Diet Composition and Activities of Elk on Different Habitat Segments in the Lodgepole Pine Type , Uinta Mountains, Utah

William B. Collins

DIET COMPOSITION AND ACTIVITIES OF ELK ON DIFFERENT HABITAT SEGMENTS

IN THE LODGEPOLE PINE TYPE, UINTA MOUNTAINS, UTAH

by

William B. Collins

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Major Professor

Committee Member

Committee Member

Committee Member

Dean of Graduate School

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William B. Collins

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ABSTRACT

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by

William B. Collins, Master of Science

Utah State University, 1977

Major Professor: Dr. Philip J. Urness
Department: Range Science

The biweekly diets of tame elk (*Cervus canadensis nelsoni*) were established on a species dry-weight basis for different habitat segments of the lodgepole pine (*Pinus contorta*) type. Principal species in the diets (5% or more) on each habitat segment were generally composed of preferred species. However, some highly abundant but non-preferred species took on principal dietary status, whereas some preferred species, scarce in the vegetation, contributed less than 5 percent to diets. Forbs contributed most to total consumption; grasses and sedges were the second largest contributors. Browse appeared to be of limited importance, but mushrooms had special significance in forested habitat segments. Preference changes were evident as forb species matured. Consumption rates were significantly higher in habitat segments having greater species diversity and forage density.

The time tame elk spent grazing, ruminating, lying, grooming, traveling, standing, drinking, and playing was referenced to specific habitat segments in which each activity occurred. One thousand and eight hours of individual elk activity were observed over a series of six 24-hour periods. Wet meadows, dry meadows, clearcuts, and revegetated roads were preferred as grazing sites, while mature and stagnated forests were clearly non-preferred. Wet meadows, revegetated roads, and mature forest were preferred for resting and non-grazing activities. The distribution of pellet groups deposited by tame elk was determined with reference to habitat segment and form of activity at the time of deposition. Pellet group distributions thus obtained, were strongly unrepresentative of relative time spent in various habitat segments.

(82 pages)

INTRODUCTION AND OBJECTIVES

Introduction

Knowledge of elk diets and preferences for habitat segments is requisite to the development of silvicultural practices that will positively affect elk summer range. The market for lodgepole pine products has increased as availability of other timber resources has declined, thus the type has taken on added commercial value in recent years. Subsequent increases in logging activity in this type will strongly impact important elk summer range in the Uinta Mountains in northeastern Utah.

Summer range, in the Uinta Mountains as well as other extensive areas dominated by lodgepole pine, may be more important to the productivity of an elk herd than winter range. It is to these summer ranges that the elk return to regain condition lost during the winter. Here too, the elk rear their young and re-establish good body condition for breeding and the onset of winter. Mature and stagnated forest occupies the major portion of the type, and forage resources in these situations are generally sparse and/or low in quality. Thus, great potential exists for increasing elk summer range values through various silvicultural practices that open the forest canopy and promote growth of high-quality elk forages. However, before guidelines on the size, density, shape, and distribution of clearings can be specified, the features of forest openings that attract elk use must first be determined.

Objectives

1. To raise and train six elk calves for use in dietary and behavioral studies.

2. To determine biweekly summer diets of elk on various habitat segments within the lodgepole pine type in terms of species composition and relative percentage by weight.

3. To determine dietary yield per unit of effort on different habitat segments within the lodgepole pine type.

4. To determine activity patterns and relative habitat segment preferences of unconfined elk on lodgepole pine summer range.

Hypotheses

The null hypotheses tested in this study were: 1) consumption rates of elk using forested and nonforested habitat segments are not significantly different, and 2) relative distributions of pellet groups and actual elk use on different habitat segments are not significantly different.

LITERATURE REVIEW

The effect of range forage quality on big game production was recognized by Cheatum and Severinghaus (1950) who found that the fertility of deer was directly related to the quality of their range. Indirect losses of big game through low reproductive success, though less obvious than winter malnutrition losses, are in some cases as or more important to herd status. This is clearly illustrated by Julander et al. (1961) who compared mule deer productivity on excellent and poor Utah summer ranges. Likewise, Buechner and Swanson (1955) suggest that population densities maintained somewhat below carrying capacity result in increased natality in elk through better nutritional status of remaining individuals.

Taber (1953) reported black-tailed deer reproduction poorest in mature, dense chaparral. Forest Service estimates of black-tailed deer populations in National Forests in Oregon indicate a four-fold increase since the mid-1940's when patch-cutting of Douglas fir became a popular practice. Brown (1961) reported similar improvements of black-tailed deer range in western Washington. Patch cutting of monotonous ponderosa pine forests in Arizona increased availability of forbs, grasses, and browse, benefiting both deer and elk (Patton 1974).

Regelin et al. (1974), working in lodgepole pine and Englemann spruce-dominated stands, demonstrated that clearcutting and possibly other cutting practices can contribute more to deer welfare than is indicated by simply comparing relative nutritional values of forages in cut and uncut areas. They found no intraspecific differences in digestibility (in vitro) of forages between cut and uncut areas, however, mean digestibilities of diets from cut areas were found to be slightly higher than those in uncut areas. Furthermore, they suggest that the greater species diversity and plant productivity stimulated deer to spend more time grazing on clearcut strips. Consequently, they obtained more than two-thirds of their dietary crude protein and digestible dry matter from clearcuts.

Hanson and Smith (1970) suggest that a "readily apparent" research need is establishment of specific guidelines on the size, density, shape, and optimum distribution of clearings for optimum wildlife production. Likewise, a report by the Wyoming Forest Study Team (1971) recommended detailed investigation of the impacts on elk of size of opening, distribution of openings, and placement of logging roads in the lodgepole pine and Englemann spruce-subalpine fir types. Such research should include data on availability, diet composition, and nutritional value of forages consumed by elk using these types.

Winn (1976), working in the lodgepole pine type on the north slope of the Uinta Mountains, attempted to assess some of the above factors by using pellet counts as indexes to relative elk use of different habitat segments. Similar approaches were used earlier by Reynolds (1962) and Patton (1974).

Several authors (Buechner 1950, Wallmo 1951, McMahan 1961, Longhurst 1968, and Neff 1974) suggest that observation of tame animals is a reliable method for determining some aspects of dietary behavior. Gilbert (1971) concludes that foster rearing of fallow deer (*Dama dama*) results in no detectable change in their social behavior. Consequently, I used tame elk in behavioral studies, specifically as an alternative to the pellet count method for determining preferential use of different habitat segments.

DESCRIPTION OF STUDY AREA

This study was conducted in the East Park area, a gently rolling forested plateau at the east end of the Uinta Mountain range. The elevation ranges from about 2600 to 3000 m and slopes gently to the south. It is about 50 km north of Vernal, Utah, and is easily accessible by road.

The East Park Reservoir watershed of the Ashley National Forest is a lodgepole pine area with recently increased logging activity. Accelerated logging began there in 1976 on the Little Brush Creek and Coyote units. A sustained-yield system utilizing small, scattered patchcuts (25 ha or less) was established. Early harvests will also include some sanitation cuts to develop healthier stands of good form trees, but funding is limited for timber stand improvements in stagnated stands.

The study area afforded opportunity to sample both mature and dense stagnated lodgepole pine stands, as well as wet meadows, dry meadows, and created upland meadows. Created upland meadows include areas logged 30 to 40 years ago, recent timber stand improvement areas, and one 18-year-old clearcut in a stagnated stand. In addition, planned follow-up studies will monitor successional changes on new timber harvest areas.

The soils in the area are typical of the lodgepole pine type elsewhere in the Uinta Mountains. They are in the Typic Cryorthent-Typic Cryochrept-Mollic Cryoboralf association. Specifically, the soils in the lower elevations of the study area (underlain by the Brown's Park formation) are Typic Cryoboralf, loamy skeletal, mixed.

Soils of higher elevations (underlain by the Uinta Mountain Quartzite formation) are Typic Cryoboralf, fine loamy, mixed. The subgroup, Argicaquic Cryaboralf, is found within this great group and is associated with semi-open parks. All soils, except those on the meadows, are well drained and dry quickly. They are moderately fertile, with mean summer soil temperatures less than 15°C, and with only local erosion and stability problems. Meadow situations are poorly to moderately well drained with relatively high water tables; they support grass-sedge communities rather than trees (Wilson et al. 1975, Chamberlain 1976[1]).

Annual precipitation on the study area is about 500 mm, as much as half in the form of snow (Wilson et al. 1975). Due to the location, elevation, and orientation of the mountains, the area receives frequent orographic and convective summer thunder showers from moisture originating in the Gulf of Mexico (Richardson 1976[2]). In 1976, general snowmelt and subsequent greenup did not occur until about 13 June. Killing frosts ended 27 June and resumed 8 September.

Ninety percent of the study area has a lodgepole pine overstory with a small percent of Englemann spruce[3] (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). About 10 percent of the area is meadow. The habitat type for the upper elevations is *Abies lasiocarpa/Vaccinium*

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[1]Personal communication with Leon Chamberlain, soil scientist for the Ashley National Forest, Vernal, Utah.

[2]Personal interview with E. Arlo Richardson, climatologist for the State of Utah, Logan.

[3]Appendix A, Table 9 lists all species with their associated common names.

scoparium. A habitat type for the lower elevations has not yet been determined, but community types known to be present are *Abies lasiocarpa-Picea pungens/Beberis repens-Carex geyeri*, *Pinus contorta/Vaccinium scoparium*, *Pinus contorta/Calamagrostis canadensis*, and *Pinus contorta/Carex geyeri*. *Pinus contorta* exists as a possible edaphic climax in close association with the *Abies lasiocarpa/Vaccinium scoparium* habitat type (Pfister 1972, Mauk 1977[4]).

Most of the lodgepole pine forest is composed of even-aged stands. Many are so dense and stagnated that they are practically devoid of understory; foresters refer to them as "dog hair stands." The primary understory species in the mature forest is grouse wortleberry (*Vaccinium scoparium*).

Dry meadows are the most common type of opening found in this forest system. They range in size from 1 to 40 ha, are located on deeper and wetter soils than occur in the surrounding forest, and produce a diverse array of forbs, grasses, and sedges. Characteristic species are alpine timothy (*Phleum alpinum*), several species of *Carex* and *Juncus*, marsh marigold (*Caltha leptosepala*), western yarrow (*Achillea lanulosa*), forest fleabane (*Erigeron superbus*), trailing fleabane (*Erigeron flagellaris*), American bistort (*Polygonum bistortoides*), and longstalk clover (*Trifolium longipes*).

The wet meadows are less widely distributed and are restricted to areas immediately adjacent to stream courses. They seldom exceed 15 m in width. Wet meadows have many of the same species as the dry

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[4]Personal interview with Ronald L. Mauk, Forestry Department, Utah State University, Logan.

meadows, but are more productive; they are dominated by water sedge (*Carex aquatalis*), blackscaled sedge (*Carex atrata*), silvery sedge (*Carex canescens*), Oregon fleabane (*Erigeron speciosus*), and mountain bluebells (*Mertensia ciliatus*).

The created upland meadows (actually forest openings) are dryer than either of the natural meadow types, but they support a wide array of forbs, grasses, and sedges. Primary species are dandelion (*Taraxacum officinale*), goldenrod (*Solidago decumbens*), aster (*Aster chilensis*), tailcup lupine (*Lupinus caudatus*), alpine timothy, bearded wheatgrass (*Agropyron subsecundum*), shortstemmed sedge (*Carex brevipes*), and elk sedge (*Carex geyeri*).

Deer and elk utilize the area from late spring to fall. Although some animals are in the area prior to substantial snowmelt, most stay at lower elevations until snowmelt is essentially complete and greenup is well under way. A two-month permit for 1000 sheep has been issued for the area, but during the 1976 season the permittee took non-use. Therefore, diets obtained do not reflect competitive relationships with livestock. Competition, based on 1975 observations, is not intense.

METHODS AND PROCEDURES

Raising and Training Elk for Diet and Behavioral Observations

In December 1974, 19 cow elk were captured at Hardware Ranch, the Utah Division of Wildlife Resource's elk winter feeding ground. The cows were kept in a large enclosure until the spring calving season. Their calves were taken to the Green Canyon facility near Logan, Utah, to be hand raised for the purposes of this study.

I originally planned to take each calf approximately 12 hours after birth or whenever it appeared to have suckled enough to have received sufficient colostrum. It was hoped that by taking the calves at such an early age, they would imprint more successfully on their human trainer. Early in the acquisition program it was discovered that imprinting on the mother was established before 12 hours of age. Thus, later calves were obtained from one to one-half to three days of age. Older calves were found to be less willing to accept bottle feeding, but they were much stronger and less susceptible to pneumonia and digestive upsets.

As soon as calves were located, their sex was determined and they were weighed. I intended to take only heifer calves because I feared that bulls would be unusable during the rut. However, bull calves eventually were accepted to ensure enough animals (seven to nine) for the requirements of the study. Some calves were left in the field because they had low birth weights, were not as strong as heavier calves, and had more problems with digestive upsets. Appendix B, Table 10 gives the birth date, birth weight, sex, and fate of each calf.

Care was taken to ensure that the trainer was the animal's only contact with humans for the first week. Upon arrival at the Green Canyon facility, I sat quietly with the calf for two to three hours, gently stroking its head and shoulders. A bottle of warm milk was then slipped into the calf's mouth. Usually, however, the animal would lie still and make no effort to suckle. This was repeated five times per day, often without success until the end of the second day. It was later discovered that by using a plastic bottle, I could greatly encourage acceptance of the bottle by squeezing it and flooding the calf's mouth. Suckling was also stimulated (and constipation prevented) in calves less than ten days old by sponging around the anus with wet paper towels (Youngson 1970).

