



Effects of livestock grazing on grizzly bear habitat along the east front of the Rocky Mountains,
Montana
by Thomas Scott Stivers

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish
and Wildlife Management
Montana State University
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Abstract:

A study on the effects of cattle grazing on grizzly bear habitat along the East Front of the Rocky Mountains, in Montana, was conducted from June 1985 to October 1986. Objectives were to determine impacts of cattle grazing on cover and forage preferred by grizzlies within aspen and willow plant communities, and to test the possibility of reestablishing preferred forage species within aspen and willow stands where they were lacking. Information collected on the phenology of bear foods growing in aspen and willow stands revealed that the more nutritious bear foods produced seeds late in the growing season. The utilization of bear foods by cattle in 5 study pastures showed that in 41-47 days all bear foods were 50% utilized. Paired contrast sites were selected in aspen and willow stands and stand structure and herbaceous bear foods were measured. Sites annually grazed after June generally produced more of the desirable bear foods (cow-parasit, sharptooth angelica, and western sweet-cicely) than did sites grazed during June. The cumulative information suggests that June cattle grazing is adversely affecting the abundance of the 3 desirable bear foods. Sites protected from cattle grazing for 2 to 9 years had more aspen and willow suckers than did grazed sites, though both sites appeared to be recruiting enough suckers for stand survival. Ungrazed vs. grazed sites and sites grazed after June vs. sites grazed during June, produced more horizontal cover to potentially conceal a bear. Results from experimental plantings of seeds from 3 Umbelliferae bear foods showed that seed germination and seedling reestablishment was possible. Management guidelines and recommendations are presented.

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ALONG THE EAST FRONT OF THE ROCKY MOUNTAINS, MONTANA

by

Thomas Scott Stivers

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ABSTRACT

A study on the effects of cattle grazing on grizzly bear habitat along the East Front of the Rocky Mountains, in Montana, was conducted from June 1985 to October 1986. Objectives were to determine impacts of cattle grazing on cover and forage preferred by grizzlies within aspen and willow plant communities, and to test the possibility of reestablishing preferred forage species within aspen and willow stands where they were lacking. Information collected on the phenology of bear foods growing in aspen and willow stands revealed that the more nutritious bear foods produced seeds late in the growing season. The utilization of bear foods by cattle in 5 study pastures showed that in 41-47 days all bear foods were 50% utilized. Paired contrast sites were selected in aspen and willow stands and stand structure and herbaceous bear foods were measured. Sites annually grazed after June generally produced more of the desirable bear foods (cow-parsnip, sharptooth angelica, and western sweet-cicely) than did sites grazed during June. The cumulative information suggests that June cattle grazing is adversely affecting the abundance of the 3 desirable bear foods. Sites protected from cattle grazing for 2 to 9 years had more aspen and willow suckers than did grazed sites, though both sites appeared to be recruiting enough suckers for stand survival. Ungrazed vs. grazed sites and sites grazed after June vs. sites grazed during June, produced more horizontal cover to potentially conceal a bear. Results from experimental plantings of seeds from 3 Umbelliferae bear foods showed that seed germination and seedling reestablishment was possible. Management guidelines and recommendations are presented.

INTRODUCTION

Studies on the East Front of the Rocky Mountains in the northwest chinook zone of Montana have provided a large data set on grizzly bear (Ursus arctos horribilis) habitat use, movements, and distribution (Schallenberger and Jonkel 1978, 1979, 1980; Aune and Stivers 1981, 1982, 1983; Aune et al. 1984; Aune 1985; Aune et al. 1986; and Aune and Brannon 1987). Along the East Front, approximately 65 percent (%) of spring and early summer grizzly range is managed primarily for the production of livestock forage. Eighty nine % of livestock grazing is by cattle. During spring / early summer, cattle and grizzly bears show considerable overlap in diet and habitat use -- primarily due to their common use of riparian plant communities (Aune 1985).

Many researchers have suggested that livestock grazing may have negative impacts on grizzly bear habitat and distribution (Mealey et al. 1977, Schallenberger and Jonkel 1980, Knight et al. 1981, and Aune and Stivers 1982). Varying intensities and seasonality of livestock grazing could change vegetation composition, phenology, and/or the structure of riparian communities in favorable or unfavorable ways. This study, conducted from April 1985 through September 1986, was designed to provide some site

specific information needed for determining impacts of cattle grazing on grizzly bear habitat along the East Front of the Rocky Mountains. The specific objectives were:

- 1) to determine the impacts of cattle grazing on cover and forage preferred by grizzly bears within mesic plant communities.
- 2) to develop guidelines to mitigate negative influences and enhance positive influences of cattle grazing on bear habitat.
- 3) to identify sites suitable for long term studies on the influence of livestock on cover types and foods preferred by bears.
- 4) to test the possibility of establishing preferred bear foods at sites where they were lacking.

This study was supported by the U.S. Bureau of Land Management through a contract with the U.S. Fish and Wildlife Service.

STUDY AREA

The study area encompassed 600 square kilometers (km²) in Teton and Pondera counties (Fig. 1). Land ownership was divided between the U.S. Forest Service, the Bureau of Land Management (BLM), Montana Department of Fish, Wildlife, and Parks (MDFWP), The Nature Conservancy, the Boone and Crockett Club's Theodore Roosevelt Memorial Ranch, and private individuals. The dominant land uses were ranching and recreation. The area had been subjected to extensive oil and gas exploration, but few wells were in production.

Elevations in the study area ranged from 1340 to 2070 meters (m). Precipitation averaged between 30 and 50 centimeters (cm) annually. Temperatures ranged from -40 to 32 C annually. The average growing season was 90 days. Strong westerly to southwesterly winds were common.

The study area was in the transition zone between the Rocky Mountains (Sawtooth Range) and the Great Plains. The foothills and prairie were abundantly trellised with small streams. Along streams, dominant plant communities consisted of aspen (Populus tremuloides), cottonwood (P. trichocarpa), and willow (Salix spp.). The prairie and higher elevation grasslands were dominated by bluebunch wheatgrass / Idaho fescue (Agropyron spicatum / Festuca

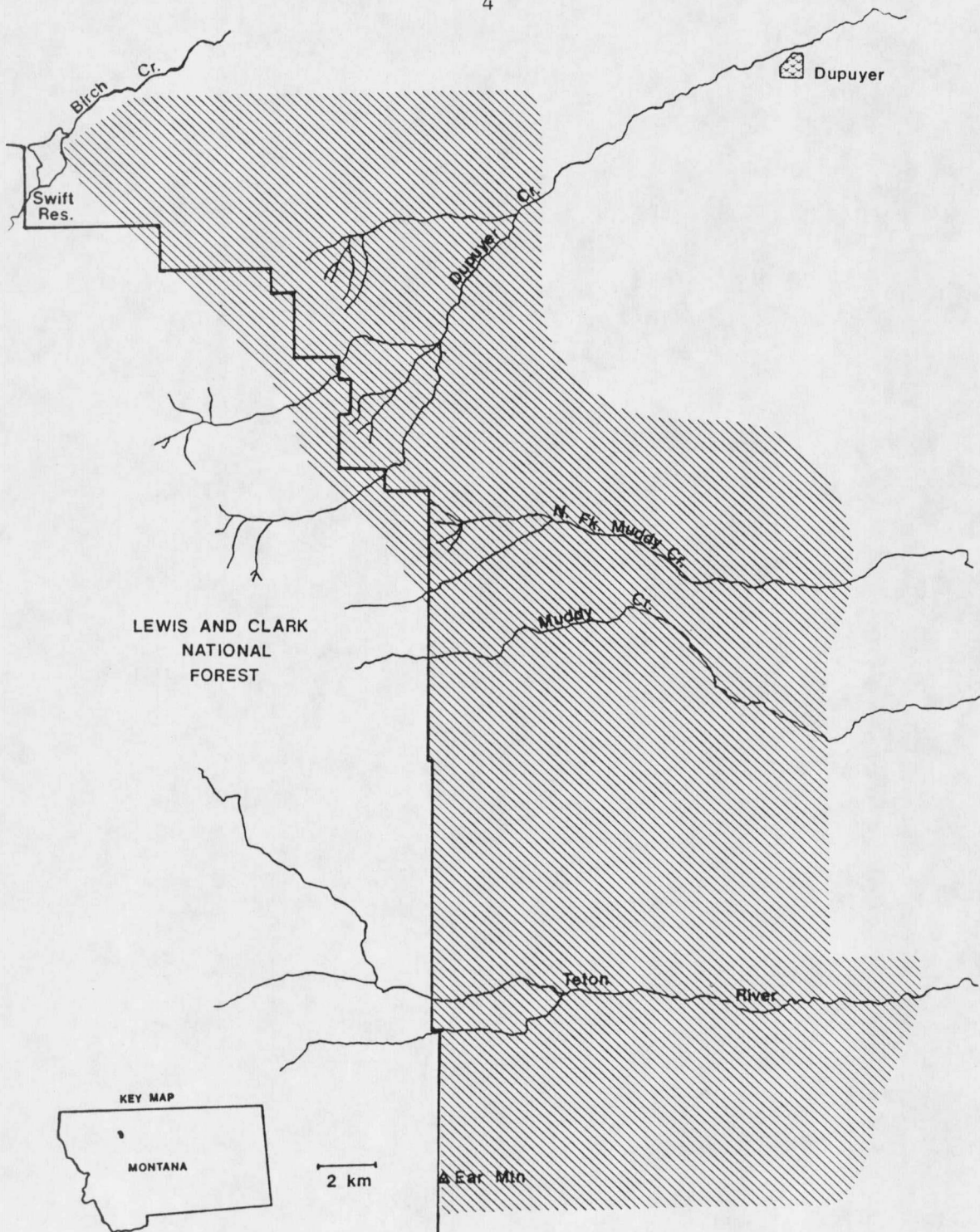


Figure 1. Map of the East Front study area showing major features.

idahoensis) and shrubby cinquefoil / rough fescue (Potentilla fruticosa / F. scabrella) habitat types. Stands of subalpine fir (Abies lasiocarpa), Douglas fir (Psuedotsuga menziesii), lodgepole pine (Pinus contorta), limber pine (P. flexilis), and Engelmann spruce (Picea engelmannii) were common at higher elevations and/or on wetter slopes of foothills. Detailed descriptions of the vegetation and habitat types are given by Harvey (1980), Kasworm (1981) and Lesica (1982).

In addition to grizzly bears, the other large mammals occupying the study area, at least seasonally, were: American black bear (U. americanus), mountain lion (Felis concolor), mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), Rocky Mountain elk (Cervus elaphus nelsoni), Rocky Mountain goat (Oreamos americanus), and Rocky Mountain bighorn sheep (Ovis canadensis canadensis).

METHODS

Paired Contrast Sites

Site Selection

Paired riparian sites were selected for intensive quantitative and qualitative vegetation measurement in 1985 and 1986. Sites within each pair were selected on the basis of similarity in vegetation communities, seral stages, slope, topography, aspect and elevation; and marked differences in grazing regimes. Both current and historic grazing regimes were considered when selecting sites.

Transect and Plot Establishment

Individual sites were mapped on USGS 1:24000 scale maps and gridded using a 10 x 10 grid adjusted to the area to be measured. Three random coordinates were selected from this grid, located on the ground, and permanently marked with a 1.25 x 100-cm steel pin. A 20-m transect was established at each pin. On a randomly chosen side of each transect, a 20 x 3-m rectangular plot was delineated using wooden stakes and a stringline. Deviations from random placement were made only to insure that plots did not overlap or fall on vegetation ecotones.

Transect Measurements:

Microplots. -- On the plot side of each transect, 40 50-cm² microplots were read at 0.5 m intervals along the transect. Measurements taken in each microplot included: percent ground coverage of leaf litter [dead plant parts and woody stems < 10 millimeters (mm) in diameter], wood, exposed soil, and moss.

Line intercept/concealment cover. -- To determine the the extent to which vegetation could conceal a grizzly bear from lateral view, a line intercept index was used. All vegetative materials, alive or dead, that intercepted the transect from 0.5 to 1.0 m above the ground, were recorded in millimeters by species. Values from the 3 transects per site were summed to give a lateral cover index value.

Arboreal canopy coverage. -- To determine arboreal canopy coverage, a modified vertical viewing tube was used (Emlen 1967). The tube had a field of vision of approximately 1 m² at a distance of 3 m. Canopy coverage was measured as the percent of the viewed field covered by vegetation. Readings were taken from 1 m above the ground at all 4 plot corners and every 5 m along the transect. Site values were based on means of readings for all 3 transects within a site.

