the ligneous associations often terminate abruptly at the lower edge of the mountain slopes where the erosional and depositional surfaces are in contact.

The stability of mountain meadow vegetation in terms of long range successional trends is somewhat of a moot question and one that is undoubtedly influenced by peculiarities of local environment. Patten (1963) in studying soil moisture relations in subalpine herbaceous communities in Montana concluded that the open areas occupied by the herbaceous vegetation would probably not give way to forest unless precipitation increased. Shorsmith (1959) reported that formerly wet meadows in the Sequoia and King's Canyon National Parks were colonized by lodgepole pine to form open woodlands. He thought that in the absence of disturbance meadow boundaries would remain unchanged for centuries.

Daubenmire (1943) refers to "mountain parks" in the Douglas fir and spruce-fir regions of the Rocky Mountains which support what appears to be climax herbaceous vegetation. It is Daubenmire's observation that these parks are able to perpetuate themselves because of special conditions of soil or microclimate. Reid and Pickford (1946), in reference to mountain meadows in eastern Oregon and eastern Washington, state:

> It is probably that forests will occupy most places now supporting meadow vegetation in the mountainous summer range.

These same authors suggested however that such vegetation should be treated as permanent because of the hundreds of years that would probably transpire before conversion to forest.

In this paper the identification and nomenclature of all grasses are according to Hitchcock (1950), all sedges according to Mackenzie (1940), and all other plants according to Hitchcock *et al.* (1959). A complete list of all meadow plant species encountered during the study is presented in Appendix I. Specimens of nearly every plant listed were placed in a voucher collection at the University of Idaho Biological Science Herbarium.

Use

The high plateau upon which the meadows are found

serves as summer and early fall range, and as calving grounds, for large numbers of Rocky Mountain elk, which are the principal herbivorous users of the meadow forage. Some meadow forage is utilized by white-tailed deer *(Odocoileus virginianus orchorourus)*, mule deer *(Odocoileus hemionus)*, and moose *(Alces alces)*, but these animals are either too few, in the case of the moose, or else use the meadows too infrequently to remove very substantial amounts of forage. Columbian ground squirrels *(Citellus columbianus)* abound on many of the meadows and remove considerable quantities of forage.

The grazing of many of the meadows throughout the high plateau by horses and mules of outfitters and guides, recreationists, and the U. S. Forest Service constitutes the only form of livestock use which occurs. Most use by livestock occurs in the fall, but some meadows receive use throughout the summer as well.

The principle form of land use on the plateau is recreation, and big game hunting is the most common activity. Elk, big horn sheep *(Ovis canadensis)*, cougar, mule deer, white-tailed deer, and black bear *(Ursus americanus)* are the big game species sought after by hunters, with bull elk being the usual objective. Fishing, camping, and hiking are other activities which attract recreationists to the area.

Information collected from trapping and marking operations of the Idaho Fish and Game Department at the

Chamberlain and Cold Meadow Forest Guard Stations indicates that the elk that summer on this high plateau winter on the main Salmon River, Big Creek, and the Middle Fork of the Salmon River. Elk which summer at Cold Meadow evidently winter on both the main Salmon and the Big Creek drainages.

Mammalian nomenclature in this paper is according to Walker *et al.* (1964).

Meadow Study Sites

Elevations and acreages for each of the five intensively studied meadows are presented in Table 1. These five meadows were treated as six sample units. Four of the meadows received uniform grazing treatment and were each sampled as entire units. Approximately 30 percent of Cold Meadow however is fenced and pastured to horses and mules, while the rest of the meadow is used nearly exclusively by big game and ground squirrels. Because of the difference in grazing treatments the pasture was considered as a separate meadow or unit and the rest of the meadow as a second. These two units are hereafter referred to as the "Horse Pasture" and "Cold Meadow" respectively. All six sample units are used each summer by big game and in varying degrees by horses and mules during the fall. Columbian ground squirrels abound on all of the units except Ginger and Phantom, where none was found.

Table 1. Elevation and total acreage of each meadow unit.

Meadow Unit	Elevation	Acres
Cold	6,700	144.85
Horse Pasture	6,700	62.21
Phantom	6,660	8.30
Ginger	6,452	17.74
Middle Cottonwood	6,285	122.26
Lower Cottonwood	6,075	74.44

Weather

The only known weather records that exist for the plateau region are the ones maintained by widely scattered fire lookouts. These records are not particularly applicable to the meadows because of the generally extreme differences in elevation and exposure between lookouts and meadows. Therefore, weather data were recorded at Cold Meadow during the three summers of field work and are referred to throughout this report. A summary of weather data is presented in Tables 2 and 3. Although averages for other meadows undoubtedly vary with elevation, exposure, and other factors, the Cold Meadow data provide a guide to overall weather patterns between months and years.

Summer precipitation consists primarily of rain, but heavy snow showers occurred during every month except July. The overall maximum and minimum temperatures for the three summers were 89° F. and 14° F. respectively, and both occurred during July of 1966. The 24-hour variation in air temperature was seldom less than 40° F. and was often 60° F. or more. Maximum temperatures occurred between 2 p.m. and 4 p.m. along with a low in relative humidity ranging from 25 to 35 percent. Minimum temperatures generally occurred about 6 a.m. Relative humidity reached its peak of 70 to 90 percent between 2 a.m. and 4 a.m. and remained high until sunrise. These

Table 2. Monthly precipitation at Cold Meadow during the summers of 1966, 1967, and 1968, measured in hundredths of inches.

Year	June[1/]	July	August	September[1/]	Total
1966	0.43	0.00	0.10	0.00	0.53
1967	0.15	0.10	0.50	0.05	0.80
1968	0.42	0.75	3.35	0.15	4.67
3-yr. mean	0.33	0.28	1.31	0.07	2.00

1/ Records were maintained for only the last week of June and the first week of September.

Table 3. Monthly maximum and minimum air temperatures at Cold Meadow during the summers of 1966, 1967, and 1968.

Year	June[1/]		July		August		September[1/]		Summer $\bar{x}$	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1966	74.3	32.7	79.0	28.5	80.4	25.5	82.3	26.2	79.4	27.5
1967	70.2	36.2	76.6	34.1	79.7	30.7	79.0	33.0	77.7	32.6
1968	61.4	31.2	74.0	30.6	64.7	32.1	73.4	26.5	68.1	31.1
3-yr. mean	68.6	33.4	76.5	31.1	74.9	29.4	78.2	28.6	75.1	30.4

1/ Records were maintained for only the last week of June and the first week of September.

24-hour-ranges in relative humidity and the timing of the highs and lows are nearly identical to those reported by Hayward (1952) for alpine meadows in the Uinta mountains of Utah.

The snow-free period generally extends from about June 1 to October 1, but varies considerably between years. A frost-free period does not exist, with freezing temperatures occurring during every month of the year.

METHODS AND PROCEDURES

Species Composition and Cover Typing

Sampling

Two techniques for determining plant species composition were tested. Because of its high degree of objectivity an attempt was made to employ the point method of Levy and Madden (1933). Since much of the vegetation is tall and subject to movement by wind, the reading of basal hits was considered to be more desirable than aerial contacts. After field testing, this technique was abandoned because of the questionable validity of comparing basal hits on the wide variety of plant forms encountered (bunchgrasses, single-stemmed species, broad-leafed forbs, shrubs, etc.).

A technique involving estimates of total ground coverage of individual species was finally selected for determining species composition. The term ground coverage or coverage, as used in this study, pertains to the percentage of total ground area covered by a downward projection of all above-ground parts of a given species. As Holscher *et al.* (1959) point out, one of the primary advantages of using ground coverage for describing species composition is that it is a good criterion for comparing different life forms. The same authors also state that an additional advantage of

the ground coverage criterion derives from the fact that:

> --cover data, per se, are independent of plot size, shape, and sampling design. This is in sharp contrast to frequency, and constancy data which permit comparisons only between identical plot sizes, shapes, and sampling designs.

Practical considerations, plus several general principles concerning sampling procedures, served as guide lines in determining the size and shape of plot. The density, complexity, and height of the vegetation made it impractical, if not impossible, to accurately estimate ground coverage percentages on large plots. After field testing plot frames ranging in size from 1 to 4-square-feet, a plot frame of 1-square-foot, measuring 8 by 18 inches was judged to be most suitable. The border of this small frame was readily discernible in the dense vegetation, the contents of the entire plot could be viewed at a glance from above, and many plots could be read in a short period of time. To facilitate the estimation of ground coverage percentages, the edge of the plot frame was calibrated and marked with colored tape.

The square-foot plot, and other small plots of similar area, have been used for many years by a variety of workers for estimating coverage values on grasslands and pastures (Brown 1954). A rectangular-shaped plot was selected because it included more variation than plots of equal size, but

different shape (Ursic and McClurkin 1959, Daubenmire 1968).

Meadow sampling procedures were conducted as follows:

1. The entire meadow, or that portion of it to be sampled, was partitioned into strata, which were adjusted so as to intersect the soil moisture gradient of the meadow at right angles. Soil moisture levels increased from the edge of the meadow inward to the center where a stream or standing water generally occurred. The strata extended from the edge of the meadow inward to a base line which bisected the entire meadow along its long axis and paralled the contours of soil moisture levels (Figure 4). Where the shape of the meadow was curved, the direction of the center base line was altered accordingly so that it continued to bisect the meadow. If curves were extreme, auxillary base lines, tangent to the curve, were established as necessary in order to avoid overlapping of sample strata and to minimize the total area left unsampled.

2. Within each stratum the position of one line transect was randomly selected from a table of random numbers representing one-foot intervals. Each transect extended, at right angles to the base line or auxillary base line, through the entire length of the stratum.

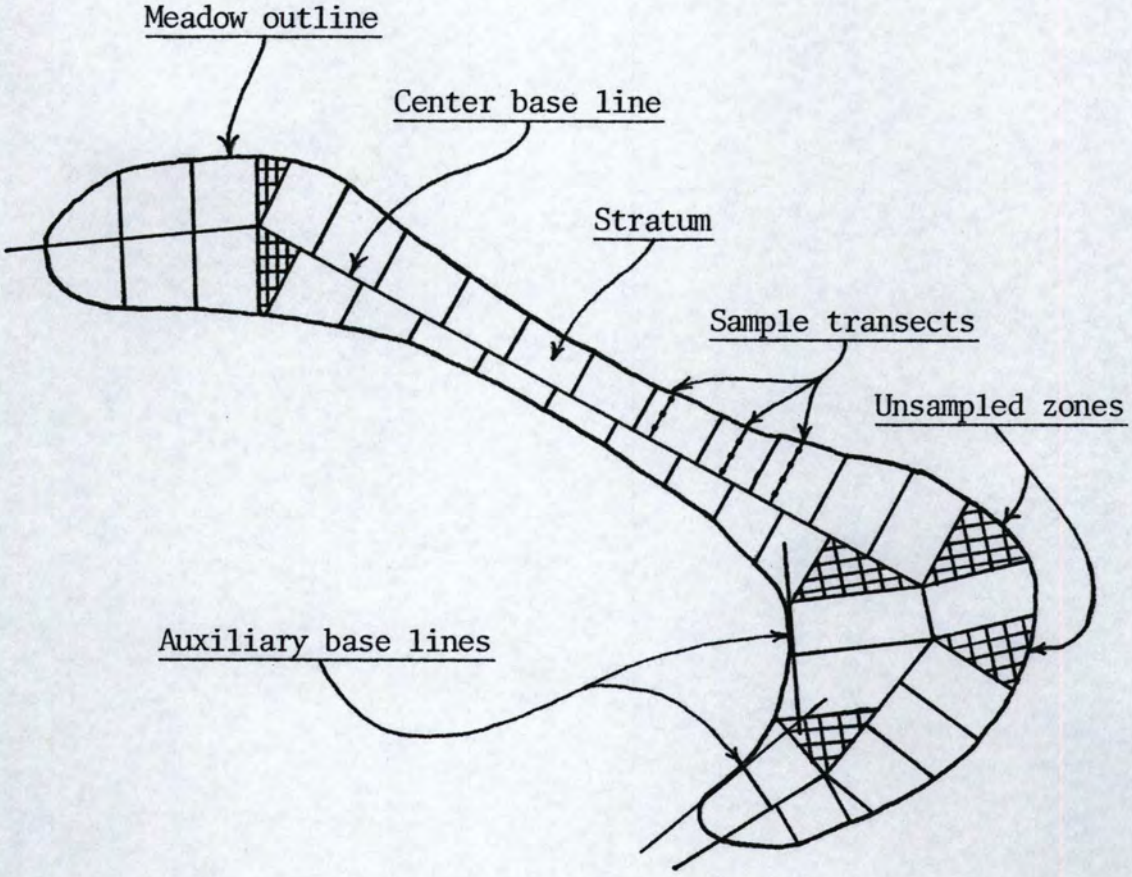

Figure 4. Diagram of design used in sampling mountain meadow vegetation.

3. Along each transect plot frames were sampled at 80-foot intervals. The distance from the base line to the first plot was randomly determined using a table of random numbers ranging from 0 to 79, with subsequent plots occurring at 80-foot intervals.

4. On each sample plot the percentage of ground covered by each species present was estimated according to the following series of six cover classes used by Trepp (1950) for describing alpine pastures in Switzerland:

Class	Percent Ground Coverage
1	less than 1.0
2	1.0 - 9.9
3	10.0 - 24.9
4	25.0 - 49.9
5	50.0 - 74.9
6	75.0 -100.0

Midpoints of the various classes were used in computing averages.

As Greig-Smith (1964) and many other writers point out, techniques involving estimates of plant species coverage are subject to errors of human judgement. Chances for such error are reduced considerably however when coverage is estimated by general classes or ranges of coverage values. Furthermore, the use of cover classes, even broad ones, does not preclude obtaining sensitive and statistically reliable results. In reference to the use of cover classes for

estimating vegetation coverages, Daubenmire (1968) states:

> The advantage of a relatively coarse scale in this operation is that there is little chance for personal error in class assignment, yet when the results from a considerable number of small plots are averaged, rather fine differences can be brought out.

Strata widths were constant for a particular meadow unit, but varied between units according to the number of transects needed to achieve desired levels of statistical reliability. Since only one transect was located within each stratum, the wider the strata the fewer the total number of transects of a meadow unit. Width of strata was adjusted to the largest dimension that would insure a sufficient number of transects to produce, for major meadow species, standard errors that were within 20 percent of the mean. Estimates of the numbers of transects needed were calculated from data collected during the pre-sampling of each meadow unit. All sampling was conducted in July after meadow vegetation had reached its maximum development, but prior to utilization by horses and mules. The Lower Cottonwood, Ginger, and Phantom units were sampled in 1968. All other units were sampled in 1966.

In the field, the classification of vegetation according to cover type was based primarily upon physiognomy. General species composition was integrally related to physiognomy and was a second criterion used in classification.

The relative amount of moisture in the surface soil was a third criterion employed. Characteristics which were useful in separating cover types are listed below by cover type.

Very Dry Cover Type. Average height of vegetation is 1 to 5 inches. Located on areas of disturbance and shallow, rocky soils. Rock outcrops often visible. Bare ground is common and sometimes exceeds 90 percent. Little or no litter accumulation. Common species include; *Achillea lanulosa, Antennaria rosea, Arenaria aculeata, Arenaria congesta, Aster integrifolius, Potentilla diversifolia, Sedum stenopetalum, Danthonia intermedia,* and *Festuca idahoensis.*

Dry Cover Type. Average height of vegetation is 4 to 8 inches. Generally found on meadow edge adjacent to timber on loose, sandy soil. Bare ground comprises 25 to 50 percent of area. Some litter, but no organic mat. *Danthonia intermedia* and the bunchgrasses *Agropyron dasystachyum, Festuca idahoensis,* and *Stipa columbiana* dominate. *Carex geyeri* reaches its maximum coverage in this type. Other common species include: *Achillea lanulosa, Antennaria rosea, Aster integrifolius, Fragaria virginiana, Geum trifolium, Penstemon procerus, Taraxacum officinale,* and *Trifolium* spp.

Moist Cover Type. Average height of vegetation is 6 to 12 inches. Generally found mid-way between the wet center of the meadow and the dry edge. No organic mat, but litter is common and almost no bare ground is visible. Areas not covered by leafy vegetation are often covered with moss. *Calamagrostis canadensis* dominates the cover type. Other common species which reach their maximum ground coverage in this cover type include: *Agoseris* spp.,*Aster foliaceus, Ligusticum filicinum, Polygonum bistortoides, Ranunculus alismaefolius, Deschampsia caespitosa, Phleum alpinum, Trisetum wolfii, Carex hoodii,* and *Luzula multiflora.* Early in the summer this cover type is characterized by the profusion of yellow blossoms of *Ranunculus alismaefolius. Ranunculus alismaefolius* is also common in the wet type, but the blooms are obscured by the tall sedges. From mid-summer through fall the moist type is characterized by the shiny stems and seed heads of *Deschampsia caespitosa,* which protrude above the rest of the vegetation.

Wet Cover Type. Average height of vegetation is 10 to 30 inches. Found on the wettest, usually central portions, of the meadow. Bare ground absent entirely

except for muck holes which dry up late in the summer. Areas not covered by leafy vegetation are covered with a solid mat of moss. The mat of organic matter is thick, sometimes forming layers of peat. The wet type is dominated by *Carex aquatilis* which comprises 30 to 100 percent of the ground cover. Other common species which reach their maximum development in this type include: *Aconitum columbianum, Pedicularis groenlandica, Senecio triangularis, Swertia perennis, Valeriana capitata, Carex rostrata, Eleocharis acicularis,* and *Juncus* spp.

Analysis of Data

Average percent ground coverage was determined for each meadow plant species for each cover type on each meadow unit. An overall average for each species was also determined, for each cover type, and represents the combined six meadow units. Estimates of the total amount of ground covered by live vegetation, excluding mosses, were made for each cover type by summing the average coverage values for all species present. Since the vegetation was seldom layered, these summations should reasonably approximate total vegetation coverage. The sample unit *(n)* for all calculations consisted of the collective area occupied by all plots

occurring in a given cover type on a particular transect. The average percent coverage of a given species on these plots constituted an n value and was averaged with the respective n values, for that species, from all the other transects on the meadow unit, to yield a meadow mean. In calculating overall means, n values were averaged over all six meadow units.

In calculating overall means it was not considered necessary to weight meadow averages by respective acreages since coverage means for individual species did not differ greatly between meadow units. In effect, therefore, the smaller units received proportionally greater weight than the larger units because of their greater numbers of transects per unit of area. This was partially offset by the fact that the larger meadow units had a greater total number of transects.

Forage Production and Utilization

Sampling

During the summer of 1968 forage production was sampled on five major meadows within a 10-mile radius of the Cold Meadow Guard Station. The purpose of this sample was to estimate gross forage production and to detect differences in production due to cover type, and to utilization

by Columbian ground squirrels, big game, and livestock. Livestock use was by pack and saddle animals, and big game use almost exclusively by elk. Utilization by mule deer, white-tailed deer, and moose was very minor.

Forage production was estimated by determining air-dried weights of clipped vegetation on 4-foot-square plots located within the three major cover types on each meadow unit. All plots were established in series of twos or threes in order to estimate production differences between protected and unprotected vegetation. One plot in each series was unprotected and all forage upon it was available to all types of grazing animals. For every unprotected plot, a second, comparable plot was established nearby within the same cover type. This second plot was protected against big game and livestock grazing, but allowed access to ground squirrels and smaller rodents. On areas used by ground squirrels, a third comparable plot was established and protected against squirrel grazing. A technique similar to that described by Klingman *et al.* (1943) was used in selecting sample sites for the two and three-plot samples. The location of the first plot site was randomly selected, with subsequent sites being subjectively selected to match the first.

A total of 176 plots were sampled on 72 sites, with 72 plots being protected against big game and livestock grazing; 72 unprotected; and 32 protected against grazing by ground squirrels. Plots which were completely unprotected are hereafter referred to as "grazing treatment one"; plots protected from big game and livestock grazing, but used by ground squirrels as "grazing treatment two"; and plots which were completely unused as "grazing treatment three."

Big game and livestock were excluded from sample plots by constructing pole frame exclosures covered with chicken wire of 2-inch mesh. Each cage was 4 feet long, 4 feet wide, and 2 feet high. The bottom edge of the wire was fastened to the framework 4 inches above ground level to insure free access to ground squirrels. Cages which excluded ground squirrels had the same dimensions and framework, but chicken wire with a 1-inch mesh was used. The bottom edge of the wire on these cages was pegged to the ground to discourage squirrels from squeezing under. All exclosure frames consisted of four vertical corner posts driven 2 feet into the ground, and two horizontal cross pieces secured diagonally to the tops of the upright corner posts.

On each meadow sampled, series of plots were located within the larger blocks of each major cover type. In selecting cover type blocks for sampling, an attempt was

made to distribute the sample as uniformly as possible over the entire meadow. The allocation of sample plot series upon each meadow and upon major cover types within each meadow was approximately proportional to the area being sampled. On the three largest meadows sample plot series were allocated at the approximate rate of one series for every 6 acres of meadow. This rate was intensified to 1:3 on the two smallest meadows to keep the sample size *(n)* large enough to be statistically viable. A ratio of 1:10 was used on the Horse Pasture, but proved to be statistically inadeauate.

Each cover type block selected for sampling was theoretically divided into numbered 4-foot squares. This was accomplished by determining the dimensions of the largest square or rectangle that would fit within the boundaries of the vegetation block, and calculating the number of 4-foot squares that such a figure would contain. All distances and angles were determined by pacing and the use of a hand compass. On paper, each 4-foot square was assigned a consecutive number, proceeding across the square or rectangular figure from left to right, and from top to bottom. Squares, bearing the same numbers as those drawn from a table of random numbers, were then selected for sample plots. The number of sites selected for sampling

within a given block of vegetation depended upon the size of the block and the sampling rate being employed on the meadow involved.

After a sample site had been located in the field, its corners were marked and its prominent features examined. A second site was then subjectively selected to match the first as closely as possible. The second site was located no further than 50 feet, and no closer than 25 feet from the first. Topography, soil moisture conditions, slope, aspect; and the gross morphology, state of development, and ground coverage of major plant species present were used as criteria for pairing plots. After the second site had been selected a coin was tossed to determine which site would be protected from grazing. The other site was marked, but left unprotected.

Where a 3-plot series was desired, a third plot site was subjectively selected to match the first two. Random numbers were then drawn from a table to determine which grazing treatment each plot would receive. In a 3-plot series the two subjectively-selected plot sites were located within a 100-foot radius of the randomly-selected sites, and no two plots were placed closer than 25 feet apart. In rare cases, where the randomly-selected site was atypical of the cover type and could not be replicated, a second random selection was made.

All sample plots were established during June, prior to any livestock utilization and after only a minimal amount of use by big game and ground squirrels. During late August and early September, the vegetation on all study plots was clipped at ground level and stored in cloth bags for curing. At the time of clipping most meadow plant species had ceased to grow and were curing, big game use of meadow forage was nearly non-existent, and most ground squirrels were in hibernation.

Immediately prior to clipping, the ground coverage of each plant species on each plot was estimated according to coverage classes described earlier in this section. This was done for the purpose of estimating the relative degree of utilization of the various forage species.

Although it was originally planned to clip only a 9-square-foot area out of the center of each plot to avoid edge effects, it was decided after examining the caged vegetation at the end of the growing season to clip entire plots. Edge effects, if they existed, were not apparent and on most areas it was nearly impossible to determine the location of the plot edge once the cage wire had been removed.

Clipped vegetation was removed from the field and placed indoors for curing. A 10 percent sample of bags was weighed every two weeks to determine when weight losses

ceased. No decreases in weights were detected after 30 days of curing, and each bag of vegetation was weighed to the nearest gram on an electronic scale. The average weight of an empty cloth bag (46 grams) was subtracted from total weights to give the weight of the cured vegetation.

Analysis of Data

The six meadow units were further classified, for purposes of analysis, into two groups based on grazing treatment. Lower Cottonwood, the Horse Pasture, and Phantom were grazed by both livestock and big game during the summer and were collectively designated as "Area I". The other three units (Cold, Middle Cottonwood, and Ginger) sustained only big game use and were classified as "Area II". Data from the collective sample were analyzed at six different levels. Means and standard errors were calculated at each of the following levels:

1. Cover type within meadow unit.
2. Meadow unit.
3. Cover type within area.
4. Area.
5. Cover type overall.
6. Overall.

Gross production data were analyzed at all six levels, but utilization data, with the exception of ground squirrel data, were analyzed only through level four.

Weighting. The means, standard errors, and variances for gross production and utilization were all weighted by the number of acres they represented. Forage utilization statistics for ground squirrels were not weighted since the sizes of the areas they represented were unknown. Weighted statistics were calculated for all but the first of the six levels at which sample data were analyzed. Weighted means were calculated according to the following formula:

$$\text{Weighted mean} = \frac{\Sigma WX}{\Sigma W}$$

where, X = the air-dried weight, in grams, of clipped vegetation from one 4 x 4-foot sample plot.

W = the number of acres of meadow unit represented by each respective X value.

Plot weights were calculated at the cover type-within-meadow unit level by dividing the total number of acres in the cover type on the meadow unit by the total number of plot series within the cover type. For example, three plot series were located within the dry cover type on the Lower Cottonwood meadow unit. The dry cover type there occupies 11.05 acres, so the weight of each plot is 3.683.

Since each plot has equal weight at level one (Cover type within meadow unit) means at this level were unweighted and were calculated merely by dividing the sum of the X's by n. In calculating a weighted mean for a meadow unit (level two) each plot value (X) was multiplied by the fraction of the meadow unit it represented (number of acres). The sum of these products (ΣWX) was then divided by the total number of acres in the meadow unit (ΣW) to give the weighted mean.

The procedure for calculating weighted means at other levels (three through six) were identical. The weights of individual plot values were constant and did not vary with the level of the analysis. Only the total number of plots averaged, or n ,varied with the level of analysis. The formula used in calculating weighted standard errors is:

$$\text{Weighted std. error} = \sqrt{\frac{\Sigma Wd^2}{\Sigma W - \frac{100\%}{n}\,\Sigma W}{n}}$$

where d = the deviation of each X value from the weighted mean.

W = the number of acres of meadow unit represented by each X value.

n = number of X values represented by the mean for which the std. error is being determined.

The value:

$$\Sigma W - \left[\frac{100\%}{n} \Sigma W\right]$$

is the weighted equivalent of n - 1. The weighted variance (Σx^2) was determined by multiplying:

$$\frac{\Sigma W d^2}{\Sigma W - \left[\frac{100\%}{n} \Sigma W\right]}$$

by n - 1. Gram weights were used in calculating all statistics and were then converted to pounds per acre figures. Student's t test was used to assess the significance of differences between means.

Gross Production. Average gross production, expressed as pounds per acre, was determined for all six of the previously described levels of analysis. By applying these averages to cover type acreages, estimates of total air-dried pounds of forage production on each cover type in each of the two areas were made.

The $\bar{X}$ values used in determining gross production means were those of the treatment three, caged-plots. No grazing use, other than that of small rodents, occurred on these plots. In a three-plot series gross production was represented by the plot which excluded both squirrels and large herbivores. Since ground squirrel grazing did not occur on the areas where two-plot series were established, the plot protected from grazing by livestock and big game was used to represent gross production.

Weight Differences (Gross-Net Production). The principal criterion employed for estimating herbivore use involved the comparison of differences in air-dried weights of clipped vegetation between grazed (net production) and ungrazed (gross production) plots. Two different measurements were made. One involved estimating ground squirrel utilization by comparing weight differences between grazing treatments two and three. The second involved estimating total utilization by comparing grazing treatments one and three. Three different techniques for estimating differences in net and gross production were tested and two of them were ultimately used.

It was anticipated that, with few exceptions, the removal of forage by grazing animals would be sufficient to reduce the weight of vegetation on unprotected plots below

that of their protected mates. Although it was expected that intrinsic differences in plot characteristics and the lack of use in some areas would result in some unprotected plots producing more forage than their protected counterparts, it was thought that such occurrences would be uncommon and that in the cases that did occur utilization would merely be recorded as zero. It was, therefore, originally planned to assess forage utilization by determining the average percentage by which production on protected plots exceeded that on the respectively-paired, unprotected plots.

Two observations raised questions as to the validity of the originally-planned analysis. First, an early examination of the data indicated that forage utilization was light on many areas and that production on unprotected plots often exceeded that of the respective protected plots. Secondly, evidence of utilization was not apparent on many of the unprotected plots which showed less production than their protected counterparts. Thus it appeared that much of the variation in production between paired plots was due to differences in intrinsic characteristics of the plots, and not to differences in grazing treatments.

If the planned analysis were to be used it would mean relegating a rather large proportion of the paired-comparisons to zero utilization status. It would also result in erroneously recording as utilization many weight differences that

were largely due to intrinsic plot differences. By applying the planned analysis to this type of data it would have been possible to produce utilization figures for areas that had sustained no use at all. Even on an ungrazed area forage production on protected plots could reasonably be expected to exceed that of their unprotected mates 50 percent of the time due to unavoidable intrinsic differences in the plots. In the proposed analysis, the positive half of the intrinsic deviations would be reduced to zero, and the negative half averaged and erroneously labeled as utilization. The originally-proposed analysis would have been valid only if utilization intensities had been sufficient to reduce the weight of vegetation on unprotected plots below that of the paired, protected plots in nearly every case. It became apparent therefore, that for these data, any valid estimate of forage utilization must include an analysis which accounted for variation in production due to intrinsic differences in plot characteristics.