Selection of a good milk source proved to be the most important consideration in the calf-raising process. The calves were first fed a commercial milk replacer to minimize costs. However, such products often produce digestive upsets in livestock; this was the case with elk calves. Two early calves were lost as a result of feeding milk replacer (veterinarian's report). Consequently, two goats were purchased for a milk source. Their milk was strained directly from the pail to the feeding bottles. Older calves were then gradually switched to milk replacer when their consumption exceeded the output of the goats. The calves were transferred from goat's milk to milk replacer when they were approximately four weeks old by increasing the relative amount of milk replacer by thirds--one-third increase every three days or whenever it was evident the new amount of milk replacer was not causing digestive upset. A detailed feeding schedule is presented in Appendix B, Table 11.

If an animal scoured, it was taken off all milk for one day and fed a compensatory amount of electrolyte solution. Beginning the second day of treatment the calf was returned to milk feedings starting with a mixture of milk and electrolyte solution, the milk portion being increased by thirds each day. Kaopectate also proved helpful in controlling scours.

Water, leafy alfalfa hay, and rolled barley were offered ad libitum until the calves were weaned. The calves were weaned at six weeks of age to overcome slow weight gains resulting from qualitative inadequacy of the formula. After weaning, the calves were fed rolled barley and stemmy alfalfa hay.

The elk did not imprint on their human trainer, but they did habituate to his presence. Thus, teaching the animals to follow any routine necessary for the study required a great amount of repetition and patience. It was found that, given enough time, elk can become habituated to many activities. Enticements greatly facilitated the process, but force, pain, stress, or excitement caused blind panic in the animal that could undo habituated behavior for an extended period, sometimes months.

The design and routine of the study required that the elk be habituated to three "new" activities: 1) letting the trainer approach sufficiently close to accurately identify and count bites of forages, 2) loading into a horse trailer for transport to and from study sites, and 3) returning to the trailer or enclosure at the termination of each sampling session. Development of the animal's trust was indispensable to the teaching of these activities. Trust was developed through daily contact with and care of the animals. By the time the elk were taken to the study area, I had spent over 1700 hours with them. Much of this time was simply spent in general contact.

Loading into the horse trailer was rehearsed daily for the first two months and twice weekly for the next ten months of the elk's life. A reward of milk, barley or hay was given inside the trailer. Once the animal began entering the trailer calmly, it was taken for short rides. There appeared to be no adverse effects due to the trailer movement, as long as the animal had accepted the trailer. Confinement in the trailer with the trainer also helped reduce the animal's anxiety toward the trainer.

At age eight weeks, the elk were taken by trailer to a large pasture and released for 15 to 30 minutes of grazing. At the end of the grazing period, I would whistle, walk back to the trailer, and entice the elk to reload for the return trip to the pens. This was rehearsed weekly except when deep snow prevented moving the trailer. Sometimes special means were required to get the elk to stop grazing and follow back to the trailer. Running, clapping hands, and exploding M-80 firecrackers were all used at one time or another; use of the latter clearly illustrated how readily the elk habituate. Upon the fifth occasion firecrackers were used, the elk responded no more than to lift their heads and watch the smoke rise into the air. It, subsequently, proved best to reserve use of "attention getters" for times when they were definitely needed.

Nine elk were eventually raised. These included five cows, three haviers, and one bull. Three bulls were castrated at age five months, because it was feared that they would be intractable during the rut in late summer. All nine animals eventually became tractable for use in the field, although only seven were actually used.

Determination of Biweekly Elk Diets

Tame elk were observed at close range to obtain dietary information outlined in objectives two and three. All diet information was estimated on a species dry-weight basis. The bite-count technique, as described by Wallmo and Neff (1970), was employed with some modifications.

Seven elk were taken by stock truck to the study area on 15 June and given a seven-day adjustment period. An adjustment period was important to ensure that the tame elk would be familiar with the vegetation and have preferences established prior to sampling. Likewise, it was important that the animals not be maintained on hay and grain which might interfere with establishment of preferences among the native forages. For these purposes, two enclosures (1.54 and 1.17 ha) were built (net wire, 2.5 m high) to encompass the five major habitat segments found in the East Park area. Two separate enclosures were built because no one location was found to have all five habitat segments within sufficient proximity to be fenced as one enclosure. The 1.54 ha enclosure encompassed wet meadow, stagnated forest, and clearcut, while the other enclosed dry meadow and mature forest. This necessitated periodic rotation of the animals between enclosures to ensure that they would be familiar with all five habitat segments.

Sampling began 24 June. Each habitat segment was sampled one day per week, six one-half hour periods per day, three periods in the morning and three in the late afternoon. The specific animal for any given sampling period was selected according to a pre-determined schedule that daily rotated the order in which the seven animals were used.

The numbers of bites on each species were counted on a tape recorder to accommodate rapid sampling. Tapes were usually transcribed soon after the sampling session in which they were made. The bite size on any given species and the plant part eaten were carefully noted. Then, five bags of 25 simulated bites were collected of each plant species observed in the diet. The collections of "bites" were made on all species initially and, thereafter, only on species which were still growing. The contents of the bags were oven dried and weighed. If there was more than 15 percent variation between the contents of the five bags, the "bites" were more carefully collected a second time.

The mean weight of the 125 "bites" was multiplied by the number of bites each animal took of that species per one-half hour sampling period. This gave the dry-weight consumption on each species per half-hour period. Mean simulated bite weights were used as a multiple of only the numbers of bites taken in the two-week period in which the mean weight was determined.

Beginning with the week starting 27 June, each two succeeding week's data were combined to form the basis for biweekly diet computations. Dry-weight consumptions were averaged across the twelve one-half hour periods by species. The dry-weight consumption means of all species were then totaled and the contribution of each individual species to the total was determined as a percent.

The similarity of the mean summer diet on each habitat segment was calculated using Kulczynski's (1937) formula as given by Oosting (1956). Species occurring in the diet overlap between any pair of habitat segments were ranked in order of abundance in each diet and a correlation coefficient computed between the pair (Sokal and Rohlf 1973).

A single classification analysis of variance was used to compare mean summer consumption rates on each habitat segment. Biweekly mean consumption rates were used as treatment observations.

Preference ratings were developed to help define which species were most preferred by the elk. This was done by dividing the percent species dry-weight consumption by the percent species dry-weight availability. "Preferred species" are defined as those species having preference quotients 2.51 to 12.50, "slightly preferred species" have quotients 1.00 to 2.50, and "highly preferred species" were those having quotients greater than 12.50. "Apparently preferred species" are species which did not occur in forage availability samples, yet regularly appeared as components of the diet. Such species were apparently preferred, though no preference quotient could be calculated. "Apparently non-preferred species" refers to species which did not appear in the diet, yet regularly occurred in forage availability samples. All preference ratings were established only for the two-week period in which species availability data were collected on specific habitat segments. Habitat segments were sampled when or shortly after the vegetation had reached maximum development. "Principal species" are defined as species comprising 5 percent or more of the diet.

The distance each elk traveled during the one-half hour sampling period was measured during August, when vegetation was at its maximum development. This was done in an attempt to describe some of the elk's response to forage availability. Measurements were made by the observer trailing a 100-foot steel tape through vegetation past temporary reference points. Each time the end of the tape passed a reference point, 100 feet was recorded, until the end of the sampling period when only the portion of tape past the last reference point was recorded. So long as care was taken to loop the tape around plants in line with ths animal's path, very accurate records of distance were possible.

Determination of Habitat Segment Preferences

Once each two-week period, all seven animals were released simultaneously from the same location and allowed to roam freely for a 24-hour period. During this time, the observer was careful to remain near the center of the herd to avoid affecting the direction of herd movement. Percent total activity time was determined with scan sampling, a behavioral sampling technique described by Altmann (1974). At the end of each 10-minute interval within the 24-hour period, the activity of each elk and its location with reference to habitat segment was noted. Grazing, ruminating, lying, sleeping, traveling, standing, playing, and drinking were the states or activities noted. The activity time total on each different habitat segment was then taken as a percent of the total specific activity time on all habitat segments combined. These percents were then divided by appropriate percents of each area, thus producing activity-specific habitat-segment preference quotients. The formula is as follows:

$$\text{Habitat Segment Preference} = \frac{\text{\% of total activity time}}{\text{\% of total area}}$$

For example, if 12 percent of the total grazing time was in habitat segment B, and B was 28 percent of the total area, preference would be 0.42 and thus non-preferred. The basic assumption for developing habitat segment preferences was that the animals would not randomly use a general area composed of two or more distinctly different habitat segments.

The area of each habitat segment was determined as a percent of the total area. This was obtained by planimetering area size from aerial photographs; the total area was defined by placing east-west and north-south boundary lines at the points of farthest elk movement as recorded over the entire summer. The elk were followed at night by placing a pen light on the collar of one elk and 10-minute interval scan samples were made with the aid of a flashlight.

A record of defecations was kept during the 24-hour periods to check the reliability of pellet counts as indexes to habitat segment preferences. Each defecation was recorded with reference to both the habitat segment in which it was deposited and the animal's activity at the time of defecation. The test for goodness of fit was made of the observed distribution of elk use versus the expected distribution of elk use based on distribution of pellet groups.

RESULTS AND DISCUSSION

Biweekly Diets

Diet sampling commenced 24 June and ended 18 September, thereby providing composition data for six biweekly diets for all habitat segments except stagnated forest. The latter area was sampled only during three periods because the elk refused to feed there until late summer. Biweekly diets by forage class are depicted in Figure 1. Diets by species dry-weight composition are presented in Tables 1 through 5. Diet composition by both species and forage class readily illustrate strong differences between habitat segments, especially between forested and non-forested segments. Therefore, all discussion of diets will be referenced to specific habitat segments.

Diets in wet meadow

Forbs were the major forage class in the wet meadow diets (Figure 1). However, their presence was much reduced after they began to mature, and the carices became the major class the last two periods. Browse, mainly the willows (*Salix* spp.), was present in the diet in consistent but small amounts throughout the summer. Mushrooms appeared in the diet in direct relation to their availability in terms of timing and amount.

The principal species in the diets were Oregon fleabane, Richardson geranium (*Geranium richardsonii*), dandelion, water sedge (*Carex aquatalis*), blackscaled sedge (*C. atrata*), and silvery sedge (*C. canescens*). Of these, Oregon fleabane, Richardson geranium, and blackscaled sedge were preferred and dandelion was highly preferred (Table 1). Hollyleaf clover (*Trifolium gymnocarpon*), grouse wortleberry, and redtop bent

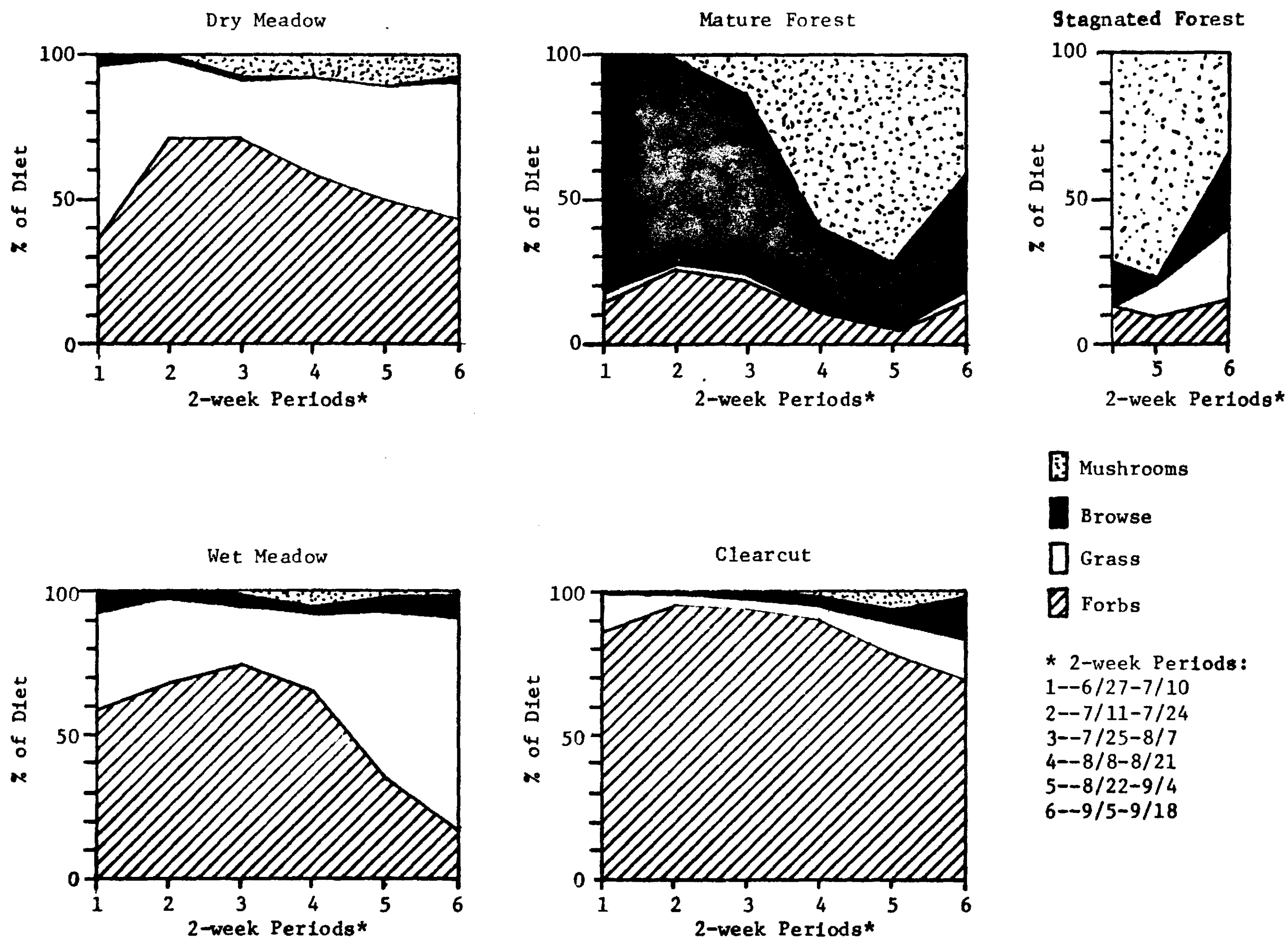

Figure 1. Biweekly elk diets by forage class on five habitat segments in the lodgepole pine ecosystem, northeastern Utah. Percentages are on a dry-weight basis.