Plot Measurements:

Herbaceous bear foods. -- Initially, canopy coverages

of herbaceous species considered desirable bear foods were estimated as a percentage of each 60 m² plot. Stems of the larger forb species considered important bear foods were counted in each plot. The average heights and phenological stages of bear foods were also recorded in each plot. The phenological categories were: new leaves, flower bud, flowering, fruit/seed set, fruit/seed ripe (fully swollen), fruit/seed dry and shedding, fruit/seed shed, and plant dry and brown. In the second half of the 1985 field season, and throughout the 1986 field season, the plots were subdivided into 3 x 5 m quarters to increase sample size from 3 to 12 per site and to decrease the area over which estimates of canopy coverage and counts of stems were made. In each quarter plot the average heights of each bear food species were multiplied times their respective number of stems, or canopy coverage, to produce a weighted mean height. These values were summed and averaged for each site.

Low and medium height shrubs. -- Percent canopy coverage by height category was estimated for all low to medium height shrubs (<2.0 m). The height categories were 0-0.5, 0.5-1, and 1-2 meters.

Stand structure. -- The taller shrubs (potentially > 2.0 m) and all trees were counted and placed into height and diameter categories by species. The height categories were 0-1, 1-2, and >2 meters. For shrubs the diameter categories

were 0-5, 5-10, 10-20, and >20 cm. Shrub diameters were measured at 0.5 m above ground to accommodate species which sprout from prostrate stems. Trees had the same diameter categories, but were measured at breast height (1.37 m above ground). Plot measurements were summed and a mean value calculated per 60 m².

Vegetative Nomenclature

For descriptive purposes vegetation communities occupying study sites were classified into cover-types based on the plant species dominating the primary and secondary canopy strata. Plant identification followed Hitchcock and Cronquist (1973).

Statistical Tests

All site comparisons were tested with "t" tests (Zar 1984) unless stated otherwise. $P < 0.05$ was required for statistical significance.

Pasture Utilization by Cattle

To determine short term impacts of cattle grazing on bear foods in mesic plant communities, 5 pastures were chosen that differed in size, shape, relief, proportions of mesic communities, timing of livestock use, stocking density, and age classes of livestock. Two null hypotheses were tested using these pastures: 1) cattle utilization of

slight; and 2) relative to the gate cattle entered the pasture, they would use the closer mesic sites more than farther ones.

Sample points were chosen in mesic vegetation at 200-m intervals from the gate cattle entered the pasture. At each point, 20 x 3-m plots were established following the procedures described for paired contrast sites. The measurements taken at each plot were also the same, except that microplots and line intercepts were not employed. Vegetation measurements were made 1 week before cattle were put on the pasture and at 2 to 3 week intervals while cattle were on the pasture.

To determine the extent to which cattle utilized bear foods, 2 bear food biomass indices were calculated for each plot. The indices were calculated by multiplying the number of stems [of sharptooth angelica (Angelica arguta), cowparsnip (Heraculem lanatum), mountain sweet-cicely (Osmorhiza chilensis), and western sweet-cicely (O. occidentalis)] and canopy coverages [of grasses/sedges, common dandelion (Taraxacum officinale), and clovers (primarily Trifolium longipes)] by the average height of each bear food per plot. Biomass values were summed by category (number of stems of members of the Umbelliferae family or percent canopy coverages of grasses/sedges, dandelions and clovers) for each plot measured through the

grazing period. Utilization was estimated by comparing the change in biomass values between measurements. This was accomplished by calculating the percentage of maximum biomass removed between measurements by consumption or trampling. Pasture utilization values were summed and averaged for all pastures in both years. Average pasture utilization over time was then determined. Biomass values and utilization calculations are presented in Appendix B.

In testing whether closer mesic sites were utilized more than distant ones, utilization plots were grouped into 0.5 kilometer (km) categories, based on plot distances from the gate cattle entered the pasture. The percentage of maximum biomass left at the end of the grazing period was then averaged for all pastures and compared by distance categories (Appendix B).

Bear Food Phenology

The phenological information collected at paired sites, utilization plots, and at sites selected specifically for monitoring phenology, was used to construct the chronology of bear food phenology. The range of dates for bear foods at the "seed ripe" phenological stage were assembled for both 1985 and 1986. Survival to this stage was deemed necessary for long term survival of plant species.

Bear Food Re-establishment

During the 1985 field season, many mesic stands lacked some of the larger and more nutritious (Sizemore 1980) spring bear foods such as cow-parsnip, sharptooth angelica, and western sweet-cicely. The absence of these Umbelliferae bear foods could have been due to lack of a seed source. To test this hypothesis, seeds from these 3 species were collected at various locations in the study area and planted in selected mesic communities to determine if establishment was possible.

Seeds were collected prior to shedding and allowed to air dry. During September and October of 1985 and 1986, seed beds were selected under aspen and willow stands that lacked these desirable bear foods. One hundred milliliters of seeds of each species were broadcast by hand over 1 m² plots from which the duff had been removed. The seeds were lightly covered with 2 to 4 cm of leaf litter. Each plot was marked with a wooden stake. In late May / early June, of the next year, seedling germination and establishment success were determined by estimating the percentage canopy coverage of the first foliage leaves (poor = 0-5 %, fair = 6-25 %, good = 26-75 %, and excellent = 76-100 %).

RESULTS

Paired Contrast Sites

Site Selection and Characteristics

Fifteen sites were established and measured in 1985 (Table 1). During 1986, the original 15 sites were remeasured and an additional 6 established and measured. From these 21 sites, 12 paired site comparisons (Appendix B, Fig. 7) were made to examine differences attributable to cattle grazing. Ten paired site comparisons were in contiguous stands of aspen or willow, and all comparisons were separated by fencelines. All aspen comparisons were made within the same clone.

Aspen dominated the upper canopy stratum at 16 sites and willow in 5 (Table 1). Sites ranged in elevation from 1381 to 1896 meters. Slopes were between 1 and 9 %, and most aspects were easterly (33 - 145°). Seven of the sites had not been grazed for 2 to 9 years prior to 1985. One site (8U) was on the MDFWP Ear Mountain Wildlife Management Area, 3 (1U, 2U, and 3U) were on the MDFWP Blackleaf Wildlife Management Area, 2 (6U and 7U) were within BLM cattle exclosures, and 1 (4U) had been rested by a private landowner.

Table 1. Characteristics of paired contrast sites.

Site/ status ^a	Cover Type ^b	Elevation (meters)	Aspect	Slope (%)	Pasture			
					Prior years rest	Stocking density ^c (A.U./ha) ^d	Aspen and willow ^e (%)	Grazing period ^f
1U	Potre/Syal	1576	90	7	5	0.3	10	June 1-Sept. 30
1G	Potre/Syal	1580	90	7	0	0.4	25	July 15-Sept. 15
2U	Potre/Syal	1567	70	3	5	0.3	10	June 1-Sept. 30
2G	Potre/Syal	1614	70	3	0	0.1	17	July 1-Sept. 1
3U	Potre/Salix	1494	35	2	5	1.5	6	Sept. 15-Oct. 31
3G	Potre/Salix	1497	35	2	0	0.5 or 1.1	1	June or Aug. 1-Oct. 15
4U	Salix/Hela	1402	120	1	2	2.2	10	Sept. 5-March 1
4EG	Salix/Hela	1408	120	1	0	1.3	19	Nov. and Feb. 15-May 15
4WG	Salix/Hela	1381	120	1	0	3.2	26	Jan. 1-March 31
6U	Potre/forb	1858	135	4	2	0.6	7	July, Aug., or Sept. 1-20 ^g
6G	Potre/forb	1858	135	4	1	0.6	5	July, Aug., or Sept. 1-20 ^g
7U	Potre/forb	1896	145	4	7	0.6	1	July, Aug., or Sept. 1-20 ^g
7G	Potre/forb	1892	145	3	0	0.6	0.5	July, Aug., or Sept. 1-20 ^g
8U	Potre/forb	1593	40	9	9	0.3	7	June 7-Sept. 1
8G	Potre/forb	1598	40	9	0	0.4	4	June 15-Aug. 15
9LG	Salix/forb	1512	85	3	0	0.4	25	July 15-Sept. 15
9EG	Salix/forb	1518	85	4	0	0.6	12	June 1-July 15
10LG	Potre/forb	1451	57	9	0	0.4	23	Aug. 15-Oct. 15
10EG	Potre/forb	1451	57	7	0	0.3	18	June 1-July 31
11LG	Potre/Salix	1498	33	6	0	0.5	26	July or Aug. or Sept. ^h
11EG	Potre/Salix	1495	33	6	0	0.3	18	June 1-July 31

^aU = ungrazed, G = grazed, EG = early grazed, WG = winter grazed, and LG = late grazed.

^bAbbreviations in Appendix A Table 9.

^cPasture area calculated minus steep slope closed timber areas, and animal units averaged since 1950.

^dA cow with calf considered one Animal Unit (A.U.) until weaning.

^eThe proportion of pasture covered by aspen and willow.

^fAveraged for 1950 through 1985, or up to date of rest.

^gA 4 pasture rest-rotation system since 1974; prior grazing season was approximately July 1 - Sept. 15.

^hA 3 pasture rotation system.

Cattle stocking densities ranged from 0.1 to 1.1 animal units per hectare (A.U./ha) on grazed pastures, and had been 0.3 to 2.2 A.U./ha on pastures protected from cattle grazing. Those sites in pastures with the highest stocking densities were in winter pastures where cattle were fed hay (4U, 4EG, and 4LG) or in pastures with a fall grazing period of short duration (3U and 3G) (Table 1).

The current, or historic, grazing periods of pastures containing study sites were: 8 pastures grazed during the month of June (1U, 2U, 3G, 8U, 8G, 9EG, 10EG, and 11EG), 8 pastures with summer grazing (1G, 2G, 6U, 6G, 7U, 7G, 9LG, 11LG), 4 pastures with fall / winter grazing (3U, 3G, 10LG, and 4U), 1 winter pasture (4WG), and 1 late winter / early spring pasture (4EG). The proportion of each pasture covered by aspen and willow communities ranged from 0.5 to 26 % (Table 1).

Transect Measurements:

Microplot ground cover. -- The 1985 and 1986 microplot measurements indicated that ungrazed and late grazed (fall - winter) sites generally had more ground covered by leaf litter and less exposed soil than grazed or early grazed sites (Table 2). Of 14 site comparisons that differed significantly in percent leaf litter and bare soil, 10 supported this trend. Only 2 paired sites differed significantly in the amount of wood laying on the ground,

Table 2. Values recorded for microplot, arboreal canopy coverage, and line intercept measurements for transects at paired contrast sites.

Site	Date	Microplot (mean percent)				Arboreal canopy coverage (%)	Line intercept (mm)
		Leaf litter	Wood litter	Exposed soil	Moss		
1U	4/28/85	98	2	tr ¹	0	7	435
1G	4/28/85	100*	0*	0	0	7	708
1U	7/26/86	94	4	1	0	56	10133
1G	7/22/86	88*	10*	1	0	49	7617
2U	5/8/85	94	5	0	0	4	831
2G	5/7/85	96	3	2*	0	4	819
2U	6/26/86	90	8	tr	0	53	7590
2G	6/19/86	98*	2*	tr	tr	62	3120
3U	5/14/85	93	5	0	0	20	3274
3G	5/15/85	86*	6	7*	0	14	1405
3U	6/24/86	81	7	7	3	56	12621
3G	6/22/86	80	7	9	2	56	3340
4U	5/17/85	82	4	12	0	17	2871
4EG	5/21/85	79	6	13	0	27	4161
4WG	5/25/85	89	3	6*,**	0	29**	5884
4U	7/10/86	78	5	14	tr	54	27947
4EG	7/9/86	76	4	17	tr	61	22430
4WG	7/11/86	92*,**	7	1*,**	tr	64	38873

Table 2. Continued.

Site	Date	Microplot (mean percent)				Arboreal canopy coverage (%)	Line intercept (mm)
		Leaf litter	Wood litter	Exposed soil	Moss		
6U	6/15/85	94	5	0	0	31	1466
6G	6/12/85	94	5	0	0	23*	616
6U	7/30/86	93	6	0	0	58	3396
6G	7/28/86	92	7	0	0	45*	925
7U	6/19/85	92	4	4	0	25	1404
7G	6/19/85	82*	3	13*	0	28	1709
7U	8/1/86	89	5	5	tr ¹	50	3170
7G	7/31/86	80*	5	14*	tr	55	3778
8U	8/21/85	84	9	6	0	42	4880
8G	8/19/85	70*	4	26*	0	46	4112
8U	6/16/86	93	4	2	0	45	6282
8G	6/17/86	79*	7	14*	0	43	3283
9LG	5/25/86	84	7	10	tr	15	2617
9EG	5/26/86	69*	7	23*	1	20	3476
10LG	6/11/86	91	7	2	0	25	16497
10EG	6/2/86	80*	6	14*	0	17	462
11LG	6/10/86	90	4	4	1	48	2082
11EG	6/9/86	84	9	3	2	36*	1355

*Significantly different at 5% level from the site above.