The principal technique finally adopted for assessing forage utilization involved the comparison of average net production for a given area with average gross production for the same area. The difference between these two averages was considered to be due to utilization and its significance was calculated by Student's t test. By averaging the actual

values of both net and gross plots respectively, rather than just their positive differences, all variation due to intrinsic differences, as well as that due to differences in grazing treatment, were included. Weighted means, previously described, were used in all comparisons.

The second of the three tested techniques which was ultimately employed in evaluating differences in gross and net production involved the use of chi-square tests. Differences between the weighted gross and net production means for each cover type within each area were converted to pounds per acre figures which were then multiplied by total acres in the respective cover types to give estimates of total pounds of forage removed from the cover type. Chi-square tests were then made to determine whether or not the total pounds of forage removed from a cover type differed significantly from expected values. Expected values were calculated according to the arbitrary assumption that, within a cover type, forage removal would be proportional to the amount of forage produced. This assumption was made, not because it was suspected of being true, but because it provided a base from which deviations could be measured. The significance of deviations of observed values from expected values was tested by the chi-square formula:

$$\text{chi-square} = \frac{\left[(O_1 - E_1) - (0.5)\right]^2}{E_1} + \frac{\left[(O_2 - E_2) - (0.5)\right]^2}{E_2}$$

where, O_1 = Pounds of forage actually removed from cover type.

E_1 = Expected value = (Total pounds of forage removed from the Area in which cover type is located) X (The percentage of gross production for the Area that is produced by the cover type).

O_2 = Pounds of forage actually remaining in the cover type after utilization.

E_2 = Expected value = (Total pounds of forage produced in cover type) - (E_1).

Chi-square values were adjusted by subtracting 0.5 from each of the two deviations. Such an adjustment is recommended by Snedecor (1956) for chi-square tests with one degree of freedom to prevent bias that would otherwise result in rejecting the null hypothesis too frequently.

Chi-square tests were also used in a second type of analysis. True differences between gross and net production averages sometimes appeared to be obscured by low significance values. This occurred because sample size, in relation to the variance encountered, was not always adequate to

achieve desired levels of statistical reliability. In some cases, for instance, production on every gross plot exceeded production on respectively-paired net plots throughout the entire sample. The difference between average gross and net production however was non-significant when tested by t. In such cases it was considered useful to point out, through the use of chi-square tests, that the proportion of gross plots upon which production exceeded that of the paired net plot was significantly higher than could be expected through chance alone.

Theoretically, in the absence of grazing, production on paired plots would be equal. In fact, however, it was impossible to pick exactly identical sites, and inherent variations caused one of the two plots to produce more forage than the other. It was assumed, that unless utilization by herbivores occurred, the net plot had as great a chance of out-producing its paired gross plots as vice versa, or 50 percent of the time. In performing chi-square tests expected values were determined accordingly. The significance of deviations of observed values from the expected 50:50 ratio was tested by the chi-square formula:

$$\text{chi-square} = \frac{\left[(O_1 - E) - (0.5)\right]^2}{E} + \frac{\left[(O_2 - E) - (0.5)\right]^2}{E}$$

where: O_1 = Observed number of cases in which the gross plot outproduces its paired net plot.

O_2 = Observed number of cases in which the net plot outproduces its paired gross plot.

E = Expected value = (50% of total number of plot pairs).

The value 0.5 was subtracted from each deviation to prevent bias that would otherwise occur in a chi-square test involving only one degree of freedom (Snedecor 1956).

Although the direct measurement of ground squirrel utilization yielded estimates of impact upon the areas used by the squirrels, they did not provide information on the impact of such use on the meadow unit as a whole. It was not known to what proportion of the meadow unit the observed utilization rate applied, or what fraction of all forage removed from the meadow unit was attributable to ground squirrels utilization. Similarly, no direct assessment was available to ascertain what proportion of total forage removal was due to livestock and big game respectively. Therefore, it was

decided to make indirect estimates of the proportion of total utilization attributable to livestock, big game, and ground squirrels for each meadow unit. In the simplest case (Ginger Meadow) no use by livestock or ground squirrels occurred and all measured utilization was attributed to big game. In cases where more than one class of grazing animal used the meadow unit, the procedure was as follows:

1. Numbers of elk-days-use and livestock-days-use were calculated for each meadow unit. Elk-days-use were determined by dividing the number of elk droppings per acre by 12.5, the estimated average number of droppings deposited by an elk during a day (Neff *et al*. 1965). Horse-days-use were determined from actual head counts.

2. Elk and horses were assumed to remove 11 pounds (U. S. Forest Service 1958), and 25 pounds (Brown 1954) of air-dried forage per day respectively. Estimates of forage removal rates or utilization were made by multiplying elk-days-use by 11 and horse-days-use by 25. All figures were expressed in terms of pounds of forage removed per acre so relative comparisons could be made between meadow units and classes of grazing animal.

3. Estimates of meadow-wide utilization rates for ground squirrels were made through deduction. The estimates of big game and livestock utilization were deducted from

total measured forage utilization, and the remainder was attributed to ground squirrel utilization.

Coverage Differences of Species. The second criterion employed in evaluating herbivore utilization involved the comparison of average ground coverage of individual plant species between grazed and ungrazed plots. Significance of differences was determined by Student's *t* test. Three separate analyses were made: one for ground squirrel use; one for the combined use of ground squirrels, big game, and livestock (Area I); and one for the combined use of ground squirrels and big game (Area II).

The consistency of the response of each plant species to the three grazing treatments was also examined, and species were classified and listed accordingly. Three types of responses were recognized. Where the average ground coverage of a species was significantly greater (P = .40 or less) on plots protected from grazing than on unprotected plots, its response was considered to be "positive." Where ground coverage was significantly less on the protected plots, the response was "negative." Where no significant difference existed, the response was "neutral."

After the response of each species had been determined for each grazing treatment, the consistency of these responses between treatments was examined and each species was

assigned an overall rating of positive, negative, neutral, or inconsistent, according to the following definitions:

Positive. A species was classified as "positive" when its response to at least one of the three grazing treatments was positive, and its responses to the other grazing treatments were nautral. Species rated as positive were further classified into three subdivisions,depending upon the number of grazing treatments to which they exhibited a positive response.

Negative. A species was classified as "negative" when its response to at least one of the three grazing treatments was negative, and its responses to the other grazing treatments were neutral. Species rated as negative were further classified into three subdivisions, depending upon the number of grazing treatments to which they exhibited a negative response.

Neutral. A species was classified as "neutral" when it exhibited non-significant responses to all grazing treatments to which it was exposed.

Inconsistent. A species was classified as "inconsistent" when it exhibited a significant positive

response to at least one grazing treatment and a significant negative response to at least one other.

Forage Preferences of Elk

Three techniques were employed in studying forage preferences of elk. The collection of quantitative data through the random sampling of entire meadows was the principal method used. Random-sample data were supplemented with information obtained through the examination of feeding sites and from direct observations of feeding elk.

A technique was developed for randomly sampling the incidence of elk utilization of meadow forage species and was employed on four meadows during 1968. Sampling procedures were as follows:

1. Each meadow was stratified in exactly the same manner as previously described under the procedures section for species composition and cover typing. Strata width was 200 yards, with a single transect being randomly located, as previously described, within each stratum.
2. Along each transect wire plot frames, 1 foot wide and 4 feet long, were sampled at 24-foot intervals. The distance from the edge of the meadow to the first

plot was determined by using a table of random numbers ranging from 0 to 5, where each number represented one 4-foot interval.

3. On each plot the presence of all plant species found was recorded. All plants were examined for evidence of grazing and the results were recorded as: none, recent, intermediate, old, or some combination of the last three categories.

Utilization that was judged to have occurred after August 1 was classified as recent; between July 7 and 31 as intermediate; and before July 7 as old. Since sampling was conducted throughout August, the total amount of recent use recorded was probably underestimated. The magnitude of the error was probably very small however, since elk use of meadow vegetation dwindled to nearly nothing by the end of July.

Average utilization percentages were calculated for every species encountered, at both the meadow unit and the overall levels. For each sample transect the number of plots in which utilization of a given species occurred was expressed as a percentage of the total number of plots in which the species occurred. This percentage constituted a single *n* value. Transect percentages or *n* values, were then averaged for each species, to produce a mean percentage or frequency of use figure. Standard errors were calculated for these

average percentages. For each of the more frequently used species the proportion of total use that was classified as recent, intermediate, and old respectively was determined and expressed as a percentage of total use.

After field testing in 1967, a sample plot with 1 by 4-foot dimensions was selected for sampling. The selection of this plot size was predicated mostly upon practical considerations. Field trials indicated that the amount of time required to accurately sample plots larger than 4 square feet would preclude the examination of a sufficient number of replications to insure that standard errors would approach 20 percent of the mean. Also, because the vegetation was dense and often complex, the incidence of human error increased sharply when plot size was so large that examination required more than a few minutes of intensive scrutiny. The elongated shape of the 1 by 4-foot plot limited the breadth of area to be examined, enabling the examiner to maintain the entire width of the plot under intensive scrutiny as examination advanced from one end of the plot to the other.

Daubenmire (1968) suggests that a useful criterion for determining plot size for frequency sampling is to increase plot size until 100 precent frequency is recorded for one, or no more than a few, species. In the case of this study, it was not physically possible to employ plots large

enough to produce 100 percent utilization frequencies on even the most palatable species. Therefore, it is likely that all utilization percentages are somewhat underestimated. Since the objective of this sampling was to obtain information on species preferences, it was the relative difference in utilization percentages and not the absolute values that are important. For this reason, the probable underestimate of absolute values is considered irrelevant.

Meadow Utilization Patterns of Elk

During 1967 and 1968 a record of total numbers of elk sighted during each daylight hour was maintained for Cold Meadow. The record is nearly continuous for the periods of June 26 through September 7, 1967 and June 10 through September 13, 1968. This record was maintained for the purpose of describing: (1) the time periods during which the elk made use of the meadow and, (2) how use varied daily, over the course of the summer, and between years. In maintaining these records, the meadow was searched from a vantage point at least once each hour with 7 x 50 mm binoculars. A variable-power spotting scope was used in counting the animals sighted. Based on these records, two types of evaluations were made:

1. The average number of daylight hours during which elk were seen was calculated for each of five consecutive observation periods extending throughout the entire summer. The extent of the first and last observation periods varied between years, but the other three were identical. Observation periods were as follows:

Observation Period	1967	1968
1	June 26 - July 5	June 10 - July 5
2	July 6 - July 21	July 6 - July 21
3	July 22 - Aug. 5	July 22 - Aug. 5
4	Aug. 6 - Aug. 19	Aug. 6 - Aug. 19
5	Aug. 20 - Sept. 7	Aug. 20 - Sept.13

Averages for the two years were plotted together for purposes of comparison.

2. The average number of hours elk were seen during each of three 6-hour periods was calculated for each of the same five observation periods listed under (1.) above. The three 6-hour periods were:

Morning: 5 a.m. - 11 a.m.
Mid-day: 11 a.m. - 5 p.m.
Evening: 5 p.m. - 11 p.m.

The purpose of these determinations was to compare the incidence of meadow use by elk during different periods of the day and to show how this use varied

over the course of the summer. Data for both 1967 and 1968 were plotted to illustrate between-year differences.

Plant Phenology

Phenology records for major meadow plant species were maintained for Cold Meadow from June 23 through August 29, 1967. During 1968 records were maintained for Cold, Middle Cottonwood, and Lower Cottonwood Meadows from June 10 through September 13. Once every 7 to 10 days a zig-zag course, extending the entire length of each meadow, was followed by an observer. Based on the observations made along the course, the developmental status of each species was evaluated and rated according to the following scale:

Index Number	Description
1	Very little or no external evidence of flower buds or florets.
2	Flower buds, or florets, beginning to emerge, but more than 50 percent of all plants do not yet show buds or florets.
3	General emergence of buds or florets in progress. Most plants show buds or florets.
4	Florets or buds are completely out and near bloom on most plants, but only a few have commenced to bloom.
5	General bloom in progress, but less than 50 percent are in bloom.

6 Full bloom. Fifty percent or more of plants are in bloom.

7 Peak of bloom is past, but general bloom is still evident. More than 50 percent of plants are done blooming.

8 Most flower heads have deteriorated, but some vigorous blooms are still evident.

9 No vigorous blooms, or very few, are present. Seed is set, or nearly so.

Ground Squirrel Activity

The intensity of ground squirrel activity was measured on three meadow units in 1966 at the same time species composition samples were being taken. All observed evidence of ground squirrel activities within 3 feet of either side of each line transect was recorded. Three types of evidence of squirrel activity were recorded. Each place where squirrels had dug shallow depressions in the soil to obtain plant roots was recorded as a "dig." These "digs" usually did not exceed several inches in diameter or depth. Active burrows were recorded and were called "holes." Numerous well-worn paths between burrows and feeding areas were apparent in squirrel communities and were recorded, labeled as "runs."

Estimates of total numbers of digs, runs, and holes per acre were made, based upon the numbers found per unit of transect area. These estimates were made for each meadow

unit and for the collective sample for each of the three major cover types. Chi-square tests were then made to determine whether the observed number of digs, runs, and holes within each cover type differed significantly from numbers that would be expected if the number of digs, runs, and holes per unit of area was the same for all cover types. This hypothesis was assumed, not because it was suspected of being true, but because it provided a base from which to measure the significance of deviations. The formula used for these tests was as follows:

$$\text{Chi-square} = \frac{\left[(O_1 - E_1) - (0.5)\right]^2}{E_1} + \frac{\left[(O_2 - E_2) - (0.5)\right]^2}{E_2}$$

where: O_1 = The number of runs (or digs or holes) recorded for a particular cover type.

E_1 = (Percentage of total transect footage for the meadow unit that fell within the particular cover type being tested) X (Total number of runs, or digs or holes, for the meadow unit).

O_2 = (Total runs, or digs or holes, for the meadow unit) - (O_1).

E_2 = (Total number of runs, or digs or holes, for the meadow unit) - (E_1).

Chi-square values were adjusted by subtracting 0.5 from each of the two deviations, as recommended by Snedecor (1956) for tests with one degree of freedom.

Soils

Soils work was limited to the identification of the major soil types underlying meadow vegetation, and to ascertaining the general range of soil moisture levels associated with the three most common vegetation cover types. Soil samples were obtained from various depths through the use of an auger 4 inches in diameter and 5 feet long. For purposes of identifying major soil types, exploratory holes were bored in each cover type on all six meadow units.

Soil moisture samples were taken on the Cold Meadow unit during late July and early August of 1967. Soil samples were removed from each of three depths (2-4 inches, 7-9 inches, and 12-15 inches) on the dry, moist, and wet cover types on each of two different locations on the meadow. Upon extraction, soil samples were weighed to the nearest one-hundredth gram and were then air-dried until losses is weight ceased to occur. Soil moisture percentages of the air-dried soils were calculated according to the formula suggested by Buckman and Brady (1965) for determining moisture percentages of oven-dried soils, where:

$$\text{Moisture percentage} = \frac{\text{weight of moisture lost}}{\text{weight of dried soil}} \times (100)$$

Moisture percentages from each of the three depths were averaged for each bore hole.

Elevations and Acreages

Elevations of meadows were estimated through the use of an altimeter. The elevation of a particular meadow was calculated by using the relative difference in altimeter readings between it and a point of known elevation, such as Cold Meadow. When possible, readings were repeated, under different conditions of barometric pressure, with the average difference being used in calculating the elevation.

Meadow area was estimated by multiplying meadow length by average width. Length was determined by summing the widths of the total number of sample strata on the meadow. Average width was determined by averaging the lengths of sample transects.

Animal Days Use

Numbers of animal-days-use by horses and mules were determined through direct observations of total numbers of animals using the various meadows. Dropping counts were

used in calculating elk-days-use. Elk droppings were counted along the transects during the course of forage preference sampling. All droppings within 3 feet of the transect were tallied, resulting in a belt transect sample 6 feet in width. Total belt transect area for the meadow was compared with total numbers of droppings tallied and the ratio was applied in calculating numbers of droppings per acre. An estimate of elk-days-use was then made by dividing the number of elk droppings per acre by 12.5, the estimated average number of droppings deposited by an elk during a 24-hour period (Neff *et al.* 1965).

Elk Migration

An elk trap was maintained and operated at Cold Meadow by the Idaho Fish and Game Department during the summers of 1967 and 1968. Eight elk were marked with colored neck bands and ear tags in 1967, and seven in 1968. Although the total number of animals marked was not large, subsequent sighting records yielded information on the migratory patterns and summer movements of the elk using the Cold Meadows area.

Weather

Continuous records of air temperature, relative humidity, and precipitation were maintained at Cold Meadow through

the three summers of field work. A hygrothermograph was housed in a portable instrument shelter mounted 4 feet above the ground on the top of a wooden post. A continuously-recording rain and snow gauge was located on the ground adjacent to the instrument shelter. A maximum-minimum thermometer was mounted inside the instrument shelter. The entire weather station was located on the southeast end of the old airstrip, 150 feet from the edge of the timber.

RESULTS

Sightings of Marked Elk

Because the amount of information available on the movements of elk using the Cold Meadow area is limited, due to small numbers of animals marked and relatively few subsequent sightings, it is not possible to draw detailed conclusions at this time. Information available indicates that elk which summer in the Cold Meadow area migrate to both the Big Creek and Salmon River drainages during the winter. During the winter of 1967-68, at least four different elk, which had been marked at Cold Meadow during the summer of 1967, were sighted on the Big Creek drainage. During the fall of 1967 one marked elk was reported in the Grass Mountain area near the Salmon River.

At Cold Meadow, five of the eight elk marked during the summer of 1967 were resighted during the summer of 1968 and observed periodically throughout the summer. Three of these elk were also seen on Middle Cottonwood Meadow during the summer of 1968. These limited observations are in keeping with the results of an extensive study of elk movements conducted by Knight (1967) in the Sun River Area of Montana, where it was found that elk tended to use the same summer range from year to year.

Meadow Utilization Patterns of Elk

Patterns of daily and summer use of Cold Meadow by elk were nearly identical for each of the three summers for which records were maintained. As illustrated in Figure 5, elk concentrated on the meadow during June but incidence of use dwindled rapidly as the summer progressed. Although the incidence of use during the June - early-July period was considerably higher in 1967 than in 1968, the pattern for the two years was essentially the same. The large difference in the incidence of early season use between 1967 and 1968 is unknown, but it is suspected that gross differences in the degree of human disturbance between the two years could be responsible. In 1967 only one man resided at Cold Meadow during the initial June-July observation period, and the degree of human disturbance was minimal. In sharp contrast, six people resided at Cold Meadow in 1968, commencing on June 10, and the level of human disturbance was higher, including intensive activities on the meadow itself. A negative response by elk to human disturbance was reported by Kowalsky (1964) for mountain meadows in the Elk City area of northern Idaho. He found that the intensity of elk use was the greatest on the meadows where disturbance by human activities was minimal and adjacent forest cover was available; and that

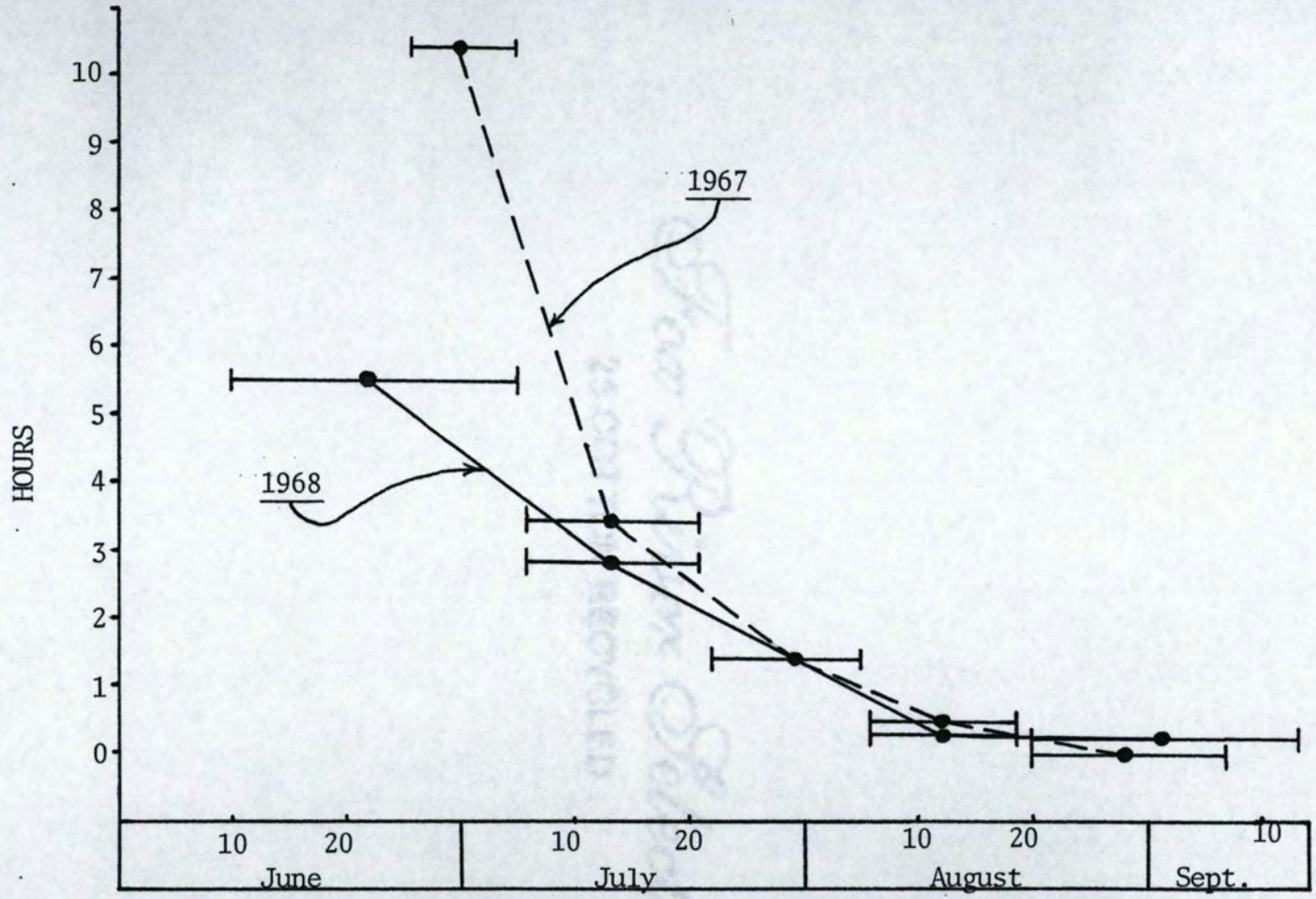

Figure 5. Average number of daylight hours during which elk were observed on Cold Meadow during the summers of 1967 and 1968.

meadow size, shape, and cover type had little effect on the degree to which the meadow was used by elk.

Daily utilization patterns were also very similar between years (Figures 6 and 7). Consistently more elk activity was recorded for the evening observation period than for the morning and mid-day periods. By the middle of July, elk were almost never observed on the meadow during mid-day, and by mid-August the few elk that continued to use the meadow were observed only during the evening. By mid-August most meadow vegetation was cured or curing, and even the livestock in the Horse Pasture regularly attempted to get out to graze elsewhere. During each of the three summers this very pronounced dissatisfaction of the livestock with Horse Pasture conditions was observed to commence in mid-August, and coincided closely with the termination of elk activity on the meadow.

Ground Coverage of Vegetation

Cover Types

The percentage of total meadow unit area occupied by each cover type varied considerably between meadow units, with the moist type being the least variable (Table 4). The dry and very dry cover types did not occur at all on some of the meadow units, while the wet type, even though it occurred

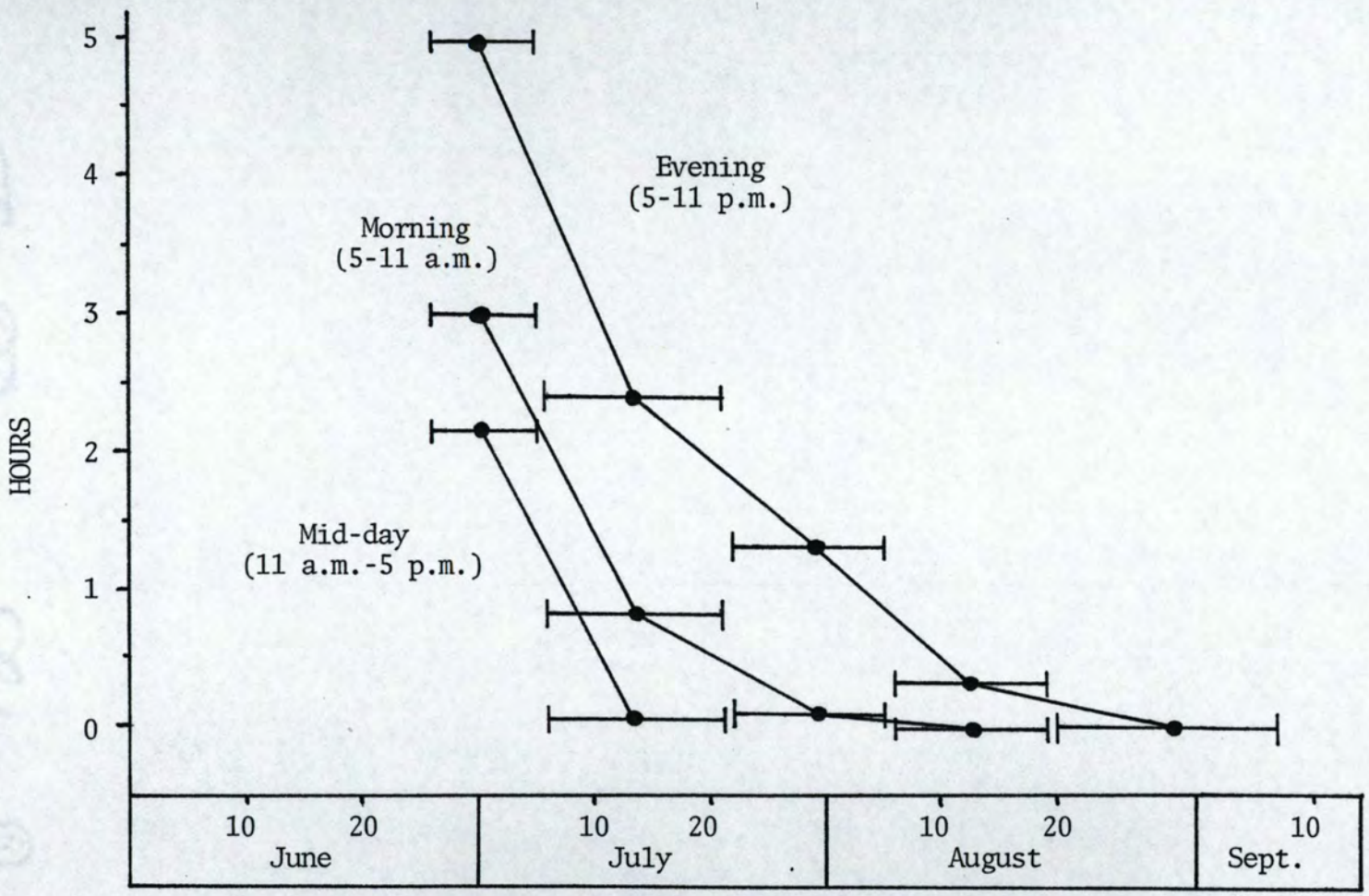

Figure 6. Average number of hours elk were seen on Cold Meadow during the summer of 1967, averaged for each of three 6-hour periods.

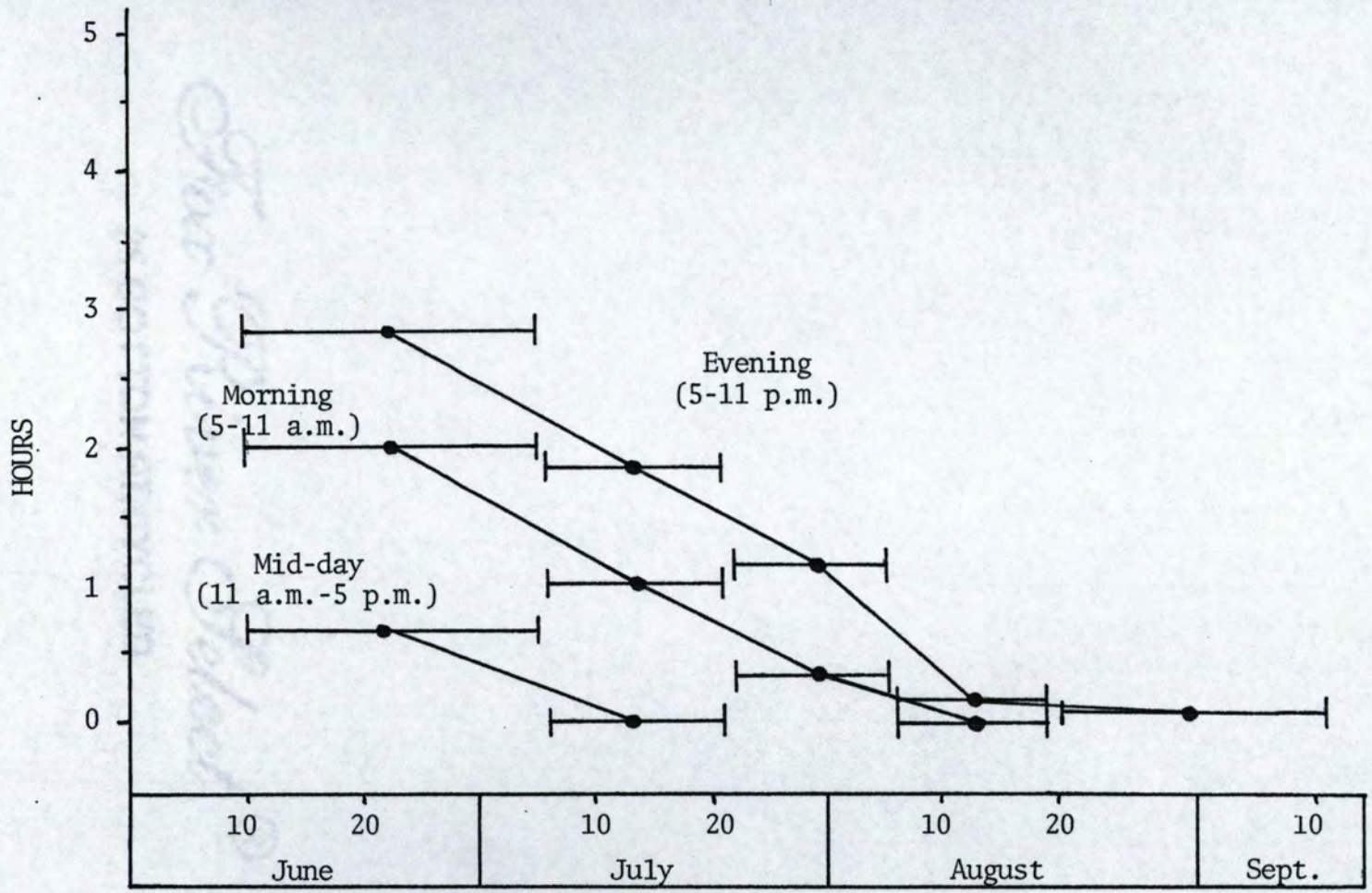

Figure 7. Average number of hours elk were seen on Cold Meadow during the summer of 1968, averaged for each of three 6-hour periods.