Table 1. Diet composition by dry weight and food preferences of elk grazing wet meadows for two-week periods from 27 June to 18 September.

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference[a]
	Percent							
Forbs								
Achillea lanulosa	0.8	0.4	1.2	1.5	1.5	1.3	1.1	21.67
Aconitum columbianum	3.0	2.4	0.6	3.6	1.7	2.5	2.3	1.92
Allium acuminatum	0.9	0.9	1.3	+[b]	+	0.0	0.5	P
Angelica pinnata	0.0	+	0.7	0.1	0.1	0.0	0.2	P
Arnica cordifolia	2.2	1.5	0.4	2.4	0.2	0.0	1.0	P
Arnica mollis	0.2	0.0	1.2	0.4	+	+	0.3	P
Astragalus decumbens	1.0	0.6	0.0	0.1	0.1	0.2	0.3	P
Caltha leptosepala	+	+	0.1	+	0.1	+	+	P
Castilleja linariaefolia	0.0	0.0	0.0	0.1	+	0.0	+	P
Epilobium angustifolium	0.1	+	+	0.1	+	+	+	P
Epilobium hornemanii	+	+	+	+	0.0	+	+	N
Erigeron flagellaris	0.0	0.0	0.8	0.1	+	0.0	0.2	P
Erigeron speciosus	8.4	19.1	22.3	14.3	10.3	7.1	13.6	4.01
Fragaria ovalis	0.1	0.2	0.1	0.6	0.2	0.1	0.2	0.63
Gallium boreale	+	+	+	+	+	+	+	N
Geranium richardsonii	13.0	7.9	7.4	9.3	4.3	2.6	7.4	1.94
Mertensia ciliata	2.0	2.6	4.3	2.9	3.1	1.9	2.8	0.65

Table 1. Continued

Plant Species	Periods						$\bar{X}$	Preference
	1	2	3	4	5	6		
	Percent							
Forbs								
Osmorhiza chilensis	0.1	0.1	0.1	0.1	+	0.0	0.1	P
Polygonum bistortoides	+	+	0.1	0.0	0.0	0.0	+	P
Potentilla glandulosa	0.9	0.7	0.2	0.2	0.3	0.1	0.4	1.00
Potentilla gracilis	0.0	0.0	+	0.2	+	+	+	P
Solidago decumbens	+	0.0	+	0.0	0.0	0.0	+	P
Stellaria jamesiana	0.0	0.0	0.0	+	+	0.0	+	P
Stellaria longipes	0.0	+	+	+	+	+	+	N
Taraxacum officinale	25.6	30.2	23.8	28.4	13.2	1.6	20.5	13.3
Thalictrum fendleri	+	+	+	+	+	0.0	+	P
Trifolium gymnocarpon	0.2	0.7	9.8	0.3	0.1	0.0	1.9	N
Veronica wormskjoldii	0.1	0.3	0.1	0.1	+	+	0.1	N
Viola spp.	+	+	+	0.1	0.1	+	+	N
Zigadenus elegans	0.0	0.0	+	0.0	0.0	0.0	+	P
Grasses, sedges								
Agropyron subsecundum	0.0	0.0	0.1	0.2	1.2	1.3	0.5	10.83
Agrostis alba	1.9	5.8	3.7	0.5	4.0	2.9	1.3	0.10
Agrostis scabra	0.0	0.0	0.0	0.0	0.1	0.0	+	N

Table 1. Continued

Plant Species	Periods 1	2	3	4	5	6	$\overline{X}$	Preference
	Percent							
Grasses, sedges								
Alopecurus alpinus	0.1	0.1	0.2	0.3	0.3	0.3	0.2	0.68
Bromus ciliatus	0.0	0.0	0.1	1.4	0.3	1.3	0.5	3.71
Carex aquatalis	12.9	1.6	1.3	1.5	12.4	19.8	8.3	0.33
Carex atrata	3.9	0.2	1.6	11.6	20.8	33.3	11.9	P
Carex canescens	13.6	16.0	9.4	9.9	18.0	13.9	13.5	N
Carex disperma	0.0	0.0	0.0	+	0.1	+	+	P
Juncus confusus	1.0	0.9	0.5	0.5	0.2	0.2	0.6	P
Juncus drummondii	0.0	1.0	0.1	0.9	0.3	0.1	0.4	P
Juncus ensifolius	0.0	0.9	2.4	0.1	0.7	0.2	0.7	P
Phleum alpinum	1.1	0.5	0.4	0.1	+	0.0	0.4	N
Poa spp.	0.2	0.7	0.5	0.3	0.1	0.5	0.4	N
Trisetum spicatum	0.0	0.0	0.0	0.0	0.1	0.2	0.1	1.00
Equisetum arvense	+	+	0.0	0.0	0.0	0.0	+	N
Browse								
Lonicera involucrata	0.2	0.2	+	0.4	+	0.3	0.2	0.83
Populus tremuloides	0.0	0.0	0.0	0.1	+	0.1	+	10.00

Table 1. Continued

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference
	Percent							
Browse								
Potentilla fruticosa	0.4	0.2	+	+	0.0	0.0	0.1	P
Rosa nutkana	0.0	0.0	0.0	+	+	+	+	P
Salix spp.	0.5	0.6	2.5	0.2	0.4	0.1	0.7	0.77
Vaccinium scoparium	1.1	0.5	0.7	0.3	0.5	0.6	0.6	P
Vaccinium caespitosum	4.4	1.2	1.6	0.7	2.8	6.6	2.9	16.10
Mushrooms[c]	0.0	0.0	0.2	5.8	2.2	0.6	1.5	P

[a] <1.00 = non-preferred, 1.00 - 2.50 = slightly preferred, 2.51 - 12.50 = preferred, >12.50 = highly preferred, P = apparently preferred, and N = apparently non-preferred.
[b] + = trace item, less than 0.05% of diet.
[c] Mushrooms not identified.

Table 2. Diet composition by dry weight and food preferences of elk grazing dry meadows for two-week periods from 27 June to 18 September.

Plant Species	Periods						$\bar{X}$	Preference[a]
	1	2	3	4	5	6		
	Percent							
Forbs								
Achillea lanulosa	1.7	2.1	1.9	1.6	1.6	4.2	2.2	1.14
Agoseris glauca	+[b]	0.1	0.0	+	0.0	0.0	+	N
Allium acuminatum	1.3	4.1	2.4	0.8	0.4	0.0	1.5	P
Aquilegia crysantha	0.0	+	0.0	0.0	0.0	0.0	+	N
Arnica cordifolia	0.0	0.2	0.2	0.2	+	0.1	0.1	1.00
Arnica mollis	+	0.0	0.0	0.0	+	0.0	+	1.00
Aster chilensis	3.4	3.0	11.3	10.8	10.2	4.8	7.3	0.47
Caltha leptosepala	0.1	0.2	0.3	+	0.1	0.1	0.1	0.59
Draba cana	+	+	+	0.0	0.0	0.0	+	N
Epilobium angustifolium	0.1	0.4	+	+	0.0	0.0	0.1	P
Epilobium hornemanii	0.1	0.1	+	0.1	0.1	0.3	0.1	0.29
Erigeron flagellaris	0.4	0.4	1.4	1.3	1.2	0.6	0.9	0.46
Erigeron superbus	13.1	12.7	6.3	4.4	3.6	2.2	7.1	P
Fragaria ovalis	0.0	0.1	0.1	0.1	+	0.1	0.1	1.00
Gallium boreale	0.0	+	+	0.0	0.0	0.1	+	N
Geranium richardsonii	0.3	0.6	1.0	0.1	0.1	0.1	0.4	1.67
Lewisia pygmaea	0.5	0.1	0.0	0.0	0.0	0.0	0.1	N

Table 2. Continued

Plant Species	Periods 1	2	3	4	5	6	$\overline{X}$	Preference
	Percent							
Forbs								
Mertensia viridis	+	0.8	0.3	0.2	+	0.1	0.2	P
Osmorhiza chilensis	0.0	0.3	0.2	0.2	0.1	0.1	0.2	P
Polygonum bistortoides	1.8	8.4	2.5	0.9	0.5	0.3	2.4	0.56
Potentilla diversifolia	+	0.2	0.1	+	0.0	+	0.1	N
Potentilla glandulosa	0.0	0.1	0.0	0.1	+	0.0	+	P
Potentilla gracilis	0.0	0.0	0.2	0.3	0.3	0.3	0.2	P
Ranunculus eschscholtzii	+	0.2	0.1	0.1	+	+	0.1	N
Sedum rhodanthum	0.0	0.0	0.0	0.0	0.0	+	+	1.00
Senecio ambrosioides	0.0	+	+	0.0	0.0	0.0	+	1.00
Solidago decumbens	0.0	0.7	0.1	0.0	+	0.0	0.1	P
Stellaria jamesiana	+	0.1	+	+	+	+	+	N
Stellaria longipes	0.0	+	+	0.1	+	+	+	1.00
Taraxacum officinale	6.8	14.2	12.5	9.8	10.0	6.9	10.0	3.06
Trifolium longipes	5.6	21.3	29.4	27.3	21.7	23.1	21.4	5.60
Veronica wormskjoldii	0.1	0.3	0.3	0.4	0.4	0.3	0.3	5.00
Viola spp.	+	+	+	+	+	+	+	P
Zigadenus elegans	0.0	0.1	0.1	+	+	+	+	P

Table 2. Continued

Plant Species	Periods						$\bar{X}$	Preference
	1	2	3	4	5	6		
	Percent							
Grasses, sedges								
Agropyron subsecundum	9.7	3.2	2.1	5.0	7.9	6.5	5.7	13.62
Agrostis alba	0.0	0.2	0.0	0.3	0.6	0.0	0.2	N
Agrostis scabra	3.9	0.0	0.8	5.7	9.5	5.3	4.2	4.44
Alopecurus alpinus	0.8	0.3	1.7	0.0	0.0	0.0	0.5	N
Carex bella	1.1	1.3	0.2	0.2	1.7	11.4	2.7	2.07
Carex microptera	28.1	9.8	3.9	8.0	6.7	13.2	11.6	0.57
Hordeum jubatum	0.0	0.0	0.0	0.1	0.2	0.0	0.1	N
Juncus confusus	3.2	5.5	2.5	3.5	6.8	3.7	4.2	4.47
Phleum alpinum	7.2	2.5	4.7	5.9	3.4	3.0	4.5	0.50
Poa spp.	5.9	3.8	4.0	3.2	1.2	2.3	3.4	0.06
Trisetum spicatum	1.4	0.5	0.7	0.9	1.3	1.6	1.1	P
Browse								
Abies lasiocarpa	0.0	0.1	0.0	0.0	0.0	0.0	+	N
Pinus contorta	0.1	0.0	0.0	0.0	0.0	0.0	+	N
Potentilla fruticosa	0.0	+	0.0	0.0	0.0	0.0	+	N
Rosa nutkana	0.0	0.0	0.0	0.0	0.0	+	+	N
Salix spp.	0.1	0.0	0.2	0.0	0.0	0.0	0.1	P

Table 2. Continued

Plant Species	Periods						$\bar{X}$	Preference[a]
	1	2	3	4	5	6		
	Percent							
Browse								
Vaccinium scoparium	1.5	0.2	0.0	0.3	0.0	1.7	0.6	N
Vaccinium caespitosum	+	+	+	+	+	+	+	N
Mushrooms[c]	0.0	0.7	8.1	8.1	9.7	6.9	5.6	P

[a] <1.00 = non-preferred, 1.00 - 2.50 = slightly preferred, 2.51 - 12.50 = preferred, >12.50 = highly preferred, P = apparently preferred, and N = apparently non-preferred.
[b] + = trace item, less than 0.05% of diet.
[c] Mushrooms not identified.

Table 3. Diet composition by dry weight and food preferences of elk grazing clearcut for two-week periods from 27 June to 18 September.