**Significantly different at 5% level from 2 sites above.

¹tr = trace, a value less than 0.5%.

and no paired sites had significant differences in the amount of moss present.

Arboreal canopy coverage. -- No trends were noticed when sites were compared for arboreal canopy coverage. Only 4 ungrazed sites differed significantly from their paired comparisons. In 1985, sites 4U and 6U had arboreal canopy coverages significantly less than the grazed sites with which they were paired, while in 1986 sites 6U and 11LG had significantly more than their respective paired sites (Table 2).

Line intercept/concealment cover. -- Since no statistical procedure was found adequate for comparing differences in the amount of total concealment cover between sites, all sites were categorized as ungrazed and late grazed vs. grazed and early grazed and tested with a paired "t" test (Zar 1984). Table 2 shows that the majority of ungrazed vs. grazed and late grazed vs. earlier grazed sites had more cover to potentially conceal a bear. In 1985, when the majority of sites were measured before the woody species had fully leaved out or herbaceous plants had reached maximum growth, ungrazed vs. grazed and late grazed vs. earlier grazed sites did not differ significantly in concealment cover ($t = 1.10$, $P > 0.30$). The 1986 paired sites (usually measured later in the growing season, 1 to 4 weeks before cattle were turned on to the grazed

sites/pastures) had significantly more cover on the ungrazed vs. grazed and late grazed vs. earlier grazed sites ($t = 2.921$, $P < 0.02$).

Plot Measurements:

Stand structure. -- Aspen and willow were the dominant woody plants at all sites (Table 3). Douglas fir, lodgepole pine, Engelmann spruce, and limber pine were present at 6 sites but made up $< 2\%$ of the total stem count. Water birch (Betula occidentalis), red-osier dogwood (Cornus stolonifera), and common chokecherry (Prunus virginiana) were present in small amounts and varying combinations at sites 3U/G, and 4U/EG/WG.

Sites protected from cattle grazing usually had more aspen, willow, and total stems in the 0-5 cm diameter and 0-1 and 1-2 m height categories than did grazed sites (Table 3). Exceptions to this trend were site pairs 3U/G (1986), 9LG/EG, 10LG/EG, and 11LG/EG. In the latter 3, stems 0-5 cm in diameter and < 2 m in height were slightly more abundant (not significantly) in the early grazed plots. At site 4, the winter grazed site (4WG) had fewer small willow and total stems than did the ungrazed (4U) or early spring grazed (4EG) sites. Although ungrazed sites generally had more stems available for stand recruitment than did grazed sites, virtually all sites had at least twice as many stems in the 0-5 diameter category as in the 10-20 or > 20

Table 3. Mean number of stems per 60 m² by diameter and height categories for aspen, willow, and total trees and tall shrubs (potentially > 2.0 m) at paired contrast sites.

Site	Date	Potre ^a							Salix spp.							Total ^b						
		Diameter (cm)				Height (m)			Diameter (cm)				Height (m)			Diameter (cm)				Height (m)		
		0-5	5-10	10-20	>20	0-1	1-2	>2	0-5	5-10	10-20	>20	0-1	1-2	>2	0-5	5-10	10-20	>20	0-1	1-2	>2
1U	4/28/85	74	15	10	tr ¹	6	33	64								74	15	10	tr	6	33	64
1G	4/28/85	29	11	4	1	tr [*]	7 [*]	38								29	11	4	1	tr [*]	7 [*]	38
1U	7/26/86	72	12	10	0	7	26	61								72	12	10	0	7	26	61
1G	7/22/86	31 [*]	10	5 [*]	1	4 [*]	7 [*]	36 [*]								31 [*]	10	5 [*]	1	4	7 [*]	36 [*]
2U	5/8/85	170	14	5	0	77	101	59								170	14	5	0	77	101	59
2G	5/7/85	54 [*]	17	7	0	23 [*]	24	31 [*]								54 [*]	17	7	0	24 [*]	24	31 [*]
2U	6/26/86	140	12	5	0	43	59	56								140	12	5	0	43	59	56
2G	6/19/86	55 [*]	14	9 [*]	0	26 [*]	19 [*]	33 [*]								55 [*]	14	9 [*]	0	26 [*]	19 [*]	33 [*]
3U	5/14/85	14	tr	3	2	10	1	7	17	4	6	2	4	7	17	87	5	9	4	59	17	28
3G	5/15/85	3	2	6	0	2	1	8	5	10	7	3	1	2	23	24 [*]	12	13	3	16	5 [*]	31
3U	6/24/86	11	tr	5	0	8	3	5	31	2	6	0	5	14	20	42	2	11	0	13	17	25
3G	6/22/86	11	1	6	0	10	tr	7	44	9 [*]	7	3	21	22	20	55	10 [*]	13	3	31	22	28
4U	5/17/85								38	16	3	1	18	12	29	101	21	3	1	68	22	37
4EG	5/21/85								16	25	18 [*]	1	11	5	44 [*]	17	25	18 [*]	1	12	5	45 [*]
4WG	5/25/85								1	7 [*]	6 [*]	5 [*]	0	0	19 [*]	7	7 [*]	6 [*]	5 [*]	2	4	20 [*]
4U	7/10/86								49	13	4	2	17	20	31	57	14	4	2	19	24	35
4EG	7/9/86								42	14	21 [*]	1	18	22	41	42	14	21 [*]	1	18	22	41
4WG	7/11/86								2 [*]	4 [*]	3 [*]	5 [*]	tr ^{***}	1	13 [*]	2 ^{***}	4 [*]	3 [*]	5 [*]	tr ^{***}	1	13 ^{***}

Table 3. Continued.

Site	Date	Potre ^a							Salix spp.							Total ^b						
		Diameter (cm)				Height (m)			Diameter (cm)				Height (m)			Diameter (cm)				Height (m)		
		0-5	5-10	10-20	>20	0-1	1-2	>2	0-5	5-10	10-20	>20	0-1	1-2	>2	0-5	5-10	10-20	>20	0-1	1-2	>2
6U	6/15/85	107	tr ¹	10	1	77	19	23								108	tr	10	1	77	19	23
6G	6/12/85	35*	1	10	tr	32	3	11								39*	1	10	tr	34	4	12
6U	7/30/86	129	0	9	2	104	17	18								130	0	9	2	105	17	18
6G	7/28/86	102	2	10	0	99	3*	13								105	2	10	0	101	3*	14
7U	6/19/85	91	9	11	0	90	tr	20								96	9	11	0	95	1	20
7G	6/19/85	23	10	15	tr	14	2	33								29	10	15	tr	20	2	33
7U	8/1/86	112	7	11	0	111	1	18								118	7	11	0	116	1	18
7G	7/31/86	88	10	14	0	80	1	31								92	10	14	0	84	2	31
8U	8/21/85	44	0	10	tr	25	16	13								44	0	10	tr	25	16	13
8G	8/19/85	27*	0	10	0	17	9	11								27*	0	10	0	17	9	11
8U	6/16/86	39	0	10	0	19	17	13								39	0	10	0	19	17	13
8G	6/17/86	34	0	10	0	24	9	11								34	0	10	0	24	9	11
9LG	5/25/86								48	12	6	1	3	31	34	48	12	6	1	3	31	34
9EG	5/26/86								68	18	6	2	7	31	52	68	18	6	2	7	31	52
10LG	6/11/86	9	3	5	1	4	2	12								9	3	5	1	4	2	12
10EG	6/2/86	15	1	5	0	11*	1	10								15	1	5	0	11*	1	10
11LG	6/10/86	37	6	13	0	29	5	22	25	3	1	tr	10	5	14	62	9	14	tr	38	11	36
11EG	6/9/86	56	10	11	0	49	2	26	9	tr	1	0	5	1	4	64	10	13	0	54	3*	30

^aAbbreviations in Appendix A Table 9.^bIncludes all tree and tall shrub species sampled per site. Additional species per site were: 6U, 7U and 7G'85 and '86 = Psme and Pien; and 6G'85 and '86 = Psme, Pien and Pico.¹tr = trace, a value less than 0.5%.

*Significantly different at 5% level from the site above.

***Significantly different at 5% level from both sites above.

categories (Table 3).

Low and medium height shrubs. -- Fifteen different low to medium height shrub species were identified in plots during the study. The 4 shrubs most often encountered were currant (Ribes spp.), rose (Rosa woodsii), red raspberry (Rubus idaeus), and common snowberry (Symphoricarpos albus) (Table 4).

Snowberry, the most abundant shrub, showed no significant differences between grazed and ungrazed sites. Rose canopy coverages were significantly greater in the 0-0.5 m height category in 1 grazed vs. ungrazed site (1G/U) and 2 early grazed vs. late grazed sites (10EG/LG and 11EG/LG). Currant canopy coverages were significantly more abundant at 2 late grazed vs. early grazed sites (9LG/EG and 11LG/EG), and red raspberry was significantly greater in the ungrazed plots at site 8. Total shrub canopy coverages were generally greater at ungrazed vs. grazed and early grazed vs. late grazed sites (Table 4).

Herbaceous bear foods. -- Grasses/sedges [primarily Kentucky bluegrass (Poa pratensis), timothy (Phleum pratensis) and smooth brome (Bromus inermis)] and common dandelion had the greatest canopy coverages. Ungrazed plots at 4 sites differed significantly from their corresponding grazed sites in grass canopy coverage. Two had more (4U vs. 4WG and 8U vs. 8G) and 2 had less (1U vs. 1G and 2U vs. 2G).

Table 4. Mean canopy coverage by height categories for the 4 most common, and total, low and medium height shrubs at paired contrast sites.

Site	Date	Ribes ^a spp.			Rowo			Ruid			Syal			Total ^b		
		Height (m)			Height (m)			Height (m)			Height (m)			Height (m)		
		0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2
1U	4/28/85	1	tr ¹	0	tr	tr	0	3	1	0	10	1	0	15	3	0
1G	4/28/85	1	tr	0	tr	tr	0	0	0	0	3	tr	0	4*	tr*	0
1U	7/26/86	tr	tr	0	tr	tr	0	8	4	tr	37	5	0	48	11	1
1G	7/22/86	tr	tr	0	3*	1	tr	tr	tr	0	18	2	0	22*	3*	tr
2U	5/8/85	tr	0	0	1	tr	0				5	tr	0	7	tr	0
2G	5/7/85	tr	0	0	tr	tr	0				4	tr	0	5	tr	0
2U	6/26/86	tr	0	0	8	4	0				24	1	0	32	5	0
2G	6/19/86	0	0	0	8	2	0				28	1	0	36	4	0
3U	5/14/85	tr	tr	0	tr	tr	0				tr	tr	0	1	tr	tr
3G	5/15/85	tr	tr	0	tr	tr	0				tr	tr	0	1	tr	tr
3U	6/24/86	tr	tr	tr	1	1	1	0	0	0	2	tr	0	9	7	2
3G	6/22/86	1	1	0	3	1	0	1	tr	0	13	tr	0	8	1*	tr
4U	5/17/85	tr	tr	0	tr	tr	0							1	tr	tr
4EG	5/21/86	tr	tr	0	0	0	0							tr	tr	0
4WG	5/25/85	tr	tr	0	tr	tr	0							tr	tr	0
4U	7/10/86	tr	tr	tr	1	1	0				tr	0	0	7	4	1
4EG	7/9/86	tr	tr	tr	0	0	0				0	0	0	tr*	tr	tr
4WG	7/11/86	1	1	tr	tr	tr	0				tr	0	0	1	2	1

Table 4. Continued.