Table 4. The percentage of total meadow unit occupied by each cover type, listed in the order of decreasing proportion of wet cover type.

Meadow Unit	Cover Type			
	Very Dry	Dry	Moist	Wet
Phantom	0.0	0.0	23.1	76.9
Ginger	0.0	0.0	39.1	60.9
Middle Cottonwood	0.0	7.4	33.1	59.5
Cold	0.0	9.1	38.3	52.6
Lower Cottonwood	T[1/]	14.8	47.9	37.3
Horse Pasture	16.5	16.6	37.5	29.4

1/ Trace, or less than 1.0 percent.

on every unit, varied in total coverage from about 30 to 77 percent.

Total ground coverage of meadow vegetation within a given cover type did not differ greatly between meadow unit (Table 5). The larger than average figures for the moist and wet types on the Lower Cottonwood unit are due primarily to the greater coverage of shrubs found there. Since the shrubs represent a second canopy layer, the inclusion of their coverage somewhat inflates the true value for total vegetation cover. The larger coverage values on the Ginger and Phantom units are representative of the very dense, lush vegetation found there, and are not distorted by shrub values.

Plant Groups

The percentage of ground covered by forbs, grasses, sedges and rushes, and shrubs on the four major cover types is illustrated in Figure 8, and represents the collective sample for all six meadow units. Total numbers of species found in each of these plant groups are presented in Table 6 by cover type. Variety is maximum in the moist cover type, both in terms of numbers of species found, and the prominence of the different plant groups. Although the wet type has nearly as many total species as the moist type, the sedges are so dominant that most other species are inconspicuous.

Table 5. Total ground coverage of meadow vegetation, expressed as the sum of the average percentages of ground covered by each species present, by cover type by meadow unit, and for the collective sample.

Cover Type	Meadow Unit						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Phantom	Ginger	Overall
Very Dry	-[1/]	36.0	-	-	-	-	36.0
Dry	42.2	46.7	51.7	57.1	-	-	48.7
Moist	60.9	53.2	48.6	74.7	71.8	72.4	58.8
Wet	64.2	68.4	62.5	84.1	79.8	76.7	68.7

1/ Dash indicates that cover type did not occur. A trace of the very dry type occurred on Lower Cottonwood, but was not sampled.

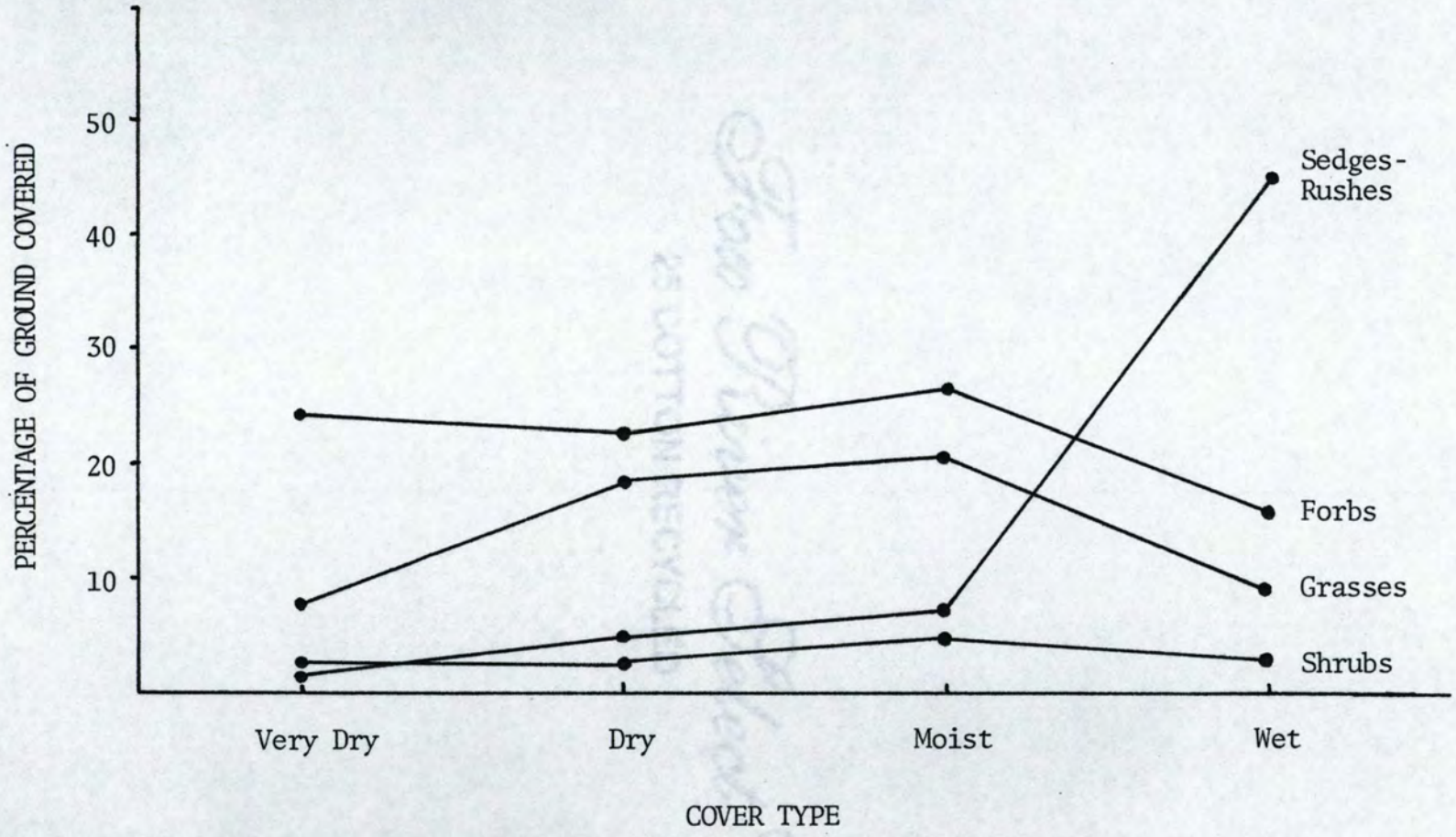

Figure 8. Percentage of ground covered by forbs, grasses, sedges and rushes, and shrubs on four mountain meadow cover types.

Table 6. Total number of species of forbs, grasses, sedges and rushes, and shrubs enumerated within four meadow cover types.

Plant Group	Cover Type			
	Very Dry	Dry	Moist	Wet
Forbs	17	33	49	45
Grasses	9	16	17	15
Sedges-Rushes	3	6	14	14
Shrubs	1	3	7	8
Total	30	58	87	82

Total number of species dropped rapidly as soil moisture levels decreased, and the dry and very dry cover types supported fewer species than the moist and wet types. Forbs dominated the very dry cover type, while grasses and forbs were co-dominant in the dry type. Relative proportions of grasses and forbs do not differ much between the dry and moist cover types, but species composition within these plant groups does.

Ground coverage averages for forbs, grasses, sedges and rushes, and shrubs are presented in Table 7 for each cover type on each meadow unit and for the collective sample. With few exceptions, values for these plant groups on any particular cover type are very similar between meadow units. Most differences between meadow unit values are thought to reflect natural differences in individual characteristics of the meadow units. Because the Horse Pasture has, over the years, consistently received much more grazing use than any of the other meadow units, and since the coverage values for forbs and grasses there differ considerably from the other units, these differences are interpreted as reflections of the heavier use. The Horse Pasture exhibits, for every cover type, a higher coverage of forbs and a lower coverage of grasses than any other meadow unit. Ginger and Phantom Meadows, the units with the histories of lightest grazing use,

Table 7. Total ground coverage of forbs, grasses, sedges and rushes, and shrubs, by major cover type for six meadow units and the collective sample.

Cover Type and Plant Group	Meadow Unit						
	Cold	Middle Cotwd.	Lower Cotwd.	Horse Pasture	Ginger	Phantom	Overall
Very Dry							
Forbs	-[1]	-	-	24.2	-	-	24.2
Grasses[2]	-	-	-	7.9	-	-	7.9
Sedges[2]	-	-	-	1.6	-	-	1.6
Shrubs	-	-	-	2.3	-	-	2.3
Dry							
Forbs	16.6	21.9	24.8	28.2	-	-	22.8
Grasses[2]	20.9	19.0	21.1	14.7	-	-	18.6
Sedges[2]	4.5	4.1	7.4	3.6	-	-	4.8
Shrubs	T	6.2	3.5	0.3	-	-	2.5
Moist							
Forbs	30.1	21.1	25.9	31.5	27.2	21.4	26.6
Grasses[2]	22.9	19.5	25.8	11.9	32.3	29.7	20.7
Sedges[2]	7.0	4.5	8.1	10.5	11.4	19.7	7.4
Shrubs	0.6	3.1	14.9	0.3	1.3	1.1	4.1
Wet							
Forbs	17.3	13.3	17.1	20.0	10.4	14.5	15.9
Grasses[2]	7.6	8.8	10.7	5.6	18.7	12.2	8.7
Sedges[2]	42.2	42.9	48.0	42.5	48.9	49.9	45.7
Shrubs	0.9	2.1	8.1	0.4	1.7	0.2	2.7

1/ Dash indicates that cover type did not occur.

2/ Species of rush and horsetail are included in this group.

exhibited coverage values for grasses that were higher than any of the other units. For some unknown reason shrubs, particularly *Potentilla fruticosa*, were much more prominent on Lower Cottonwood than on any other meadow unit. In general, coverage of this shrub appeared to increase as elevation decreased.

Species

Average ground coverage percentages for each plant species encountered are presented in Tables 8, 9, and 10 for each cover type. Except in the very dry cover type, the living portions of the total vegetation complex generally covered from 50 to 70 percent of the ground surface. The coverage of individual species however, was generally small, with only four species exceeding 5 percent within any particular cover type. *Calamagrostis canadensis* and *Carex aquatilis* exhibited the highest coverage values. *Calamagrostis canadensis* dominated the moist type, where it covered 12.3 percent of the ground. *Carex aquatilis* dominated the wet type, covering 38.4 percent of the ground.

Ground coverage percentages for individual plant species for each cover type on each meadow unit are presented in Tables 11 through 18. In these tables, *Agoseris* spp. includes the species *glauca, aurantiaca,* and one unidentified species; *Arenaria* spp. includes *congesta* and *aculeata*;

Table 8. Percentage ground coverage of forb species, averaged over five mountain meadows for each of four cover types.

Species	Cover Type							
	Very Dry		Dry		Moist		Wet	
	$\bar{x}$[1/]	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Achillea lanulosa	2.1	0.7	2.9	0.3	1.4	0.1	0.3	0.1
Aconitum columbianum	0.0	-	0.0	-	0.2	0.1	0.3	0.1
Agoseris spp.	0.0	-	0.4	0.1	0.8	0.1	0.1	0.1
Antennaria rosea	3.8	1.0	3.1	0.5	2.5	0.2	0.7	0.1
Aquilegia coerulea	0.0	-	0.0	-	T	-	T	-
Arenaria congesta	1.2	0.3	0.2	0.1	T	-	0.0	-
Arnica chamissonis	0.0	-	0.1	0.1	0.3	0.1	0.5	0.1
Arnica mollis	0.0	-	0.0	-	T	-	T	-
Aster foliaceus	0.5	0.2	1.0	0.2	4.0	0.2	3.4	0.2
Aster integrifolius	3.6	0.4	1.9	0.2	0.4	0.1	0.0	-
Aster modestus	0.0	-	0.0	-	T	-	T	-
Caltha leptosepala	0.0	-	0.0	-	T	-	T	-
Castelleja cusickii	0.0	-	T	-	T	-	0.0	-
Cirsium foliosum	0.0	-	0.3	0.1	0.1	0.1	0.0	-
Dodecatheon jeffreyi	0.0	-	0.0	-	0.1	0.1	0.2	0.1
Eriogonum umbellatum	T	-	1.3	0.7	0.0	-	0.0	-
Fragaria virginiana	0.8	0.3	2.0	0.3	1.7	0.2	0.3	0.1
Gentiana affinis	0.0	-	0.0	-	0.1	0.1	T	-
Geum macrophyllum	0.0	-	0.0	-	0.1	0.1	T	-
Geum triflorum	0.5	0.3	0.3	0.1	0.0	-	0.0	-
Habenaria dilatata	0.0	-	0.0	-	T	-	T	-
Ligusticum canbyi	0.0	-	0.0	-	0.0	-	T	-
Ligusticum filicinum	0.0	-	0.4	0.1	1.9	0.2	1.7	0.1
Lupinus sp.	0.1	0.1	T	-	0.0	-	0.0	-
Mimulus guttatus	0.0	-	0.0	-	0.0	-	T	-
Mitella breweri	0.0	-	0.0	-	0.0	-	T	-
Oenothera heterantha	0.0	-	0.1	0.1	0.1	0.1	0.0	-
Parnassia intermedia	0.0	-	0.0	-	0.0	-	T	-
Pedicularis groenlandica	0.0	-	0.0	-	0.0	-	T	-
Pedicularis bracteosa	0.0	-	0.0	-	T	-	0.0	-
Penstemon procerus	1.6	0.3	1.8	0.3	T	-	-	-
Penstemon rydbergia	0.0	-	0.6	0.2	0.7	0.1	0.7	0.1
Polemonium occidentale	0.0	-	0.0	-	T	-	T	-
Polygonum bistortoides	0.2	0.1	0.6	0.1	1.4	0.1	0.9	0.1
Polygonum viviparum	0.0	-	0.0	-	0.1	0.1	0.1	0.1
Potentilla diversifolia	5.5	1.6	1.0	0.4	1.5	0.2	0.2	0.1

Table 8. Continued.

Species	Cover Type							
	Very Dry		Dry		Moist		Wet	
	$\bar{x}$ 1/	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Potentilla gracilis	0.0	-	T	-	0.1	0.1	T	-
Ranunculus alismaefolius	0.2	0.1	0.4	0.1	2.4	0.2	1.3	0.1
Ranunculus uncinatus	0.0	-	0.0	-	T	-	0.0	-
Saxifraga arguta	0.0	-	0.0	-	0.0	-	T	-
Saxifraga oregana	0.0	-	0.0	-	0.3	0.1	0.3	0.1
Sedum stenopetalum	0.1	0.1	0.1	0.1	T	-	0.0	-
Senecio crassulus	0.0	-	T	-	0.4	0.1	0.6	0.1
Senecio integerrimus	0.4	0.2	T	-	0.6	0.1	0.5	0.1
Senecio subnudus	0.0	-	0.0	-	T	-	T	-
Senecio triangularis	0.0	-	0.0	-	0.0	-	T	-
Solidago multiradiata	0.0	-	0.0	-	T	-	0.0	-
Spiranthes romanzoffiana	0.0	-	0.0	-	T	-	T	-
Swertia perennis	0.0	-	0.0	-	T	-	0.2	0.1
Taraxacum officinale	0.7	0.2	1.0	0.2	1.2	0.2	0.4	0.1
Trifolium spp.	3.1	1.2	2.8	0.4	3.2	0.2	1.6	0.2
Trollius laxus	0.0	-	0.0	-	T	-	T	-
Valeriana capitata	0.0	-	T	-	0.7	0.1	1.3	0.1
Viola bellidifolia	0.0	-	0.1	0.1	T	-	0.0	-
Zigadenus elegans	0.0	-	0.0	-	0.0	-	T	-

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 9. Percentage ground coverage of grass, sedge, rush, and horsetail species, averaged over five mountain meadows for each of four cover types.

Species	Cover Type							
	Very Dry		Dry		Moist		Wet	
	$\bar{x}$ [1/]	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Grasses								
Alopecurus aequalis	0.0	-	0.0	-	T	-	0.0	-
Agropyron dasystachyum	0.2	0.1	2.7	0.4	2.1	0.3	0.3	0.2
Agrostis scabra	0.0	-	T	-	0.3	0.1	0.1	0.1
Bromum ciliatus	0.0	-	T	-	0.2	0.1	0.1	0.1
Calamagrostis canadensis	0.3	0.2	1.3	0.3	12.3	0.9	6.8	0.6
Calamagrostis rubescens	0.3	0.2	0.2	0.1	0.0	-	0.0	-
Danthonia intermedia	2.8	0.4	7.5	1.0	1.9	0.3	T	-
Deschampsia caespitosa	0.1	0.1	T	-	1.9	0.2	0.5	0.1
Deschampsia elongata	0.0	-	0.0	-	T	-	T	-
Festuca idahoensis	3.4	0.4	4.8	0.7	T	-	0.0	-
Glyceria pauciflora	0.0	-	0.0	-	0.1	0.1	T	-
Melica spectabilis	0.0	-	T	-	0.0	-	0.0	-
Muhlenbergia richardsonis	0.1	-	T	-	0.1	0.1	0.1	0.1
Phleum alpinum	0.1	0.1	0.9	0.2	1.2	0.1	0.2	0.1
Poa spp.	0.0	-	0.2	0.1	0.1	0.1	0.2	0.1
Stipa columbiana	0.6	0.2	1.0	0.2	T	-	T	-
Trisetum spicatum	0.0	-	T	-	T	-	T	-
Trisetum wolfii	0.0	-	T	-	0.5	0.1	0.3	0.1
Sedges-Rushes-Horsetails								
Carex aquatilis	0.0	-	0.5	0.1	4.1	0.3	38.4	1.3
Carex aurea	0.0	-	0.0	-	T	-	T	-
Carex canescens	0.0	-	0.0	-	T	-	T	-
Carex geyeri	0.6	0.2	2.3	0.6	T	-	0.0	-
Carex hoodii	0.8	0.3	1.6	0.4	2.5	0.3	1.3	0.5
Carex rostrata	0.0	-	0.0	-	T	-	0.5	0.2
Eleocharis acicularis	0.0	-	0.0	-	T	-	0.1	0.1
Equisetum spp.	0.0	-	0.0	-	T	-	T	-
Juncus spp.	0.0	-	0.2	0.1	0.2	0.1	0.9	0.1
Luzula spp.	0.2	0.1	0.2	0.1	0.6	0.1	0.1	0.1

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 10. Percentage ground coverage of shrub species averaged over five mountain meadows for each of four cover types.

Species	Cover Type							
	Very Dry		Dry		Moist		Wet	
	$\bar{x}$ 1/	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Berberis repens	0.0	-	T	-	0.0	-	0.0	-
Betula glandulosa	0.0	-	0.0	-	0.1	0.1	0.3	0.1
Ledum glandulosum	0.0	-	0.0	-	0.0	-	T	-
Lonicera utahensis	0.0	-	0.0	-	0.1	0.1	0.2	0.1
Potentilla fruticosa	0.0	-	2.3	0.9	3.4	0.7	0.8	0.3
Ribes viscosissimum	0.0	-	0.0	-	0.0	-	T	-
Salix spp.	0.0	-	0.0	-	0.1	0.1	1.3	0.1
Vaccinium membranaceum	2.3	0.6	0.2	0.1	0.4	0.1	0.0	-
Vaccinium occidentale	0.0	-	0.0	-	T	-	0.1	0.1

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 11. Average percentage ground coverage of forb species on the dry cover type on four meadow units.

Species	Meadow Unit[1/]				
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Overall
Achillea lanulosa	1.6	3.4	1.9	5.3	2.9
Agoseris spp.	0.3	T	1.0	T	0.4
Antennaria rosea	1.9	3.5	2.9	4.5	3.1
Arenaria spp.	0.2	0.2	T	0.7	0.2
Arnica chamissonis	T	0.2	0.2	0.4	0.1
Aster foliaceus	0.5	9.3	2.2	0.9	1.0
Aster integrifolius	2.3	4.6	0.2	0.0	1.9
Castelleja cusickii	T	0.1	0.0	0.0	T
Cirsium foliosum	0.2	T	0.8	T	0.3
Eriogonum umbellatum	T	1.4	T	4.7	1.3
Fragaria virginiana	2.0	1.3	2.0	3.1	2.0
Geum triflorum	0.2	0.9	T	T	0.3
Ligusticum filicinum	0.1	T	1.2	0.3	0.4
Lupinus sp.	T	T	0.2	T	T
Oenothera heterantha	0.0	0.5	0.0	T	0.1
Penstemon procerus	2.0	3.0	0.5	1.9	1.8
Penstemon rydbergia	0.9	1.1	0.2	0.0	0.6
Polygonum bistortoides	0.6	0.6	0.9	0.0	0.6
Potentilla diversifolia	1.1	1.8	0.9	0.0	1.0
Potentilla gracilis	T	0.2	0.0	0.0	T
Ranunculus alismaefolius	0.1	0.6	0.8	0.0	0.4
Sedum stenopetalum	T	T	0.2	0.4	0.2
Senecio crassulus	0.0	0.0	0.0	0.1	T
Senecio integerrimus	T	0.2	0.0	0.0	T
Taraxacum officinale	0.4	0.8	1.6	1.4	1.0
Trifolium spp.	2.2	3.5	4.1	0.7	2.8
Valeriana capitata	0.0	T	0.1	0.0	T
Viola bellidifolia	T	0.0	0.0	0.4	0.1

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 12. Average percentage ground coverage of grass, sedge, rush, and shrub species on the dry cover type on four meadow units.

Species	Meadow Unit[1/]				
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Overall
Grasses					
Agropyron dasystachyum	2.2	2.5	2.1	4.3	2.7
Agrostis scabra	0.1	0.0	0.6	0.0	T
Bromus ciliatus	0.0	0.0	T	0.0	T
Calamagrostis canadensis	2.0	0.3	2.0	0.7	1.3
Calamagrostis rubescens	0.2	0.2	0.2	T	0.2
Danthonia intermedia	7.3	3.0	10.6	9.5	7.5
Festuca idahoensis	7.7	6.6	1.1	3.8	4.8
Melica spectabilis	T	0.0	0.0	0.0	T
Muhlenbergia richardsonis	0.0	0.0	T	0.0	T
Phleum alpinum	1.3	0.2	1.6	0.3	0.9
Poa spp.	T	T	T	0.9	0.2
Stipa columbiana	0.1	1.9	0.7	1.6	1.0
Trisetum spicatum	T	0.0	0.0	0.0	T
Trisetum wolfii	T	0.0	0.1	0.0	T
Sedges-Rushes					
Carex aquatilis	0.4	T	1.3	T	0.5
Carex geyeri	2.7	0.8	1.8	4.6	2.3
Carex hoodii	1.1	2.2	1.0	1.9	1.6
Juncus spp.	0.0	0.0	0.0	0.9	0.2
Luzula multiflora	0.3	0.6	T	0.0	0.2
Shrubs					
Berberis repens	0.0	0.0	0.0	0.1	T
Potentilla fruticosa	0.0	0.0	6.0	3.1	2.3
Vaccinium membranaceum	T	0.3	0.2	0.3	0.2

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 13. Average percentage ground coverage of forb species on the moist cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Achillea lanulosa	0.4	1.2	1.4	3.5	0.0	0.0	1.4
Aconitum columbianum	0.1	0.2	0.1	0.2	1.5	T	0.2
Agoseris spp.	1.7	0.5	0.3	0.2	3.0	0.6	0.8
Antennaria rosea	3.4	2.1	1.8	2.8	2.5	2.6	2.5
Aquilegia coerulea	0.0	0.0	T	0.0	0.0	0.0	T
Arenaria spp.	T	0.0	0.0	0.0	0.0	0.0	T
Arnica chamissonis	T	0.2	0.5	0.7	0.1	0.0	0.3
Arnica mollis	T	0.0	0.0	0.0	0.0	0.0	T
Aster foliaceus	3.7	3.4	3.8	4.9	6.8	2.3	4.0
Aster integrifolius	0.3	1.5	T	0.0	0.6	0.0	0.4
Caltha leptosepala	T	0.0	T	0.0	0.0	0.0	T
Castelleja cusickii	0.0	T	0.0	0.0	0.0	0.0	T
Cirsium foliosum	T	0.0	0.1	0.4	0.0	0.0	0.1
Dodecatheon jeffreyi	0.2	0.1	T	T	T	2.2	0.1
Fragaria virginiana	0.4	0.2	1.6	4.8	3.1	T	1.7
Gentiana affinis	0.1	T	0.1	0.2	0.0	0.0	0.1
Geum macrophyllum	T	0.3	0.0	0.1	0.0	0.0	0.1
Habenaria dilatata	T	0.0	0.0	0.0	T	T	T
Ligusticum filicinum	2.3	0.5	2.2	1.4	4.3	2.5	1.9
Mitella breweri	T	0.0	0.0	0.0	0.0	0.0	T
Oenothera heterantha	0.0	T	T	T	0.0	0.0	T
Pedicularis bracteosa	0.0	0.0	0.0	0.0	0.1	0.0	T
Penstemon procerus	T	T	0.0	T	0.0	0.0	T

Table 13. Continued.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Penstemon rydbergia	1.5	1.1	0.2	0.1	0.1	3.7	0.7
Polemonium occidentale	T	0.0	0.0	0.0	0.0	0.0	T
Polygonum bistortoides	2.9	2.0	0.9	0.1	0.0	0.0	1.4
Polygonum viviparum	T	0.0	0.1	0.2	0.0	0.0	0.1
Potentilla diversifolia	2.8	2.7	0.6	0.0	1.8	0.0	1.5
Potentilla gracilis	0.0	0.3	T	0.3	0.0	0.0	0.1
Ranunculus alismaefolius	4.4	4.1	1.6	0.2	0.3	T	2.4
Ranunculus uncinatus	T	0.0	T	0.0	0.0	0.0	T
Saxifraga oregana	0.4	1.2	T	0.1	0.1	0.0	0.3
Sedum stenopetalum	0.0	0.0	T	0.1	0.0	0.0	T
Senecio crassulus	T	0.1	0.5	0.9	0.9	0.0	0.4
Senecio integerrimus	0.4	2.4	T	0.1	0.2	T	0.6
Senecio subnudus	T	0.0	T	0.0	0.0	0.0	T
Spiranthes romanzoffiana	T	0.0	0.0	0.0	0.0	0.0	T
Solidago multiradiata	0.0	T	0.0	0.0	0.0	0.0	T
Swertia perennis	T	1.4	T	0.0	0.0	0.0	T
Taraxacum officinale	0.1	0.6	1.6	2.3	0.5	5.9	1.2
Trifolium spp.	4.5	4.8	2.9	1.3	0.0	T	3.2
Trollius laxus	T	0.0	T	0.0	0.0	0.0	T
Valeriana capitata	0.5	0.6	0.8	0.8	0.9	1.6	0.7
Viola bellidifolia	T	0.0	T	0.2	0.4	T	T

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 14. Average percentage ground coverage of grass species on the moist cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Alopecurus aequalis	0.0	0.0	T	0.1	0.0	0.0	T
Agropyron dasystachyum	0.5	0.5	1.3	7.4	1.5	0.0	2.1
Agrostis scabra	0.7	T	0.4	0.1	0.1	T	0.3
Bromus ciliatus	T	0.0	0.2	0.2	1.6	T	0.2
Calamagrostis canadensis	14.4	4.2	12.7	13.5	26.1	14.6	12.3
Calamagrostis rubescens	T	0.0	0.0	0.0	0.0	0.0	T
Danthonia intermedia	2.1	1.9	1.8	1.9	1.6	0.0	1.9
Deschampsia caespitosa	3.2	3.6	0.9	0.2	0.0	5.3	1.9
Deschampsia elongata	T	0.0	0.0	0.0	0.0	0.3	T
Festuca idahoensis	T	0.1	0.0	T	0.0	T	T
Glyceria pauciflora	0.0	0.0	0.0	0.1	T	5.8	0.1
Muhlenbergia richardsonis	0.1	T	0.3	0.1	T	T	0.1
Phleum alpinum	1.5	1.4	1.1	0.8	0.8	2.5	1.2
Poa spp.	0.2	0.1	0.1	0.1	T	0.0	0.1
Stipa columbiana	T	0.1	T	0.2	0.0	0.0	T
Trisetum spicatum	T	0.0	T	0.0	T	0.0	T
Trisetum wolfii	0.2	T	0.7	1.1	0.6	1.2	0.6

1/ . Values less than 0.1 percent are entered as *T*, or trace.