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference[a]
	Percent							
Forbs								
Achillea lanulosa	0.2	0.2	0.2	0.1	0.2	0.2	0.2	3.33
Antennaria spp.	0.8	0.1	0.1	0.3	0.4	0.7	0.6	0.11
Arabis holboellii	0.8	0.6	0.2	0.1	+[b]	0.0	0.3	N
Arnica cordifolia	5.4	4.2	1.8	0.9	0.2	0.0	2.1	0.51
Aster chilensis	12.5	20.1	15.3	23.3	18.9	13.6	17.3	4.71
Astragalus decumbens	+	+	0.2	0.1	0.3	1.0	0.3	0.11
Epilobium angustifolium	0.0	+	+	+	0.0	0.0	+	P
Erigeron flagellaris	0.0	0.1	0.2	0.1	0.0	0.0	0.1	P
Erigeron superbus	0.0	0.0	0.2	+	0.1	0.0	0.1	P
Fragaria ovalis	3.4	1.6	1.1	1.2	0.2	0.9	1.4	0.20
Gentiana romanzovii	0.0	0.0	0.1	0.2	0.1	+	0.1	P
Geranium richardsonii	0.4	0.4	0.5	0.6	0.1	+	0.3	P
Habenaria dilatata	0.0	+	0.0	0.0	0.0	0.0	+	N
Moldavica parviflora	0.0	+	0.0	+	0.0	0.0	+	P
Phacelia sericea	+	0.2	0.0	0.0	0.0	0.0	+	N
Potentilla gracilis	+	0.0	0.8	0.1	+	0.0	0.2	0.54
Solidago decumbens	26.2	35.7	36.7	34.7	39.4	37.9	35.1	3.02

Table 3. Continued

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference
	Percent							
Forbs								
Stellaria jamesiana	0.1	0.1	0.1	+	+	+	0.1	P
Taraxacum officinale	43.0	30.7	35.9	28.8	18.2	11.1	28.0	1.75
Trifolium repens	0.3	0.1	0.0	0.0	0.0	0.2	0.1	P
Grasses, sedges								
Agropyron subsecundum	0.3	0.3	0.2	0.6	0.5	0.7	0.4	1.19
Carex brevipes	2.1	0.3	0.4	1.7	5.1	7.7	2.9	0.19
Carex douglasii	0.8	0.2	1.3	1.1	1.1	0.4	0.8	P
Carex geyeri	1.6	0.2	0.1	1.3	4.3	5.4	2.2	2.18
Juncus confusus	0.1	0.0	0.0	+	0.0	0.2	0.1	P
Phleum alpinum	0.2	0.3	0.1	0.0	0.2	0.0	0.1	P
Poa spp.	0.7	2.0	0.1	0.3	0.1	3.7	1.2	0.01
Trisetum spicatum	+	0.0	0.0	0.2	0.0	+	+	P
Browse								
Arctostaphylos uva-ursi	0.0	+	0.1	0.0	0.0	0.3	0.1	P
Pachystima myrsinites	0.0	0.0	0.2	+	0.0	0.1	0.1	P
Pinus contorta	0.7	+	0.1	0.7	0.2	9.9	1.9	N

Table 3. Continued

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference
	Percent							
Browse								
Populus tremuloides	+	0.3	1.2	0.6	2.5	3.4	1.3	15.63
Ribes viscosissmum	+	+	0.0	0.0	0.0	0.0	+	P
Rosa nutkana	+	+	0.0	0.0	0.0	0.0	+	P
Rubus strigosus	0.0	0.0	+	+	0.0	0.0	+	P
Salix spp.	0.5	1.0	2.2	1.2	1.6	1.0	1.3	1.76
Vaccinium scoparium	0.0	0.2	0.4	0.3	0.7	0.2	0.3	14.00
Mushrooms[c]	0.0	0.0	0.0	1.6	5.4	1.5	1.4	P

[a] <1.00 = non-preferred, 1.00 - 2.50 = slightly preferred, 2.51 - 12.50 = preferred, >12.50 = highly preferred, P = apparently preferred, and N = apparently non-preferred.
[b] + = trace item, less than 0.05% of diet.
[c] Mushrooms not identified.

Table 4. Diet composition by dry weight and food preferences of elk grazing mature forest for two-week periods from 27 June to 18 September.

Plant Species	Periods						$\bar{X}$	Preference[a]
	1	2	3	4	5	6		
	Percent							
Forbs								
Achillea lanulosa	0.3	0.3	0.0	0.0	0.1	0.3	0.2	P
Arnica cordifolia	3.2	6.8	8.6	4.3	0.7	4.2	4.6	1.09
Epilobium angustifolium	0.2	0.0	0.1	+[b]	0.1	0.0	0.1	P
Erigeron superbus	5.4	13.5	12.2	5.1	2.2	8.2	7.8	7.86
Fragaria ovalis	0.3	+	+	+	+	0.6	0.2	N
Gallium boreale	0.1	+	0.0	0.0	0.0	+	+	P
Geranium richardsonii	2.5	1.0	0.3	0.1	0.3	0.4	0.8	P
Habenaria dilatata	0.0	0.0	0.0	+	0.0	0.0	+	N
Hieracium albiflorum	0.0	0.0	0.0	0.2	0.1	0.4	0.1	0.69
Osmorhiza chilensis	0.1	0.4	0.0	0.2	0.1	+	0.1	P
Polygonum bistortoides	1.6	1.3	0.2	0.0	0.0	0.0	0.5	P
Solidago decumbens	0.0	0.0	0.0	0.4	0.2	0.3	0.2	5.00
Stellaria jamesiana	+	0.0	+	0.1	0.0	+	+	N
Trifolium gymnocarpon	0.7	1.0	0.2	+	+	0.1	0.4	P
Zigadenus elegans	0.5	1.2	0.0	0.0	0.1	0.3	0.4	P
Grasses, sedges								
Bromus ciliatus	0.0	0.0	1.5	0.1	0.3	2.1	0.7	P

Table 4. Continued

Plant Species	Periods						$\bar{X}$	Preference
	1	2	3	4	5	6		
	Percent							
Grasses, sedges								
Carex geyeri	2.3	0.2	0.0	0.2	0.0	0.2	0.5	P
Trisetum spicatum	0.0	0.0	0.0	0.0	0.1	0.1	+	P
Browse								
Pachystima myrsinites	0.0	0.0	0.1	0.1	0.4	0.1	0.1	0.65
Pinus contorta	0.0	0.0	0.0	0.1	0.0	0.0	+	N
Populus tremuloides	0.4	0.6	0.0	0.1	0.1	0.0	0.2	P
Ramischia secunda	0.2	0.0	0.0	0.0	0.0	0.1	0.1	N
Rosa nutkana	0.1	+	0.0	0.1	+	0.0	+	1.00
Vaccinium caespitosum	0.0	0.0	0.0	+	0.0	0.0	+	N
Vaccinium scoparium	82.4	72.8	62.1	29.8	24.1	42.1	52.2	0.26
Mushrooms								
Aleuria aurantia	0.0	0.8	7.0	26.7	26.9	9.3	14.0	32.40
Boletus crysenteron	0.0	0.2	3.1	27.8	40.0	27.2	19.7	32.40
Russula emetica	0.0	0.5	4.0	4.8	3.8	4.1	3.4	32.40

[a] <1.00 = non-preferred, 1.00 - 2.50 = slightly preferred, 2.51 - 12.50 = preferred, >12.50 = highly preferred, P = apparently preferred, and N = apparently non-preferred.
[b] + = trace item, less than 0.05% of diet.

Table 5. Diet composition by dry weight and food preferences of elk grazing stagnated forest for two-week periods from 27 June to 18 September.

Plant Species	Periods 1	2	3	4	5	6	$\bar{X}$	Preference[a]
	Percent							
Forbs								
Achillea lanulosa	0.0	0.0	0.0	0.0	+[b]	0.0	+	+
Arnica cordifolia	0.0	0.0	0.0	5.5	1.5	+	2.3	0.14
Astragalus decumbens	0.0	0.0	0.0	0.0	0.4	12.0	4.1	0.42
Erigeron superbus	0.0	0.0	0.0	2.8	2.3	0.7	1.9	2.45
Fragaria ovalis	0.0	0.0	0.0	0.0	+	0.0	+	P
Gallium boreale	0.0	0.0	0.0	0.0	+	0.1	+	1.00
Geranium richardsonii	0.0	0.0	0.0	0.0	0.5	0.0	0.2	0.13
Habenaria dilatata	0.0	0.0	0.0	0.2	+	0.1	0.1	N
Hieracium albiflorum	0.0	0.0	0.0	3.5	0.4	1.9	1.9	P
Osmorhiza chilensis	0.0	0.0	0.0	0.0	+	0.0	+	P
Solidago decumbens	0.0	0.0	0.0	0.2	0.7	0.7	0.5	2.69
Stellaria jamesiana	0.0	0.0	0.0	0.2	+	0.1	0.1	N
Viola spp.	0.0	0.0	0.0	0.0	+	0.0	+	P
Zigadenus elegans	0.0	0.0	0.0	0.0	+	0.0	+	P
Grasses, sedges								
Bromus ciliatus	0.0	0.0	0.0	0.0	1.5	0.0	0.5	P
Carex spp.	0.0	0.0	0.0	0.0	8.5	24.8	11.1	49.70

Table 5. Continued

Plant Species	Periods						$\bar{X}$	Preference
	1	2	3	4	5	6		
	Percent							
<u>Grasses, sedges</u>								
Poa spp.	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.13
Trisetum spicatum	0.0	0.0	0.0	0.0	+	0.0	+	P
<u>Browse</u>								
Populus tremuloides	0.0	0.0	0.0	7.7	2.4	15.0	8.4	P
Ramischia secunda	0.0	0.0	0.0	0.0	0.0	0.3	0.1	N
Rosa nutkana	0.0	0.0	0.0	0.0	+	0.0	+	N
Vaccinium caespitosum	0.0	0.0	0.0	0.0	1.1	0.0	0.4	P
Vaccinium scoparium	0.0	0.0	0.0	6.2	2.0	11.8	6.7	0.03
<u>Mushrooms</u>								
Aleuria aurantia	0.0	0.0	0.0	14.7	15.5	5.0	11.7	30.15
Boletus crysenteron	0.0	0.0	0.0	55.3	59.6	27.2	47.4	30.15
Russula emetica	0.0	0.0	0.0	3.7	2.4	1.0	2.4	30.15

[a] <1.00 = non-preferred, 1.00 - 2.50 = slightly preferred, 2.51 - 12.50 = preferred, >12.50 = highly preferred, P = apparently preferred, and N = apparently non-preferred.

[b] + = trace item, less than 0.05% of diet.

(*Agrostis alba*) were principal species for one to three two-week periods but not in the summer average. Apparently preferred but minor components of the diet were western yarrow, aspen (*Populus tremuloides*), grouse wortleberry, and bearded wheatgrass.

Diets in dry meadow

By forage class, elk diets on dry meadows consisted mostly of forbs (Figure 1). However, grasses and sedges were more important than forbs in the first two-week period when forb availability was low. As the forb component matured in late summer, the animals again used more grasses and sedges. Browse contributed less to diets on dry meadows than on wet meadows, perhaps because less was available on dry meadows.

The principal species in the diet were aster, forest fleabane, dandelion, longstalk clover, bearded wheatgrass, smallwing sedge (*Carex microptera*), and mushrooms (Table 2). Of these, dandelion, longstalk clover, bearded wheatgrass, and smallwing sedge were preferred, and mushrooms were highly preferred. American bistort, rough bent (*Agrostis scabra*), showy sedge (*Carex bella*), Colorado rush (*Juncus confusus*), alpine timothy, and bluegrass (*Poa* spp.) also appeared as principal species for some portion of the summer diet. Apparently preferred species were Wormskjold speedwell (*Veronica wormskjoldii*) and showy sedge.

Diets in clearcut

Forbs contributed, by far, the most to diets on clearcut areas, likely a reflection of their relative abundance in the community (Figure 1). Aster, goldenrod, and dandelion were the principal species in the clearcut diets (Table 3). Aster and goldenrod were preferred, but dandelion was only slightly preferred. These three species were among the most available species in the forb class as was tailcup lupine, but the latter was consistently rejected by the elk; if even one leaf was accidentally grazed, the entire mouthful was dropped.

Western yarrow, aspen, grouse wortleberry, and mushrooms were apparently preferred but minor components in the diets. Of these, however, aspen probably was not preferred until the last two-week period. The sharp increase in browse utilization during the last period resulted from increased use of aspen and a sudden increase in the browsing of current annual growth on lodgepole pine.

Diets in mature forest

Grouse wortleberry, the principal browse species (Table 4), was distinctly non-preferred but persisted as the major part of the elk diet in the mature forest during four out of six two-week periods (Figure 1). This probably was because wortleberry represented 93 percent of the total forage resource and selection of a diet containing larger portions of forbs, grasses, and sedges would have required excessive time and effort from the animal. Even with selection of what was probably the optimum mix of forbs, browse, grasses, and sedges, the elk were unable to consume forage at a rate enabling them to meet quantitative dry-weight requirements. This is demonstrated by the fact they constantly drifted out of the mature forest to some other habitat segment. Only when mushrooms became available for substitution of browse species did the elk appear content to graze the mature forest for any length of time (Figure 2).