Site	Date	Ribes ^a spp.			Rowo			Ruid			Syal			Total ^b		
		Height (m)			Height (m)			Height (m)			Height (m)			Height (m)		
		0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2	0-.5	.5-1	1-2
6U	6/15/85	tr ¹	tr	0	tr	tr	0				tr	0	0	tr	tr	0
6G	6/12/85	tr	0	0	tr	tr	0				0	0	0	2*	tr	0
6U	7/30/86	1	tr	0	tr	0	0				tr	0	0	1	tr	0
6G	7/28/86	tr	tr	0	1	tr	0				0	0	0	2	tr	0
7U	6/19/86	tr	0	0				1	0	0	0	0	0	1	0	0
7G	6/19/85	1	0	0				0	0	0	tr	0	0	1	0	0
7U	8/1/86	1	tr	0	tr	0	0	7	2	0	0	0	0	9	2	0
7G	7/31/86	2	0	0	0	0	0	0	0	0	tr	0	0	2	0	0
8U	8/21/85	tr	0	0	4	tr	0	1	0	0	1	tr	0	7	tr	0
8G	8/19/85	2	tr	0	2	tr	0	8	0	0	6	tr	0	18	tr*	0
8U	6/16/86	1	1	0	5	2	0	1	tr	0	2	tr	0	9	3	0
8G	6/17/86	2	tr	0	2	tr	0	9*	3	0	5	1	0	19*	4	tr
9LG	5/26/86	13	2	0	tr	tr	0							13	3	0
9EG	5/26/86	6*	1	0	tr	tr*	0							6*	1	0
10LG	6/11/86	0	0	0	tr	tr	0				9	tr	0	9	1	0
10EG	6/2/86	2	tr	0	3*	2*	0				22	tr	0	28*	3*	0
11LG	6/10/86	4	tr	0	2	tr	0				14	1	0	20	2	tr
11EG	6/9/86	tr*	tr*	0	6*	1	0				16	tr	0	23	2	0

^aAbbreviations in Appendix A Table 9.

^bIncludes all low to medium height shrubs sampled per site. Additional shrubs species per site are:
 6G⁸⁵ and ⁸⁶ = Aruv, Juco and Pofr; 6U⁸⁶ and 7U⁸⁵ and ⁸⁶ = Pofr; 7G⁸⁵ and ⁸⁶, and 9EG⁸⁶,
 = Juco and Pofr; 8U⁸⁵ and ⁸⁶ = Spbe; 8G⁸⁵ and ⁸⁶ = Acgl, Sara and Spbe; 9LG⁸⁶ = Juco; 10LG⁸⁶
 = Amal and Prvi; 10EG⁸⁶ = Amal; and 11LG and 11EG⁸⁶ = Amal, Pofr and Shca.

¹tr = trace, a value less than 0.5%.

*Significantly different at 5% level from the site above.

Of the 3 late grazed vs. early grazed sites, 2 late grazed sites had significantly more grass (9LG/EG and 10LG/EG). Common dandelion canopy coverage was greater on 2 grazed (1G/U and 6G/U) and 2 early grazed (10EG/LG and 11EG/LG) sites. Clover (primarily Trifolium longipes) was never very abundant, but seemed to be more common on grazed sites, significantly so at site 6G. Strawberry was another uncommon bear food. At the 3 paired sites with significant differences, 2 ungrazed sites (7U and 8U) and 1 early grazed vs. late grazed site (11EG/LG) had greater canopy coverages (Table 5).

The number of stems were counted for 5 herbaceous plant species -- sharptooth angelica, cow-parsnip, mountain and western sweet-cicely, and glacier lily (Erythronium grandiflorum). The least common of these was glacier lily. This species was more abundant at 4 grazed vs. ungrazed sites, but not significantly.

The most common bear food counted was mountain sweet-cicely. Six paired site comparisons differed significantly. In 4 of these, the ungrazed plots had fewer stems (3U/G, 4U/EG/WG). One comparison of early and late grazed plots (10LG/EG) had significantly fewer stems in the late grazed plots. The only comparison in which an ungrazed treatment had significantly more was at site 1 (ungrazed vs. summer grazed). The "Osmo spp." category (which generally

Table 5. Mean numbers or canopy coverage, and mean heights of herbaceous bear foods in 60 m² plots at paired contrast sites. Heights were not measured in some plots in 1985.

Site	Date	Anar ^a #/Ht.	Hela #/Ht.	Osmo spp. ^b #/Ht.	Oscl #/Ht.	Osoc #/Ht.	Ergr #/Ht.	Frvi %/Ht.	Grass ^c %/Ht.	Taof %/Ht.	Trlo %/Ht.
1U	4/28/85		0	71/5				¹ tr/5	tr/8	tr/5	0
1G	4/28/85		*16/6	132/5				tr/4*	5/8	5/6	tr/4
1U	7/26/86	0	0		9/42	195/66		tr/11	4/65	tr/8	0
1G	7/22/86	9/48	*69/55		7/36	*443/60		1/11	*23/66	*8/13*	tr/11
2U	5/8/85			8/			0	tr/	tr/	tr/	
2G	5/7/85			34/			98/	tr/	tr/	tr/	
2U	6/26/86				75/24	20/69	0	1/15	tr/43	tr/24	
2G	6/19/86				82/14*	*253/40*	14/5	4/14	*3/51*	1/18*	
3U	5/14/85	188/13	13/20	50/			0	tr/5	5/12	3/9	tr/
3G	5/15/85	*2/8	0	267/5			65/	tr/3	1/7	3/9	tr/3
3U	6/24/85	306/59	30/78		201/21			tr/10	10/60	2/24	tr/7
3G	6/22/86	*6/50	0		*450/30*			tr/9	7/57	3/12*	2/5
4U	5/17/85	0	328/25	15/7				tr/3	11/12	tr/5	tr/2
4EG	5/21/85	tr/7	731/10	145/				tr/3	3/7*	1/7	0
4WG	5/25/85	0	487/	*155/5				tr/5	1/5	tr/15*	0
4U	7/10/86		490/88		10/12			0	18/72	tr/20	tr/9
4EG	7/9/86		594/62*		*30/45*			1/14	11/58*	2/19	tr/15
4WG	7/11/86		726/130**		**160/21*			tr/12	**3/80*	tr/25**	0

Table 5. Continued.

Site	Date	Anar ^a #/Ht.	Hela #/Ht.	Osmo spp. ^b #/Ht.	Osos #/Ht.	Osoc #/Ht.	Ergr #/Ht.	Frvi %/Ht.	Grass ^c %/Ht.	Taof %/Ht.	Trlo %/Ht.
6U	6/15/85				558/9	6/22	97/10	1/8	11/25	11/16	8/7
6G	6/12/85				*58/6*	12/20	347/9	6/6	10/13*	*16/11*	*24/7
6U	7/30/86				179/20	22/24		5/8	24/60	12/11	3/9
6G	7/28/86				*65/11*	5/25		*2/7	17/30*	*20/10	*11/7*
7U	6/19/85		0		1247/7		293/11	7/7	6/15	10/14	
7G	6/19/85		1/15		1025/8		317/12	*1/7	7/13*	13/11*	
7U	8/1/86		0		483/23			4/8	18/34	9/12	
7G	7/31/86		tr/22		401/29*			*tr/6*	20/29*	8/7*	
8U	8/21/85				77/7			tr/13	24/32	2/12	
8G	8/19/85				124/5*			tr/	*13/9*	5/9*	
8U	6/16/86				151/13			1/11	24/43	6/21	
8G	6/17/86				*339/13			tr/7*	16/51*	7/15*	
9LG	5/25/86	143/15	0		94/4			tr/3	17/17	9/9	tr/3
9EG	5/26/86	*0	*58/6		86/4			tr/3	*8/14*	8/7*	tr/3
10LG	6/11/86		243/54		25/	1198/65		tr/7	23/53	1/27	
10EG	6/2/86		*11/15*		*70/12	*549/27*		tr/6*	*7/29*	*15/17*	
11LG	6/10/86	95/43	38/46		186/24	126/47		tr/7	20/44	16/20	1/7
11EG	6/9/86	*0	*1/25		353/23	34/25*		*3/10*	12/41	*11/18	1/5*

^aAbbreviations in Appendix A Table 9.^bOsmorhiza plants not keyed to species.^cIncludes all grasses and sedges. Sedges never exceeded a trace in any plot.¹tr = trace, a value less than 0.5%.

*Significantly different at 5% level from the site above.

**Significantly different at 5% level from 2 sites above.

contained more mountain than western sweet-cicely) also tended toward lower counts in the ungrazed plots, although differences were significant at only 1 site (4U compared to 4WG) (Table 5).

Sharptooth angelica, cow-parsip, and western sweet-cicely were the most desirable spring bear foods encountered in plots. Of these, cow-parsnip was the most common -- occurring at 11 sites. Two late grazed sites had significantly more cow-parsnip stems than did early grazed sites (10LG/EG and 11LG/EG), and 1 summer grazed site (1G) had significantly more than its paired ungrazed site. Paired site 9EG/LG had more stems at the early grazed site than at the late grazed site. Sharptooth angelica had significantly more stems at an ungrazed vs. early or late grazed site (3U/G), and 2 late grazed vs. early grazed sites (9LG/EG and 11LG/EG). Western sweet-cicely was significantly more abundant at 2 grazed vs. ungrazed sites (1G/U and 2G/U) and 1 late grazed vs. early grazed site (10LG/EG) (Table 5).

Since plot data on phenology were too incomplete for statistical analyses, weighted mean heights were used as an index to phenology. These data (Table 5) show that among paired sites more ungrazed vs. grazed and late grazed vs. early grazed sites had significantly taller bear foods.

Effects of historical grazing on bear foods. -- In the

above analyses of herbaceous bear foods, it was apparent that the current grazing regimes (particularly no grazing from 2 to 9 years) were inadequate predictors of bear food abundances. Consequently, historical information on grazing period, stocking density, and the proportion of each pasture covered by mesic plant communities were used as criteria to compare sites that differed significantly in amount of bear foods (Table 6). In 1986 (the year all sites were measured), there were significantly more desirable bear foods (sharptooth angelica, cow-parsnip, and western sweet-cicely) in pastures that were historically grazed after the month of June (sites 1G, 2G, 3U, 9LG, 10LG, and 11LG). Four of the 6 sites/pastures had more animal units per area, and all 6 had proportionately more aspen and willow than their paired pastures that were grazed during June.

The historical information did not adequately explain why mountain sweet-cicely, the most common Umbelliferae measured, was more abundant at certain sites than others. Of the paired site comparisons, it was more abundant in 4 early grazed sites (3G, 10EG, 4EG, and 4WG) regardless of grazing intensity or proportions of aspen and willow in the pastures. It was also more abundant at 2 sites (6U and 8G) that, compared to their paired sites, had similar grazing periods, very similar stocking densities, and similar proportions of riparian vegetation (Table 6).

Table 6. Relationships between pasture characteristics and abundance of specific herbaceous bear foods. Pluses indicate significantly greater ($p < 0.05$) abundance (number or canopy coverage) than the other site in the pair.

Site	Bear foods								Historic pasture characteristics ^b		
	Anar ^a #	Hela #	Oscl #	Osoc #	Frvi %	Grass %	Taof %	Trlo %	Months cattle grazed	Stocking density ^c (A.U./ha) ^d	Aspen and willow ^e (%)
1U									June-Sept.	0.3	10
1G		+		+		+	+		July-Sept.	0.4	25
2U									June-Sept.	0.3	10
2G				+		+			July-Sept.	0.1	17
3G			+						June/Aug.-Oct. ^f	0.5/1.1	1
3U	+								Sept.-Oct.	1.5	6
9EG		+							June-July	0.6	12
9LG	+					+			July-Sept.	0.4	25
10EG			+				+		June-July	0.3	18
10LG		+		+		+			Aug.-Oct.	0.4	23
11EG						+			June-July	0.3	18
11LG	+	+					+		July/Aug./Sept. ^g	0.5	26
4EG			+						Feb.-May	1.3	19
4U									Sept.-Feb.	2.2	10
4EG									Feb.-May	1.3	19
4WG			+			+			Jan.-March	3.2	26
4U									Sept.-Feb.	2.2	10
4WG			+			+			Jan.-March	3.2	26
6U			+		+				July-Sept.	0.6	7
6G							+	+	July-Sept.	0.6	7
7U					+				July-Sept.	0.6	1
7G									July-Sept.	0.6	1
8U									June-Aug.	0.3	7
8G			+						June-Aug.	0.4	4

^aAbbreviations in Appendix A Table 9.

^bAveraged for 1950 through 1985, or up to date of rest.

^cPasture area calculated minus steep slope closed timber areas.

^dA cow with calf considered one Animal Unit (A.U.) until weaning.

^eThe proportion of pasture covered by aspen and willow.

^fGrazed annually in either June or August through October.

^gGrazed annually in either July, August, or September.