Table 15. Average percentage ground coverage of sedge, rush, horsetail, and shrub species on the moist cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Sedges-Rushes-Horsetails							
Carex aquatilis	2.7	4.1	3.7	4.6	10.3	11.9	4.1
Carex aurea	T	0.0	0.1	0.0	0.0	T	T
Carex canescens	T	0.0	T	0.0	0.1	0.0	T
Carex geyeri	T	0.1	T	0.0	0.0	0.0	T
Carex hoodii	3.2	4.6	0.6	2.6	0.4	7.2	2.5
Carex rostrata	0.0	0.0	T	0.0	0.5	0.3	T
Eleocharis acicularis	T	T	T	T	0.1	T	T
Equisetum spp.	T	T	T	T	T	0.3	T
Juncus spp.	0.1	0.1	T	0.9	0.0	0.0	0.2
Luzula spp.	1.0	1.6	0.1	T	T	T	0.6
Shrubs							
Betula glandulosa	0.0	0.0	0.3	0.0	0.0	0.0	0.1
Lonicera utahensis	T	0.0	0.1	0.3	0.1	T	0.1
Potentilla fruticosa	0.0	0.0	2.5	14.1	0.0	0.0	3.4
Salix spp.	T	0.0	T	0.0	0.7	1.1	0.1
Vaccinium membranaceum	0.6	0.3	0.2	0.5	0.5	0.0	0.4
Vaccinium occidentale	T	0.0	0.0	0.0	0.0	0.0	T

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 16. Average percentage ground coverage of forb species on the wet cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Achillea lanulosa	0.1	0.3	0.3	0.7	0.0	0.0	0.3
Aconitum columbianum	T	1.1	0.1	0.4	0.3	T	0.3
Agoseris spp.	0.4	0.1	0.1	0.0	0.1	T	0.1
Antennaria rosea	1.0	0.4	0.7	0.3	1.0	0.2	0.7
Aquilegia coerulea	T	0.0	0.0	0.0	0.0	0.0	T
Arnica chamissonis	T	0.4	0.9	0.4	0.2	0.0	0.5
Arnica mollis	T	0.0	T	0.0	0.0	0.0	T
Aster foliaceus	3.2	2.7	2.5	6.2	3.8	3.2	3.4
Aster modestus	T	0.0	0.0	0.4	0.0	0.5	0.1
Caltha leptosepala	T	0.0	T	0.0	0.1	0.0	T
Dodecatheon jeffreyi	0.4	0.6	T	0.0	0.1	0.1	0.2
Fragaria virginiana	T	T	0.3	1.0	T	T	0.3
Gentiana affinis	0.0	T	0.0	T	0.0	0.0	T
Geum macrophyllum	T	0.0	0.0	T	0.0	0.0	T
Habenaria dilitata	T	0.0	0.1	0.0	T	T	T
Ligusticum canbyi	T	0.0	0.0	0.0	0.0	0.2	T
Ligusticum filicinum	1.7	1.1	2.0	1.7	1.4	1.6	1.7
Mimulus guttatus	T	0.0	T	T	0.0	0.5	T
Mitella breweri	T	0.0	T	0.0	T	0.0	T
Parnassia intermedia	T	0.0	T	0.1	0.0	T	T
Pedicularis groenlandica	T	T	T	0.1	T	0.0	T
Penstemon rydbergia	1.3	1.4	0.2	0.1	0.4	3.8	0.7
Polemonium occidentale	T	0.0	T	0.0	0.0	T	T

Table 16. Continued.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Polygonum bistortoides	1.4	2.0	0.6	0.1	0.0	0.0	0.9
Polygonum viviparum	T	T	0.1	T	0.0	0.0	0.1
Potentilla diversifolia	0.5	0.5	0.1	0.0	0.3	0.0	0.2
Potentilla gracilis	0.0	0.1	0.0	0.0	0.0	0.0	T
Pyrola minor	T	0.0	T	0.0	0.0	0.0	T
Ranunculus alismaefolius	1.7	3.0	1.1	0.2	T	0.2	1.3
Ranunculus uncinatus	T	0.0	T	0.0	0.0	0.0	T
Saxifraga arguta	T	0.0	T	0.0	0.0	T	T
Saxifraga oregana	0.5	0.8	0.1	0.2	0.2	0.0	0.3
Senecio crassulus	0.5	0.8	0.4	1.0	0.7	0.1	0.6
Senecio integerrimus	1.0	1.1	0.2	0.0	0.4	T	0.5
Senecio subnudus	0.1	0.0	T	0.0	0.0	T	T
Senecio triangularis	T	T	T	0.3	T	0.1	T
Spiranthes romanzoffiana	T	0.0	T	T	T	0.0	T
Swertia perennis	T	0.3	0.4	0.1	0.1	0.0	0.2
Taraxacum officinale	T	T	0.4	1.1	T	2.1	0.4
Trifolium spp.	2.6	2.2	1.4	0.8	0.0	0.0	1.6
Trollius laxus	T	0.0	T	0.0	0.0	0.0	T
Valeriana capitata	0.1	1.1	1.3	1.8	1.3	1.9	1.3
Viola bellidifolia	0.7	0.0	T	0.1	0.0	0.0	0.1
Zigadenus elegans	0.0	0.0	0.0	0.0	0.0	T	T

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 17. Average percentage ground coverage of grass species on the wet cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Agropyron dasystachyum	0.1	0.1	0.1	1.7	T	0.0	0.3
Agrostis scabra	0.2	0.0	0.2	T	0.2	0.0	0.1
Bromus ciliatus	T	0.2	0.1	T	0.7	0.3	0.1
Calamagrostis canadensis	5.9	3.9	7.1	7.6	17.5	4.3	6.8
Danthonia intermedia	0.0	0.0	0.1	T	0.0	0.0	T
Deschampsia caespitosa	1.0	0.9	0.2	0.2	T	T	0.5
Deschampsia elongata	T	0.0	0.0	0.0	0.0	0.1	T
Glyceria pauciflora	T	0.0	0.0	0.0	0.1	1.2	T
Muhlenbergia richardsonis	T	0.0	0.1	0.1	0.0	4.7	0.1
Phleum alpinum	0.1	0.3	0.2	0.5	T	0.6	0.2
Poa spp.	0.1	0.2	0.3	0.2	T	0.0	0.2
Stipa columbiana	0.0	T	0.0	0.0	0.0	0.0	T
Trisetum spicatum	0.0	0.0	T	0.0	0.0	0.0	T
Trisetum wolfii	0.2	T	0.4	0.4	0.2	1.0	0.3

1/ Values less than 0.1 percent are entered as *T*, or trace.

Table 18. Average percentage ground coverage of sedge, rush, horsetail, and shrub species on the wet cover type on six meadow units.

Species	Meadow Unit[1/]						
	Cold	Horse Pasture	Middle Cottonwood	Lower Cottonwood	Ginger	Phantom	Overall
Sedges-Rushes-Horsetails							
Carex aquatilis	37.5	39.6	35.8	43.3	39.2	43.5	38.4
Carex aurea	T	T	T	T	T	0.1	T
Carex canescens	T	T	T	T	T	0.5	T
Carex hoodii	0.5	1.4	2.4	3.2	T	3.3	1.8
Carex rostrata	3.8	0.2	4.6	0.3	8.3	1.3	4.9
Eleocharis acicularis	T	T	T	0.2	1.3	0.4	0.1
Equisetum spp.	T	T	T	T	T	0.8	T
Juncus spp.	0.3	1.0	0.1	0.8	T	T	0.4
Luzula spp.	0.1	0.3	T	0.2	0.1	T	0.1
Shrubs							
Betula glandulosa	0.0	0.0	0.1	1.2	0.0	0.0	0.3
Ledum glandulosum	T	0.0	T	0.0	T	T	T
Lonicera utahensis	T	T	0.3	0.4	T	0.0	0.2
Potentilla fruticosa	0.0	0.0	0.7	3.0	0.0	0.0	0.8
Ribes viscosissimum	T	0.0	T	0.0	0.0	0.0	T
Salix spp.	0.7	0.4	1.0	3.5	1.2	0.2	1.3
Vaccinium occidentale	0.1	T	T	0.0	0.5	0.0	0.1

1/ Values less than 0.1 percent are entered as *T*, or trace.

Trifolium spp. consists primarily of *longipes*, but also includes two unidentified species; *Poa* spp. includes *pratensis* and *compressa*; *Juncus* spp. consists primarily of *drummondii*, but also includes *confusus, ensifolius,* and *mertensianus; Luzula* spp. consists primarily of *multiflora* with a trace of *divaricata*; and *Salix* spp. includes two unidentified species. *Botrychium lunaria*, a fern species which, according to Flowers (1950) has been reported for only Custer county in Idaho, was collected on the wet cover type on Cold Meadow. This fern was never found on a sample plot however and is not, consequently, included in the ground-coverage tables.

The variation in ground coverage values of individual species within a particular cover type between meadow units was generally not great. The variation was sufficient however to give the cover type a slightly different character for each meadow unit upon which it was found.

All cover types on the Lower Cottonwood unit appeared to be somewhat drier than those on other units and coverage values of the species tend to reflect this. Plant species which exhibited substantially greater coverage on Lower Cottonwood than on other units tend to be the ones with a greater tolerance of dry conditions. Such species include: *Achillea lanulosa, Antennaria rosea, Arenaria* spp., *Eriogonum*

unbellatum, *Sedum stenopetalum*, *Agropyron dasystachyum*, and *Carex geyeri*. Other species which show greater coverage on Lower Cottonwood include *Fragaria virginiana*, *Viola bellidifolia*, and *Potentilla fruticosa*. Conversely, most of the species which had lower coverage values on Lower Cottonwood were ones which normally exhibited an affinity for moisture. Such species include: *Ligusticum filicinum*, *Polygonum bistortoides*, *Ranunculus alismaefolius*, *Senecio integerrimus*, *Trifolium* spp., *Calamagrostis canadensis*, *Deschampsia caespitosa*, *Phleum alpinum*, and *Carex rostrata*. Other species which decreased include *Aster integrifolius*, and *Penstemon rydbergia*. *Potentilla diversifolia* did not occur at all on Lower Cottonwood.

Ground coverage percentages of species are remarkably similar for the Horse Pasture and the Cold Meadow Unit, in spite of the gross difference in grazing history. The differences that do exist are generally not extreme, but are consistent, and a pattern or trend towards decreasing coverage of palatable grasses and increasing coverage of unpalatable forbs appears to be indicated. Unpalatable forbs which exhibit greater coverage values in the Horse Pasture than on the Cold Meadow Unit include: *Achillea lanulosa*, *Aster integrifolius*, *Eriogonum umbellatum*, *Geum triflorum*, *Oenothera heterantha*, *Penstemon procerus*, and *Senecio integerrimus*.

Other species exhibiting greater coverage in the Horse Pasture include: *Trifolium* spp., *Carex hoodii*, and *Stipa columbiana*. Species which exhibit substantially lower coverage values in the Horse Pasture include: *Agoseris* spp. *Ligusticum filicinum*, *Agrostis scabra*, *Calamagrostis canadensis*, *Danthonia intermedia*, *Festuca idahoensis*, *Phleum alpinum*, *Carex geyeri*, and *Carex rostrata*.

Total numbers of species enumerated in a particular cover type varied between meadow units and appeared to be influenced mostly by the total size of the area sampled (Table 19). Environmental variation on the extremely wet Ginger and Phantom units was more limited than on the other units and was undoubtedly partly responsible, along with the small size of these units, for the relatively small number of species encountered there.

Other Research

Although species composition varies considerably, the general characteristics of the four cover types described in this study are comparable to those of various other herbaceous communities which have been described by different workers in a variety of locations throughout the West.

In Wyoming, Beetle (1961) described what he termed "Fescue grassland," "mountain meadow," "intervale," and "sedge meadow" which are very similar to the very dry, dry,

Table 19. Total number of species of forbs, grasses, sedges and rushes, and shrubs for three cover types on six meadow units.

Cover Type and Plant Group	Meadow Unit					
	Cold	Middle Cottonwood	Lower Cottonwood	Horse Pasture	Ginger	Phantom
Dry						
Forbs	30	26	21	29	Dry type	
Grasses 1/	12	12	8	8	did not	
Sedges 1/	8	8	5	5	occur	
Shrubs	1	2	3	1		
Total	51	48	37	43	-	-
Moist						
Forbs	42	37	30	32	23	18
Grasses 1/	16	14	15	12	11	10
Sedges 1/	12	9	9	13	11	10
Shrubs	5	6	3	1	4	3
Total	75	70	57	54	49	41
Wet						
Forbs	44	40	29	28	26	26
Grasses 1/	12	12	11	9	9	8
Sedges 1/	13	13	13	11	14	14
Shrubs	7	8	5	4	5	3
Total	76	73	58	52	54	51

1/ Species of rush and horsetail are included in this group.

moist, and wet types of this study. Beetle's sedge meadow type is located in the central portions of meadow areas and is dominated by tall, water-loving sedges. The intervale occurs at the edge of the sedge meadow on moist to wet soil and is characterized by *Deschampsia caespitosa, Potentilla fruticosa,* or *Artemisia cana.* Beetle described his mountain meadow and Fescue grassland as "dry meadows," occurring between the timber edge and the intervale.

Johnson (1962) in a study of the vegetation of high-altitude ranges in Wyoming described what he termed *Festuca/Poa, Carex/Deschampsia,* and wet meadow communities. These communities were found in the sub-alpine zone and exhibited general characteristics quite comparable, respectively, to the dry, moist, and wet vegetation types described in this study.

Lewis and Riegelhuth (1964) briefly describe several meadow communities in the Sawtooth Valley and Stanley Basin of south-central Idaho that closely resemble the wet and moist types of this study. Their *Deschampsia caespitosa* community, occurring on well-drained to moderately wet soils appears to be comparable to the moist type described in this study. Their *Carex aquatilis* community occurs on wet soils, is characterized by *Carex aquatilis*, produces large quantities of forage, and is comparable to the wet type described in this

study. Communities comparable to the *Carex rostrata* communities described by these authors also occurred on the wettest portions of four of the meadows described in this study. The extent of area covered by the community was so limited however, that it was included within the wet type.

Smiley (1915) in describing the alpine and subalpine vegetation of the Lake Tahoe region in Nevada classified meadow vegetation into three zones ranging outward from the wettest central zone, through a zone of intermediate moisture, to the driest, best-drained zone on the outer edge next to the timber. The species composition of these zones is completely different from that described in this study, but the genera and soil moisture conditions within the respective zones are very similar to the dry, moist, and wet types of this study. Pickford and Reid (1942) and Reid and Pickford (1946) describe moist mountain meadows in eastern Oregon and eastern Washington that are characterized by vegetation very comparable to the moist type described in this study. The soils of the meadows they describe were saturated or flooded during the spring, but became dry on the surface later during the summer. Meadows in good condition were characterized by the preponderance of *Deschampsia caespitosa*. These authors reported that extended overuse produced a drastic decrease of perennial grasses and sedges and an

increase in less palatable forb species. They described the characteristics of four range condition classes (good, fair, poor, and very poor), and outlined the degenerative process that ensues if overgrazing persists, and forbs, or weeds, predominate. In their 1942 paper, they stated:

> The weeds in general cure earlier than grasses and regrow less following grazing leaving the soil surface exposed. Weed vegetation does not possess the extensive fibrous roots so characteristic of grasses, which tend to bind the upper soil layers into a firm sod. The soil of meadows vegetated principally with weeds therefore is more exposed to accelerated run-off and erosion. If the plant cover is reduced sufficiently to permit accelerated run-off, headward erosion of stream channels frequently lowers the water table of meadows so much that subirrigation is destroyed and a dry-land vegetation takes over. This is the end of true meadow conditions and high grazing capacities until the water table can be raised and the former species reintroduced, either by careful management or by artificial reseeding and engineering works.

Compositional differences between Cold Meadow and the Horse Pasture are not great, but the trend toward increasing forb coverage and decreasing grass coverage follows very closely the pattern of degeneration described by Reid and Pickford. In spite of this similarity in the general pattern of vegetation response to intensive grazing, the actual coverage values of grasses and forbs for communities of presumably comparable condition differ somewhat between the two studies.

Coverage values of perennial forbs and grasses in the moist cover type of this study were approximately equal on every meadow unit except the Horse Pasture, where past utilization had evidently reduced the grass cover (Table 7). Even on Ginger Meadow, the most pristine meadow examined, the coverage of grasses (32.3 percent) was only slightly greater than forbs (27.2 percent). Reid and Pickford however reported that on meadows in good condition coverage by perennial grasses and forbs was 50 percent, and less than 10 percent, respectively. Coverage values were nearly equal (about 20 percent) on meadows in fair condition, and forb coverage was greater than that of grasses on ranges in poor condition. Since coverage values for perennial forbs and grasses were consistently so nearly equal in this study, even on the most pristine meadows, it must be concluded that the characteristics of the various condition classes described by Reid and Pickford are applicable in only the most general sense to the vegetation of the moist cover type in this study.

Soil Moisture

The overall ranges in soil moisture levels associated with the three cover types sampled are presented in Figure 3. Since these determinations were made late in the summer, all values are probably minimal, but do illustrate the important

relationship between cover type and the soil moisture gradient. The general pattern of moisture relations within the three major cover types in this study were observed to be as follows:

Dry Type. Well-drained, coarse textured soils, never saturated or flooded, and drying out early in summer.

Moist Type. Degree of drainage appears to vary from good to poor. Soil is flooded during the spring, remaining wet until at least early July, but drying on the surface by mid-July.

Wet Type. Drainage is poor. Flooded during the spring, remaining very wet or inundated throughout the summer.

The close association observed in this study between the nature of the vegetation and general soil moisture conditions has been reported by many other workers who have studied mountain meadow vegetation. The following investigators, among others, have described mountain meadow vegetation in a wide variety of locations in the western United States and have concluded that soil moisture level is the principle, or at least a major factor in determining the presence of absence of a particular plant community or cover type: (Smiley 1915, Ramaley 1916, Reed 1917, Reid and Pickford 1946, Shorsmith 1959, Beetle 1961, Johnson 1962, Johnson and Billings 1962, Patten 1963, and Lewis and Riegelhuth 1964).

Klikoff (1965) measured soil moisture levels on what he classified wet, moist, and dry alpine meadows in Gaylor Basin of Yosemite National Park. Soil moisture tensions, recorded in atmospheres at 1 dm depth, were as follows: wet meadow (never in excess of one-third atmosphere); moist meadow (often more than one-third, but never exceeding 15 atmospheres); and dry meadow (tensions exceeded 15 atmospheres by early to mid-August).

Gross Production

The standard errors for all means presented in this section are listed in Appendix II.

Cover Type - Meadow Unit Level

The significance of differences in gross production within cover types between meadow units is presented in Tables 20, 21, and 22. Due to limitations of time, the weight of shrub forage was not measured on any of the sample plots. Since shrub forage was not abundant on most of the meadow units, this did not reduce production estimates greatly. In the wet and moist cover types on the Lower Cottonwood unit however, shrubs were more prevalent than on other meadow units (Table 7), and production estimates are probably smaller than the true values.

Table 20. Differences in average pounds-per-acre gross forage production within the dry cover type between meadow units.

Meadow Unit						Difference Between Meadow Units			
							Significance of		
Cold	Middle Cottonwood	Lower Cottonwood	Horse Pasture	Ginger[1/]	Phantom[1/]	Percent	*t*	*P*[2/]	*df*
2428	2100					15.4	0.938	.40	6
2428		2074				16.5	0.962	.40	6
2428			1921			22.7	-	-	-
	2100	2074				1.2	0.179	-	4
	2100		1921			8.5	-	-	-
		2074	1921			7.4	-	-	-

1/ The dry cover type did not occur on the Ginger and Phantom units.

2/ *P* values greater than .40 are not listed.

Table 21. Differences in average pounds-per-acre gross forage production within the moist cover type between meadow units.

Meadow Unit						Difference Between Meadow Units			
							Significance of		
Cold	Middle Cottonwood	Lower Cottonwood	Horse Pasture	Ginger	Phantom	Percent	*t*	*P*[1/]	*df*
2358	2055					12.8	2.421	.05	10
2358		1729				26.7	2.500	.05	9
2358			2014			14.6	2.346	.10	7
2358				1942		17.7	2.146	.10	7
2358					2095	11.2	-	-	-
	2055	1729				15.9	0.945	.40	7
	2055		2014			2.0	0.197	-	5
	2055			1942		5.5	0.433	-	5
	2055				2095	1.9	-	-	-
		1729	2014			14.2	0.515	-	4
		1729		1942		11.0	0.366	-	4
		1729			2095	17.5	-	-	-
			2014	1942		3.6	0.196	-	2
			2014		2095	3.9	-	-	-
				1942	2095	7.3	-	-	-

1/ *P* values greater than .40 are not listed.

Table 22. Differences in average pounds-per-acre gross forage production within the wet cover type between meadow units.

Meadow Unit						Difference Between Meadow Units			
							Significance of		
Cold	Middle Cottonwood	Lower Cottonwood	Horse Pasture	Ginger	Phantom	Percent	*t*	*P*[1/]	*df*
3291	2971					9.7	1.012	.40	20
3291		2857				13.2	1.122	.30	19
3291			3487			5.6	0.330	-	13
3291				4487		26.7	1.883	.10	13
3291					4441	25.9	2.260	.05	14
	2971	2857				3.8	0.298	-	15
	2971		3487			14.8	1.113	.30	9
	2971			4487		33.8	2.798	.05	9
	2971				4441	33.1	3.455	.01	10
		2857	3487			18.1	0.878	-	8
		2857		4487		36.3	2.094	.10	8
		2857			4441	35.7	2.563	.05	9
			3487	4487		22.3	1.115	.40	2
			3487		4441	21.5	1.551	.30	3
				4487	4441	1.0	0.054	-	3

1/ *P* values greater than .40 are not listed.

Because of small sample sizes and frequently low levels of significance, it is difficult to draw firm conclusions about differences in cover type gross production between meadow units. However, by comparing the significance levels of the differences between means (Tables 20, 21, and 22) with listings of cover type means arranged in the order of decreasing magnitude (Table 23), three general patterns seem to be indicated:

1. Production tends to be less in areas with histories of intensive grazing, particularly where moisture is limiting. This is illustrated by comparing Cold Meadow and the Horse Pasture which are at the same elevation and location, but have grossly different histories of grazing. Production on the dry and moist types, where soil moisture levels become progressively lower as the summer progresses, is much lower in the heavily-grazed Horse Pasture. In the wet type, however, where moisture levels remain high throughout the summer, Horse Pasture production does not differ significantly from that on Cold Meadow. The consistently low production of all three cover types on the Lower Cottonwood Unit probably reflects the combined effects of a history of moderately heavy grazing by both big game and livestock and errors of underestimation due to not

Table 23. Gross forage production averages for the three major cover types on each meadow unit, listed in the order of decreasing magnitude.

Meadow Unit	Production in pounds per acre
Dry Cover Type	
Cold	2484
Middle Cottonwood	2100
Lower Cottonwood	2074
Horse Pasture	1921
Moist Cover Type	
Cold	2358
Phantom	2095
Middle Cottonwood	2055
Horse Pasture	2014
Ginger	1942
Lower Cottonwood	1729
Wet Cover Type	
Ginger	4487
Phantom	4441
Horse Pasture	3487
Cold	3291
Middle Cottonwood	2971
Lower Cottonwood	2857

measuring the forage production of shrubs.

2. At a given elevation, production per unit of area within the wet cover type tends to be higher on the smaller meadow units. Ginger and Phantom are the two smallest units sampled (17.74 and 8.30 acres respectively), and exhibit significantly greater wet type production than any of the other meadow units. Because of their small size, both these units are shaded a greater portion of the time than the larger units. The dry type does not occur on these small units and the moist type is generally sparse. The wet type, however, appears to be at its maximum production.

3. Production in the dry and moist cover types is significantly higher on Cold Meadow than on the other meadow units. It is suspected that availability of soil moisture in these cover types is higher at Cold Meadows during the growing season than on other meadow units. This is probably due, at least in part, to the fact that the incidence and duration of summer precipitation was higher at Cold Meadow than on the other meadow units. In the wet cover type, where moisture is not a factor limiting plant growth, the production on Cold Meadow does not differ greatly from other meadow units, except Ginger and Phantom.

Meadow Unit

Gross production differences at the meadow unit level, and the significance of these differences, are presented in Table 24. In Table 25 the meadow units are arranged in the order of decreasing average gross production.

As previously described, differences in production exist within cover types between meadow units, and contribute to differences found at the meadow unit level. Another factor that greatly affects gross production at the meadow unit level is the proportion of meadow unit occupied by the wet cover type. Since gross production on this cover type averages much higher than on the dry or moist types (Table 26), the proportion of meadow it occupies has a great effect upon the gross production average for the meadow. It can be seen by comparing Tables 25 and 4 that a listing of meadow units arranged in the order of decreasing average gross production is nearly identical to a listing of meadow units arranged in the order of decreasing size of respective wet cover types. The reversal of the Cold Meadow and Middle Cottonwood units constitutes the only exception, perhaps because the higher rainfall at Cold Meadow is a more important factor than the rather small difference in proportions of wet cover type between the two units.

Table 24. Differences in average pounds-per-acre gross production between meadow units.

Meadow Unit						Difference Between Meadow Units			
							Significance of		
Cold	Middle Cottonwood	Lower Cottonwood	Horse Pasture	Ginger	Phantom	Percent	*t*	*P*[1/]	*df*
2861	2603					9.0	1.129	.30	40
2861		2200				23.1	2.463	.05	38
2861			2156			24.6	1.908	.10	29
2861				3491		22.0	1.297	.30	27
2861					3899	26.6	2.234	.05	27
	2603	2200				15.5	1.438	.20	30
	2603		2156			17.2	1.231	.30	21
	2603			3491		25.4	1.790	.10	19
	2603				3899	33.2	2.792	.05	19
		2200	2156			2.0	0.097	-	19
		2200		3491		37.0	2.130	.05	17
		2200			3899	43.6	2.949	.01	17
			2156	3491		38.2	1.609	.20	8
			2156		3899	44.7	2.269	.10	8
				3491	3899	10.4	0.375	-	6

1/ *P* values greater than .40 are not listed.

Table 25. Gross production averages for each meadow unit, expressed in pounds-per-acre, listed in the order of decreasing magnitude.

Meadow Unit	Production[1/]
Ginger and Phantom	3491 - 3899
Cold	2861
Middle Cottonwood	2603
Horse Pasture and Lower Cottonwood	2156 - 2200

1/ Means listed on separate lines differed significantly (P = .30 or less), while those listed on the same line did not.

Table 26. Differences in average pounds-per-acre gross forage production between cover types, averaged over all six meadow units.

Cover Type			Difference Between Means			
				Significance of		
Dry	Moist	Wet	Percent	*t*	*P*[1/]	*df*
2167	2076		4.2	0.576	-	31
	2076	3237	35.9	6.015	.01	56
2167		3237	33.1	4.283	.01	49

1/ *P* values greater than .40 are not listed.

The significantly higher gross production of the Ginger and Phantom units is not surprising since these units not only have higher proportions of wet cover type than any of the other units, but also have significantly higher average production in the wet type. On the other end of the scale, the Horse Pasture, with the lowest proportion of wet cover type (20 percent), has the lowest average production of all the meadow units.

Cover Type - Area Level

Differences in gross production within cover types between Areas are presented in Table 27. Production in the wet cover type is nearly identical on both areas and the 1.3 percent difference is not significant. Production in the dry and moist types on Area I however, averages 14.1 and 16.4 percent lower, respectively, than Area II. The rather low probability level for the significance of the difference between means for the dry type is thought to be due to small sample size and not lack of true difference.

Area

Gross production means for area are also presented in Table 27. The significantly greater average production of Area II is due to two factors. First, gross production on the dry and moist cover types of Area I is lower than Area II.

Table 27. Cover type and overall pounds-per-acre forage production differences between Areas I and II.

Cover Type	Net Production plots open to grazing		Gross Production plots protected from grazing		Difference Between Means				
							Significance of		
	Area I	Area II	Area I	Area II	Percent	Pounds Per acre	t	P[1/]	df
Dry	1293		2000		35.5	707	2.310	.10	6
Dry		1889		2327	18.8	438	1.600	.20	14
Dry			2000	2327	14.1	-	1.080	.40	10
Moist	1359		1849		26.5	491	1.821	.10	12
Moist		1950		2211	11.8	260	2.313	.05	26
Moist			1849	2211	16.4	-	2.098	.05	19
Wet	2733		3270		16.4	537	1.551	.20	24
Wet		3216		3226	0.3	10	0.043	-	46
Wet			3270	3226	1.3	-	0.150	-	35
Overall	1776		2278		22.1	502	1.727	.10	48
Overall		2656		2789	4.8	134	0.750	-	90
Overall			2278	2789	18.32	-	2.269	.05	69

1/ P values greater than .40 are not listed.

Secondly, the wet type is more abundant on Area II (56.1 percent) than on Area I (36.2 percent), and increases the Area II average considerably.

Cover Type - Overall

The overall means for gross production by cover type are listed in Table 26. The averages for the dry and moist cover types are remarkably close, considering the differences in soil moisture levels and species composition which exist between them, and do not differ significantly. The difference in production between the wet and either of the other types is highly significant, with the wet type producing from 33.1 to 35.9 percent more forage.

Overall

Average overall gross production for the entire sample (all six meadow units) is 2,617 pounds per acre, with a standard error of 111 pounds.

Total Pounds

Estimates of total pounds of forage produced by each cover type on each area are presented in Tables 28 and 29, along with the percentages of total area production contributed by each cover type. Although the percentages vary with the area, it can be seen that roughly one-half to two-thirds

Table 28. Gross forage production, by cover type, expressed in total pounds and as a percentage of total Area I production.