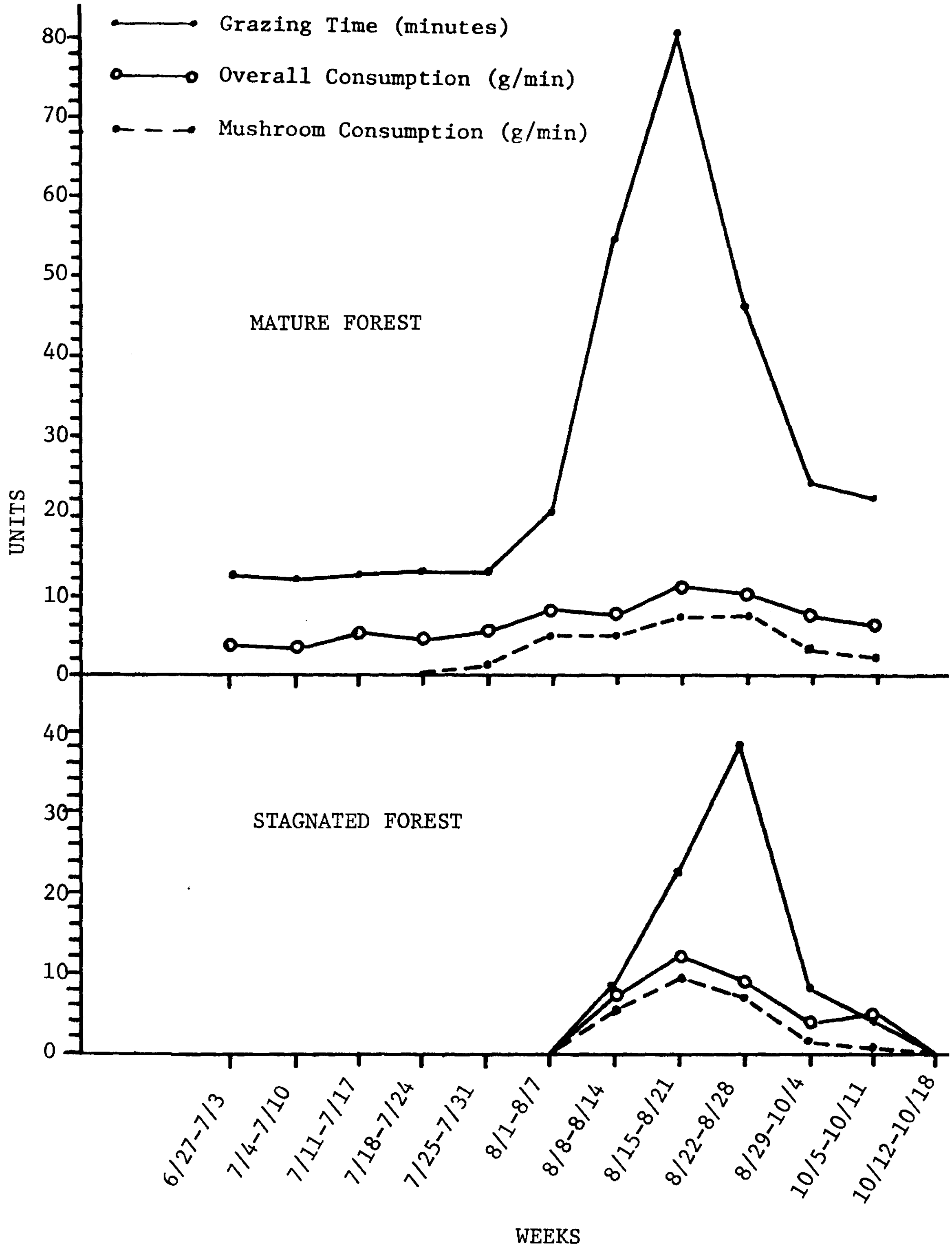

Figure 2. Effect of mushrooms on overall time spent and consumption within forested segments. Time measurements are the average time elk would graze these segments before moving to a non-forested segment.

The principal species of the diet were forest fleabane, grouse wortleberry, and mushrooms (Table 4). Forest fleabane was preferred, and mushrooms were highly preferred. Goldenrod and all other forbs eaten were preferred but minor components in the diet.

Diets in stagnated forest

The elk's reluctance to graze a grouse wortleberry-dominated type was even more evident in the stagnated forest, where forage was more sparse than in the mature forest. There, the elk refused to feed at all for seven weeks of the summer, and when they did use it, the apparent attraction was mushrooms. Thus, mushrooms were the major forage class of this diet (Figure 1, Table 5). Figure 2 illustrates how the mushroom crop stimulated the overall consumption rate, and thereby increased the attractiveness of both the stagnated and mature forest habitat segments in late summer. It is assumed that the time the elk spent grazing the forested segments before walking to non-forested segments can be used as an index to relative attractiveness.

Similarity of diets

Although several preferred species occurred in each habitat segment's array of forage, differences in relative forage abundance prevented consumption of markedly similar diets between most pairs of habitat segments. Significant similarities existed between the following pairs: wet meadow and dry meadow, dry meadow and mature forest, dry meadow and stagnated forest, and mature forest and stagnated forest (Table 6). Of these, however, only the mature forest and stagnated forest had a substantial degree of similarity (>50%).

Table 6. Similarity indexes (%) and rank order correlation coefficients (r_s) comparing on a species dry-weight basis the diets of elk on different habitat segments of the lodgepole pine type, Uinta Mountains, Utah.

Statistic	Habitat Segments Compared[a]									
	Wet vs. Dry	Wet vs. Clearcut	Wet vs. Mature	Wet vs. Stagnated[b]	Dry vs. Clearcut	Dry vs. Mature	Dry vs. Stagnated	Clearcut vs. Mature	Clearcut vs. Stagnated	Mature vs. Stagnated
%	21.6	26.2	12.8	17.7	14.8	16.0	20.3	5.7	12.4	68.9
r_s	0.51*	0.18	0.41	0.33	0.12	0.54*	0.54*	-0.34	0.45	0.47*

[a]Mean summer diets compared.
[b]For diets paired with stagnated forest diets, only that portion of summer diet consumed during the period the elk used the stagnated forest was used in calculations.
*Significant correlation (P = .05)

General relationships

Considering all factors, forbs appear to be the most important forage class in the elk's summer diet. In all habitat segments, forbs were relatively more abundant in the diet than in the forage, and as later discussion will show, elk preferred those habitat segments where forbs were the major portion of the diet (i.e. dry meadows, wet meadows, and clearcuts).

Grasses and sedges are the second most important forage class, because they are generally less preferred and less abundant in the diet than forbs. They are, however, by far the most available forage class in the preferred habitat segments.

A comparison between browse-dominated forest segments and habitat segments containing little browse seems to indicate that browse is important but to a lesser extent in elk summer diets. Higher browse preference is exhibited in those segments containing little browse. Also, it was not uncommon for the elk to occasionally move for brief periods from forb-grass-dominated habitat segments to adjacent browse-dominated segments and graze only upon browse. This phenomenon may have been in response to a monotony factor (Kiley 1971).

Mushrooms, though highly preferred, were restricted in availability over time and were primarily associated with non-preferred habitat segments. When available, they attracted elk to areas otherwise lightly used, and they may prove to be nutritionally important.

Tame elk methods

The use of tame animals is expensive and requires long-term investments in raising and training, but it appeared to be the method best suited for the needs of this study. Some of the advantages of the method for the gathering of diet composition data are: (1) Unlike rumen content analysis, the method requires no sacrifice of animals; (2) The observer knows exactly where, geographically, any species or portion of the diet was consumed (a major failing of the fecal analysis method); (3) Positive identification can be made of all species either eaten or consistently rejected; (4) The portion of the plant selected and the phenological state of the plant can be noted; (5) Tame animals can be used as a source of rumen fluid for subsequent forage digestibility analyses; (6) Observations can be planned in relation to the needs and design of the study; (7) Large amounts of data can be gathered in a relatively short time; and (8) Consumption rates can be estimated with reasonable accuracy.

Maintenance on native forage

A common objection to tame animal studies is that the animal's unfamiliarity with native forages causes it to exhibit unnatural forage preferences. Likewise, some researchers have indicated that the experience an animal has had with a particular feeding site can influence the efficiency of its foraging and selection process (Arnold 1969, Neff 1974). However, the two enclosures, constructed to provide an adjustment period and maintenance on native forage, served well their purposes.

When taken out of the enclosures for diet sampling, the elk did not appear to express any greater eagerness in the first few minutes of feeding than they did at the beginning of grazing activity occurring after the animals had been free ranging for 24 hours. Additionally, measured average daily weight gains of approximately 575 g per animal indicate that the elk were adequately maintained while in the enclosures. This is in sharp contrast to the situation reported by Neff (1974) wherein tame deer were observed to spend much sampling time exploring and establishing forage preferences and, consequently, to consume native forage at a rate which would have required 21.5 hours of grazing per day to meet maintenance dry-weight requirements. At no time during the summer were the elk observed to exhibit the exploratory behavior described for mule deer by Neff (1974).

Only in the last two periods did the 1.54 ha enclosure appear to produce an inadequate amount of forage; 15 bales of hay were fed to supplement native forages during those periods. The elk were also given a handful of barley as a reward for returning to the enclosures after each sampling period, but this seemed unnecessary much of the time because they often exhibited preference for native forage over the barley and would not eat it. One elk never ate barley.

Diet preference ratings

The degree of vegetational sampling required for accurate preference ranking of all forage species was beyond the scope of this study. Some species in the lodgepole pine type are so aggregated that extremely large samples would be required to glean even a rough approximation of relative availability. The same is true for uniformly distributed but sparse species comprising less than 0.5 percent of the forage dry weight. Relative preference, ranked by broad categories, is as accurate as can be justified under the limitations of the availability data (Tables 1 through 5).

Habitat Segment Preferences

Six 24-hour scan sampling periods were completed during the summer. This amounted to almost 144 hours of group observation and 1008 hours of individual elk observation. Sampling was carried out on schedule in all types of weather, and the data are complete except for nine 10-minute intervals. Figure 3 gives the breakdown of a typical summer elk day.

Grazing

Table 7 related voluntary elk use of different habitat segments to the relative available area of each segment. Preference quotients are used to interpret the evident non-random use of the area. The quotients indicate wet meadows were highly preferred habitat segments for grazing; revegetated roads, dry meadows, and clearcuts were preferred, and forested segments were clearly non-preferred as forage sources. Areas of openings farther than 60 m from forested edge were never grazed and thus deemed behaviorally unavailable for grazing.

The understory on revegetated roads and clearcuts is similar, yet revegetated roads appeared considerably more preferred. Possible explanations for this are that the revegetated roads often represented access routes through timber connecting preferred meadow grazing sites and they had higher cover values than clearcuts.

Resting and other activities

Ruminating and lying were recorded as two separate activities, but they usually occurred on the same locations, lying generally interspercing or immediately following rumination. Both were classed as the state of resting for the purposes of discussion (Figure 3). Resting

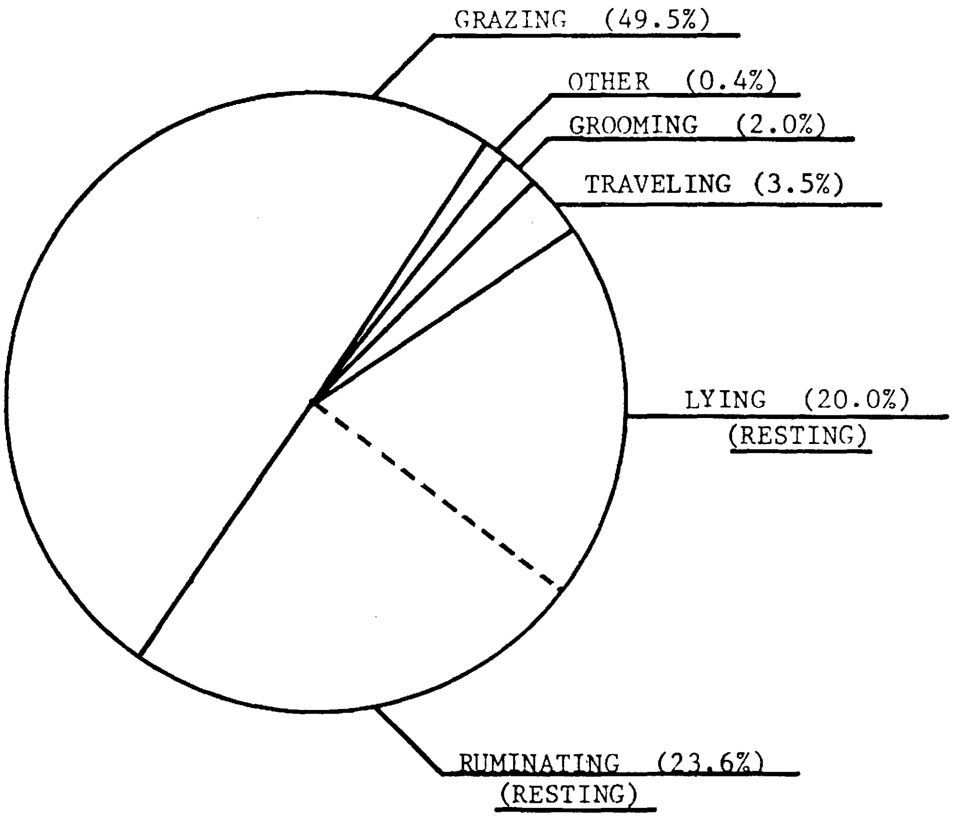

Figure 3. Mean relative time expenditures for the 24-hour elk day based on observations of seven elk for six 24-hour periods.

Table 7. Comparative voluntary use of different habitat segments in the lodgepole pine ecosystem, Uinta Mountains, Utah.

Habitat Segment	% Total Area	Grazing		Resting and Other Activities[b]	
		% Total	Preference Quotient[a]	% Total	Preference Quotient
Wet Meadow	2.7	43.6	16.1	49.9	18.5
Dry Meadow	11.7	33.6	2.9	7.9	0.7
Clearcut	4.4	14.6	3.3	2.4	0.5
Roads	0.6	3.0	5.3	1.0	1.8
Mature Forest	11.9	3.3	0.3	21.4	1.8
Stagnated Forest	68.7	2.0	0.1	17.4	0.3

[a]Preference quotient less than 1.00 indicates non-preferred, greater than 1.00 indicates preferred.
[b]Other activities include ruminating, lying, traveling, grooming, playing, sleeping, standing, and drinking. See Figure 3.

usually occurred on or immediately adjacent to sites where grazing periods were completed. Notable exceptions were when flies or mosquitos were noticeably irritating the elk. At such times, the elk moved to upland sites where they preferred to rest in either forest edges which projected in peninsular fashion into openings or small islands of trees within openings. It was likely these configurations of timber were preferred because breezes could penetrate such sites and reduce insect activity.