In 4 of the 6 paired site/pasture comparisons of grazing in June vs. later than June, grasses were more abundant when grazed after June (1G, 2G, 9LG, and 10LG). All 4 sites with significantly greater amounts of grass had a higher proportion of riparian vegetation in their respective pastures, and 2 (1G and 11LG) had greater stocking densities. Grass was also more abundant at site 4WG, where the pasture was grazed from January-March by more animal units and contained more riparian vegetation than sites 4EG and 4U with which it was compared (Table 6).

Common dandelion was more abundant at 4 paired site/pasture comparisons. Two of the sites with more dandelions (1G and 11LG) were grazed later than June (vs. during June) by more animal units in pastures with proportionately more riparian vegetation than the sites/pastures with which they were paired. Site 10EG had more dandelions, was grazed during June (vs. later than June), by less animal units, and occurred in a pasture with proportionately less riparian vegetation than did 10LG; and site 6G had more dandelions than 6U even though their respective pastures had the same grazing period, stocking densities, and proportions of riparian vegetation. Strawberry and clover differed significantly in 3 comparisons (strawberry in 6U/G and 7U/G, and clover in 6U/G) even though grazing period, stocking density, and

proportions of aspen and willow did not differ (Table 6).

Pasture Utilization by Cattle

Five pastures were measured to determine short term impacts of cattle grazing on herbaceous bear foods in mesic communities (Table 7). The Kurt Heinrich (KH) and North Cow Creek (NC) pastures were measured in 1985, the Tom Salansky (TS) and Hightower (HT) pastures in 1986, and the South Dupuyer Creek (SD) pasture in both years. These pastures varied in shape (Appendix D, Fig. 8), physiography (from a relatively flat grassland with shallow coulees, to gently rolling to steep foothills), and size (from 66 to 324 ha). The number of plots in each pasture ranged from 3 to 10 and was roughly proportional to the amount of aspen and willow present (ranging from 4 to 15 %). The distances of plots from the gate through which cattle entered the pasture ranged from 0.2 to 2.0 km. Black angus or crossbreed black angus yearlings or cow/calf pairs grazed the study pastures. Stocking densities were from 0.4 to 1.0 A.U./ha. All pastures were grazed for at least a 30 day period between June 1 and September 30. The earliest entry date was May 18, and the latest was July 1 (Table 7).

Cattle utilization of 2 categories of bear foods (1) grasses/sedges, common dandelion, and clover; and 2) members of the Umbelliferae family (sharptooth angelica, cow-parsnip, mountain and western sweet-cicely) varied widely

Table 7. Characteristics of 5 pastures in which cattle utilization patterns were monitored.

	Pasture				
	KH	NC	SD	TS	HT
Year	1985	1985	1985 and 1986	1986	1986
Plots/ pasture (#)	10	10	10	3	5
Range of plot distances from gate (km)	0.8-1.6	0.2-1.2	0.2-2.0	1.4-1.8	0.4-1.6
Pasture physiography	prairie and gently rolling foothills	prairie and shallow coulees	gently rolling to steep foothills	gently rolling prairie	gently rolling to steep foothills
Proportion of pasture in aspen and willow (%)	13	12	15	4	4
Pasture area (ha)	259	259	324	66	222
Class of livestock	yearling heifer	cow/calf	cow/calf	yearling heifer	cow/calf
Stocking density (A.U./ha)	0.6	1.0	0.5	0.6	0.4
Period grazed	June 10 - July 10	June 6 - July 5	June 25 - Aug. 21, '85 July 1 - Aug. 17, '86	June 1 - Sept. 30	May 18 - Aug. 1

among pastures (Appendix B, Tables 10-16), but on average cattle utilized 30% of the bear foods in 22-28 days (Figures 2 and 3). In 41-47 days, all bear foods were 50% utilized. Umbelliferae were 80% utilized by day 61, while grasses, sedges, dandelions, and clovers were 67% utilized after 82 days of grazing.

At the end of the grazed period, average use of plots closest to the gate of entry was generally no different than farther ones (Figures 4 and 5). Cattle utilization of Umbelliferae was similar in plots 0 to 0.5 and 1.0 to 1.5 km from the gate and greater at more distant plots. Grasses, sedges, dandelions, and clover were more heavily utilized at sites further from the entry point than at sites near the gate (Appendix B, Table 17).

Bear Food Phenology

Seven bear foods were analyzed for earliest and latest dates at the "seed ripe" stage (Fig. 6). The earliest plant species to produce seeds was common dandelion (May 19). Next were clover, the grasses (primarily Kentucky bluegrass, smooth brome, and timothy), and mountain sweet-cicely, which produced seeds in early June. Later were western sweet-cicely (June 15), cow-parsnip (June 25), and sharptooth angelica (July 14).

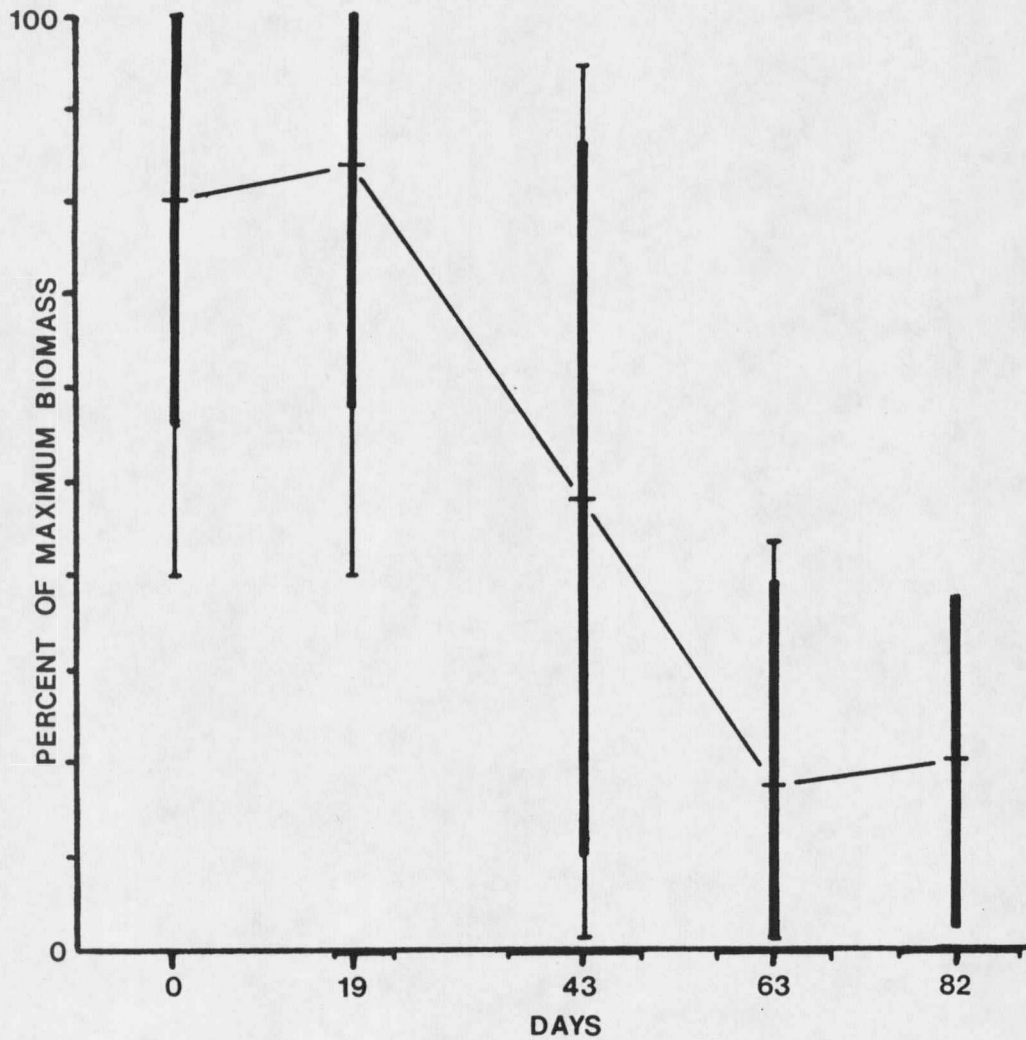


Figure 2. Average, standard deviation, and range of residual biomass of the Umbelliferae category of bear foods in 5 pastures measured through the grazing period. The index of maximum biomass is defined in the text.

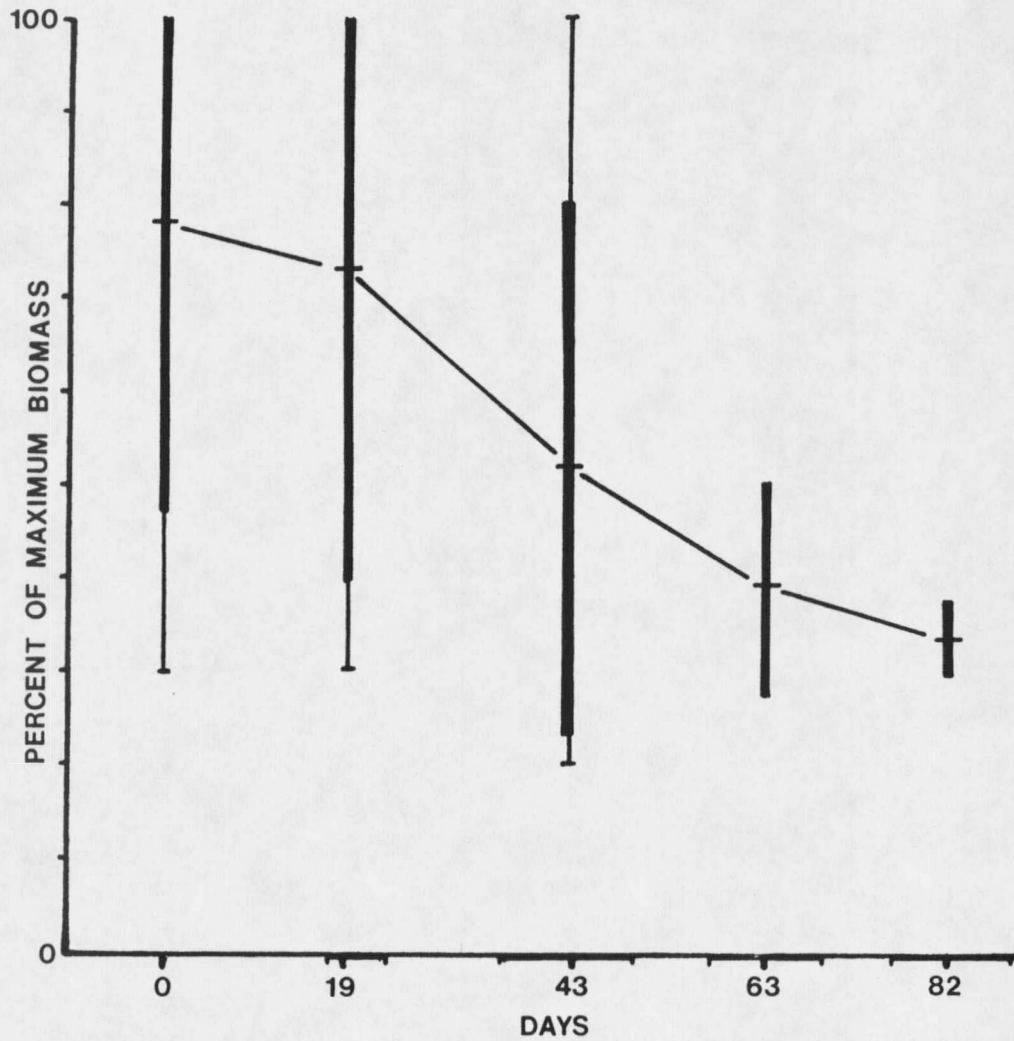


Figure 3. Average, standard deviation, and range of residual biomass of the grass/sedge, dandelion, and clover category of bear foods in 5 pastures measured through the grazing period. The index of maximum biomass is defined in the text.