Cover Type	Pounds of production per acre	Total acres	Percent of area occupied by cover type	Total cover type production	
				Pounds	Percent of area production
Very Dry	354	10.31	7.1	3,650	1.1
Dry	2000	21.36	14.7	42,720	12.9
Moist	1849	60.90	42.0	112,604	34.1
Wet	3270	52.38	36.2	171,283	51.9
Total	2278	144.95		330,257	100.0

Table 29. Gross forage production, by cover type, expressed in total pounds and as a percentage of total Area II production.

Cover Type	Pounds of production per acre	Total acres	Percent of area occupied by cover type	Total cover type production	
				Pounds	Percent of area production
Dry	2327	22.21	7.8	51,683	6.5
Moist	2211	102.84	36.1	227,379	28.6
Wet	3226	159.80	56.1	515,515	64.9
Total	2789	284.85		794,577	100.0

of all forage produced comes from the wet cover type. The moist type produces the second greatest total amount of forage on both areas, while the dry type produces the least. The very dry type occurs only on Area I and contributes very little to total production.

Other Research

On Wyoming sheep ranges Smith and Johnson (1965) measured forage production on subalpine hairgrass communities which closely resemble the moist type described in this study. They found considerably more variation in production between sites (254 to 2,500 pounds of air-dried forage per acre) than were encountered in this study. Although one of their study areas produced volumes of forage comparable to the moist type of this study, the other two produced much less. The overall average of 2,076 pounds for the moist type in this study is approximately 30 percent higher than the overall 1,300 to 1,500 pound average of their study. The lower average for the Wyoming study may be due in part to the intensive sheep grazing the study area had received in past years, and also to differences in site potentialities. Smith and Johnson (1965) found that the maximum standing crop, in terms of air-dried weights, occurred during the month of July, with the exact time varying between years. It is their maximum production figures that have been compared with the

results of this study. Since vegetation in this study was harvested late in the summer it is likely that the production averages represent something less than maximum standing crop.

Johnson (1962) estimated green weight production for subalpine communities in Wyoming. His *Festuca/Poa*, *Carex/Deschampsia*, and wet meadow communities are comparable in many respects to the dry, moist, and wet types, respectively, in this study. Although all of his production averages are much lower than the figures from this study, his *Festuca/Poa* and *Carex/Deschampsia* communities produced essentially the same volume of forage, as was the case for the dry and moist types in this study. His wet meadow community however produced only half as much as either of the drier communities, which is quite the opposite of the case in this study.

Strickler (1961) reports an average production of 2,197 pounds of air-dried forage per acre for a green fescue (*Festuca viridula*) range of good condition in eastern Oregon. The genera supported by this community are very similar to those exhibited in the dry type in this study, and total production figures for the two studies are nearly identical (2,197 pounds for Oregon, and 2,167 pounds for Idaho). Grasses in Strickler's community were somewhat more prominent than in this study however, covering an average of 27.9 percent of the ground, as opposed to 18.6 percent in this

study. Forbs in the Oregon study exhibited an average coverage of only 3.6 percent, as opposed to 22.8 percent in this study. Sedges were not present in the green fescue community, but covered 4.8 percent of the ground in the dry type of this study.

Forage Utilization

The standard errors for all means presented in this section are listed in Appendix II. Differences in gross and net production weights are probably minimal since the re-growth of grazed vegetation was not measured.

Weight of Forage Used by Ground Squirrels

Differences between gross and net production, representing forage removal by ground squirrels, by cover type, are presented in Table 30. Although differences in gross and net production varied little between cover types, only the one for the moist cover type was highly significant. The low significance and non-significance of differences in the other cover types is thought to be the result of sample size being too small to achieve desired levels of statistical reliability and not because true differences failed to exist. Evidence in support of this conclusion is the fact that on 26 of the 31 paired-plots, production on the ungrazed plot

Table 30. Forage removal by ground squirrels by cover type.

Cover Type	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1/]	Gross[2/]	Percent	Pounds per acre	*t*	*P*[3/]	*df*
Very Dry	282	354	20.3	72	-	-	-
Dry	2040	2311	11.7	271	1.089	.30	20
Moist	2108	2308	8.7	200	2.183	.05	20
Wet	3006	3238	7.2	232	0.766	-	12

1/ Forage production on plots grazed by ground squirrels

2/ Forage production on plots protected from grazing by ground squirrels.

3/ *P* values greater than .40 are not listed.

exceeded that of its paired, grazed plot. Similar ratios existed within each of the cover types. It was decided therefore, to determine, through the use of chi-square tests, whether or not the proportion of ungrazed plots upon which production exceeded that of the paired, grazed plot was significantly higher than could be expected by chance alone. The results of these determinations are presented in Table 31, and show that, except for the very dry type, production on ungrazed plots was greater than on grazed equivalents a significantly greater number of times than could be expected from chance alone. Since only a single sample occurred on the very dry type tests of significance were not applicable.

The general pattern suggested by the data in Table 30 is one of rather uniform ground squirrel use of the three major cover types. The percentage of forage removed varies somewhat between cover types, but the number of pounds of forage removed per acre is, except for the very dry type, remarkably similar. Utilization on the very dry cover type is represented by a single series of three plots. Although the sample plot grazed only by ground squirrels produced 20.3 percent less forage than the completely protected plot, the completely unprotected plot showed no utilization at all (Table 38). Because of the small sample and the variability of the results, the reliability of the estimates is highly

Table 31. Chi-square tests of significance of difference between observed numbers of ungrazed plots, upon which forage production exceeded that of paired plots grazed by ground squirrels, and numbers expected due to chance alone.

Cover Type	Observed values[1]		Expected values[2]	n[3]	Chi-square	P
	Grazed	Ungrazed				
Very Dry	0	1	0.5	1	-	-
Dry	2	9	5.5	11	2.909	.10
Moist	2	9	5.5	11	2.909	.10
Wet	1	7	4.0	8	3.125	.10

1/ The respective number of times that the grazed or ungrazed plot, from a series of matched plot pairs, was observed to produce more forage than its paired counterpart.

2/ Expected value = $\frac{\text{Number of plot pairs}}{2}$

It is assumed that, in the absence of grazing, a protected plot has as great a chance of outproducing an unprotected plot as vice versa.

3/ n = number of plot pairs.

questionable. Since an examination of the vegetation on the respective plots revealed no visible evidence of ground squirrel utilization it is likely that the observed difference in production is due to intrinsic differences in the characteristics of the vegetation between the plots.

A comparison of ground squirrel forage removal rates for the four meadow units on which squirrels occurred is presented in Table 32. These figures represent only those portions of meadow units inhabited or used by squirrels since these were the only areas sampled. Estimates were later made of the extent to which these utilization rates apply to the entire meadow units, are presented in Table 43, and are discussed later on in this section.

The significance of differences between gross and net production is, with the exception of the Cold Meadow Unit very low. Chi-square tests indicate however that for every meadow unit the proportion of ungrazed plots upon which production exceeds that of the paired, grazed plot is significantly higher than can be expected due to chance alone, with a probability level of .30 or less (Table 33). Again, the overall pattern is such that the differences in Table 32 are thought to be real, but sample size is inadequate to achieve desired levels of statistical significance.

The intensity of ground squirrel utilization varies considerably between meadow units, with the forage removal

Table 32. Forage removal by ground squirrels by meadow unit.

Meadow Unit	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1/]	Gross[2/]	Percent	Pounds per acre	*t*	*P*[3/]	*df*
Cold	2356	2682	12.2	326	1.890	.10	20
Middle Cottonwood	2327	2428	4.2	101	0.296	-	16
Horse Pasture	1703	2066	17.6	363	0.353	-	6
Lower Cottonwood	2129	2330	8.6	201	0.914	.40	14

1/ Forage production on plots grazed by ground squirrels

2/ Forage production on plots protected from grazing by ground squirrels.

3/ *P* values greater than .40 are not listed.

Table 33. Chi-square tests of significance of difference between observed numbers of ungrazed plots, upon which forage production exceeded that of paired plots grazed by ground squirrels, and numbers expected due to chance alone.

Meadow Unit	Observed values[1]		Expected values[2]	n[3]	Chi-square	P
	Grazed	Ungrazed				
Cold	2	9	5.5	11	2.909	.10
Middle Cottonwood	2	7	4.5	9	1.777	.20
Horse Pasture	0	4	2.0	4	2.250	.20
Lower Cottonwood	2	6	4.0	8	1.125	.30

1/ The respective number of times that the grazed or ungrazed plot, from a series of matched plot pairs, was observed to produce more forage than its paired counterpart.

2/ Expected value = $\frac{\text{Number of plot pairs}}{2}$

It is assumed that, in the absence of grazing, a protected plot has as great a chance of outproducing an unprotected plot as vice versa.

3/ n = number of plot pairs.

rate on the Horse Pasture being more than three times that on the Middle Cottonwood Unit. The removal rates on Cold Meadow and the Horse Pasture differed little, but both rates are approximately one-third larger than that on Lower Cottonwood.

Weight of Forage Used by All Herbivores

Cover Type - Meadow Unit Level. Average gross and net production, and the significance of their differences, for each cover type on each meadow unit, are presented in Tables 34, 35, and 36. In the dry and moist cover types gross production was consistently greater than net by 10.6 to 55.6 percent. It is likely that the rather low levels of significance of some of these differences reflect the small size of the sample and not lack of real difference.

In the wet cover type the nature and degree of the difference between gross and net production is quite variable and, in general, the results probably do not accurately represent the actual amounts of forage removal that occurred on this cover type. On Cold Meadows, for example, average net production exceeded average gross production by 5.6 percent in spite of the fact that big game were known to have used this cover type extensively.

Table 34. Forage removal averages, representing total herbivore utilization, within the dry cover type for each meadow unit.

Meadow Unit	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1]	Gross[2]	Percent	Pounds per acre	*t*	*P*[3]	*df*
Cold	2036	2484	18.0	448	1.075	.40	8
Middle Cottonwood	1676	2100	20.2	424	1.760	.20	4
Lower Cottonwood	1704	2074	17.8	370	1.229	.30	4
Horse Pasture	852	1921	55.6	1069	-	-	-
Ginger		None					
Phantom		None					

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

[3] *P* values greater than .40 are not listed.

Table 35. Forage removal averages, representing total herbivore utilization, within the moist cover type for each meadow unit.

Meadow Unit	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1]	Gross[2]	Percent	Pounds per acre	*t*	*P*[3]	*df*
Cold	2064	2358	12.5	294	2.063	.10	12
Middle Cottonwood	1838	2055	10.6	217	1.184	.30	8
Lower Cottonwood	1351	1729	21.9	378	0.798	-	6
Horse Pasture	1347	2014	33.1	666	3.138	.10	2
Ginger	1699	1942	12.5	243	0.495	-	4
Phantom	1645	2095	21.5	450	-	-	-

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

[3] *P* values greater than .40 are not listed.

Table 36. Forage removal averages, representing total herbivore utilization, within the wet cover type for each meadow unit.

Meadow Unit	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1]	Gross[2]	Percent	Pounds per acre	*t*	*P*[3]	*df*
Cold	3485	3291	5.6	-	0.578	-	23
Middle Cottonwood	2884	2971	2.9	87	0.298	-	16
Lower Cottonwood	2559	2857	10.4	298	0.609	-	14
Horse Pasture	2698	3487	22.6	789	1.276	.40	2
Ginger	3547	4487	20.9	939	1.061	.30	4
Phantom	3539	4441	20.3	902	1.979	.20	4

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

[3] *P* values greater than .40 are not listed.

Although the actual values for the wet cover type are probably unreliable, a comparison of their relative magnitudes suggest a pattern that, when considered along with several other factors, may partially explain the variability. Vegetative growth in the wet cover type begins earlier and extends later in the season than in any other meadow cover type. Elk made the most use of the wet cover type in early spring and late summer when the growth of vegetation in the other cover types was very slight. During the interim, the elk concentrated on the forbs and grasses of the dry and moist types. Elk use of Cold Meadow, Middle Cottonwood, Lower Cottonwood and the Horse Pasture was the most intensive early in the season, declining rapidly as the summer progressed. Therefore, most of the elk use of the wet cover type on these meadow units occurred during a short period in the early spring. It is likely that such early use was obscured by regrowth of the vegetation and that it may have had an invigorating effect upon the vegetation which caused it to outproduce protected vegetation. The effect is more pronounced on Cold Meadow than on Middle Cottonwood, probably because Middle Cottonwood received approximately twice the intensity of elk utilization as Cold Meadow. The effect is obscured on Lower Cottonwood and the Horse Pasture because of extensive use in the wet type by livestock.

Since degrees of freedom were 23 and 16 respectively and since standard errors were relatively small, sample size is presumably not the principle cause for the lack of significance of difference between gross and net production on the Cold and Middle Cottonwood units. Variation on the Lower Cottonwood unit however was much greater and small sample size probably is the cause for lack of significance.

The relatively heavy use of the wet cover type on the Ginger and Phantom units is possibly a reflection of late summer use of these units by elk. Elk leave the large meadows in mid-summer and withdraw into the timber, particularly to the heads of moist spruce-draws. Both the Ginger and Phantom units are small, very wet, and heavily-shaded meadows located near the heads of small drainages.

Meadow Unit. Gross and net production averages for each meadow unit are presented in Table 37. Levels of significance for differences between gross and net production are uniformly low, due largely to the inadequacy of the relatively small sample to cope with the rather large amount of variation involved in averaging values for unlike cover types. The average for the Cold Meadow unit is somewhat misleading since the values for the wet type mask the significant use that occurred on the dry and moist types. As explained previously in the section dealing with total utilization of cover

Table 37. Forage removal averages representing total herbivore utilization for each meadow unit.

Meadow Unit	Pounds of production per acre		Difference Between Means				
					Significance		
	Net[1]	Gross[2]	Percent	Pounds per acre	*t*	*P*[3]	*df*
Cold	2810	2861	1.8	51	0.203	-	38
Middle Cottonwood	2448	2603	6.0	155	0.625	-	32
Lower Cottonwood	1861	2200	15.4	339	1.018	.40	30
Horse Pasture	1498	2156	30.5	658	1.298	.30	10
Ginger	2824	3491	19.1	667	0.675	-	6
Phantom	3101	3899	20.5	798	0.932	.40	6

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

[3] *P* values greater than .40 are not listed.

types at the meadow unit level, measurements in the wet type are thought to underestimate actual forage removal rates for big game, particularly on the Cold Meadow and Middle Cottonwood units. Averaging these low estimates with the values for the other cover types produces meadow unit means which are correspondingly low.

Cover Type - Area Level. Gross and net production averages for each cover type are presented in Table 27 for the Area level. The relative difference in the intensity of utilization between Areas is apparent within all of the cover types. The substantially heavier forage removal rates on Area I no doubt reflect the 1,365 horse-days-use which occurred there. Forage removal rates on the dry, moist, and wet cover types of Area I are greater than those of Area II by 38, 47, and 98 percent respectively. The much greater relative difference in utilization rates on the wet type is due, at least in part, to the fact that little elk use occurred on most meadow units during the later part of the summer. During this time the livestock concentrated on the wet cover type, while the elk withdrew into the surrounding timbered areas.

Area. Area averages for gross and net production are also presented in Table 27. Forage removal rates on Area I averaged 73 percent higher than Area II.

Total Pounds. Estimates of total pounds of forage removed from each cover type on each area are presented in Tables 38 and 39. Except for the dry cover type, the patterns of use on the two areas are quite different. On Area I, essentially the same amounts of forage were removed from the moist and wet cover types. The dry type, however, provided only about half as much forage as either the moist or wet types. On Area II however, the dry and moist types account for nearly all forage removed, with the moist type alone providing 70 percent.

Chi-square was used to test whether or not the observed removal rates for the three cover types differed significantly from values that would be expected if forage removal were proportional to forage production. The results are presented in Tables 40 and 41. The results for both areas are the same. In both the dry and moist cover types the amounts of forage removed are significantly more than expected, while the reverse is true in the wet type.

Removal by Class of Grazing Animal. Estimates of the proportion of total utilization attributable to the various classes of grazing animals are presented in Table 42, for each meadow unit. The estimates for the Lower Cottonwood, Horse Pasture, and Middle Cottonwood units proved to be very consistent and are thought to be reasonably accurate.

Table 38. Cover type utilization for Area I expressed as total pounds of forage removed, and as a percentage of Area I utilization.

		Forage Removed		
Cover Type	Acreage	Pounds per acre	Total pounds	Percent of total for Area I
Very Dry	10.31	0	0	0.0
Dry	21.36	707	15,102	20.7
Moist	60.90	491	29,902	40.9
Wet	52.38	537	28,128	38.4
Total	144.95	502	73,132	100.0

Table 39. Cover type utilization for Area II expressed as total pounds of forage removed, and as a percentage of Area II utilization.

		Forage Removed		
Cover Type	Acreage	Pounds per acre	Total pounds	Percent of total for Area II
Dry	22.21	438	9,728	25.6
Moist	102.84	260	26,738	70.2
Wet	159.80	10	1,598	4.2
Total	284.85	134	38,064	100.0

Table 40. Chi-square tests of significance of difference in observed and expected values for forage removal on the cover types of Area I.

Cover Type	Expected[1/]	Observed	Significance	
			Chi-square	*P*
Very Dry	804	0	1,031-	.01
Dry	9,434	15,102	4,371+	.01
Moist	24,938	29,902	1,269+	.01
Wet	37,956	28,128	3,269-	.01

1/ Expected value = (Total pounds of forage removed from Area I) X (The percentage of Area I gross production produced by the cover type) See page 45 for an explanation of the formula used in calculating chi-square values.

Table 41. Chi-square tests of significance of differences in observed and expected values for forage removal on the cover types of Area II.

Cover Type	Expected[1/]	Observed	Significance	
			Chi-square	*P*
Dry	2,474	9,728	22,339+	.01
Moist	10,886	26,738	24,244+	.01
Wet	24,704	1,598	22,699-	.01

1/ Expected value = (Total pounds of forage removed from Area II) X (The percentage of Area II gross production produced by the cover type).

See page 45 for an explanation of the formula used in calculating chi-square values.

Table 42. Proportions of total forage utilization on each meadow unit attributable to the various classes of grazing animals.

Meadow Unit	Animal-days-use per acre		Pounds of forage removal per acre				Total elk days-use
	Elk	Horse	Elk	Horse	Ground squirrel	Total	
Cold	5.21	0.00	57.3	0.0	154.3	51 (212)[1/]	755
Middle Cottonwood	9.93	0.00	109.2	0.0	45.8	155	1,314
Lower Cottonwood	5.67	6.02	62.4	150.4	126.2	339	422
Horse Pasture	5.21	14.11	57.3	352.8	247.9	658	324
Ginger	3.49 (60.64)[1/]	0.00	667.0	0.0	0.0	667	774
Phantom	4.15 (61.86)[1/]	4.70	680.5	117.5	0.0	798	430

[1/] Values not in brackets were derived from actual measurements. Values in brackets are ones that would be required to account for the other measured values for the meadow unit. For instance, 60.64 elk-days-use per acre, and not the 3.49 figure calculated from dropping counts, would be necessary to account for the measured forage removal rate of 667 pounds per acre on the Ginger unit.

Several inconsistencies are apparent however in the figures for the Cold, Phantom, and Ginger units, and probably reflect the inadequacies of some of the criteria used in making the estimates. Some of the information obtained from the presumably more reliable figures for the Lower Cottonwood, Horse Pasture, and Middle Cottonwood units was used as a guide in an attempt to interpret the discrepancies in the estimates for the other units. Two types of discrepancy exist: (1) forage removal measurements on the Ginger and Phantom units far exceed values that might be expected from the number of elk droppings found; and (2) measured forage removal on Cold Meadow was less than might be expected from the elk dropping density and the intensity of ground squirrel utilization measured there.

After meadow-wide forage removal rates for ground squirrels had been deduced for the Lower Cottonwood, Horse Pasture, and Middle Cottonwood units, they were compared with the ground squirrel forage removal rates that had been recorded on the areas used by squirrels on the respective meadow units (Table 32). The meadow-wide rates were naturally smaller than the ones for the strictly "squirrel areas," since large portions of the meadow units were not used by squirrels. For purposes of relative comparison, calculations were made to determine the percentage of each meadow unit to

which the measured ground squirrel forage removal rate would have to apply in order to arrive at the deduced meadow-wide removal rate. For example, it was deduced that an average of 126.2 pounds of forage per acre was removed by ground squirrels on the Lower Cottonwood unit as a whole (Table 42). The recorded ground squirrel forage removal rate on "squirrel areas" on Lower Cottonwood was 201 pounds per acre (Table 32). Assuming that both of these rates are reasonably accurate, the measured rate of 201 pounds per acre would have to apply to 63 percent of the 74.44 acres of Lower Cottonwood in order to arrive at the meadow-wide average of 126.2 pounds per acre. The results of these determinations are presented in Table 43.

After the above-described determinations had been completed, it was observed that the proportions of meadow units to which the measured ground squirrel forage removal rate applied were nearly identical to the proportions of the respective meadow units occupied by the dry and moist cover types.

As previously discussed, the low estimated total use on Cold Meadow is due to the fact that the estimate of net production in the wet type on this unit exceeded that of gross production by 194 pounds per acre. Since it is known from direct observations that grazing elk made substantial use of the wet cover type on Cold Meadow it is concluded

Table 43. A comparison of the proportions of meadow units to which measured ground squirrel forage utilization rates apply and proportions occupied by the combined dry and moist cover types.

Meadow Unit	Percentage of meadow unit to which observed ground squirrel utilization rate applies	Percent occupied by dry and moist cover types
Middle Cottonwood	45	40.5
Lower Cottonwood	63	62.8
Horse Pasture	68	70.6
Cold	47[1/]	47.3

1/ On the basis of the similarity of the proportions for the first three meadow units listed it is speculated that the relationship for the Cold Meadow unit will follow the same pattern. The value 47 is an assumption, not a measurement.

that the measurement does not accurately reflect the forage removal that occurred there and that this value should not be included in any estimate of forage removal for the meadow unit as a whole. The effect of including such a value is to mask the significant utilization that was measured in the dry and moist types, and to underestimate the average forage removal rate for the meadow unit as a whole.

What is considered to be a more reasonable or "expected" value for total forage utilization on Cold Meadow was calculated and appears in brackets under the measured value. In determining this value the following procedure was followed: (1) forage removal for elk was estimated from dropping counts, the same as for other meadow units; (2) on the basis of the relationship exhibited in Table 43 by the data for the Middle Cottonwood, Horse Pasture, and Lower Cottonwood units it was assumed that for Cold Meadow the proportion of meadow unit to which the measured ground squirrel forage removal rate applied would be the same as the proportion of meadow unit covered by the dry and moist cover types; and (3) based on the assumption in (2) above, an estimate of total forage removal by ground squirrels was made and then added to that for elk to give an estimate of 212 pounds of total forage removal per acre. When measured forage removal for the dry and moist cover

types is deducted from this estimate the remainder is 8,471 pounds, or 58.5 pounds per acre. This is equivalent to a 1.73 percent utilization rate of the wet cover type and it is likely that at least this amount of use did occur there.

Dropping densities on the Ginger and Phantom units fell far short of accounting for the amount of forage removal measured there. The numbers of elk-days-use per acre that would be required to produce the utilization recorded appears in brackets under the measured values in Table 42. The discrepancy is large, but rather consistent in magnitude, for the two units. On the Phantom unit the estimate of elk-days-use derived from dropping counts was 14.9 times less than necessary to account for the amount of utilization measured. On the Ginger unit the dropping count estimate was 17.4 times too small.

Field observations indicated that elk activities on wet areas are generally limited to feeding or passing through. They bedded, ruminated, and played on dryer areas. Since the Ginger and Phantom units were exceptionally wet it is likely that the elk used them primarily during feeding periods and that they spent most of their time in the better-drained timber types adjacent to the meadows. Such a pattern would help explain the inconsistency of the high rates of utilization and the low dropping densities found there. Another factor

that undoubtedly is involved is the failure to detect many pellet groups because of the large proportions of these units that are covered with water.

The relative differences in recorded densities of ground squirrel burrows on the Cold Meadow, Middle Cottonwood, and Horse Pasture meadow units are of the same general proportions as the relative differences in ground squirrel forage removal rates for the same units. This close similarity provides some evidence that the calculated forage removal rates for ground squirrels are reasonably accurate. For example, 5.83 holes were recorded on the Horse Pasture for every one on Middle Cottonwood. Similarly, the measured forage removal rate for ground squirrels was 5.41 times greater on the Horse Pasture than on Middle Cottonwood. The similarities in relative differences between the Horse Pasture and Cold Meadow were even greater, being 1.15 and 1.11 respectively.

Effects on Species Coverage

Plant species which exhibited significant increases in ground coverage when protected from grazing by ground squirrels and from herbivore use on Areas I and II are listed in Tables 44, 45, and 46 respectively. Plant species which exhibited significant decreases in ground coverage are presented in Tables 47, 48, and 49, and those which did not exhibit any

Table 44. Plant species which exhibited significant increases in ground coverage when protected from grazing by ground squirrels for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Agoseris spp.	0.3	1.9	87.0	1.688	.20	10
Arnica chamissonis	3.0	6.5	53.8	1.107	.40	8
Aster foliaceus	6.3	10.8	41.4	1.786	.10	44
Aster integrifolius	2.1	5.7	63.2	1.078	.40	8
Ligusticum filicinum	0.8	1.7	51.4	1.059	.40	18
Penstemon procerus	1.8	5.0	63.4	2.005	.20	4
Polygonum bistortoides	1.1	3.0	65.6	1.957	.10	18
Taraxacum officinale	2.1	7.2	71.2	1.656	.20	24
Viola bellidifolia	0.1	0.4	67.4	2.489	.05	12
Grasses - Sedges						
Carex hoodii	6.8	12.8	47.1	1.232	.30	38
Stipa columbiana	1.4	4.2	65.6	1.239	.30	14
Trisetum wolfii	5.8	9.9	40.9	2.890	.01	18
Shrubs						
Potentilla fruticosa	11.4	20.6	44.4	1.415	.30	6

1/ Grazed vegetation was exposed to use by Columbian ground squirrels but was protected from use by larger herbivores.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 45. Plant species of Area I which exhibited significant increases in ground coverage when protected from grazing for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Achillea lanulosa	2.4	4.5	46.4	1.306	.30	28
Arnica chamissonis	0.3	2.7	87.6	2.220	.10	10
Aster foliaceus	4.5	12.7	64.4	2.776	.01	34
Penstemon procerus	1.8	9.2	80.0	1.648	.20	4
Polygonum bistortoides	0.9	2.6	65.6	1.525	.20	12
Ranunculus alismaefolius	2.4	3.7	34.3	1.298	.30	18
Saxifraga oregana	1.1	2.6	58.1	1.118	.30	10
Senecio crassulus	0.2	3.3	94.9	1.886	.20	4
Trifolium longipes	0.3	0.9	62.6	1.396	.20	30
Grasses-Grass-likes						
Agropyron dasystachyum	5.6	13.6	58.8	1.583	.20	26
Carex rostrata	1.7	7.5	77.7	1.067	.40	4
Luzula multiflora	0.2	1.6	84.6	1.215	.30	6
Trisetum wolfii	2.1	5.7	62.8	1.625	.20	20

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels and an average of 9.42 horse-days-use per acre.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 46. Plant species of Area II which exhibited significant increases in ground coverage when protected from grazing for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Achillea lanulosa	1.5	4.9	69.2	1.595	.20	14
Arnica chamissonis	1.3	5.6	76.8	1.308	.30	8
Aster foliaceus	4.7	8.6	45.1	2.498	.05	94
Aster integrifolius	0.0	4.8	100.0	1.457	.20	8
Ligusticum filicinum	2.3	3.2	28.0	0.988	.40	70
Penstemon procerus	1.8	5.0	63.4	2.005	.20	4
Polygonum bistortoides	0.6	3.0	78.4	3.146	.01	26
Potentilla diversifolia	8.2	11.7	30.6	0.990	.40	30
Saxifraga oregana	1.6	4.0	59.1	1.245	.30	24
Taraxacum officinale	2.5	5.5	54.2	1.203	.30	32
Viola bellidifolia	0.3	2.0	86.8	1.102	.30	20
Grasses-Grass-likes						
Bromus ciliatus	0.1	9.0	98.5	1.808	.20	6
Carex geyeri	3.3	9.2	63.7	1.301	.30	4
Deschampsia caespitosa	1.9	3.3	42.6	1.248	.30	46
Luzula multiflora	0.3	0.9	62.9	1.076	.30	16
Phleum alpinum	0.5	0.9	38.4	1.051	.30	56
Poa pratensis	0.2	0.7	66.7	1.261	.30	22
Stipa columbiana	1.8	4.7	60.8	0.921	.40	10
Trisetum wolfii	3.9	6.1	35.1	1.045	.40	26

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels, but no livestock use.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 47. Plant species which exhibited significant decreases in ground coverage when protected from grazing by ground squirrels for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Aconitum columbianum	0.5	0.2	66.0	1.960	.20	4
Fragaria virginiana	11.7	7.2	38.4	0.918	.40	22
Senecio integerrimus	3.5	0.0	100.0	2.333	.10	4
Valeriana capitata	5.0	0.0	100.0	12.250	.01	4
Grasses						
Calamagrostis canadensis	17.0	10.2	40.2	1.338	.20	34
Danthonia intermedia	8.6	5.8	32.8	1.369	.20	34
Shrubs						
Salix spp.	2.0	0.2	91.5	1.212	.30	4

1/ Grazed vegetation was exposed to use by Columbian ground squirrels, but was protected from use by larger herbivores.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 48. Plant species of Area I which exhibited significant decreases in ground coverage when protected from grazing during one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Gentiana affinis	1.2	0.2	83.3	1.051	.40	8
Grasses						
Danthonia intermedia	5.4	3.6	33.5	1.135	.30	26
Deschampsia atropurpurea	1.1	0.1	86.9	1.407	.20	8

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels and an average of 9.42 horse-days-use per acre.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 49. Plant species of Area II which exhibited significant decreases in ground coverage when protected from grazing for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Antennaria rosea	4.2	2.8	33.2	1.033	.40	52
Dodecatheon jeffreyi	4.1	1.6	60.4	0.988	.40	12
Senecio integerrimus	2.1	0.7	67.4	1.578	.20	18
Trifolium longipes	1.7	1.0	38.7	0.932	.40	58
Grasses						
Deschampsia atropurpurea	0.5	0.0	100.0	1.225	.30	4

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels, but no livestock use.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant.