Table 7 shows wet meadows were also highly preferred for resting and non-grazing activities. Revegetated roads and mature forest were preferred; clearcuts, dry meadows, and stagnated forest were not preferred for these activities. One would expect resting and other non-grazing activities to occur in relatively secluded spots within the type. In considering the high preference for wet meadows, one must realize that most of the wet meadows in the area have high cover values because they seldom exceed 15 m width and are often densely covered with live and fallen trees, beaver dams, high shrubs, and tall grass. Similarly, revegetated roads are less than 10 m wide and generally lined with dense cover along both sides. Thus, in these situations, elk apparently have no need to seek additional cover for resting, but simply lie down in a preferred feeding location. The fact that dry meadows and clearcuts are considerably more open and were non-preferred for resting activities further supports this view. Stagnated forest was non-preferred as a resting area since it seldom occurred immediately adjacent to areas where grazing activity ended; resting usually was initiated soon after the elk drank and stagnated stands are usually located on upland sites away from water. Exceptions occurred when the elk sought relief from insect irritation. Resting, which interspersed grazing activity associated with dry meadows and clearcuts, seldom occurred more than 10 meters into adjacent timber stands or more than 2 meters out from the edge.

Traveling, an activity distinctly separate from the act of grazing, took place mostly in the mature or stagnated forests as the elk were moving from one forest opening to another. Certain old roads were also regularly used as trails between openings.

Grooming occurred at any place or time of day. However, 48 percent of grooming was in the stagnated forest and 43 percent in the mature forest. Most grooming was done in the forested segments because 92 percent of all grooming entailed rubbing aspen. In this grooming act, the elk scraped the aspen bark with their teeth, wetted the scraped bark with saliva, and then rubbed the head, ears, neck, and foresides on the wetted bark. None of the bark was ingested, and the activity sometimes continued for 15 minutes at a time.

The elk seldom went more than 12 hours without drinking. They drank wherever water was available, excluding central portions of large openings.

Standing, as a distinctly observable state, preceded elk movement from one area to another and often appeared to be associated with the animal orienting direction of travel.

Sleeping occupied an average of 0.2 percent of the elk day and never lasted more than 5 minutes at a time. The sleeping animal was always located near the center of the herd, and seldom did more than one of the seven sleep at one time.

Play typically occurred during early morning or evening hours shortly after the elk arose to feed. It consisted of tag, frolicking in beaver ponds, or mock fighting. However, mature elk may not be found to exhibit quite as much play behavior as did these yearlings.

Elk day

The elk day always began about one-half hour after the sky began to lighten. At that time the animal would rise, stretch and groom. It then would proceed to graze, eagerly for the first 10 to 15 minutes, then at a fairly constant rate for 3.5 to 4.0 hours. During this time, the animal would either graze one habitat segment continuously or shift several times from one segment to another. By 1000, the animal would usually lie down to ruminate on a forested upland site. From 1000 to 1600, the elk would ruminate or lie still and, occasionally, get up to graze for 10 to 20 minutes. About 1600, the animal would begin grazing in earnest once again. This would continue until about one-half hour before dark. During this period, the elk would return to preferred bedding areas, often traveling more than 2 km to do so. At dark, the animals would graze for another 1.5 hours before lying and alternately ruminating and lying still. At 0100 or 0130, they would again graze for another 1.0 to 1.5 hours. The remainder of the night was spent lying, ruminating, and occasionally grazing for 10 to 20 minute periods.

Effects of moon phase and weather

The phase of the moon had no observable effect on the nighttime activities of the elk. They appeared to be keenly adapted to grazing and moving through timber on even the darkest of nights.

Summer rains did not alter the elk's activity, but hot, humid weather did cause the elk to remain in shade for a greater portion of the daylight hours (Edgerton and McConnell 1976). Such days were associated with swarms of flies and mosquitos which kept the elk from productive grazing until the cool night hours when insect activity was reduced. Breezy days reduced insect attacks on the elk, but strong winds caused them to be nervous and graze inefficiently (McCullough 1971, p. 69, p. 71).

Pellet group distributions and defecation rates

Those who use pellet counts as an index to relative habitat segment use assume that ungulates defecate at uniform rates (Riney 1957, Neff 1968). However, Anderson (1969) questioned this assumption. Early in the summer, it became apparent that the elk were not defecating at uniform rates. For example, they often grazed 2.0 to 2.5 hours without defecating, then, upon moving to water or another feeding site, would defecate one to four times in a period of 3 to 15 minutes. Also, the animals commonly defecated immediately upon rising from ruminating or resting, or after the first few steps.

The hypothesis that relative distributions of pellet groups and actual elk use are not significantly different was rejected ($G = 171.3 > X^2_{.005(5)} = 16.750$). Clearly, the distribution of pellet groups did not give accurate representation of relative habitat segment use. Likewise, distribution of pellet groups does not accurately reflect observed distribution of grazing activity ($G = 255.7 > X^2_{.005(5)} = 16.750$). Figure 4 compares the distribution of pellet groups with the

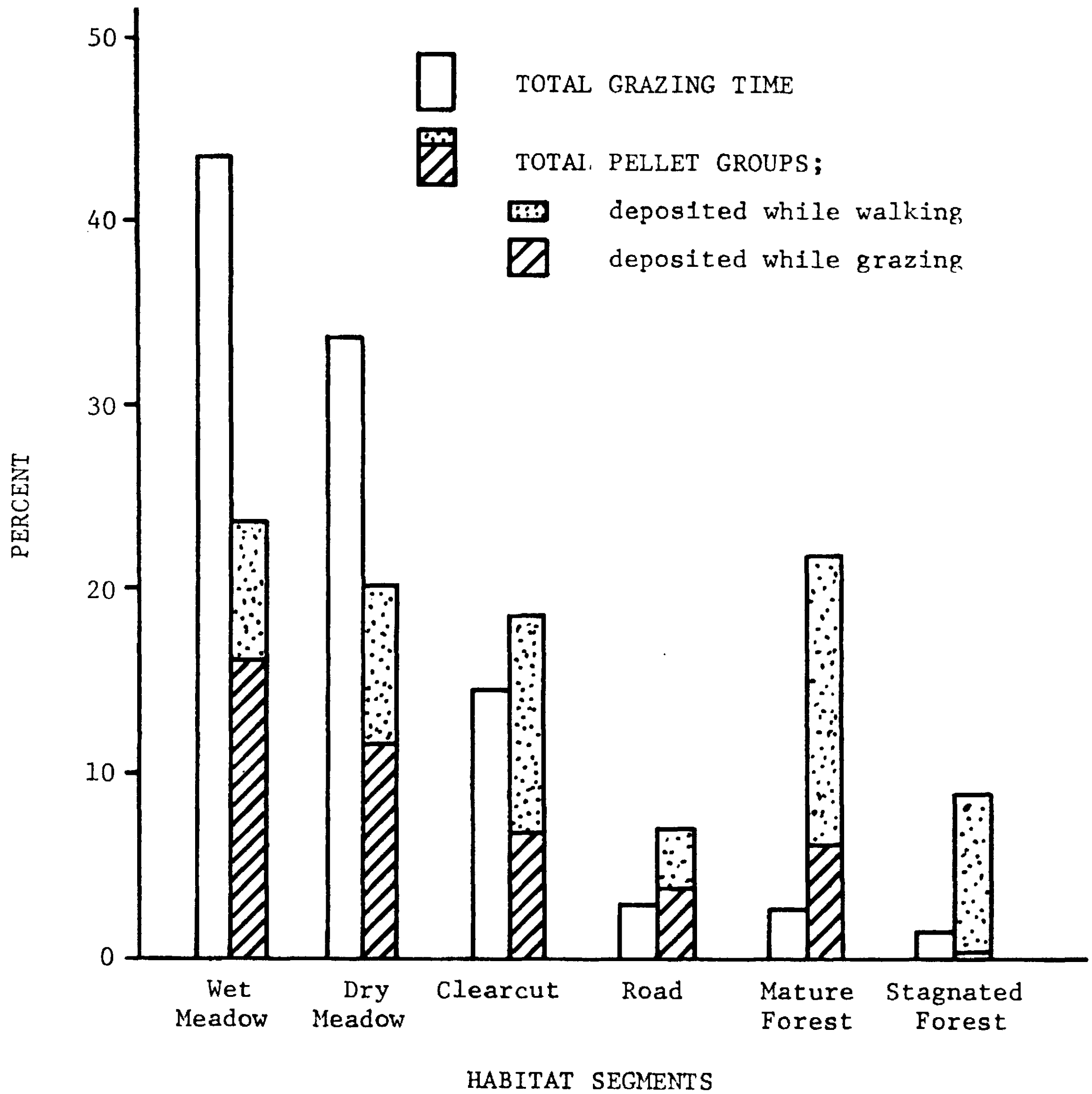

Figure 4. Pellet-group distribution related to mean grazing time and walking by habitat segment. One-hundred percent of all observed defecations occurred during grazing or walking activity.

mean distributions of grazing and walking activities; the elk were never observed to defecate during any other form of activity.

It was eventually realized that the elk defecated most when they were most active (i.e. walking from one area to another). The second bar in Figure 4 separates the percent of all pellet groups which were deposited when the animal was simply walking through an area from those deposited during actual grazing activity. Likewise, it seemed logical that elk would defecate more per unit of time in habitat segments where more walking would be required in the grazing activity. Such was found to be the case in a comparison conducted during the diet observation studies between the clearcut and stagnated forest habitat segments. These two segments were chosen for the comparison because they are adjacent and the elk tended to wander back and forth between them every 5 to 10 minutes; use was being made of the stagnated forest because mushrooms were available at the time. Under these conditions, the elk were observed to defecate 4.1 times more per unit of time in the stagnated forest than in the clearcut.

A mean defecation rate was calculated after the first scan sampling period to check the observer's ability to witness most defecations. Surprisingly, this mean was 24 defecations per elk per day, much higher than expected. This was verified by counting pellet groups inside one of the enclosures. The total number of pellet groups deposited by seven elk in 351 hours in the 1.17 ha enclosure, resulted in a calculated rate of slightly more than 23 pellet groups per elk per day. Thus, it is safe to say that most defecations occurring in the scan sampling periods were witnessed by the observer.

Tame elk methods

Tame animals were well suited for observation of elk activity because: (1) The observer's presence did not disrupt elk activity, (2) Exact location of the animal's activity could be referenced to specific habitat segments, and (3) The observer was able to stay with the elk over great distances and long periods of time to record a continuum of elk activity.

The presence of the observer never appeared to inhibit the elk in any way. Likewise, once the elk had a few minutes to adjust, they payed no further attention to the lights used for following and observing them at night. Aside from their habituation to the observer's activities, the elk in all ways appeared to behave as wild elk. Any strange noise, odor, or sight brought as instantaneous alarm to the tame elk as to wild elk. In fact, the observer's presence was so ignored by the elk that his only option for gaining their attention was to act as if alarmed by something in the timber.

Grazing Values

Selection of habitat segments by elk for grazing appears to be strongly influenced by forage availability and associated grazing values. Alden (1962) proposed that increased forage availability increases consumption while at the same time decreasing grazing time and number of bites required. The elk in this study appeared to respond to availability in much this way, although they were not sampled in a pasture situation.

The hypothesis that the mean forage consumption rate on forested habitat segments is not significantly different from the mean consumption rate on non-forested segments was rejected ($P \leq .05$). Individual habitat segment means are compared in Table 8. Differences in consumption rates were the result of strong differences in forage availability. Figure 5 shows the elk spent most of their grazing time on more productive habitat segments where high consumption rates were possible. Elk appear to prefer (Table 7) grazing areas where they can receive the greatest dietary return on their grazing time investment within the constraints imposed by forage preferences.

Table 8. Mean consumption rates of elk (gms/min) on different habitat segments in the lodgepole pine type, Uinta Mountains, Utah.

	Habitat Segments				
	Wet Meadow	Dry Meadow	Clearcut	Mature Forest	Stagnated Forest
Mean Rates	13.5 [a]	10.6	9.5	6.2	3.7

[a]Means connected by a continuous underline are not significantly different ($\alpha = .05$) by Duncans multiple range test.

Figure 6 integrates four measures of feeding behavior which may help explain differences in consumption rates. Two principal factors are the size and spatial frequency of forage plants; increases in either or both allow higher consumption rates. Moisture content of mean bites on green forage also strongly affects consumption rates converted to dry weight basis. Both bites per minute and distance traveled in the grazing activity are expressions of the combined effects of these factors.