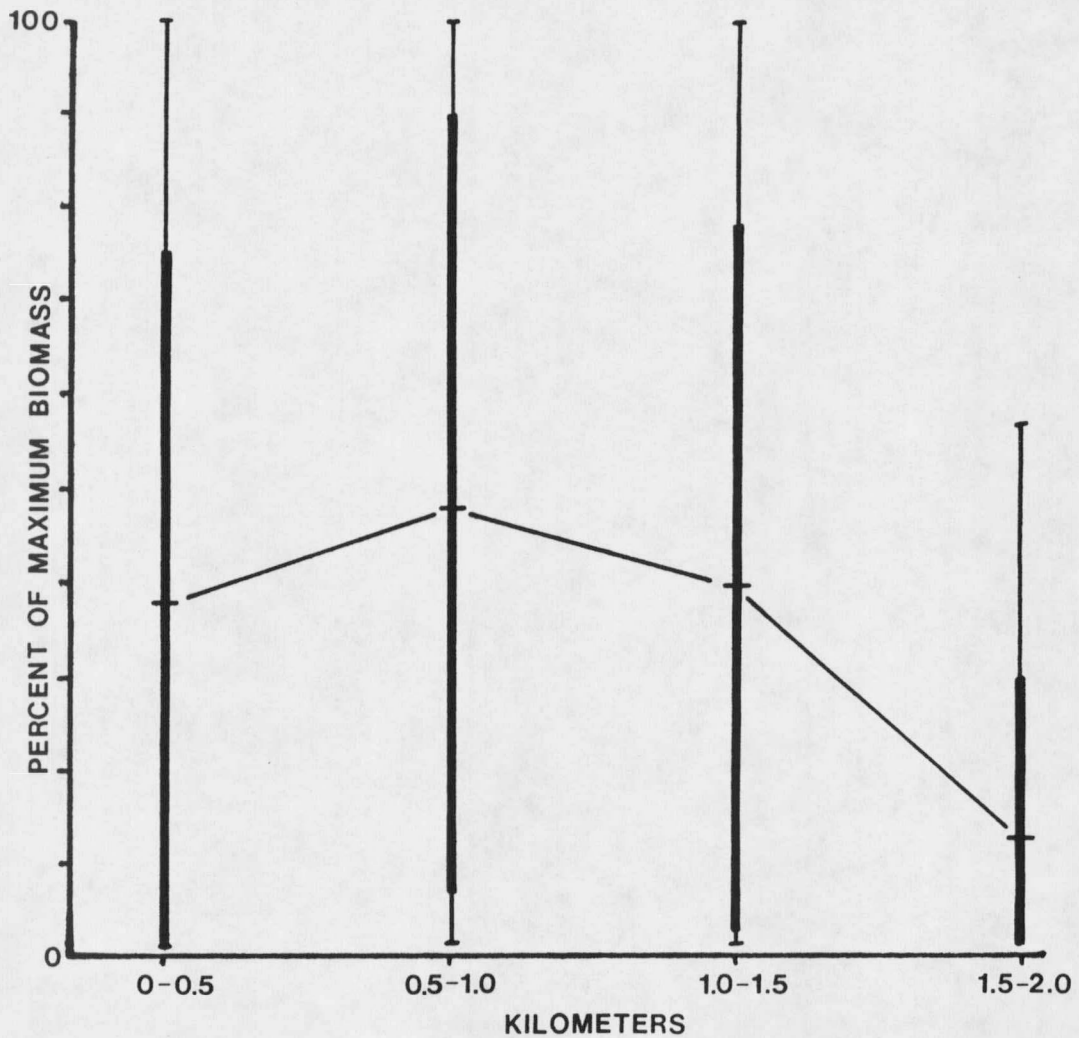


Figure 4. Average, standard deviation, and range of residual biomass at the end of the grazing period for the Umbelliferae category of bear foods for plots at varying distances from the gate cattle entered a pasture.

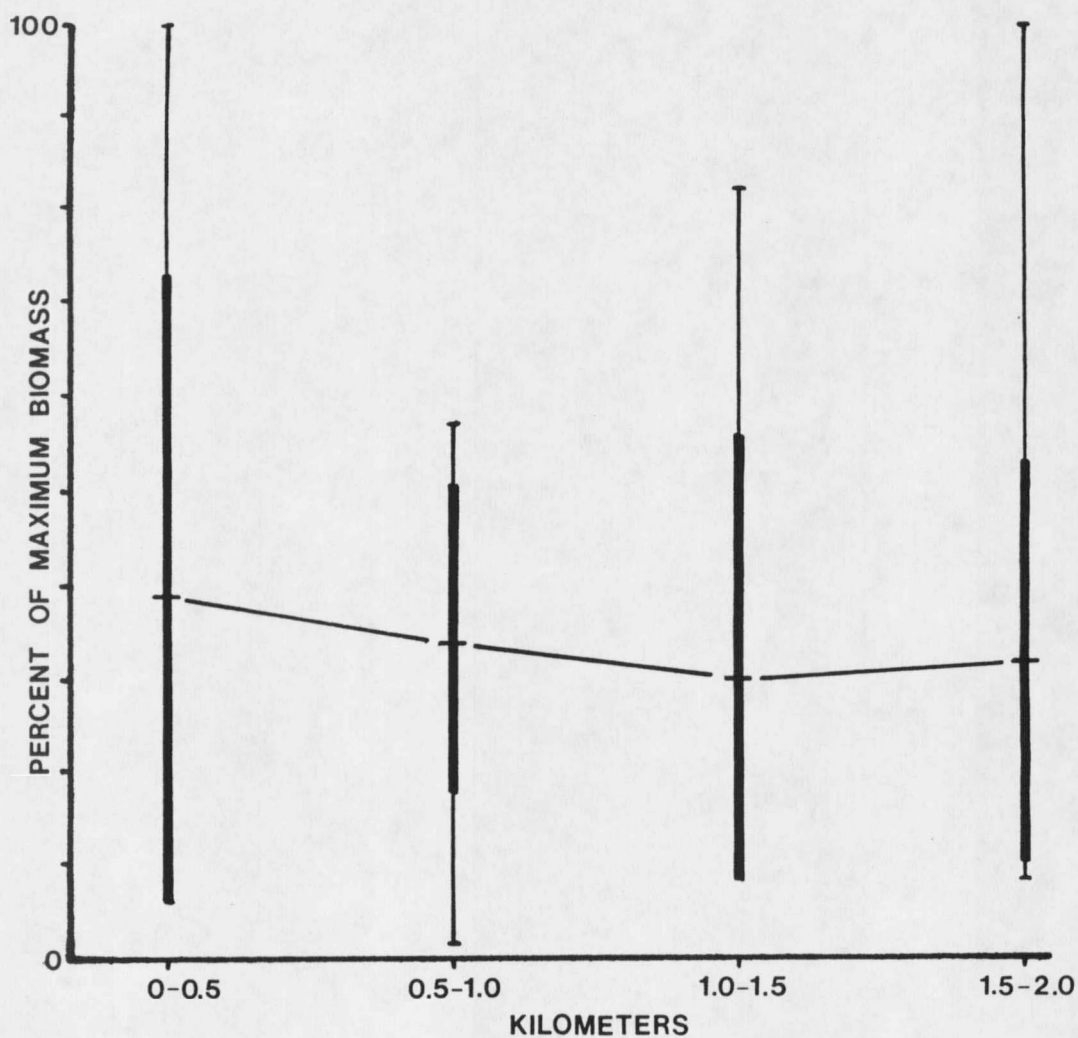


Figure 5. Average, standard deviation, and range of residual biomass at the end of the grazing period for the grass/sedge, dandelion, and clover category of bear foods for plots at varying distances from the gate cattle entered a pasture.

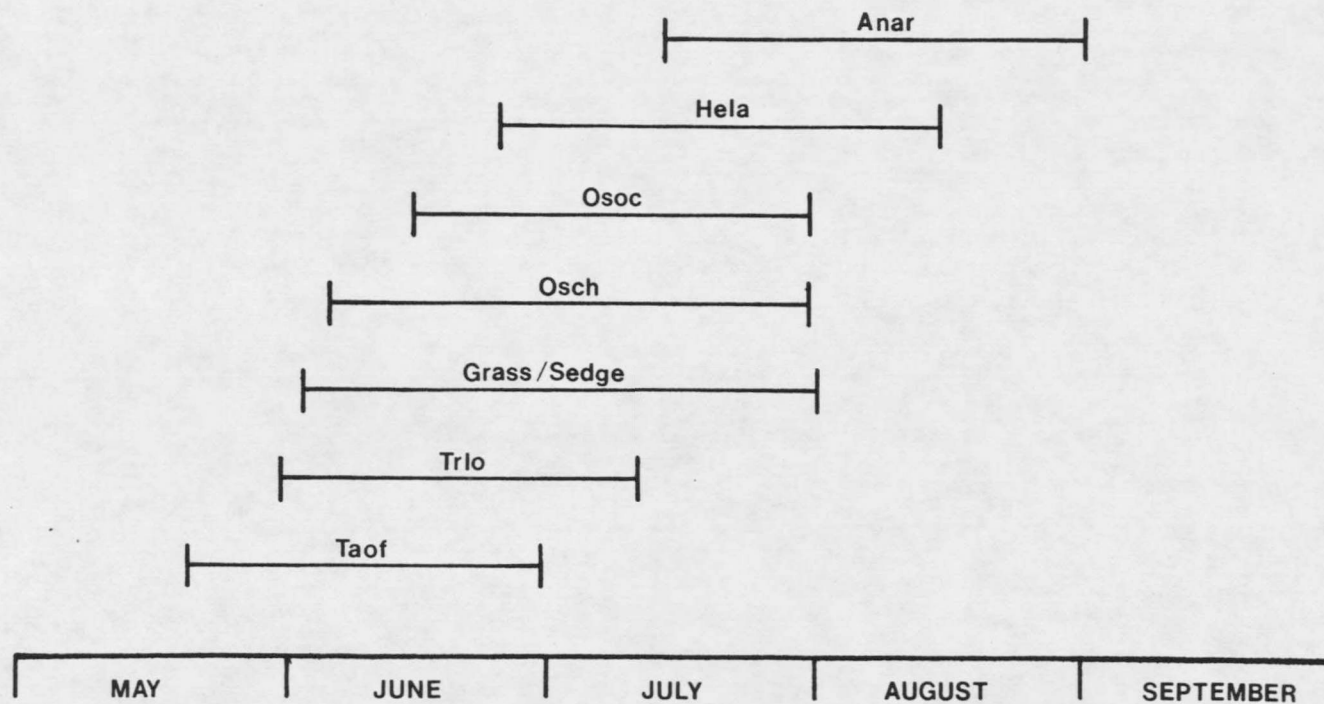


Figure 6. The range of earliest and latest dates at which bear foods reached "seed ripe" phenological stage within the study area, 1985 and 1986.

Bear Food Re-establishment

Ten sites in 1985 (E1-E10) and 5 sites in 1986 (E11-E15) were used for experimental plantings of from 1 to 3 members of the Umbelliferae family (Table 8 and Appendix D). In 1985, 10 plantings were made of cow-parsnip, 6 of sharptooth angelica, and 6 of western sweet-cicely. Germination success and seedling establishment varied. The E3 Potre/Salix site, the wettest of the 15 sites, was most favorable for sharptooth angelica, cow-parsnip, and western sweet-cicely. At site E3, cow-parsnip had the greatest canopy coverage and was the tallest at the end of the growing season, averaging 15 cm on August 23. The species tested did worse on drier Potre/grass and Potre/Syal sites. Two plantings of cow-parsnip and 1 of western sweet-cicely were inundated with water for a portion of the next spring. Flooding inhibited either germination or seedling establishment.

In 1986, 5 plantings were made of cow-parsnip and 5 of western sweet-cicely. The western sweet-cicely seeds planted the previous year had been collected when still succulent (the seeds had not dried on the stem) and had the poorest success of the 3 species planted. The 1986 plantings were made with drier, more mature seeds. Those plantings also had poor to fair success when checked in spring. Results for cow-parsnip plantings were similar to those of

Table 8. Results of 1985 and 1986 experimental plantings of 3 Umbelliferae bear foods.

Site	Cover type	Year planted	Germination success and seedling establishment ^a		
			Sharptooth angelica	Cow-parsnip	Western sweet-cicely
E1	Potre/grass	1985	Fair	Good	Poor ^b
E2	Potre/Salix	1985	Good	Good	Fair
E3	Potre/Salix	1985	Good	Excellent	Fair
E4	Salix	1985		Poor ^b	
E5	Salix	1985		Poor	
E6	Potre/grass	1985	Fair	Good	Poor
E7	Potre/Syal	1985		Poor	
E8	Potre/Syal	1985	Poor	Fair	Poor
E9	Potre/Syal	1985	Poor	Fair	Poor
E10	Salix	1985		Poor ^b	
E11	Potre/Salix	1986		Fair	Fair
E12	Potre/Salix	1986		Fair	Poor
E13	Potre/grass	1986		Poor	Poor
E14	Potre/Salix	1986		Poor	Poor
E15	Potre/Syal	1986		Poor	Poor

^aCanopy coverage of 0-5 % = Poor, 6-25 % = Fair, 26-75 % = Good, and 76-100 % = Excellent.

^bExperimental planting site inundated with water in spring.

western sweet-cicely (Table 8).