Table 50. Plant species which did not exhibit significant changes in ground coverage when protected from grazing by ground squirrels for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Achillea lanulosa	4.0	5.4	26.1	0.655	-	30
Antennaria rosea	3.7	3.2	12.3	0.308	-	44
Penstemon rydbergia	12.4	14.4	13.9	0.246	-	14
Potentilla diversifolia	8.8	12.5	29.5	0.577	-	14
Potentilla gracilis	3.6	2.2	38.1	0.517	-	12
Ranunculus alismaefolius	4.3	4.9	11.7	0.445	-	24
Saxifraga oregana	4.7	5.5	14.5	0.173	-	8
Trifolium longipes	0.5	0.6	4.2	0.074	-	38
Grasses-Grass-likes						
Agropyron dasystachyum	16.1	14.3	10.8	0.343	-	32
Carex aquatilis	29.5	25.1	15.2	0.499	-	34
Carex rostrata	1.4	1.5	8.7	0.077	-	6
Deschampsia caespitosa	2.1	2.3	6.5	0.140	-	18
Festuca idahoensis	19.0	21.5	11.6	0.162	-	8
Muhlenbergia richardsonis	1.7	3.3	49.8	0.704	-	4
Phleum alpinum	0.7	0.9	21.8	0.457	-	36
Poa pratensis	1.8	2.0	9.3	0.078	-	4

1/ Grazed vegetation was exposed to use by Columbian ground squirrels, but was protected from use by larger herbivores.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant and are not listed.

Table 51. Plant species of Area I which did not exhibit significant changes in ground coverage when protected from grazing for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1/]	Ungrazed	Percent	*t*	*P*[2/]	*df*
Forbs						
Agoseris spp.	0.2	0.3	48.5	0.672	-	4
Antennaria rosea	3.5	3.2	8.6	0.201	-	32
Fragaria virginiana	9.2	7.9	14.0	0.277	-	16
Ligusticum filicinum	1.2	1.8	30.6	0.580	-	18
Penstemon rydbergia	12.9	13.5	4.3	0.060	-	10
Potentilla diversifolia	15.0	23.1	35.1	0.660	-	6
Potentilla gracilis	1.5	2.3	34.5	0.594	-	12
Taraxacum officinale	2.3	1.8	23.6	0.471	-	16
Valeriana capitata	2.2	4.5	51.1	0.643	-	8
Grasses-Grass-likes						
Calamagrostis canadensis	14.1	14.3	1.4	0.029	-	32
Carex aquatilis	41.0	38.3	5.3	0.184	-	30
Carex hoodii	7.7	8.6	10.3	0.245	-	24
Deschampsia caespitosa	2.7	1.8	33.4	0.650	-	10
Festuca idahoensis	9.2	9.2	0.0	-	-	4
Juncus spp.	18.5	20.0	7.5	0.105	-	4
Muhlenbergia richardsonis	1.7	1.8	8.7	0.069	-	4
Phleum alpinum	0.6	0.7	17.3	0.409	-	22
Poa pratensis	0.3	1.8	81.9	0.938	-	4
Stipa columbiana	2.6	2.7	4.7	0.069	-	6
Shrubs						
Potentilla fruticosa	8.3	12.9	35.5	0.694	-	10

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels and an average of 9.42 horse-days-use per acre.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant and are not listed.

Table 52. Plant species of Area II which did not exhibit significant changes in ground coverage when protected from grazing for one summer.

Plant Species	Percent Ground Cover		Difference Between Means			
				Significance		
	Grazed[1]	Ungrazed	Percent	*t*	*P*[2]	*df*
Forbs						
Aconitum columbianum	0.9	1.0	14.0	0.145	-	12
Agoseris spp.	0.8	1.4	40.1	0.647	-	16
Cirsium foliosum	0.2	0.3	48.5	0.672	-	4
Fragaria virginiana	4.8	7.4	34.5	0.695	-	20
Penstemon rydbergia	8.5	8.8	3.4	0.095	-	42
Ranunculus alismaefolius	4.3	4.2	2.1	0.080	-	42
Senecio crassulus	2.3	1.4	36.1	0.785	-	20
Senecio subnudus	5.7	12.0	52.1	0.659	-	6
Swertia perennis	2.7	1.7	36.4	0.696	-	10
Valeriana capitata	4.8	3.7	24.0	0.448	-	16
Grasses-Grass-likes						
Agropyron dasystachyum	6.6	7.4	10.3	0.216	-	24
Agrostis scabra	1.8	1.8	0.0	-	-	10
Calamagrostis canadensis	15.5	16.7	7.2	0.293	-	84
Carex aquatilis	39.3	40.2	2.3	0.123	-	86
Carex hoodii	10.6	11.8	10.1	0.225	-	56
Carex rostrata	14.7	17.5	15.7	0.311	-	26
Danthonia intermedia	9.0	6.4	28.7	0.709	-	38
Eleocharis acicularis	14.0	10.0	28.6	0.406	-	6
Festuca idahoensis	27.5	33.7	18.5	0.515	-	6
Muhlenbergia richardsonis	5.4	6.5	16.5	0.291	-	12
Shrubs						
Lonicera utahensis	1.0	1.2	20.0	0.255	-	14
Salix spp.	6.9	5.7	16.6	0.321	-	32

1/ Grazed vegetation was exposed to summer use by big game and Columbian ground squirrels, but no livestock use.

2/ Differences with *P* values greater than .40 were considered to be nonsignificant and are not listed.

significant change are presented in Tables 50, 51, and 52. By and large, plant species responded similarly to the three grazing treatments analyzed. This similarity can be seen in Tables 53, 54, and 55, where the response of each species to the three grazing treatments are compared. Under exposure to grazing, 25 of the 53 species sampled showed significant decreases in ground coverage; 16 exhibited no significant change; 11 showed significant increases; and one (*Trifolium longipes)* exhibited a significant increase under one grazing treatment and a significant decrease under another.

Response of Grazing Animals to Cages

Study cages appeared to have little effect upon the grazing behavior of herbivores. Livestock and elk both grazed right up to vegetation cages, paying little attention to them. Elk calves however, sometimes "played" with the cages and butted them with their heads. Of the 104 cages, only two sustained any form of physical damage. The chicken wire on the two damaged cages was partially torn loose, but the cause is unknown.

No evidence was found that would indicate any ground squirrel use of vegetation protected by the 1-inch mesh wire. Ground squirrels droppings and chewed stems were frequently recorded however inside the "grazing treatment two" cages, indicating that the presence of the cages did not deter use

Table 53. Plant species exhibiting significantly greater average ground coverage on plots protected from grazing than on plots exposed to grazing.

Plant Species	Response[1]			Probability Level		
	GS[2]	I[3]	II[4]	GS[2]	I[3]	II[4]
Arnica chamissonis	+	+	+	.40	.10	.30
Aster foliaceus	+	+	+	.10	.01	.05
Penstemon procerus	+	+	+	.20	.20	.20
Polygonum bistortoides	+	+	+	.10	.20	.01
Trisetum wolfii	+	+	+	.01	.20	.40
Achillea lanulosa	o	+	+	ns	.30	.20
Aster integrifolius	+	o	+	.40	ns	.20
Ligusticum filicinum	+	o	+	.40	ns	.40
Saxifraga oregana	o	+	+	ns	.30	.30
Taraxacum officinale	+	o	+	.20	ns	.30
Viola bellidifolia	+	o	+	.05	ns	.30
Stipa columbiana	+	o	+	.30	ns	.40
Luzula multiflora	o	+	+	ns	.30	.30
Agoseris spp.	+	o	o	.20	ns	ns
Potentilla diversifolia	o	o	+	ns	ns	.40
Ranunculus alismaefolius	o	+	o	ns	.30	ns
Senecio crassulus	o	+	o	ns	.20	ns
Agropyron dasystachyum	o	+	o	ns	.20	ns
Deschampsia caespitosa	o	o	+	ns	ns	.30
Phleum alpinum	o	o	+	ns	ns	.30
Poa pratensis	o	o	+	ns	ns	.30
Carex rostrata	o	+	o	ns	.40	ns
Carex hoodii	+	o	o	.30	ns	ns
Carex geyeri	o	o	+	ns	ns	.30
Potentilla fruticosa	+	o	o	.30	ns	ns

1/ Where average ground coverage was significantly greater (P = .40 or less) on plots protected from grazing than on unprotected plots, the response is positive (+). Where ground coverage was significantly less on the protected plots the response is negative (-). Where no significant difference existed the response is neutral (o).

2/ Represents use by ground squirrels.

3/ Represents use by ground squirrels, big game, and livestock.

4/ Represents use by ground squirrels and big game.

Table 54. Plant species exhibiting non-significant differences in average ground coverage between plots protected from grazing and plots exposed to grazing.

Plant Species	Response[1]			Probability Level		
	GS[2]	I[3]	II[4]	GS[2]	I[3]	II[4]
Cirsium foliosum	o	o	o	ns	ns	ns
Eriogonum umbellatum		o			ns	
Penstemon rydbergii	o	o	o	ns	ns	ns
Potentilla gracilis	o	o	o	ns	ns	ns
Senecio subnudus			o			ns
Swertia perennis			o			ns
Agrostis scabra	o	o	o	ns	ns	ns
Bromus ciliatus		o	o		ns	ns
Festuca idahoensis	o	o	o	ns	ns	ns
Muhlenbergia richardsonis	o	o	o	ns	ns	ns
Trisetum spicatum	o	o	o	ns	ns	ns
Carex aquatilis	o	o	o	ns	ns	ns
Carex canescens			o			ns
Eleocharis acicularis			o			ns
Juncus spp.	o	o		ns	ns	
Lonicera utahensis			o			ns

1/ Where no significant difference existed (P = more than .40), the response is neutral (o).

2/ Represents use by ground squirrels.

3/ Represents use by ground squirrels, big game, and livestock.

4/ Represents use by ground squirrels and big game.

Table 55. Plant species exhibiting significantly less average ground coverage on plots protected from grazing than on plots exposed to grazing.

Plant Species	Response[1]			Probability Level		
	GS[2]	I[3]	II[4]	GS[2]	I[3]	II[4]
Aconitum columbianum	-	o	o	.20	ns	ns
Antennarea rosea	o	o	-	ns	ns	.40
Dodecatheon jeffreyi	o		-	ns		.40
Fragaria virginiana	-	o	o	.40	ns	ns
Gentiana affinis	o	-	o	ns	.40	ns
Valeriana capitata	-	o	o	.01	ns	ns
Calamagrostis canadensis	-	o	o	.20	ns	ns
Salix spp.	-	o	o	.30	ns	ns
Senecio integerrimus	-	o	-	.10	ns	.20
Danthonia intermedia	-	-	o	.20	.30	ns
Deschampsia atropurpurea	o	-	-	ns	.20	.20

1/ Where average ground coverage was significantly greater (P = .40 or less) on plots protected from grazing than on unprotected plots, response is positive (+). Where ground coverage was significantly less on the protected plots the response is negative (-). Where no significant difference existed the response is neutral (o).

2/ Represents use by ground squirrels.

3/ Represents use by ground squirrels, big game, and livestock.

4/ Represents use by ground squirrels and big game.

by squirrels. Pocket gophers tunneled into two "grazing treatment three" cages and partially biased the measurements. Subterranean deterrents would be a necessity in areas of high pocket gopher activity.

Plant Phenology

The midpoints of full bloom periods for major plant species are presented in Tables 56 and 57 for three meadow units. Two year's data are presented for the Cold Meadow unit to illustrate between-year differences. The durations of full bloom periods for major plant species on the same three meadow units are illustrated in Figures 9 and 10.

The difference in developmental progress of plant species between meadow units is not great, but it is consistent and the pattern is what might logically be expected. A gradual gradient of developmental status extends from the meadow unit of lowest elevation to the highest unit. Most plant species bloom first on Lower Cottonwood (elevation 6,075 feet), next on Middle Cottonwood (elevation 6,285 feet), and last on Cold Meadow (elevation 6,700 feet). The variation in blooming periods between meadow units is greater in some species than others. The midpoints of the full bloom periods for *Gentiana affinis* were the same for all three meadow units.

Table 56. Midpoints of full bloom periods of twenty-seven meadow forb species on three mountain meadows.

Plant Species	Meadow Unit			
	Cold (1967)	Cold (1968)	Middle Cottonwood	Lower Cottonwood
Gentiana affinis	Aug. 24	Aug. 25	Aug. 25	Aug. 25
Aster integrifolius	Aug. 14	Aug. 13	Aug. 13	Aug. 6
Arnica chamissonis	Aug. 12	Aug. 9	Aug. 6	Aug. 6
Aster foliaceus	Aug. 7	Aug. 6	Aug. 6	July 31
Agoseris spp.	July 18	Aug. 6	Aug. 6	July 30
Ligusticum filicinum	July 23	Aug. 6	Aug. 2	Aug. 6
Achillea lanulosa	Aug. 1	Aug. 2	July 26	July 25
Aconitum columbianum	July 23	July 29	July 29	July 28
Arenaria congesta	July 13	July 29	July 29	July 28
Senecio crassulus	July 26	July 29	July 29	July 17
Penstemon procerus	July 18	July 23	July 23	July 17
Eriogonum umbellatum	July 15	July 23	July 9	July 5
Senecio integerrimus	July 18	July 16	July 23	July 17
Potentilla gracilis	July 22	July 16	July 23	July 9
Geum macrophyllum	July 13	July 16	July 17	July 9
Pedicularis groenlandica	July 15	July 16	July 16	July 21
Cirsium foliosum	July 13	July 16	July 13	July 13
Polygonum bistortoides	July 18	July 13	July 13	July 9
Penstemon rydbergia	July 13	July 13	July 9	July 1
Antennaria rosea	July 24	July 13	July 8	July 5
Trifolium longipes	July 13	July 10	July 9	July 1
Oenothera heterantha	July 15	July 10	June 28	June 27
Saxifraga oregana	June 28	July 1	July 7	July 1
Fragaria virginiana	July 4	July 1	July 1	June 23
Valeriana capitata	June 28	July 1	July 1	July 1
Taraxacum officinale	June 28	June 27	June 24	June 18
Ranunculus alismaefolius	June 21	June 21	June 21	June 16
Overall Mean	July 19	July 20	July 19	July 15

Table 57. Midpoints of full bloom periods of major grass and sedge species on three mountain meadows.

Plant Species	Meadow Unit			
	Cold (1967)	Cold (1968)	Middle Cottonwood	Lower Cottonwood
Grasses				
Calamagrostis canadensis	Aug. 14	Aug. 13	Aug. 13	Aug. 13
Stipa columbiana	Aug. 3	Aug. 6	July 30	July 23
Agropyron dasystachyum	July 27	July 30	July 30	July 23
Deschampsia caespitosa	July 25	July 30	July 30	July 30
Trisetum wolfii	July 27	July 30	July 30	July 23
Festuca idahoensis	July 27	July 30	July 30	July 23
Danthonia intermedia	July 25	July 23	July 23	July 23
Poa pratensis	July 23	July 23	July 23	July 16
Phleum alpinum	July 23	July 16	July 9	July 9
Overall Mean	July 28	July 29	July 27	July 24
Sedges				
Carex rostrata	July 18	July 9	July 5	July 1
Carex aquatilis	July 18	July 1	July 1	June 24
Carex geyeri	July 13	June 24	June 24	June 18
Carex hoodii	July 13	June 24	June 24	June 18
Overall Mean	July 16	June 29	June 28	June 23

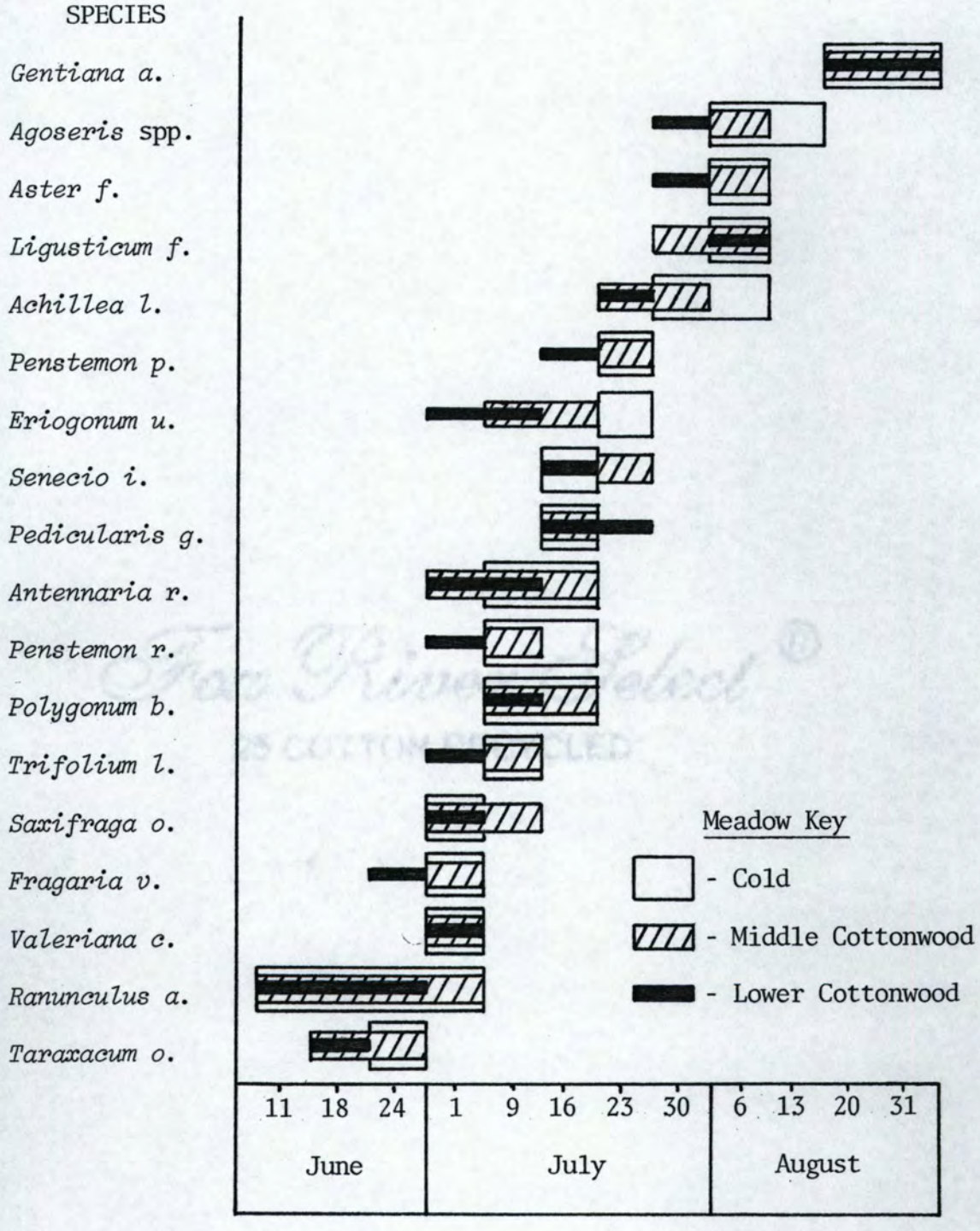

Figure 9. Full bloom periods of eighteen species of forbs on three mountain meadows.

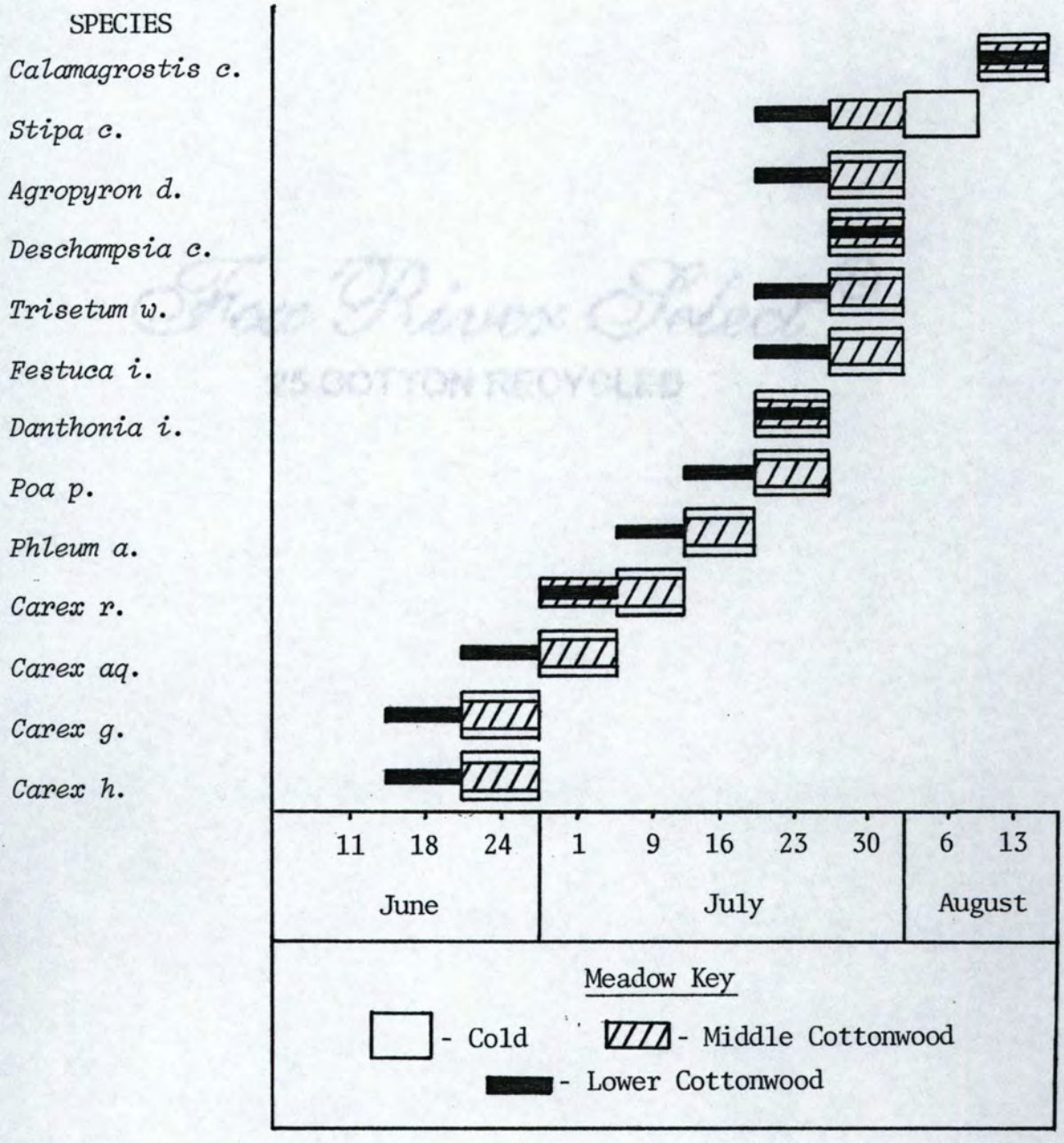

Figure 10. Full bloom periods of major grass and sedge species on three mountain meadows.

Eriogonum umbellatum and *Stipa columbiana* represent the other extreme, with midpoints of bloom differing by 18 to 14 days respectively between Lower Cottonwood and Cold Meadow.

The average full bloom date on the Lower Cottonwood unit was earlier than the Cold Meadow average by five days for grass and forb species, and six days for sedges. The Middle Cottonwood averages were only slightly earlier than those on Cold Meadow, being one day for forbs, and two days for grasses and sedges. Although individual species varied considerably, the midpoints of full bloom for forbs and grasses at Cold Meadow did not vary greatly between 1967 and 1968, with overall averages differing by only one day. The average date for sedges however was over two weeks later in 1967 than in 1968. This difference is due perhaps to the fact that 1967 was much drier than 1968 (Table 2). For the three meadow units average midpoints of bloom in sedges were three to four weeks earlier than forbs, which averaged 8 to 9 days earlier than the grasses.

Although the overall average peak of blooming activity occurs in mid-July, the various species present a progression of blooming periods that extend from one end of the growing season to the other (Figures 9 and 10). Forb species tended to bloom for longer periods than grasses and sedges,

and some of them, such as *Agoseris* spp. and *Taraxacum officinale*, exhibited at least a few blooms throughout most of the summer. *Ranunculus alismaefolius* maintained full bloom longer than any other meadow plant species. *Potentilla fruticosa*, not illustrated, bloomed from early July until the end of August, with the peak of bloom occurring about July 20th.

The sequence of bloom periods was very similar to that described by other investigators of subalpine meadows. Ellison (1954) reported that for the Wasatch Plateau in Utah, the lily and buttercup families tend to bloom early and the composite and grass families late in the summer. He found that the dates of blooming in any given species varied considerably between years, with some species varying more than others.

For high altitude sheep range in Wyoming, Smith and Johnson (1965) report that forb species tended to bloom throughout the summer while grasses and sedges tended to have a single blooming period. The results of this study are very similar to the finding of Smith and Johnson in regards to grasses and sedges. Most of the forbs studied by this investigator however exhibited distinct periods of blooming and fruiting.

Forage Preferences of Elk

Average frequency of utilization percentages and standard errors for every plant species enumerated are presented in Tables 58 through 61 for each meadow unit and for the collective sample. Each species is listed in one of six groupings, according to its overall frequency of utilization percentage. Utilization frequencies of less than 50 percent were listed under one of the following five groups: 0.0 - 9.9, 10.0 - 19.9, 20.0 - 29.9, 30.0 - 39.9, and 40.0 - 49.9 percent. Every value of 50 percent or over was placed in a sixth group.

Only four species of forbs, two sedges, and *Juncus* spp. exhibited utilization frequencies greater than 50 percent. Of these species, all but the sedges occurred too infrequently to be considered important constituents of the elk's diet. Both *Carex aquatilis* and *Carex geyeri* however are common and very important items in the summer diet. Most of the few plant species that were unused occurred so infrequently that sample size was probably not large enough to accurately represent them. On the other extreme, some of the infrequently-used species were very common constituents of the meadow community and occurred on many sample transects. Frequency of use of most grass and shrub species was less than 10 percent, but exceeded 10 percent for most forb species.

Table 58. Frequency of utilization of meadow forb species by big game.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 0.0 - 9.9%							
Antennaria rosea	1.3	0.0	0.0	0.0	0.7	0.6	91
Aquilegia coerulea	0.0	0.0	-[2/]	-	0.0	-	4
Arenaria congesta	-	0.0	-	-	0.0	-	1
Aster modestus	0.0	-	-	-	0.0	-	3
Fragaria virginiana	7.9	7.0	7.1	0.0	7.2	2.7	69
Geum triflorum	0.0	0.0	-	-	0.0	-	2
Mimulus guttatus	0.0	-	-	0.0	0.0	-	2
Mitella breweri	0.0	0.0	0.0	-	0.0	-	7
Parnassia intermedia	-	0.0	-	0.0	0.0	-	3
Polemonium occidentale	5.2	0.0	-	-	4.4	-	19
Pyrola spp.	0.0	0.0	-	-	0.0	-	6
Sedum stenopetalum	-	0.0	-	-	0.0	-	1
Senecio triangularis	25.0	4.2	-	0.0	9.1	-	11
Viola bellidifolia	1.3	3.6	0.0	5.0	2.2	1.5	78
Overall $\bar{x}$ = 10.0 - 19.9%							
Achillea lanulosa	10.6	12.3	-	-	11.5	2.9	47
Aconitum columbianum	28.1	6.9	4.0	16.7	17.5	3.8	69
Arnica chamissonis	50.0	13.5	50.0	-	19.3	7.6	19
Caltha leptosepala	18.7	0.0	0.0	-	13.6	-	11
Gentiana affinis	0.0	25.0	-	-	10.0	-	10
Geum macrophyllum	21.4	0.0	-	-	16.7	-	9
Penstemon procerus	9.6	12.5	-	-	10.0	4.2	14
Potentilla gracilis	0.0	22.2	-	-	16.7	-	8
Ranunculus uncinatus	0.0	30.0	-	-	12.0	-	5
Senecio crassulus	1.6	19.2	0.0	100.0	12.0	3.7	56
Senecio subnudus	7.4	18.3	-	0.0	10.4	4.7	37
Swertia perennis	22.6	1.7	50.0	-	17.2	6.5	29
Valeriana capitata	13.9	28.6	16.6	0.0	16.7	6.0	36

Table 58. Continued.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 20.0 - 29.9%							
Aster integrifolius	29.1	37.5	0.0	-[2/]	23.9	11.9	8
Cirsium foliosum	30.6	16.7	-	-	23.6	-	12
Habenaria dilatata	0.0	8.3	100.0	33.3	20.8	11.4	12
Ligusticum filicinum	24.3	19.5	16.3	4.2	20.5	2.0	97
Pedicularis groenlandica	29.6	16.7	0.0	-	22.9	10.0	16
Polygonum bistortoides	20.6	33.8	-	-	27.2	5.2	26
Polygonum viviparum	40.0	8.3	-	-	22.7	12.4	11
Saxifraga oregana	26.5	22.2	4.1	-	23.2	5.6	39
Taraxacum officinale	14.2	42.2	46.7	20.1	29.6	4.7	60
Trifolium spp.	21.3	17.5	-	0.0	20.0	2.3	56
Overall $\bar{x}$ = 30.0 - 39.9%							
Arnica mollis	20.0	100.0	-	-	33.3	-	6
Aster foliaceus	41.1	42.8	30.6	10.2	38.9	2.7	100
Potentilla diversifolia	39.9	11.1	25.7	-	32.4	4.9	48
Saxifraga arguta	-	44.4	-	0.0	33.3	-	4
Senecio integerrimus	35.5	37.0	27.5	0.0	31.7	5.8	45
Trollius laxus	0.0	55.5	-	-	33.3	-	10
Overall $\bar{x}$ = 40.0 - 49.9%							
Agoseris spp.	45.2	37.3	49.8	33.3	43.7	6.0	45
Dodecatheon jeffreyi	42.2	41.1	50.0	47.6	42.9	6.2	41
Penstemon rydbergia	39.9	44.4	100.0	42.2	42.5	5.8	31
Ranunculus alismaefolius	35.0	51.8	27.8	50.0	40.5	4.0	75
Spiranthes romanzoffiana	28.7	-	100.0	-	40.6	13.2	12

Table 58. Continued.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 50.0 - 100%							
Ligusticum canbyi	66.7	12.5	-[2/]	100.0	62.5	22.9	5
Oenothera heterantha	-	100.0	-	-	100.0	-	1
Pedicularis bracteosa	-	-	100.0	-	100.0	-	1
Zigadenus elegans	-	-	-	50.0	50.0	-	1

1/ For each sample transect, the number of plots in which utilization of a given species occurred was expressed as a percentage of the total number of plots in which the species occurred. Transect percentages were averaged to produce a mean percentage or frequency of use figure.