Consumption rates were highest on the most productive and species-diverse communities. Forage availability and consumption rates were

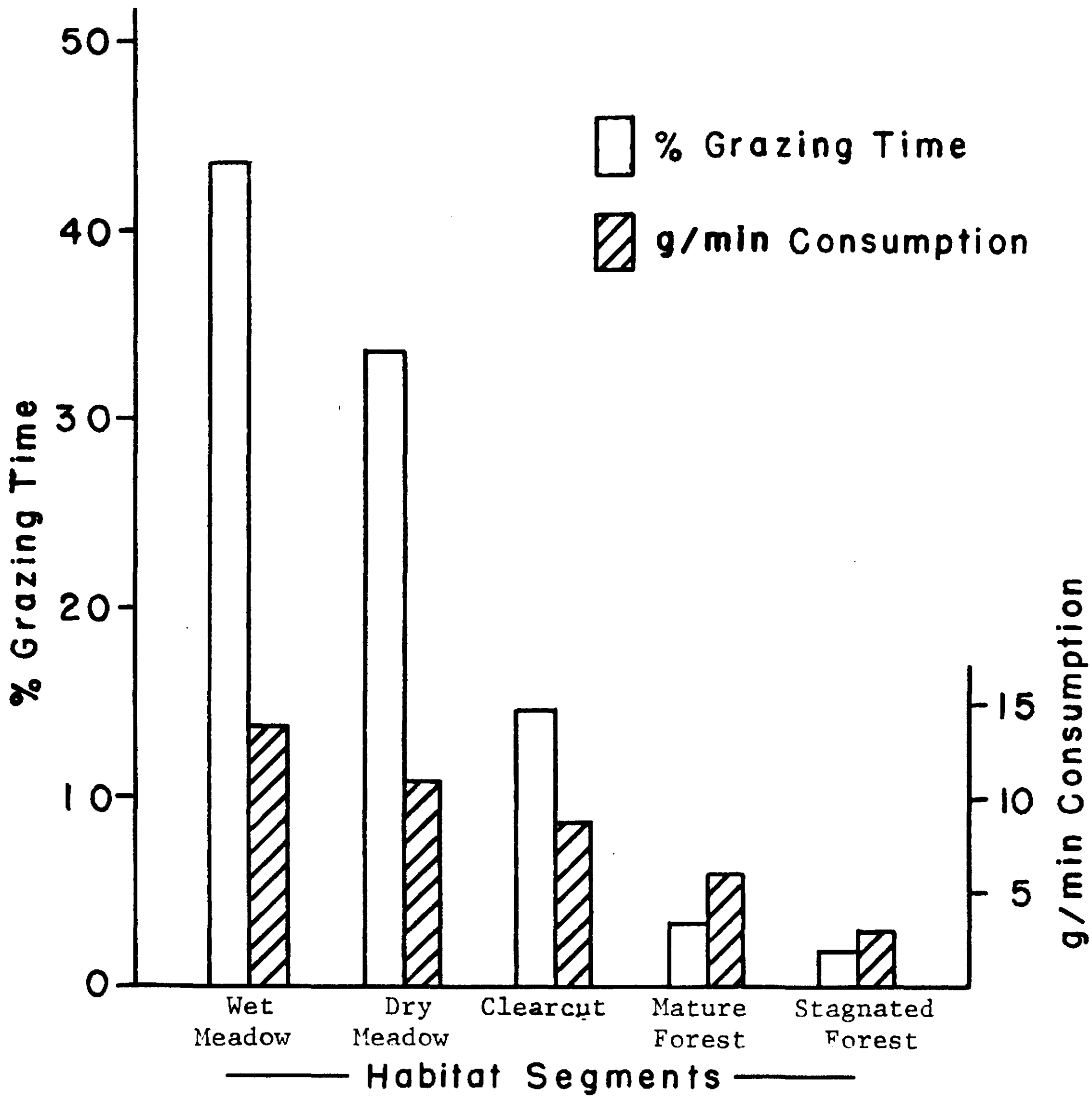

Figure 5. Relationship of dry-weight consumption rate to grazing use.

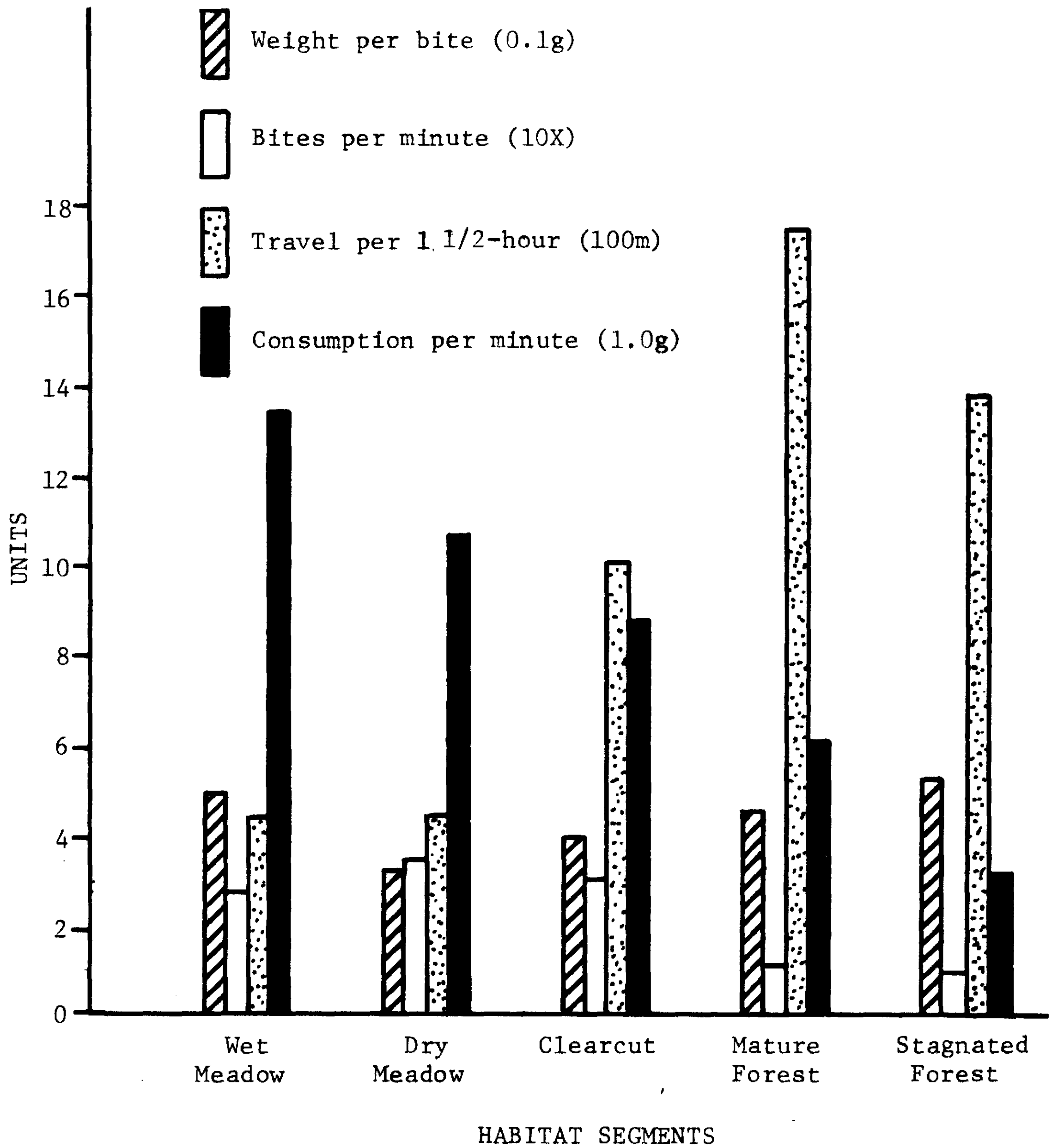

Figure 6. Comparative grazing values for elk of five habitat segments in the lodgepole pine type.

higher for wet meadows than dry meadows because wet meadow plants are taller, greater in volume, and are taken in larger bites that yield higher dry-weights. Availability and consumption rates were lowest for clearcut and forested segments because preferred species were not only smaller, but more importantly, less dense.

Bite dry-weights were high for forested segments because mushrooms were the major contributors to the diets; mushrooms have relatively low moisture content and are usually eaten in large bites. Grouse wortleberry is also high in dry matter and contributed substantially to mature forest diets. Bite dry-weights were high in wet meadow diets because the forage there was eaten in large bites.

Elk may compensate for low forage availability resulting from relatively short, low-volume plants by increasing their number of bites per unit time. This is especially evident in the comparison between wet and dry meadow diets (Figure 6), where both segments are densely populated with palatable species, but where species of the dry meadow are shorter in stature and low in volume. When availability is the result of low forage density the elk use time, otherwise devoted to bites, for traveling and searching for preferred species. This is evident in the contrast of dry meadow diets against clearcut and forest diets where bites per unit time were reduced and distance traveled increased (Figure 6). Although bites were heavier for clearcut and forested segments, overall availability was lower, as indicated by lower consumption rates.

Consumption rates can determine whether or not a habitat segment will be grazed at all. This threshold for acceptance of a segment as a forage source may be dependent on the elk's minimum daily dry-weight forage requirement. Figure 7 relates biweekly consumption rates to the lowest rate meeting the apparent daily dry-weight requirement of elk. This was established by determining that rate which would allow an elk to consume 5 kg dry-weight of forage in 12 hours of grazing time. Five kg is the Forest Service (1969) estimate of the daily dry-weight requirement of one mature cow elk and 12 hours is about the average time the elk were observed to graze during the 24-hour scan sampling periods. As can be seen from Figure 7, the relatively unproductive forested segments were below the apparent dry-weight requirement rate most of the summer. Peak consumption rates for the forested segments were found to coincide with the periods of peak elk use. Some of the upward trend in consumption rates for the first four two-week periods in all types may have resulted from increasing grazing efficiencies and demand on the part of the growing elk, but most of the increase was probably due to growth and increased availability of forage. Increased forage availability with advancement of time was especially evident in forested, clearcut, and dry meadow segments. Similarly, the rates declined after plants matured and began to deteriorate because much less forage was available to the elk. The exception to this was the wet meadow where a dietary shift to erect, heavy sedges caused the consumption rate to increase further.

Figure 8 presents relative grazing times weighted by appropriate consumption rates to further delineate each habitat segment's value as a forage resource. The relationship of percent of total consumption to available area illustrates an important point; small clearcut openings greatly increase forage resources for elk because they are developed

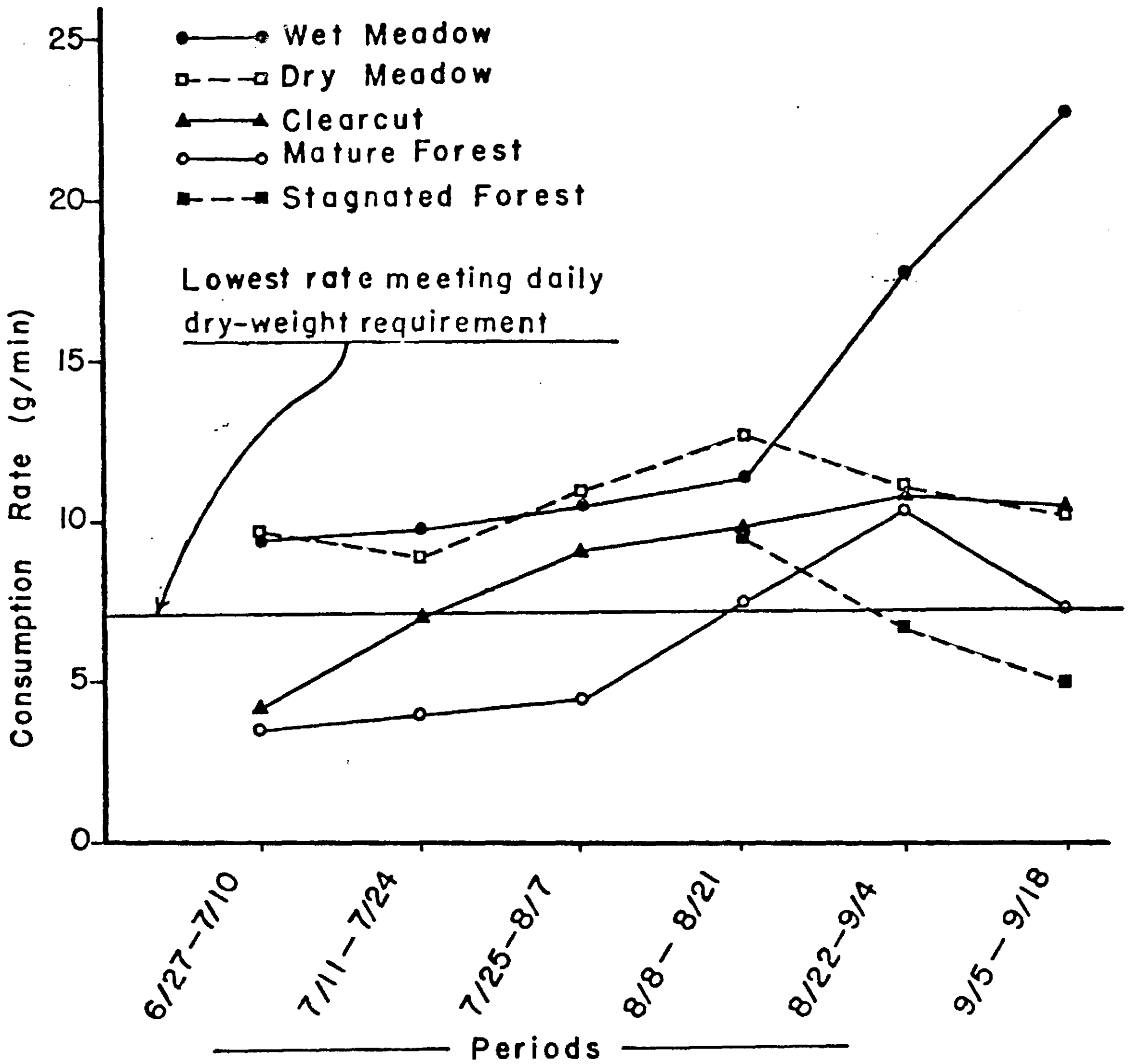

Figure 7. Biweekly consumption rates of elk in reference to the lowest rate allowing consumption of 5 kg dry matter per day, the apparent dry-weight requirement for a mature cow elk (USFS 1969), in 12 hours of grazing (mean observed daily grazing time for free-ranging elk in the lodgepole pine type).