When the 1985 plantings were checked the second spring, germination and seedling establishment success had not changed. Plants on the wetter plots had increased in height. At site E3 cow-parsnip was averaging 21 cm, sharptooth angelica 16 cm, and western sweet-cicely 11 cm on May 19, 1987.

DISCUSSION AND CONCLUSIONS

Grizzly bears within the study area use aspen and willow stands in significantly higher proportions than their availability would suggest (Aune 1986). During spring and early summer the stands are important sources of succulent vegetation used by the bears for food. The structural cover of these stands can provide a secure habitat for resting and foraging. The stands growing along the dendritic stream courses often form contiguous riparian corridors. These corridors aid the bears in their search for winter-killed wild ungulates and the dead cattle annually available in boneyards of ranches (Aune and Brannon 1987). The following discussion pertains to the effects cattle grazing has on these food and cover values of aspen and willow communities within the study area.

Grazing Effects on Stand Structure/Survival

The aspen literature from the Central Rocky Mountains suggests that once a mature stand is established, regeneration is minor until the stand is cut or destroyed by fire or other natural agents (DeByle and Winokur 1985, Smith et al 1972). Then the even-aged suckers grow quickly and enough can usually survive cattle grazing to regenerate the

stand if the total area of the stand is large enough (Mueggler and Bartos 1977, Smith et al 1972). In uneven-aged aspen stands, regeneration is usually sparse and the suckers grow slowly. Cattle grazing can then inhibit stand regeneration (Beetle 1974, Krebill 1972). Sucker production and stand regeneration are also influenced by carbohydrate reserves, hormonal growth promoters in the roots, genotype, and nongenetic factors such as clone history, stem age, and environmental factors at the site (Schier 1981 and 1975, Schier and Campbell 1980, Jones 1975, Schier and Johnston 1971, Tew 1970).

In my study area, aspen appears to be a climax species. The aspen parklands of Canada extend southward into northern Montana along the east slope of the Rocky Mountains (Lynch 1955). Unlike aspen of the Central Rocky Mountains, the climax aspen parklands of Canada are expanding in the absence of fire (Bailey and Wroe 1974, Moss 1932).

Stand structure was measured to determine if browsing and trampling by cattle were affecting aspen and willow recruitment deemed necessary for stand survival. The data suggested that ungrazed sites produced more aspen and willow suckers than grazed sites. Apparently, this was because many of the stands were uneven-aged. At 2 of the late grazed sites, it appeared that the herbaceous understory was

out competing aspen suckers. There were also portions of some stands that were heavily impacted by cattle. For example, within stands, cattle generally had preferred places for loafing. Cattle consumed and trampled suckers in those localized areas. Though not reflected in these data, there also were pastures within the study area where stock water was only available in a fenced alley-way leading to a stream. This practice concentrated cattle and could cause excessive browsing and trampling on aspen and willow suckers.

In most aspen and willow stands, cattle grazing was not intensive enough to affect stand survival. The majority of pastures containing study sites, regardless of stocking density or the proportion of aspen and willow, had suckers that survived cattle use. Most aspen stands appeared to be quite dynamic. Decadent aspen clones were observed that had been toppled by wind and then produced prolific suckering. No sites were observed where remnant aspen or willow stands had been displaced by coniferous, shrub, or grassland plant communities. The majority of aspen and willow stands within the study area appeared to be stable in size or expanding.

Cattle grazing within the study area appeared to have little effect on the occurrence and abundances of shrub species. Rose was the exception. It appeared to be more abundant where early or heavy cattle grazing allowed it to

have a competitive advantage over other plant species. The presence of most shrubs seemed to be controlled by site factors other than grazing. I suspect that many shrub species (for example, snowberry) were present prior to aspen encroachment. None of the shrubs that produced berries utilized by bears for food appeared abundant enough in measured plots to have had an effect on bear energetics. The only shrub showing signs of heavy browsing was red-osier dogwood, and it appeared to be used by deer.

Grazing Effects on Food and Cover Values

Cattle grazing did affect concealment cover. The line intercept method indicated that ungrazed and late grazed vs. early grazed sites had more cover from 0.5 to 1.0 m above the ground, which is thought important for concealing a bear. Since the optimum cover level is unknown, these data do not mean that grazed sites had inadequate cover for bears. Other factors, not measured in this study, are also thought important in making cover secure for bears. Aune (1986) showed that grizzly bears avoided aspen and willow sites located close to roads (0-500 m), and the use of a particular site is also probably dependent on its juxtaposition to other plant communities and/or cover types.

The analyses of herbaceous bear foods showed that plants in ungrazed vs. grazed and late grazed vs. early grazed plots were on the average taller. This is probably

because the bear foods at these sites were more vigorous. It also appeared that these bear foods were phenologically more advanced -- possibly because of less soil compaction during the wetter portion of the growing season.

Sites/pastures historically grazed after the month of June had more of the desirable bear foods (cow-parship, sharptooth angelica, and western sweet-cicely) than sites/pastures grazed during June. The one site/pasture grazed earlier in the growing season than June had as much cow-parship as its contrasted sites/pastures grazed in the fall or winter. At this particular site, cow-parship plants were observed that had been eaten by cattle down to ground level and still grew to produce seeds that summer when cattle were removed before June. This suggests that June cattle grazing is adversely affecting the abundance of these desirable bear foods. The historical information also suggests that if 2 pastures differ in their proportion of aspen and willow but are equal in their stocking densities and period of grazing during the growing season, it will probably take the cattle longer to impact the desirable bear foods in the pastures containing more aspen and willow.

Of the other bear foods measured at paired sites, mountain sweet-cicely was found at virtually all sites regardless of current or historical grazing season or intensity. It was the shortest Umbelliferae species

measured and the earliest to grow to maturation, which probably indicates it demands less soil moisture for growth. Its short stature also helped it escape herbivory. Its ability for regrowth following herbivory also appeared to be great.

The 3 common grasses (timothy, Kentucky bluegrass, and smooth brome) seemed to be more abundant in sites/pastures grazed after June, yet were also common in June sites/pastures. Smooth brome and Kentucky bluegrass are rhizomatous, and all 3 are quite tolerant to grazing and trampling. Common dandelion and clovers were low growing plants that did well at sites grazed during June and/or grazed heavily after June. The occurrence of strawberry can not adequately be explained by the cattle grazing information found in this study.

The 3 most nutritious bear foods had median dates for development of mature seeds in July or August. The median date for all grasses and sedges was around the first of July, and common dandelion and clover developed ripe seeds in June. This suggests that June cattle grazing of bear foods (assuming cattle diet preferences were equal for all bear foods) probably would not allow sharptooth angelica, cow-parsnip, and western sweet-cicely time to produce the seeds necessary for survival. It would also follow that sites/pastures grazed during June should have lower impacts

on the overall vigor, and therefore seed production, of dandelions, clovers, grasses and sedges, and mountain sweet-cicely than the 3 more nutritious bear foods. The relative abundances of plants in measured plots supports this idea.

Grazing Patterns and Their Effects on Bear Food Availability

The 5 utilization pastures that were studied showed that cattle do eat and/or trample herbaceous bear foods, that by 41-47 days all bear foods were on average 50% utilized, and that by the end of the grazing period cattle had utilized aspen and willow sites and bear foods throughout the pastures. My observations of cattle movements and activities support these quantitative findings. Some of the factors which seemed to have influenced the rate at which cattle reached and consumed herbaceous bear foods in aspen and willow stands within studied pastures were: pasture physiography, grassland and aspen and willow forage production, the proportion of a pasture covered by aspen and willow, stocking density, grazing period, and weather.

Typically, when cattle were turned into pastures in June or early July, the grassland vegetation was still succulent and the days were cool. Within 2 days the cattle were evenly distributed over the grasslands. Their rate of movement and consumption when foraging seemed to be dependent on the volume of succulent grasses and how easily

they could be procured. When there were no topographical or physical obstructions and forage volume was great, they moved slowly. When the succulent grasses were consumed, or became dry and/or unpalatable, cattle either moved faster or shifted to aspen and willow stands to forage. The cattle first chose open areas within aspen and willow stands where there were ample amounts of succulent vegetation (and herbaceous bear foods) to enable them to fill their rumens with the least amount of effort. Such areas were often used for "shading up" and loafing during the heat of mid-day. Loafing areas were often dominated by grasses, dandelions, and clovers. When these plant species were consumed or trampled, cattle shifted to adjacent areas and fed on the more nutritious bear foods (sharptooth angelica, cow-parsnip, and western sweet-cicely).

Cattle generally consumed the smaller more tender, lateral, stems of these plants before the apical, seed-bearing stems. If these apical stems were mature enough, they either escaped herbivory altogether or were not eaten until the more tender stems were gone, a process which often took 2 to 3 weeks.

The pattern traditionally followed by operators along the East Front when rotating cattle through their pastures also appeared to affect bear food availability. Many operators have their cattle in willow / hay meadow pastures

during winter and early spring. These pastures generally have an abundance of the more desirable bear foods.

During May and June most operators had their bulls in with their cows for breeding purposes. Many operators used small pastures during these 2 months which insured a high stocking density and maximum fertilization of the cows. (The desirable herbaceous bear foods can potentially regrow and produce seeds if cattle are removed before June, and soil moisture is adequate during June.) Pastures grazed in June were generally deficient in large Umbelliferae species but had ample amounts of grazing-tolerant bear foods such as grasses, dandelions, and clovers.

Most summer pastures were large and grazed from July into September. Some operators rotated cattle among several pastures during this period. Most summer pastures contained enough area of aspen and willow that the majority of western sweet-cicely and cow-parsonip plants on favorable sites produced seeds before being damaged or consumed by cattle. Sharptooth angelica, the phenologically latest bear food to flower and produce seeds, seemed to require wetter sites than the other Umbelliferae species. It was locally common at microsites within summer pastures where wet "swampy" areas or willow brush denied cattle access.

During October, ranchers typically turned their cattle back onto hay meadow pastures to fatten cows and calves

prior to weaning and selling of the calves. Again, the herbaceous bear foods that grew in these pastures had already shed their seeds by this time. These pastures generally produced the largest biomasses of nutritious bear foods.

Aune and Brannon (1987) reported the results for 1020 East Front grizzly bear scats collected and analyzed from 1979-1986. Their results showed that mammals (primarily domestic cattle) were the most frequently found food items in March scats. Mammals and graminoids were the most important bear foods found in April scats. During May, graminoids were most important, followed by forbs, insects, and mammals. Graminoids and forbs were most important during June and July, followed by insects and mammals, respectively.

I feel that the results from this scat analysis reflects both preference and availability of spring bear foods. I have noticed that bears spend much of their time visiting ranch boneyards in search of dead cattle. Dead domestic calves are most abundant in early spring (March and April). This food source is usually consumed by May. During May and June, some herbaceous bear foods are available virtually everywhere bears travel and in quantities greater than the grizzly bear population within the study area could possibly consume despite elimination

or declines in Umbelliferae species in some pastures. If one considers that most ranch operations within the study area have annual calving mortality of approximately 5% and an annual mortality rate on adult cattle of approximately 1%, the biomass of domestic cattle carrion may energetically offset, or surpass, the negative effects of cattle on herbaceous bear foods.

Bear Food Re-establishment

During this study some aspen and willow stands were found that were deficient, or totally lacking, in the more nutritous herbaceous bear foods (cow-parsnip, sharptooth angelica, and western sweet-cicely). The majority of these stands were isolated (not contiguous with larger riparian areas) or were historically grazed in June even though some were protected from cattle grazing at the time of this study. Since the seeds of these 3 species are relatively heavy and unarmed, recolonization of pastures from which they have been extirpated would be slow. Current grazing practices could allow re-establishment of these plant species in many pastures, if seeds were planted.

Hoffman (1985) and McDonough (1969) conducted laboratory tests on germination requirements for cow-parsnip and western sweet-cicely. They found that the seeds of both species needed to imbibe water and be subjected to a cold stratification period of 112 to 120 days to achieve maximum

germination. McDonough also found that a 4-hr wash of these seeds prior to cold stratification improved germination success.

The reseeded experiment results were promising. Some seeds germinated at every planting site. Survival was low through summer in many sites, but improvements in technique and appropriate weather conditions during the germination/establishment period should improve results.

Weather data from the Choteau, Montana airport (the nearest reporting weather station) shows that during the first spring of the experiment, precipitation was below average for March, April, May, and June (Appendix C). Those seeds that did germinate may have soon withered. During the second September that seeds were planted, precipitation was above average, but temperatures were below average. This may have prevented the seeds from adequately absorbing water, thus nullifying the following cold stratification.