2/ Dashes indicate that the species did not occur on sample plots.

Table 59. Frequency of utilization of meadow grass species by big game.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 0.0 - 9.9%							
Agrostis scabra	0.0	0.0	0.0	-[2/]	0.0	-	36
Alopecurus aequalis	-	0.0	-	-	0.0	-	1
Bromus ciliatus	3.3	4.2	0.0	-	2.8	1.5	52
Deschampsia caespitosa	5.8	5.6	0.0	20.8	6.8	1.8	48
Deschampsia atropurpurea	0.0	0.0	-	0.0	0.0	-	39
Deschampsia elongata	0.0	-	-	-	0.0	-	2
Festuca idahoensis	1.1	0.0	-	0.0	0.7	-	18
Glyceria pauciflora	-	-	0.0	5.0	3.3	-	7
Melica spectabilis	0.0	-	-	-	0.0	-	2
Muhlenbergia richardsonis	2.5	0.0	0.0	0.0	1.7	-	30
Poa pratensis	0.0	0.0	0.0	0.0	0.0	-	42
Stipa columbiana	0.0	0.0	-	-	0.0	-	10
Trisetum spicatum	0.0	0.0	0.0	-	0.0	-	10
Trisetum wolfii	5.0	7.8	22.2	0.0	6.2	2.7	58
Overall $\bar{x}$ = 10.0 - 19.9%							
Agropyron dasystachyum	6.3	19.7	30.6	-	15.4	3.9	48
Calamagrostis rubescens	16.6	-	-	-	16.6	-	2
Phleum alpinum	12.0	6.2	21.4	18.7	11.6	2.4	80
Overall $\bar{x}$ = 20.0 - 29.9%							
Calamagrostis canadensis	18.4	25.2	27.9	31.9	22.5	2.2	99
Danthonia intermedia	25.7	16.2	16.6	-	21.3	3.5	51

1/ For each sample transect, the number of plots in which utilization of a given species occurred was expressed as a percentage of the total number of plots in which the species occurred. Transect percentages were averaged to produce a mean percentage or frequency of use figure.

2/ Dashes indicate that the species did not occur on sample plots.

Table 60. Frequency of utilization of meadow sedge, rush, and horsetail species by big game.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 0.0 - 9.9%							
Carex canescens	0.7	0.0	0.0	0.0	0.3	-	39
Equisetum spp.	0.0	0.0	-[2/]	64.3	9.2	7.3	14
Overall $\bar{x}$ = 10.0 - 19.9%							
Carex rostrata	10.9	5.5	11.4	53.0	11.9	2.2	74
Luzula spp.	21.8	6.7	54.2	0.0	19.5	3.7	75
Overall $\bar{x}$ = 20.0 - 29.9%							
Carex aurea	14.3	33.3	100.0	0.0	25.0	13.1	12
Carex hoodii	19.5	24.2	31.2	20.8	21.9	3.4	74
Overall $\bar{x}$ = 40.0 - 49.9%							
Eleocharis acicularis	31.6	56.2	52.0	83.3	44.6	7.4	39
Overall $\bar{x}$ = 50.0 - 100.0%							
Carex aquatilis	64.6	80.5	79.2	80.4	72.7	2.2	99
Carex geyeri	46.7	66.7	-	-	51.3	13.9	13
Juncus spp.	55.6	50.0	100.0	-	61.1	20.0	6

1/ For each sample transect, the number of plots in which utilization of a given species occurred was expressed as a percentage of the total number of plots in which the species occurred. Transect percentages were averaged to produce a mean percentage or frequency of use figure.

2/ Dashes indicate that the species did not occur on sample plots.

Table 61. Frequency of utilization of meadow shrubs by big game.

Plant Species	Mean Percentage of Plots Showing Use[1/]						
	Meadow Unit				Overall		
	Cold	Middle Cotton-wood	Gin-ger	Phan-tom	$\bar{x}$	*SE*	*n*
Overall $\bar{x}$ = 0.0 - 9.9%							
Ledum glandulosum	0.0	0.0	-[2/]	0.0	0.0	-	10
Lonicera utahensis	0.0	5.4	0.0	50.0	3.6	1.9	36
Ribes viscosissimum	0.0	0.0	-	-	0.0	-	5
Vaccinium membranaceum	0.0	11.1	50.0	-	8.7	-	23
Vaccinium occidentale	0.0	-	0.0	-	0.0	-	5
Overall $\bar{x}$ = 10.0 - 19.9%							
Betula glandulosa	-	11.4	-	-	11.4	-	10
Potentilla fruticosa	-	12.3	-	-	12.3	-	12
Overall $\bar{x}$ = 40.0 - 49.9%							
Salix spp.	45.6	39.2	20.8	18.7	40.5	4.3	68

1/ For each sample transect, the number of plots in which utilization of a given species occurred was expressed as a percentage of the total number of plots in which the species occurred. Transect percentages were averaged to produce a mean percentage or frequency of use figure.

2/ Dashes indicate that the species did not occur on sample plots.

In terms of frequency of utilization percentages, the relative importance of the various classes of meadow forage to elk rank as follows: forbs first, sedges second, grasses third, and shrubs last.

Many of the forage preferences indicated by these data are in close agreement with the findings of various other workers, but some differ considerably. The important, and sometimes dominant, role of forbs in the summer diet of elk has been reported by a number of workers in Montana (Rouse 1957, Picton 1960, Mackie 1961, Kirsch 1962, Stevans 1965, Eustace 1967, and Knight 1967). Murie (1957) mentions however that grasses and grasslike plants generally constitute the year-round staple food of elk when available, and other workers have reported the dominance of grasses in the summer diet (Morris and Schwartz 1957, Harper *et al.* 1967).

Timing of Forage Species Use by Elk

The elk grazed very selectively throughout the entire summer, concentrating first on one group of forage species and then another. Some species were used only during a relatively short and definite period, while others were used throughout the summer. Presented in Tables 62 and 63 are the percentages of total utilization of palatable meadow forage species that occurred during each of three periods

Table 62. Percentage of total recorded elk utilization of palatable meadow forbs which occurred during each of three periods during the summer of 1968.

Plant Species[1]	(June 10-July 6)	(July 7-31)	(August 1-25)
Saxifraga oregana	*92.9*[2]	7.1	0.0
Dodecatheon jeffreyi	*71.7*	26.1	2.2
Ranunculus alismaefolius	*66.8*	*30.8*	2.4
Senecio integerrimus	*39.7*	*57.1*	3.2
Polygonum bistortoides	*37.9*	*60.4*	1.7
Potentilla diversifolia	22.0	*65.9*	12.1
Penstemon rydbergia	18.8	*63.8*	17.4
Taraxacum officinale	15.5	*64.8*	19.7
Achillea lanulosa	4.8	*81.0*	14.3
Aconitum columbianum	0.0	*76.9*	23.1
Trifolium spp.	2.6	*72.8*	24.6
Ligusticum filicinum	8.7	*59.6*	*31.7*
Aster foliaceus	5.6	*57.4*	*37.0*
Agoseris spp.	1.0	*49.0*	*50.0*

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ All percentages over 30 percent are italicized.

Table 63. Percentages of total recorded elk utilization of palatable meadow grasses, sedges, rushes, and shrubs which occurred during each of three periods during the summer of 1968.

Plant Species[1/]	(June 10-July 6)	(July 7-31)	(August 1-25)
Grasses			
Agropyron dasystachyum	*47.8*[2/]	*52.2*	0.0
Calamagrostis canadensis	*39.2*	*53.1*	7.7
Deschampsia caespitosa	*39.1*	*60.9*	0.0
Phleum alpinum	20.0	*75.0*	5.0
Danthonia intermedia	15.2	*83.3*	1.5
Sedges and Rushes			
Eleocharis acicularis	*76.0*	20.0	4.0
Carex rostrata	*74.5*	21.6	3.9
Carex aquatilis	*56.9*	*35.0*	8.1
Carex hoodii	*35.2*	*61.0*	3.8
Luzula spp.	*35.9*	*64.1*	0.0
Shrubs			
Salix spp.	*93.0*	7.0	0.0

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ All percentages over 30 percent are italicized.

during the summer of 1968. Forbs were used regularly throughout the summer, but between July 7th and 31st they were used more intensively, and constituted a larger proportion of the elk's diet, than during any other period of the summer. Some grass species were used intensively during early summer, but the heaviest use occurred between July 7th and 31st. The bulk of sedge and rush utilization occurred early in the summer (June 10 - July 6), although several species were used more heavily later in July. Nearly all utilization of *Salix* spp., the only major shrub forage species, occurred during the early summer period (June 10 to July 6). Use of *Salix* consisted of the stripping of newly-emerging leaves and the nipping of terminal buds.

In Tables 64 through 69 a comparison is made, between meadow units, of the proportions of total utilization that occurred during the three summer periods on the various types of forage plants. Except for several unexplainable exceptions, the percentages do not vary greatly between meadow units, indicating that the timing of use of the various species was very similar on all the meadows studied.

Relationships of blooming dates and peaks of elk utilization of major forage species are compared in Figures 11 and 12. The bulk of elk utilization on most species of forbs occurred just before, during, or shortly after the full

Table 64. Proportions of total recorded elk utilization of palatable meadow forbs which occurred during the period of June 10 through July 6, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization					
	Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Achillea lanulosa	0.0	10.0	-[3]	-	4.8	21
Aconitum columbianum	0.0	0.0	0.0	0.0	0.0	26
Agoseris spp.	0.0	0.0	4.6	0.0	1.0	96
Aster foliaceus	5.0	6.3	9.4	0.0	5.6	444
Dodecatheon jeffreyi	82.1	20.0	100.0	100.0	71.7	46
Ligusticum filicinum	7.3	6.0	28.6	0.0	8.7	161
Penstemon rydbergia	17.3	0.0	0.0	36.4	18.8	69
Polygonum bistortoides	76.0	9.1	-	-	37.9	58
Potentilla diversifolia	22.2	0.0	50.0	-	22.0	91
Ranunculus alismaefolius	74.3	41.2	100.0	100.0	66.8	208
Saxifraga oregana	96.3	0.0	0.0	-	92.9	30
Senecio integerrimus	40.0	25.0	50.0	-	39.7	63
Taraxacum officinale	16.7	14.0	0.0	28.6	15.5	71
Trifolium spp.	4.5	0.0	-	-	2.6	114

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

Table 65. Proportions of total recorded elk utilization of palatable meadow forbs which occurred during the period of July 7 through 31, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization					
	Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Achillea lanulosa	100.0	60.0	-[3]	-	81.0	21
Aconitum columbianum	75.0	71.4	100.0	100.0	76.9	26
Agoseris spp.	42.0	71.4	40.9	66.6	49.0	96
Aster foliaceus	60.7	47.6	62.5	100.0	57.4	444
Dodecatheon jeffreyi	14.3	80.0	0.0	0.0	26.1	46
Ligusticum filicinum	72.9	34.0	64.3	0.0	59.6	161
Penstemon rydbergia	65.4	50.0	100.0	54.5	63.8	69
Polygonum bistortoides	24.0	87.9	-	-	60.4	58
Potentilla diversifolia	66.7	83.3	25.0	-	65.9	91
Ranunculus alismaefolius	22.4	58.8	0.0	0.0	30.8	208
Saxifraga oregana	3.7	100.0	100.0	-	7.1	30
Senecio integerrimus	58.2	75.0	25.0	-	57.1	63
Taraxacum officinale	72.2	65.1	33.3	57.1	64.8	71
Trifolium spp.	82.1	59.6	-	-	72.8	114

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

Table 66. Proportions of total recorded elk utilization of palatable meadow forbs which occurred during the period of August 1 through 25, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization					
	Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Achillea lanulosa	0.0	30.0	-[3]	-	14.3	21
Aconitum columbianum	25.0	28.6	0.0	0.0	23.1	26
Agoseris spp.	58.0	28.6	54.5	33.3	50.0	96
Aster foliaceus	34.3	46.1	28.1	0.0	37.0	444
Dodecatheon jeffreyi	3.6	0.0	0.0	0.0	2.2	46
Ligusticum filicinum	19.8	60.0	7.1	100.0	31.7	161
Penstemon rydbergia	17.3	50.0	0.0	9.1	17.4	69
Polygonum bistrotoides	0.0	3.0	-	-	1.7	58
Potentilla diversifolia	11.1	16.7	25.0	-	12.1	91
Ranunculus alismaefolius	3.3	0.0	0.0	0.0	2.4	208
Saxifraga oregana	0.0	0.0	0.0	0.0	0.0	30
Senecio integerrimus	1.8	0.0	25.0	-	3.2	63
Taraxacum officinale	11.1	20.9	66.7	14.3	19.7	71
Trifolium spp.	13.4	40.4	-	-	24.6	114

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

Table 67. Proportions of total recorded elk utilization of palatable meadow grasses, sedges, rushes, and shrubs which occurred during the period of June 10 through July 6, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization — Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Grasses						
Agropyron dasystachyum	66.7	46.2	25.0	-[3]	47.8	23
Calamagrostis canadensis	52.0	19.5	57.7	28.6	39.2	222
Danthonia intermedia	20.0	0.0	33.3	-	15.2	66
Deschampsia caespitosa	40.0	33.3	-	0.0	39.1	23
Phleum alpinum	33.3	14.3	0.0	0.0	20.0	60
Sedges and Rushes						
Carex aquatilis	58.3	53.2	56.2	65.9	56.9	984
Carex hoodii	39.7	21.5	50.0	50.0	35.2	105
Carex rostrata	92.6	50.0	60.0	57.1	74.5	51
Eleocharis acicularis	82.6	54.5	70.0	100.0	76.0	50
Luzula spp.	32.1	80.0	16.7	-	35.9	39
Shrubs						
Salix spp.	98.2	88.6	66.7	100.0	93.0	100

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

Table 68. Proportions of total recorded elk utilization of palatable meadow grasses, sedges, rushes, and shrubs which occurred during the period of July 7 through 31, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization					
	Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Grasses						
Agropyron dasystachyum	33.3	53.8	75.0	-[3]	52.2	23
Calamagrostis canadensis	43.1	70.0	38.5	57.1	53.1	222
Danthonia intermedia	77.8	100.0	66.7	-	83.3	66
Deschampsia caespitosa	60.0	66.7	-	0.0	60.9	23
Phleum alpinum	66.7	85.7	85.7	50.0	75.0	60
Sedges and Rushes						
Carex aquatilis	36.7	33.4	40.4	25.9	35.0	984
Carex hoodii	58.9	71.4	50.0	0.0	61.0	105
Carex rostrata	7.4	33.3	40.0	42.9	21.6	51
Eleocharis acicularis	17.4	27.3	30.0	0.0	20.0	50
Luzula spp.	67.9	20.0	83.3	-	64.1	39
Shrubs						
Salix spp.	1.8	11.4	33.3	0.0	7.0	100

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

Table 69. Proportions of total recorded elk utilization of palatable meadow grasses, sedges, rushes, and shrubs which occurred during the period of August 1 through 25, 1968.

Plant Species[1]	Percentage of Total Recorded Utilization					
	Meadow Unit					
	Cold	Middle Cotton-wood	Ginger	Phantom	Overall	n[2]
Grasses						
Agropyron dasystachyum	0.0	0.0	0.0	-[3]	0.0	23
Calamagrostis canadensis	4.9	11.5	3.8	14.3	7.7	222
Danthonia intermedia	2.2	0.0	0.0	-	1.5	66
Deschampsia caespitosa	0.0	0.0	-	0.0	0.0	23
Phleum alpinum	0.0	0.0	14.3	50.0	5.0	60
Sedges and Rushes						
Carex aquatilis	5.0	13.4	3.4	8.2	8.1	984
Carex hoodii	1.4	7.1	0.0	50.0	3.8	105
Carex rostrata	0.0	16.7	0.0	0.0	3.9	51
Eleocharis acicularis	0.0	18.2	0.0	0.0	4.0	50
Luzula spp.	0.0	0.0	0.0	-	0.0	39
Shrubs						
Salix spp.	0.0	0.0	0.0	0.0	0.0	100

1/ Only those species for which utilization was recorded on a minimum of 20 sample plots are listed.

2/ Total number of 1 x 4-foot sample plots upon which utilization was recorded.

3/ Dashes indicate that the species did not occur on sample plots.

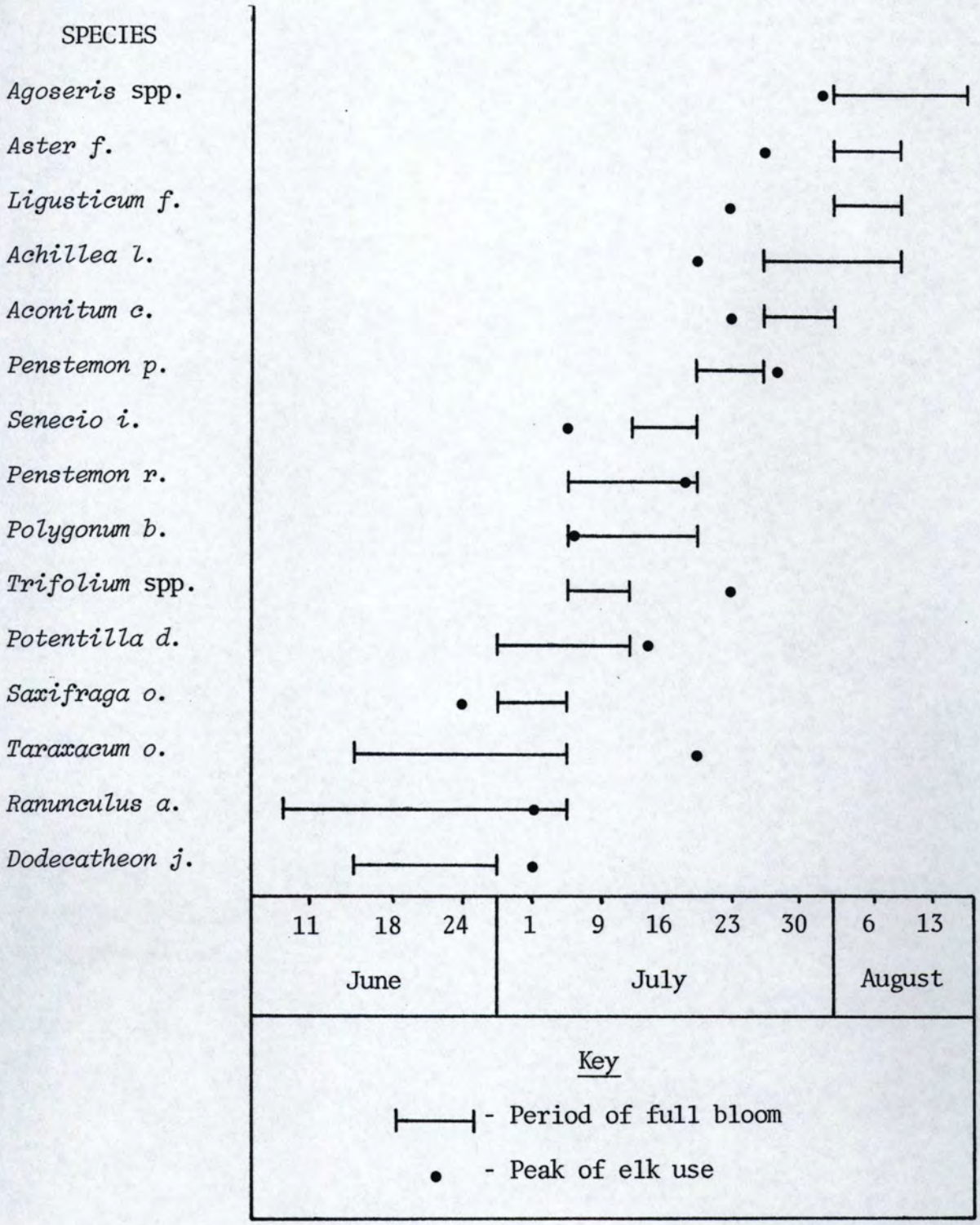

Figure 11. The relationship between dates of blooming and peaks of elk utilization for common meadow forbs.

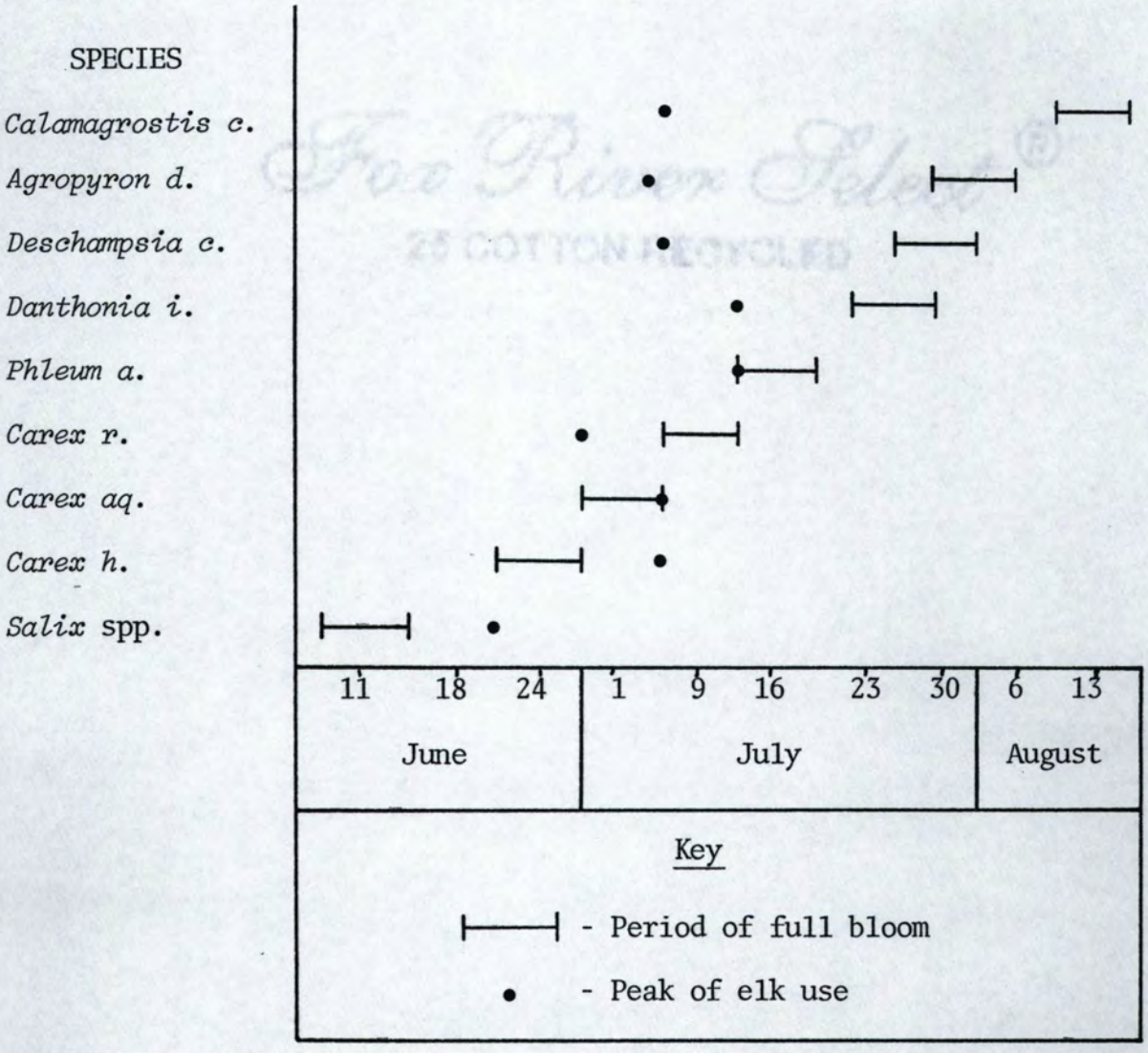

Figure 12. The relationship between dates of blooming and peaks of elk utilization for common meadow grasses, sedges, and shrubs.

bloom period. *Taraxacum officinale* and *Trifolium* spp. are the only exceptions to this general pattern. The greatest concentration of utilization on all grass species, except *Phleum alpinum*, occurred well in advance of blooming, during the first half of July. Maximum incidence of utilization on sedges coincided very closely with blooming periods. *Salix* spp. bloomed earlier than other species, with the peak of utilization occurring several weeks later.

Ground Squirrel Activities

The incidence of ground squirrel activities for three meadow units and the collective sample are presented in Table 70 for each of the three major meadow cover types. The dry type is the center of activity, with more holes and digs than any other type. The incidence of both holes and digs decreased as soil moisture levels increased. There are consistently more runs in the moist type than in the other types, implying that the squirrels spent considerable time running back and forth between the dry and wet types, through the moist type. Field observations tend to support this implication, as squirrels were often seen feeding in the wet type.

There are several possible explanations for the higher incidence of digs in the drier types. First, digs were

Table 70. Incidence of ground squirrel activities, expressed as the nearest whole number of runs, digs, and holes per acre.

Cover Type	Horse Pasture			Cold Meadow			Middle Cottonwood			Total Sample		
	Digs	Holes	Runs	Digs	Holes	Runs	Digs	Holes	Runs	Digs	Holes	Runs
Dry	1,488+	244+	21-	751+	369+	74	83+	67+	45+	1,065+	223+	34
Moist	312-	71-	47+	387+	76-	85+	101+	43+	55+	252-	62-	60+
Wet	42-	11-	25	92-	21-	51-	0-	0-	0-	27-	6-	16-
Totals	699	121	30	334	106	69	39	21	21	347	76	34

+ = Chi-square test indicates number is significantly greater (P = .01) than expected due to chance alone.

- = Chi-square test indicates number is significantly less (P = .01) than expected due to chance alone.

undoubtedly easier to spot in the more open vegetation of the drier types, and many could have gone unobserved in the dense wet type. Secondly, feeding activities may be increasingly restricted by distance from the safety of the hole, which is of necessity located in the better-drained soils of the drier cover types. Thirdly, underground plant parts may be less frequently used in the more mesic types where vigorous above-ground growth of the vegetation persists further into the summer.

DISCUSSION AND CONCLUSIONS

Applicability of Results

The detail with which the results of this study apply to other mountain meadows undoubtedly decreases with the distance of the other meadows from the study area. The results of this work resemble those of workers on other mountain meadows in many general ways, but the detailed characteristics of the flora are unique to the study area and intensive application of the results is probably limited to the Cold Meadow-Chamberlain Basin Area.

Information collected from the 12 meadows scattered throughout the northwestern portion of the Big Creek District indicated that these meadows did not differ in major respects from the 5 meadows which were studied intensively. The relative positions of the three major cover types were identical and differences in species composition within cover type were not large. No two meadows were exactly alike however, and past use, elevation, orientation, size, and shape of the meadow, as well as adjacent topography, all appear to be factors affecting the nature of the vegetation. It appears however, that the effects of these various factors are mostly indirect, and their net effect is proportional to the degree to which they effect soil moisture levels.

Status of Meadow Forage Resource

The status of condition of the meadow forage resource on the Big Creek District would have to be rated excellent by most any standards. Evidence of overgrazing or range deterioration is nearly non-existent. Ground coverage of vegetation is high; evidence of erosion and pedestalling is lacking; the vegetation is tall, comprised of a wide variety of palatable species, and productive of large quantities of palatable forage. Livestock and game animals using the meadow forage maintain excellent condition, and cow-calf ratios of the elk herds using the area are high.

Meadow Values

The primary value of the mountain meadows on the Big Creek District is the forage they provide for summering cow-calf herds, and pack and saddle animals. Another important value is the opportunity they offer for collecting ecological information concerning relatively pristine plant communities.