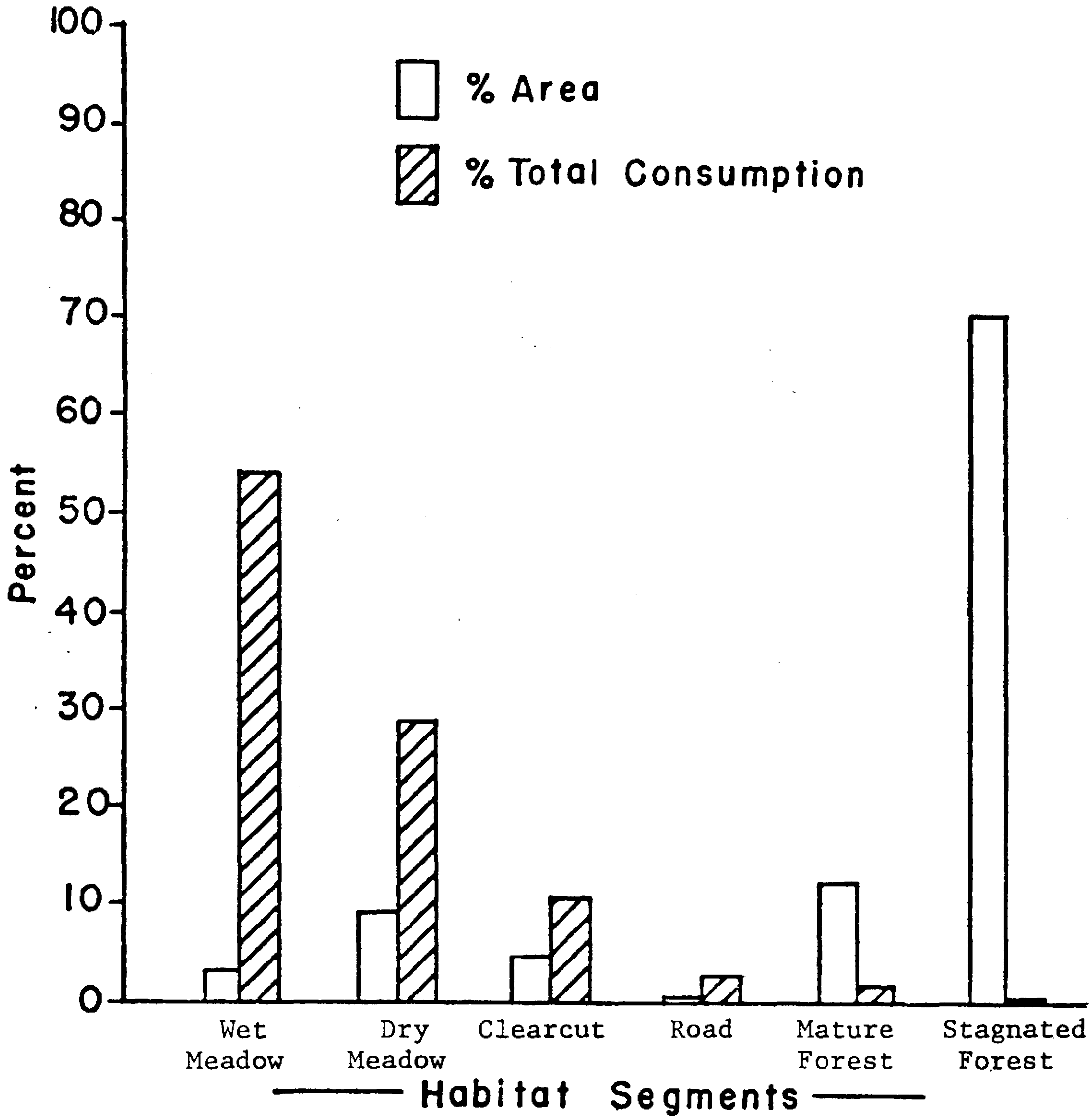

Figure 8. Total consumption relative to available area of each habitat segment.

directly out of unproductive forested segments. Wet and dry meadows are relatively fixed resources.

SUMMARY AND CONCLUSIONS

Knowledge of elk diets and behavior in reference to specific habitat segments is requisite to the development of silvicultural practices which will affect elk summer range. The objectives of this study were to determine diet compositions and habitat segment preferences of elk using subunits within the lodgepole pine type.

1. Tame elk were observed feeding on different lodgepole pine habitat segments and their diets were established on a species dry-weight basis. Fewer than half of the paired comparisons between diets showed significant similarities; only one pair had substantial ($>$50%) overlap, namely, mature and stagnated forest.

2. Forbs were the major forage class in summer elk diets and they were generally preferred. Grasses and sedges were the second greatest contributors to the diets, but were usually non-preferred. Browse was important but to a lesser extent than the other forage classes. Mushrooms, though highly preferred, were restricted in availability over time. Mushrooms had special significance in attracting elk in mid-summer to forested segments which were otherwise lightly used.

3. Plant species preferences were established and ranked by broad categories. Such rankings are as precise as can be justified when availability data are extensively gathered.

4. Observations on the behavior of free-ranging elk were made to determine relative elk use of different habitat segments. Segment preferences were established on the basis of percent of grazing time and total area available. Segment preferences for grazing in descending order of importance were: wet meadows, revegetated roads, clearcuts,

and dry meadows. Wet meadows were highly preferred. Preference quotients for clearcuts and dry meadows were biased downward because of behaviorally unusable center portions. Forested segments were non-preferred for grazing.

5. Elk preference of segments for resting and non-grazing activities in descending order of importance were: wet meadows, revegetated roads, and mature forest. Wet meadows were highly preferred because cover was adequate and foraging usually terminated there. Revegetated roads and mature forests had almost identical preference quotients. Dry meadows and clearcuts were non-preferred presumably because they lacked cover, and stagnated forest was non-preferred because grazing seldom terminated in habitat segments commonly adjacent to such stands.

6. Behavioral observations indicated that, of all types of summer weather, only hot, still days or windy days altered elk activity. Elk avoided grazing during hot, still days because insect attacks were intense then. Windy days caused elk to become nervous and graze inefficiently.

7. Record was made of defecations with reference to the habitat segments in which they were deposited. The null hypothesis that relative distributions of pellet groups and actual elk use were not significantly different was rejected ($P \leq .005$). Elk were found to defecate relatively less while grazing in preferred habitat segments. Therefore, pellet group accumulations as indicators of habitat segment use and value should be cautiously interpreted.

8. The summer defecation rate for elk in the lodgepole pine type was determined to be about 23 pellet groups per elk per day.

9. Dry-weight consumption rates were determined from diet data. Habitat segment grazing preferences and consumption rates were highest on the most productive and species-diverse communities. Consumption rates were significantly different ($P \leq .05$) between all habitat segments except the dry meadow and clearcut.

10. Behavioral parameters such as walking rates and bite rates were also determined during diet observation periods. Data indicated elk compensate for low availability resulting from short, low-volume plants by increasing their bite rate. Low availability resulting from low plant density was associated with increased walking and searching activity.

11. Elk appeared to prefer grazing areas where they could maximize intake of preferred species with a minimal expenditure of time and effort.

12. Small created openings in the lodgepole pine type greatly increased behaviorally acceptable forage supplies, especially when they were established in stagnated stands.

13. Tame elk, with minor exceptions, were found to be ideally suited for both diet and habitat segment preference studies.

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APPENDICES

Appendix A
Plant Species Names

Table 9. Common and botanical names of plant species appearing in the text.

Common Name	Botanical Name
Agoseris, pale	*Agoseris glauca*
Angelica, small-leaf	*Angelica pinnata*
Arnica, hairy	*Arnica mollis*
Arnica, heartleaf	*Arnica cordifolia*
Aspen, quaking	*Populus tremuloides*
Aster, Pacific	*Aster chilensis*
Barberry, creeping	*Berberis repens*
Bedstraw, northern	*Gallium boreale*
Bent, redtop	*Agrostis alba*
Bent, rough	*Agrostis scabra*
Bistort, American	*Polygonum bistortoides*
Bluebells, greenleaf	*Mertensis viridis*
Bluebells, mountain	*Mertensis ciliata*
Blueberry, dwarf	*Vaccinium caespitosum*
Bluegrass	*Poa* spp.
Brome, fringed	*Bromus ciliatus*
Bugorchid, white	*Habenaria dilatata*
Buttercup, Eschscholtz	*Ranunculus eschscholtzii*
Calypso, fairyslipper	*Calypso bulbosa*
Cinquefoil, blueleaf	*Potentilla diversifolia*
Cinquefoil, bush	*Potentilla fruticosa*
Cinquefoil, gland	*Potentilla glandulosa*
Cinquefoil, northwest	*Potentilla gracilis*
Clover, hollyleaf	*Trifolium gymnocarpon*
Clover, longstalk	*Trifolium longipes*
Clover, white	*Trifolium repens*
Columbine, golden	*Aquilegia crysantha*
Current, sticky	*Ribes viscosissmum*
Dandelion, common	*Taraxacum officinale*
Deathcamas, mountain	*Zigadenus elegans*
Draba	*Draba cana*
Dragonhead, American	*Moldavica parviflora*
Fir, subalpine	*Abies lasiocarpa*
Fleabane, forest	*Erigeron superbus*
Fleabane, Oregon	*Erigeron speciosus*
Fleabane, trailing	*Erigeron flagellaris*
Foxtail, alpine	*Alopecurus alpinus*

Table 9. Continued

Common Name	Botanical Name
Foxtail, barley	*Hordeum jubatum*
Gentian, Romanzoff	*Gentiana romanzovi*
Geranium, Richardson	*Geranium richardsonii*
Goldenrod, decumbent	*Solidago decumbens*
Groundsell, ragweed	*Senecio ambrosioides*
Hawkweed, white	*Hieracium albiflorum*
Honeysuckle, bearberry	*Lonicera involucrata*
Horsetail, field	*Equisetum arvense*
Lewisia, least	*Lewisia pygmaea*
Lupine, tailcup	*Lupinus caudatus*
Manzanita, bearberry (Kinnikinnick)	*Artostaphylos uva-ursi*
Marigold, marsh	*Caltha leptosepala*
Milkvetch, decumbent	*Astragalus decumbens*
Onion, tapertip	*Allium acuminatum*
Pachystima, myrtle	*Pachystima myrsinites*
Paintbrush, Wyoming	*Castilleja linariaefolia*
Phacelia, silky	*Phacelia sericea*
Pine, lodgepole	*Pinus contorta*
Pussytoes	*Antennaria* spp.
Ramischia	*Ramischia secunda*
Raspberry, American red	*Rubus strigosus*
Rockcress, Holboell	*Arabis holboellii*
Rose, bristly nootka	*Rosa nutkana*
Rue, fendler meadow	*Thalictrum fendleri*
Rush, Colorado	*Juncus confusus*
Rush, Drummond	*Juncus drummondii*
Rush, swordleaf	*Juncus ensifolius*
Sedge, blackscaled	*Carex atrata*
Sedge, Douglas	*Carex douglasii*
Sedge, elk	*Carex geyeri*
Sedge, shortstemmed	*Carex brevipes*
Sedge, showy	*Carex bella*
Sedge, silvery	*Carex canescens*
Sedge, smallwing	*Carex microptera*
Sedge, softleafed	*Carex disperma*
Sedge, water	*Carex aquatalis*
Speedwell, Wormskjold	*Veronica wormskjoldii*

Table 9. Continued

Common Name	Botanical Name
Starwort, longstalk	*Stellaria longipes*
Starwort, tuber	*Stellaria jamesiana*
Stonecrop, rosecrown	*Sedum rhodanthum*
Strawberry	*Fragaria ovalis*
Sweetroot, spreading	*Osmorhiza chilensis*
Timothy, alpine	*Phleum alpinum*
Trisetum, spike	*Trisetum spicatum*
Violet	*Viola* spp.
Wheatgrass, bearded	*Agropyron subsecundum*
Willow	*Salix* spp.
Willowherb, fireweed	*Epilobium angustifolium*
Willowherb, Hornemann	*Epilobium hornemanii*
Wortleberry, grouse	*Vaccinium scoparium*
Yarrow	*Achillea lanulosa*

Appendix B
Calf Raising Data

Table 10. Capture and training success data.

Calf#	Tag#	Sex[a]	Birth Date	Capture Date	Capture Weight	Tractability and Disposition
1	7686	F	5-24-75	5-25-75	18.8	Tractable, slightly nervous
2	7687	F	5-25-75	5-25-75	15.9	Tractable, calm
3	7688	F	5-29-75	5-29-75	14.1	Tractable (intractable first six months), nervous
4	----	F	6-2-75	6-2-75	13.6	Died of enteritis 6-5-75
5	----	M	6-1-75	6-2-75	18.6	Died suddenly of pneumonia and enteritis 6-9-75
6	----	F	6-2-75	6-3-75	17.2	Died of enteritis 6-8-75
7	7989	F	6-7-75	6-8-75	15.0	Tractable, very excitable
8	7694	MC	6-18-75	6-19-75	18.6	Tractable, easy to handle, calm
9	7693	MC	6-23-75	6-25-75	16.8	Tractable, easy to handle, calm
10	7695	M	6-27-75	6-29-75	15.0	Tractable, easy to handle, calm, tractable during rut
11	7675	F	7-7-75	7-9-75	19.5	Tractable, nervous
12	----	F	7-8-75	7-10-75	15.0	Died of dehydration, because it would never allow the trainer to approach it for feeding.
13	7674	MC	7-10-75	7-12-75	19.5	Tractable, slightly nervous

[a]F = female, M = male, and MC = male castrated at age five months.

Table 11. Feeding schedule and amounts for elk calves[a].

Week	Amount	Feeding Hour(s)		
		0600 h	1400 h	2200 h
1	340 cc	X	X	X
2	420 cc	X	X	X
3	500 cc	X		X
4	500 cc	X		X
5	500 cc	X		
6	500 cc	X[b]		

[a]Schedule found most acceptable; early attempts were to feed 160 cc, 180 cc or 300 cc five times per day for the first 10 days.

[b]Some calves were weaned at five weeks of age, when they appeared to be consuming sufficient hay and barley.