There is a growing body of evidence that indicates that the quality of summer forage is at least as important as that of winter foods in maintaining vigorous herbivore populations. Robinette *et al.* (1955) concluded that the fertility of adult mule deer in Utah was affected more by the quality of the

summer range than by that of the winter range. Verme (1967) after conducting an 8-year study of the effects of various year-round diets on the productivity of white-tailed deer in northern Michigan concluded:

> Findings from these experiments, therefore, strongly indicate that reproduction of northern whitetails reflects the particular value of the total environment rather than being mainly influenced by winter range conditions. I suggest that the quality of spring, summer, and fall foods of the white-tail might be more important than many people think in determining the number of future targets for the hunter.

In light of this evidence, it is very likely that the role played by mountain meadows in maintaining the general health and productivity of cow-calf herds in the study area is more critical than has been generally imagined. These meadows offer a wide variety of high quality forage, in a relatively small area. This could be a very important factor in restoring a margin of reserve strength to the bodies of cow elk which, after having endured the rigors of many months on the winter range while carrying calves, place additional demands on their bodies by bearing and then nursing the calves. It seems unlikely, in view of Verme's work, that such animals could regain sufficient body reserves by the following fall to ovulate and conceive new calves in the absence of high quality summer range.

The mountain meadows provide ideal conditions for the cow elk and their calves. The concentration of palatable forage species enables the cows to eat and rest much, while traveling minimal distances. Herds were often observed to spend the entire day on the meadows, grazing and bedding within a 1/2-mile radius. The good visibility and strong air currents on the meadows greatly reduce the probability of predator ambush of calves. Cows were able to detect the presence of predators at great distances and were often observed driving coyotes from the meadows, and on one occasion, a pair of young black bears.

Since recreation is the primary use the area receives, and since nearly all users employ pack and saddle animals, the meadow forage resource is, or will eventually become, a key factor in regulating area use. The lush forage on the meadows not only sustains the livestock of recreational users, but also provides the means for holding free-ranging animals in an area with a minimum of effort. Since there are essentially no other areas suitable for sustaining and holding livestock, and since recreational use is bound to increase, the regulation of numbers of livestock grazing the meadows is inevitable, and essential to maintaining the forage resource.

Effects of Past Use

The detectable effects of past use are not great, but are indicative of the course that significant degeneration would probably take under conditions of prolonged overuse. The wet type is the most resilient, and appears to be little affected by even substantial grazing use. Mueggler (1962) reports essentially the same thing for comparable mountain meadows in northern Idaho, stating that: "Meadows can withstand a surprising amount of abuse before erosion becomes obvious."

Meadow areas where moisture is the most limiting are the most affected by grazing and are the first to reflect abuse. In this study the dry and moist cover types which had been exposed to sustained intensive livestock use exhibited fewer palatable grasses and more unpalatable forbs than comparable, less-intensively-grazed areas. Elk probably do not suffer from such vegetation changes as much as the livestock, because of the greater extent to which they utilize forb species. There are some indications that a certain amount of livestock use may increase the desirability of an area to elk because of increases in the coverage of forb species palatable to elk. There is a very definite correlation between degree of past disturbance and density of ground squirrel populations, perhaps for the same reason.

Ground squirrel populations tend to be proportional to the size of the dry cover type available and the abundance of forbs upon it, and are the least populous on the meadows that exhibit the least disturbance.

Trend

Present levels of utilization on the meadows are so light that the forage can reasonably be expected to maintain its excellent condition indefinitely, or until grazing pressures increase considerably.

The successional trend appears to be toward the reduction of total meadow area through natural process. Unless some unforeseen factor results in raising the water table in the meadow areas, it is likely that the dry and at least part of the moist cover type will eventually convert to timber, thus reducing the size of some meadows considerably.

The elimination of the dry and moist cover types will greatly decrease the value of these meadows to grazing animals. Although the drier portions of the wet cover type often receive considerable use by livestock and elk, little use of the wetter areas is made, except by moose. Trout Meadow for example, was the wettest meadow examined, and showed the least sign of use by wildlife.

Recommendation

Because of the importance of mountain meadows to grazing animals and the likelihood that their total area will in time be reduced through natural process and/or outside influences, it is highly desirable that a long range study program be initiated to quantitate trends and to describe cause and effect relationships. It should be definitely ascertained whether or not meadow areas are being decreased or are growing, and what effects fire control policies, various levels of herbivore use, and climatological trends have on their status. Rates, as well as direction, of change need to be determined. For an area abounding in forested land and faced with the prospect of an increasing demand for livestock forage, the encroachment of the highly-preferred moist cover type by trees would, in itself, represent a great loss.

Because of the apparently great effect of soil moisture levels on the character of meadow vegetation, it is very likely that long term records of meadow moisture patterns would indirectly indicate the trend of the vegetation, and provide information for managerial decisions. Soil moisture patterns and gradients for each meadow could be recorded through the air-borne use of a thermal infrared sensor which operates in the 7-15 micron band and remotely detects

terrestrial heat emissions. Tonal values of the resultant thermographs are indicative of the amount of surface and subsurface moisture present on the area scanned (Colwell and Olson 1964, Estes 1966, Colwell 1967).

Infrared thermographs could be made of each meadow at regular intervals throughout the growing season to determine the seasonal pattern or change in soil moisture levels. These patterns could then be correlated with the characteristics of the vegetation growing there. By producing thermographs at 5-year intervals, for example, patterns of moisture and change could be detected. The minimal amount of ground work that such a technique entails is an important factor in the vast, remote areas involved.

SUMMARY

Although mountain meadow vegetation in Idaho produces a significant proportion of total summer forage in most forested regions, very little information concerning its basic ecology is available. With the prospect of increasing demands upon the forage resources of these meadows, the need for ecological information has become urgent.

In July of 1965 a research project was initiated for the purpose of describing the general characteristics, vegetation, and herbivore use of five mountain meadows on the Big Creek Ranger District in the Idaho Primitive Area. Field data were collected during the summers of 1966, 1967, and 1968.

Thirty major meadows occur on the Big Creek Ranger District and are used extensively as summer range by resident elk herds. Many of the meadows are also used by the pack and saddle stock employed or brought in by recreationists. Elk hunting is currently the most common form of user activity.

Observations of elk marked by the Idaho Fish and Game Department indicate that animals which summer on the meadows studied migrate to either the Big Creek or main Salmon River drainages to winter. Five of the eight elk marked at Cold Meadow during the summer of 1967 returned to Cold Meadow during the summer of 1968.

All of the meadows studied occur in valleys or basins along the courses of streams, within the Douglas fir and spruce-fir zones, and varied in elevation from approximately 5,500 to 8,000 feet. The meadows appear to have developed on sites of former lakes and ponds through the process of hydrarch succession. Moisture-saturated soils of fine texture and poor aeration apparently preclude or retard the invasion of trees and help to perpetuate the meadow vegetation.

The nature of meadow vegetation appears to be directly related and perhaps primarily controlled by, the degree and duration of moisture saturation of underlying soils. Most meadows exhibited a wet central "core" with moisture levels progressively decreasing outward from the "core" towards the edge of the meadow. Plant physiognomy and species composition were distinctly stratified along the soil moisture gradient. Hydromorphic and alluvial soils predominate, but sandy loams derived from residual granite underlie the drier outer edges of some meadows.

Meadow vegetation was classified into four major cover types, termed the "wet," "moist," "dry," and "very dry" types, according to prevailing soil moisture conditions. The wet type was the most prevalent, and occupied from 30 to 77 percent of the area of the various meadows studied. The moist type occupied 23 to 48 percent of meadow area and the dry and and very dry types from 0 to 17 percent each.

Soil moisture levels were measured on the dry, moist, and wet cover types by air-drying soil samples from each of three depths. The general range in soil moisture content was: 3 to 15 percent for the dry type, 10 to 60 percent for the moist type, and 35 to 300 percent for the wet type.

Soils of the dry type were well-drained and coarse-textured, were never moisture-saturated or flooded, and dried out early in the summer. Soils of the moist type were well to poorly drained, flooded during the spring, and dried on the surface by mid-July. Soils of the wet type were poorly drained and remained slightly inundated or saturated throughout the summer.

Average canopy coverage percentages were calculated for all plant species on the five meadows. Entire meadows were sampled, with coverage being estimated on 1-square-foot plots along randomly distributed transects. Total vegetation coverage, excluding mosses, was 36.0 percent for the very dry cover type, 48.7 percent for the dry type, 58.8 percent for the moist type, and 68.7 percent for the wet type. The very dry type was dominated by forb species; the dry and moist types by nearly equal proportions of grasses and forbs, with small proportions of sedges and shrubs; and the wet type by sedges, with smaller proportions of forbs,

grasses, and shrubs. The moist and wet types supported the richest floras, with 87 and 82 species respectively. The dry type exhibited 58 species, and the very dry type 30. Only four species exceeded 5 percent coverage in any cover type, with *Calamagrostis canadensis* and *Carex aquatilis* being the most prominent. *Calamagrostis canadensis* covered 12.3 percent of the moist type, and *Carex aquatilis* 38.4 percent of the wet type.

A tendency towards generally drier conditions, with associated shifts in species composition, was observed to occur with a decrease in meadow elevation. Years of intensive grazing by livestock in one area has resulted in a decrease of palatable perennial grasses and an increase in less palatable perennial forbs.

Gross forage production was estimated for the four major vegetation cover types on the five meadows by clipping vegetation which had been protected from grazing. All samples were air-dried before weighing. Gross production on the very dry cover type was sampled on only one location and was 354 pounds per acre. Gross production overages for each of the other three cover types varied somewhat between meadows, depending upon moisture conditions, species composition, and degree of past use. The overall means, and ranges in means between meadows, for the three cover types were: dry type

$\bar{x}$ = 2,167, range = 1,921 - 2,484; moist type $\bar{x}$ = 2,076, range = 1,729 - 2,358; and wet type $\bar{x}$ = 3,237, range = 2,857 - 4,487. The wet type produced from one-half to two-thirds of all forage, the moist type approximately one-third, and the dry type from 6 to 12 percent. The very dry type produced less than 1 percent of total forage.

Forage utilization by herbivores was estimated by comparing the air-dried weights of vegetation on plots protected from grazing with weights of vegetation on paired-grazed plots. Estimates of forage removed were made for livestock, elk, and Columbian ground squirrels. Total forage removed by herbivores varied between meadows from a minimum of 1.8 percent (51 pounds per acre) to a maximum of 30.5 percent (798 pounds per acre). Ground squirrels removed from an average of 46 to 248 pounds of forage per acre from the various meadow units, elk 62 to 680 pounds, and livestock 117 to 353 pounds.

Much meadow area was completely unused by ground squirrels. On the areas they frequented, the average amount of forage they removed from the major cover types was very similar: (dry = 271 pounds per acre), (moist = 200), and (wet = 232). Total forage removed within the radius of activity of the squirrel colonies varied between meadow units from 4.2 percent (101 pounds per acre) to 17.6 percent (363 pounds per acre). Squirrels were estimated to make use of

from 45 to 68 percent of the area of the meadows they inhabited. Squirrels were not found at all on the wettest, most pristine meadows.

Approximately 70 percent of all forage used by elk came from the moist cover type, 26 percent from the dry, and 4 percent from the wet. Livestock made substantial use of all cover types, but obtained roughly 40 percent of their forage from each of the wet and moist cover types, and 20 percent from the dry.

Total forage removed by herbivores on the dry type ranged from 17.8 percent (370 pounds per acre) to 55.6 percent (1,069 pounds per acre). On the moist type averages ranged from 12.5 percent (243 pounds per acre) to 33.1 percent (666 pounds per acre). Wet type averages ranged from 2.9 percent (87 pounds per acre) to 22.6 percent (789 pounds per acre).

When protected from herbivore grazing for a single summer, 14 forb, 6 grass, 3 sedge, 1 shrub and 1 rush species exhibited significantly greater average ground coverage than unprotected plants. Six forb, 5 grass, 2 sedge, 2 rush, and 1 shrub species exhibited no significant response; and 7 forb, 3 grass, and 1 shrub species exhibited significantly smaller averages.

In terms of numbers of animals observed during daylight hours, elk use of the meadows was highest during June, dropped rapidly as the summer progressed and was essentially zero by late August. Elk activity was maximum from 5 to 11 p.m., minimum from 11 a.m. to 5 p.m., and intermediate from 5 a.m. to 11 a.m..

Average incidence of elk utilization of plant species was assessed on 1 by 4-foot plots along randomly distributed transects. Of the plots upon which a species occurred, the percentage of plots upon which it was utilized varied from zero in some species to 100 percent in others. Forbs were the most frequently used plants, sedges second, grasses third, and shrubs last. Heaviest use of sedges and rushes occurred early in the summer (June 10 - July 6). Heaviest use of both grasses and forbs occurred between July 7 and July 31. Forb utilization was greatest near the full bloom period of the respective species, but use of grasses occurred well in advance of blooming. *Salix* spp. was used the most intensively several weeks after it bloomed.

The incidence of ground squirrel holes, run-ways, and diggings was recorded on three meadow units on three major cover types. The dry type is the center of squirrel activity and exhibited more holes and digs than the other types. Runs were most common in the moist type, implying that the

squirrels spent much time running back and forth between the dry and wet types.

In many general ways, the results of this work resemble those of other workers in various areas throughout the West, but the detailed characteristics of the flora are unique to the study area and intensive application of results is probably limited to a rather small region of central Idaho.

In view of the likelihood of an increasing demand for a limited supply of mountain meadow forage, it is recommended that a long range study program be initiated for the purpose of providing information for managerial decisions. Such a program should quantify vegetation changes and describe in detail the cause and effect relationships. Because of the apparently great effect of soil moisture levels on the character of the meadow vegetation, it is very likely that long term records of meadow moisture patterns would indirectly indicate the trend of the vegetation. It is suggested that, after an initial period of ground work, an air-borne thermal infrared sensor would be useful in assessing meadow status and trend, and would involve a minimum of effort.

LITERATURE CITED

Beetle, A. A. 1961. Range survey in Teton County, Wyoming. (Part I. Ecology of range resources). Univ. Wyo. Agric. Expt. Sta. Bul. 376. 42 p.

Brown, D. 1954. Methods of surveying and measuring vegetation. Commonwealth Bureau of Pastures and Field Crops Bul. 42. Commonwealth Agric. Bur., Farnham Royal, Bucks, England. 223 p.

Buckman, H. O. and N. C. Brady. 1965. The nature and properties of soils. 6th ed. Macmillan Co., New York. 567 p.

Colwell, R. N. 1967. Remote sensing as a means of determining ecological conditions. Bio Science 17: 444-449.

Colwell, R. N. and D. L. Olson. 1964. Thermal infrared imagery and its use in vegetation analysis by remote aerial reconnaissance. Proc. 3rd. Symp. on remote sensing of environment. Inst. of Sc. and Tech., Univ. Mich. 607-621.

Daubenmire, R. F. 1943. Vegetation zonation in the Rocky Mountains. Bot. Rev. 9: 325-393.

Daubenmire, R. F. 1968. Plant communities, a textbook of plant synecology. Harper and Row, New York. 300 p.

Douglas, L. M. 1964. Idaho Primitive Area, Report of exploration and reconnaissance. Sierra Club. Multilith. 65 p.

Ellison, L. 1954. Subalpine vegetation of the Wasatch Plateau, Utah. Ecol. Monographs 24: 89-184.

Estes, J. E. 1966. Some geographic applications of aerial infrared imagery. Proc. 4th. Symp. on remote sensing of environment. Inst. of Sci. and Tech., Univ. Mich. 173-181.

Eustace, C. D. 1967. Elk-livestock relationships to the Madison-Wall Creek Game Range. Job Completion Rpt. W-73-R-12. Mont. Fish and Game Dept. Multilith. 55 p.

Flowers, S. 1950. A list of ferns of Idaho. Amer. Fern. J. 40: 121-131.

Greig-Smith, P. 1964. Quantitative Plant Ecology. 2nd ed. Butterworths, Inc., Washington, D. C. 256 p.

Harper, J. A., J. H. Harn, W. W. Bentley, and C. F. Yocum. 1967. The status and ecology of the Roosevelt elk in California. Wildl. Monographs No. 16. 49 p.

Hayward, C. L. 1952. Alpine biotic communities of the Uinta Mountains, Utah. Ecol. Monog. 22: 93-120.

Hitchcock, A. S. 1950. Manual of the grasses of the United States. 2nd ed. U. S. Dept. Agric. Misc. Pub. 200. U. S. Govt. Printing Office, Washington, D. C. 1,051 p.

Hitchcock, C. L., A. Cronquist, M. Ownbey, and J. W. Thompson. 1959. Vascular plants of the Pacific Northwest. Univ. Wash. Press, Seattle. 5 v.

Holscher, C. E., H. E. Grelan, P. E. Hoekstra, K. W. Parker, R. W. Harris, R. W. Larson, H. A. Miller, R. W. Cooper, R. A. Klawitter, D. C. McClurkin, S. J. Ursic, T. E. Avery, G. P. Haney, R. W. Rich, C. E. Poulton, H. G. Meginnis, F. W. Stearns, and J. D. Hewlett. 1959. Report of the committee on plant cover and composition, p. 96-99. In U. S. Forest Service, Techniques and methods of measuring understory vegetation. Southern and Southeastern Forest Expt. Sta. Multilith. 174 p.

Hornocker, M. G. 1967. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Ph. D. Dissertation, Univ. British Columbia. 115 p.

Johnson, W. M. 1962. Vegetation of high-altitude ranges in Wyoming as related to use by game and domestic sheep. Univ. Wyoming Agric. Expt. Sta. Bul. 387. 31 p.

Johnson, W. M. and W. D. Billings. 1962. The alpine vegetation of the Beartooth Plateau in relation to cryopodogenic process and patterns. Ecol. Monog. 32: 105-135.

Kirsch, J. B. 1962. Little Belt elk food habits and range use investigations. Job Completion Rpt. W-98-R-2. Mont. Fish and Game Dept. Multilith. 44 p.

Klikoff, L. G. 1965. Photosynthetic response to temperature and moisture stress of three timberline meadow species. Ecology 46: 516-517.

Klingman, D. E., S. R. Miles and G. O. Mott. 1943. The case method for determining consumption and yield of pasture herbage. Amer. Soc. Agron. J. 35: 739-746.

Knight, R. R. 1967. Elk population trends, food habits, and range relationships in the Sun River Area. Job Completion Rpt. W-98-R-6-7. Mont. Fish and Game Dept. Multilith. 237 p.

Kowalsky, S. I. 1964. Ecology of mountain meadows and use by elk. M. S. Thesis. Univ. Idaho. 51 p.

Levy, E. B. and E. A. Madden. 1933. The point method of pasture analysis. New Zealand J. Agric. 46: 267-279.

Lewis, M. E. and R. Riegelhuth. 1964. Sawtooth Mountain study area (ecology and vegetation). Prepared jointly by U. S. Forest Serv. and Nat. Park Serv. Multilith. 24 p.

Mackenzie, K. K. 1940. North American *Cariceae*. New York Botanical Garden. New York. 2 v.

Mackie, R. 1961. Deer, elk, and cattle food habits and range relationships in the Missouri Breaks Area. Job Completion Rpt. W-98-R-1. Mont. Fish and Game Dept. Multilith. 229 p.

Morris, M. S. and J. E. Schwartz. 1957. Mule deer and elk food habits on the National Bison Range. J. Wildl. Mgmt. 21: 189-193.

Mueggler, W. F. 1962. Range resources and management problems in northern Idaho and northeastern Washington. U. S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Paper 68. Multilith. 31 p.

Murie, O. J. 1956. The elk of North America. The Stackpole Co., Harrisburg, Penn. 376 p.

Neff, D. J., O. C. Wallmo and D. C. Morrison. 1965. A determination of defecation rate for elk. J. Wildl. Mgmt. 29: 406-407.

Outdoor Recreation Resources Review Commission. 1962. Study Report No. 3, Wilderness and recreation - a report on resources, values, and problems. U. S. Govt. Printing Office, Washington, D. C. 352 p.

Patten, D. T. 1963. Vegetational pattern in relation to environments in the Madison Range, Montana. Ecol. Monographs 33: 375-406.

Pickford, G. D. and E. H. Reid. 1942. Guides to determine range condition and proper use of mountain meadows in eastern Oregon. U. S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Range Res. Rpt. 3. Mimeographed. 19 p.

Picton, H. D. 1960. Migration patterns of the Sun River elk herd, Montana. J. Wildl. Mgmt. 24: 279-290.

Ramaley, F. 1916. Dry grassland of a high mountain park in northern Colorado. Plant World 19: 249-270.

Reed, E. L. 1917. Meadow vegetation in the montane region of northern Colorado. Torrey Bot. Club Bul. 44: 97-109.

Reid, E. H. and G. D. Pickford. 1946. Judging mountain meadow range condition in eastern Oregon and eastern Washington. U. S. Dept. Agric. Circ. 748. U. S. Govt. Printing Office, Washington, D. C. 31 p.

Robinette, W. L., J. S. Gashweiler, D. A. Jones, and H. S. Crane. 1955. Fertility of mule deer in Utah. J. Wildl. Mgmt. 19: 115-135.

Rouse, R. A. 1957. Elk food haibts, range use and movements, Gravelly Mountains, Montana. M. S. Thesis. Mont. State College. 29 p.

Shorsmith, C. W. 1959. A report on the status, changes, and ecology of back country meadows in Sequoia and King's Canyon National Parks. Western Regional Office, Nat. Park Serv. San Francisco. Typewritten. 122 p.

Simpson, G. V. and B. McConnell. 1956. Chamberlain elk herd management plan. U. S. Forest Serv., Payette Nat. Forest, McCall, Idaho. Unpublished report. Typewritten. 8 p.

Smiley, F. J. 1915. The alpine and subalpine vegetation of the Lake Tahoe Region. Bot. Gaz. 59: 265-286.

Smith, D. R. and W. M. Johnson. 1965. Vegetation characteristics on a high altitude sheep range in Wyoming. Univ. Wyoming Agric. Expt. Sta. Bul. 430. 6 p.

Snedecor, G. W. 1956. Statistical methods applied to experiments in agriculture and biology. 5th ed. Iowa State Univ. Press, Ames. 534 p.

Stevens, D. R. 1965. Range relationships of elk and livestock, Crow Creek Drainage, Montana. J. Wildl. Mgmt. 30: 349-363.

Strickler, G. S. 1961. Vegetation and soil condition changes on a subalpine grassland in eastern Oregon. U. S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 40. Multilith. 46 p.

Trepp, W. 1950. Ein Beitrag zu Bonitierungsmethoden von Alpweiden. Schweiz. landw. Mh. 28: 366-371.

Ursic, S. J. and D. C. McClurkin. 1959. Small plots for measuring vegetation composition and cover, p. 70-78. In U. S. Forest Service, Techniques and methods of measuring understory vegetation. Southern and Southeastern Forest Expt. Sta. Multilith. 174 p.

U. S. Forest Service. 1958. Wildlife Management, Section 2620, U. S. Forest Service Handbook, Region 4. 861 p.

Verme, L. J. 1967. Influence of experimental diets on white-tailed deer reproduction. Trans. N. Am. Wildl. Conf. 32: 405-420.

Walker, E. P., F. Warnick, K. I. Lange, H. E. Uible, S. E. Hamlet, M. A. Davis, and P. F. Wright. 1964. Mammals of the world. Vol. I and II. Johns Hopkins Press, Baltimore. 1,500 p.

APPENDIX I

List of plant species encountered on five mountain meadows

Table 71. List of plant species encountered on Cold, Middle Cottonwood, Lower Cottonwood, Ginger, and Phantom Meadows during the summers of 1966, 1967, and 1968.

Forbs

Achillea lanulosa
Aconitum columbianum
Agoseris aurantiaca
Agoseris glauca
Agoseris sp.
Antennaria rosea
Aquilegia coerulea
Arabis sp.
Arenaria aculeata
Arenaria congesta
Arnica chamissonis
Arnica mollis
Aster foliaceus var. *parryi*
Aster integrifolius
Aster modestus
Astragalus sp.
Brassica nigra
Caltha leptosepala
Castelleja cusickii
Chrysanthemum leucanthemum
Cirsium foliosum
Claytonia lanceolata
Dodecatheon jeffreyi
Epilobium sp.
Erigeron sp.
Eriogonum umbellatum
Fragaria virginiana
Gentiana affinis
Geum macrophyllum
Geum triflorum
Habenaria dilatata
Haplopapus sp.
Ligusticum canbyi
Ligusticum filicinum
Lupinus sp.
Mimulus guttatus
Mitella breweri
Oenothera heterantha
Parnassia intermedia
Pedicularis bracteosa
Pedicularis groenlandica
Penstemon procerus
Penstemon rydbergia
Polemonium occidentale
Polygonum bistortoides
Polygonum viviparum
Potentilla diversifolia
Potentilla gracilis
Potentilla norvegica
Pyrola asarifolia
Pyrola minor
Pyrola sp.
Ranunculus alismaefolius var. *alismellus*
Ranunculus uncinatus
Rumex acetosella
Saxifraga arguta
Saxifraga oregana
Sedum stenopetalum
Senecio crassulus
Senecio integerrimus
Senecio subnudus
Senecio triangularis
Spiranthes romanzoffiana
Solidago multiradiata
Swertia perennis
Taraxacum officinale
Trifolium longipes
Trifolium sp.
Trifolium sp.
Trollius laxus
Valeriana capitata
Viola bellidifolia
Zigadenus elegans

Table 71. Continued.

Grasses	Sedges, Rushes, and Horsetails
Alopecurus aequalis	*Carex aquatilis*
Agropyron dasystachyum	*Carex aurea*
Agrostis scabra	*Carex canescens*
Bromus ciliatus	*Carex geyeri*
Calamagrostis canadensis	*Carex hoodii*
Calamagrostis rubescens	*Carex rostrata*
Danthonia intermedia	*Eleocharis acicularis*
Deschampsia atropurpurea	*Equisetum* sp.
Deschampsia caespitosa	*Equisetum* sp.
Deschampsia elongata	*Juncus confusus*
Festuca idahoensis	*Juncus drummondii*
Glyceria pauciflora	*Juncus ensifolius*
Melica spectabilis	*Juncus mertensianus*
Muhlenbergia richardsonis	*Luzula divaricata*
Phleum alpinum	*Luzula multiflora*
Phleum pratense	
Poa compressa	
Poa pratensis	
Stipa columbiana	
Trisetum spicatum	
Trisetum wolfii	

Shrubs	Ferns
Berberis repens	*Botrychium lunaria*
Betula glandulosa	
Ledum glandulosum	
Lonicera utahensis	
Potentilla fruticosa	
Ribes viscosissimum	
Salix sp.	
Salix sp.	
Vaccinium membranaceum	
Vaccinium occidentale	

APPENDIX II

Lists of standard errors for forage production and utilization means

Table 72. Means and standard errors for pounds-per-acre forage production for each cover type on each meadow unit.

Cover Type and Meadow Unit	Gross $\bar{x}$	Gross *SE*	Net $\bar{x}$	Net *SE*	*n*
Dry					
Cold	2484	281	2036	307	5
Middle Cottonwood	2100	224	1676	89	3
Ginger	0	-	-	-	-
Phantom	0	-	-	-	-
Horse Pasture	1921	-	852	-	1
Lower Cottonwood	2074	276	1704	120	3
Moist					
Cold	2358	67	2064	126	7
Middle Cottonwood	2055	116	1838	142	5
Ginger	1942	333	1699	360	2
Phantom	2095	-	1645	-	1
Horse Pasture	2014	153	1347	147	2
Lower Cottonwood	1729	364	1351	304	4
Wet					
Cold	3291	222	3485	243	13
Middle Cottonwood	2971	202	2884	233	9
Ginger	4487	831	3547	306	2
Phantom	4441	435	3539	135	3
Horse Pasture	3487	336	2698	519	2
Lower Cottonwood	2857	337	2559	354	8

Table 73. Means and standard errors for pounds-per-acre forage production for each meadow unit.

	Gross		Net		
Meadow Unit	$\bar{x}$	*SE*	$\bar{x}$	*SE*	*n*
Cold	2861	153	2810	199	25
Middle Cottonwood	2603	162	2448	188	17
Ginger	3491	818	2824	554	4
Phantom	3899	715	3101	471	4
Horse Pasture	2156	416	1498	290	6
Lower Cottonwood	2200	236	1861	235	15

Table 74. Means and standard errors for pounds-per-acre forage production for each cover type on each area and for the overall sample.

Cover Type and Area	Gross $\bar{x}$	Gross *SE*	Net $\bar{x}$	Net *SE*	*n*
Dry					
Area I	2000	168	1293	256	4
Area II	2327	194	1889	193	8
Overall	2167	131	-	-	12
Moist					
Area I	1849	209	1359	170	7
Area II	2211	66	1950	91	14
Overall	2076	93	-	-	21
Wet					
Area I	3270	255	2733	234	13
Area II	3226	164	3216	166	24
Overall	3237	135	-	-	37
All Cover Types					
Area I	2278	215	1776	196	25
Area II	2789	118	2656	134	46
Overall	2617	111	-	-	71

Table 75. Means and standard errors for pounds-per-acre forage production on areas used by ground squirrels, listed by meadow unit and by cover type.

Meadow Unit or Cover Type	Gross		Net		
	$\bar{x}$	*SE*	$\bar{x}$	*SE*	*n*
Meadow Unit					
Cold	2682	165	2356	79	6
Middle Cottonwood	2428	228	2327	270	9
Horse Pasture	2066	710	1703	744	4
Lower Cottonwood	2330	180	2129	126	8
Cover Type					
Dry	2311	251	2040	255	10
Moist	2308	70	2108	91	9
Wet	3238	205	3006	222	7
Overall	2510	123	2295	129	26