Weather conditions may be optimum for seedling germination and subsequent establishment in a low proportion of years; therefore, several annual plantings at each site may be necessary. To maximize seedling survival, seedlings should be protected from livestock herbivory and trampling. Additional efforts at enhancing stands with these plant species could help persuade bears to stay in the mountain and foothill habitats, instead of venturing further onto the

plains where problems with humans are more likely to occur.

MANAGEMENT GUIDELINES AND RECOMMENDATIONS

Management Guidelines

1. Livestock grazing on riparian plant communities should be deferred until after July 1.
2. In pastures grazed after July 1, cattle should be removed before the use of the riparian forage base reaches 50%.
3. Exceptions to the July 1 entry date can be made when a pasture is part of a grazing system (for example, rest rotation, deferred rest rotation, or a 1-2 week grazing period in June followed by 60-90 days of rest prior to regrazing) that does not cause a decrease in the condition or size of the riparian plant communities or the abundance of three important bear foods: Angelica arguta, Heracleum lanatum, and Osmorhiza occidentalis.

Management Recommendations

1. The condition and trend in riparian plant communities and the production of Angelica arguta, Heracleum lanatum, and Osmorhiza occidentalis in these communities need to be determined on all public lands grazed by livestock on the East Front.
2. For pastures where the condition of riparian plant

communities needs improving, the construction of special use pastures is recommended. A special use pasture should be constructed where large areas of riparian vegetation can be enclosed to form a pasture with an adequate forage base to allow for stocking rates compatible with livestock operations. Cattle should be removed before the utilization of the riparian forage base reaches 50%, or the special use pastures should be incorporated into a deferred rest rotation grazing system similar to that described by Marlow (1985). Exclosures should be considered if riparian areas are small, need protection, and cannot be incorporated into a special use pasture.

3. For riparian areas where important plant species used by grizzlies for cover (Populus tremuloides, P. tricocarpa, Salix spp., or Betula spp.) or food (Angelica arguta, Heracleum lanatum, or Osmorhiza occidentalis) have been reduced, reestablishment through plantings should be attempted.

[Re-establishment methodologies are available in Beson and Pillmor (1983) and Redente et al. (1982).]

LITERATURE CITED

LITERATURE CITED

- Aune, K. 1985. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 138pp.
- _____, and B. Brannon. 1987. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 195pp.
- _____, M. Madel, and C. Hunt. 1986. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 175pp.
- _____, and T. Stivers. 1981. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 50pp.
- _____ and _____. 1982. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 143pp.
- _____ and _____. 1983. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 180pp.
- _____, _____, and M. Madel. 1984. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dep. Fish, Wildl., Parks, Helena. 238pp.
- Bailey, A. W. and R. A. Wroe. 1974. Aspen invasion in a portion of the Alberta parklands. J. Range Manage. 27(4):263-266.
- Beetle, A. A. 1974. Range survey in Teton County, Wyoming. Part 4 -- quaking aspen. Agric. Exper. Sta. SM-27. Univ. of Wyoming, Laramie. 28pp.
- Beson, P. T. and R. Pillmor. 1983. Maintaing the cottonwood willow association.. Sec. 4, Implementation of Multiple Use Management. R. A. Schmidt ed., Management of cottonwood willow riparian associations in Colorado. Wildl. Soc., Colorado Chapter.

- DeByle, N. V. and R. P. Winokur. 1985. Aspen: Ecology and Management in the Western United States. USDA For. Ser. Gen. Tech. Rep. RM-119. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 283pp.
- Emlen, J. T. 1967. A rapid method for measuring arboreal canopy cover. Ecology 48:158-160.
- Harvey, S. J. 1980. The potential and current vegetation of the Sun River Game Range. Allen Foundation and Fed. Aid in Wildl. Rest. Proj. 2-130-R. Mont. Dept. Fish, Wildl., Parks, Helena. 85pp.
- Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. U. Wash. Press, Seattle. 730pp.
- Hoffman, G. R. 1985. Germination of herbaceous plants common to aspen forests of western Colorado. Bull. Torrey Bot. Club 112:409-413.
- Jones, J. R. 1975. Regeneration on an aspen clearcut in Arizona. USDA For. Ser. Res. Note RM-285, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. 8pp.
- Kasworm, W. F. 1981. Distribution and population characteristics of mule deer along the East Front, Northcentral Montana. M.S. Thesis. Mont. State Univ., Bozeman. 73pp.
- Knight, R., J. Basile, B. Blanchard, K. Greer, S. Judd, K. Kendall, L. Oldenberg, and L. Roop. 1975-1981. Yellowstone grizzly bear investigations. Ann. Rep. U.S.D.I.-N.P.S. Interagency Study Team.
- Krebill, R. G. 1972. Mortality of aspen on the Gros Ventre elk winter range. USDA For. Ser. Res. Paper INT-129, Intermountain Forest and Range Experiment Station, Ogden, Utah. 16pp.
- Lesica, P. 1982. Vegetation of the wetland and riparian areas of Pine Butte Preserve, Teton County, Montana. Report to the Nature Conservancy, Big Sky Field Office, 50pp.
- Lynch, D. L. 1955. Ecology of the aspen groveland in Glacier County, Montana. Ecol. Monogr. 25:321-344.

- Marlow, C. B. 1985. Controlling riparian zone damage with little forage loss. Montana Agresearch. Montana Agricultural Experiment Station. Montana State University. Bozeman, MT. 2:1-7.
- McDonough, W. T. 1969. Effective treatments for the induction of germination in mountain rangeland species. Northwest Sci. 43:18-22.
- Mealey, S. P., C. Jonkel, and R. Demarchi. 1977. Habitat criteria for grizzly bear management. Proc. 13th Inter. Cong. Game Biol., Atlanta, GA. Washington DC: Wildlife Society, WMI, pp. 277-289.
- Moss, E. H. 1932. The vegetation of Alberta: 4. The poplar association and related vegetation of central Alberta. J. Ecol. 20:380-415.
- Mueggler, W. F. and D. L. Bartos. 1977. Grindstone and Big Flat exclosures -- A 41-year record of changes in clear-cut aspen communities. USDA For. Ser. Res. Paper INT-195, Intermountain Forest and Range Experiment Station, Ogden, Utah. 16pp.
- Redente, E. F., P. R. Ogle, and N. E. Hargis. 1982. Growing Colorado plants from seed: a state of the art. Vol. III: Forbs. USDI Fish and Wildlife Service, FWS/OBS-82/30, 141pp.
- Schallenger, A. and C. Jonkel. 1978. Rocky Mountain east front studies, 1977. First Ann. Rept. Border Grizzly Project. School For., Univ. Montana., Missoula. BGP Spec. Rept. No. 18. 69pp.
- _____, and _____. 1979. Rocky Mountain east front studies, 1978. Univ. Montana., Missoula. BGP Spec. Rpt. No. 27. 115pp.
- _____, and _____. 1980. Rocky Mountain east front studies, 1979. Univ. Montana., Missoula. BGP Spec. Rpt. No. 39. 209pp.
- Schier, G. A. 1975. Deterioration of aspen clones in the middle Rocky Mountains. USDA For. Ser. Res. Paper INT-170, Intermountain Forest and Range Experiment Station, Ogden, Utah. 14pp.

- _____. 1981. Physiological research on adventitious shoot development in aspen roots. USDA For. Ser. Gen. Tech. Rep. INT-107, Intermountain Forest and Range Experiment Station, Ogden, Utah. 12pp.
- _____ and R. B. Campbell. 1980. Variation among healthy and deteriorating aspen clones. USDA For. Ser. Res. Paper INT-264, Intermountain Forest and Range Experiment Station, Ogden, Utah. 12pp.
- _____ and R. S. Johnston. 1971. Clonal variation in total nonstructural carbohydrates of trembling aspen roots in three Utah areas. Can. J. For. Res. 1:252-255.
- Sizemore, D. L. 1980. Foraging strategies of the grizzly bear as related to its ecological energetics. M.S. thesis, Univ. Montana., Missoula. 67pp.
- Smith, A. D., P. A. Lucas, C. O. Baker, and G. W. Scotter. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Utah Div. Wildl. Resources, Pub. No. 72-1, Logan. 32pp.
- Tew, R. K. 1970. Root carbohydrate reserves in vegetative reproduction of aspen. For. Sci. 16:318-320.
- Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J. 718pp.

APPENDICES

APPENDIX A

PLANT ABBREVIATIONS

Table 9. Key to plant species abbreviations.

Abbreviations	Scientific name	Common name
Abla	<u>Abies lasiocarpa</u>	subalpine fir
Acgl	<u>Acer glabrum</u>	Rocky Mountain maple
Agsp	<u>Agropyron spicatum</u>	bluebunch wheatgrass
Amal	<u>Amelanchier alnifolia</u>	western serviceberry
Anar	<u>Angelica arguta</u>	sharptooth angelica
Aruv	<u>Arctostaphylos uva-ursi</u>	bearberry
Beoc	<u>Betula occidentalis</u>	water birch
Brin	<u>Bromus inermis</u>	smooth brome
Cost	<u>Cornus stolonifera</u>	red-osier dogwood
Ergr	<u>Erythronium grandiflorum</u>	glacier lily
Feid	<u>Festuca idahoensis</u>	Idaho fescue
Fesc	<u>Festuca scabrella</u>	rough fescue
Frvi	<u>Fragaria virginiana</u>	strawberry
Hela	<u>Heracleum lanatum</u>	cow-parsnip
Juco	<u>Juniperus communis</u>	mountain juniper
Osch	<u>Osmorhiza chilensis</u>	mountain sweet-cicely
Osoc	<u>Osmorhiza occidentalis</u>	western sweet-cicely
Phpr	<u>Phleum pratensis</u>	timothy
Pico	<u>Pinus contorta</u>	lodgepole pine
Pien	<u>Picea engelmannii</u>	Engelmann spruce
Pifl	<u>Pinus flexilis</u>	limber pine
Pofr	<u>Potentilla fruticosa</u>	shrubby cinquefoil
Popr	<u>Poa pratensis</u>	Kentucky bluegrass
Potre	<u>Populus tremuloides</u>	quaking aspen
Potri	<u>Populus trichocarpa</u>	cottonwood
Prvi	<u>Prunus virginiana</u>	chokecherry
Psme	<u>Psuedotsuga menziesii</u>	Douglas fir
Ribes	<u>Ribes spp.</u>	currant
Rowo	<u>Rosa woodsii</u>	rose
Ruid	<u>Rubus idaeus</u>	red raspberry
Salix	<u>Salix spp.</u>	willow
Sara	<u>Sambucus racemosa</u>	elderberry
Shca	<u>Shepherdia canadensis</u>	Canadian buffalo-berry
Spbe	<u>Spiraea betulifolia</u>	shiny-leaf spirea
Syal	<u>Symphoricarpos albus</u>	common snowberry
Taof	<u>Taraxacum officinale</u>	common dandelion
Trlo	<u>Trifolium longipes</u>	common clover

APPENDIX B

PASTURE BIOMASS VALUES

Table 10. Biomass values from the Kurt Heinrich (KH) pasture, 1985, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured			Percent of maximum at end of grazing period U / NU
		Day 0	Day 18	Day 48	
		U ^a / NU ^b	U / NU	U / NU	
KHI	1600	4085 / 20	2891 / 7	1649 / 6	40 / 30
KHII	1600	5225 / 10	1998 / 5	2976 / 11	57 / 100
KHIII	1400	2703 / 12	1774 / 6	1070 / 5	40 / 41
KHIV	1000	490 / 323	108 / 39	208 / 64	42 / 20
KHV	1000	809 / 235	582 / 76	799 / 88	99 / 37
KHVI	1200	3809 / 6	1205 / 1	1672 / 1	44 / 10
KHII	1000	28 / 179	30 / 116	39 / 89	100 / 50
KHIII	800	678 / 11	1305 / 9	1439 / 6	100 / 52
KHIX	1200	301 / 43	292 / 9	241 / 11	80 / 25
KHX	1400	1800 / 13	2836 / 4	3601 / 11	100 / 82
Total		19928 / 852	13020 / 272	13694 / 291	
Percent of maximum biomass		100 / 100	65 / 32	69 / 34	

^aU = Umbelliferae bear foods (Anar, Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

Table 11. Biomass values from the North Cow Creek (NC) pasture, 1985, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured			Percent of maximum at end of grazing period U / NU
		Day 0	Day 17	Day 46	
		U ^a / NU ^b	U / NU	U / NU	
NCI	800	581 / 126	599 / 25	405 / 12	68 / 9
NCII	600	1601 / 61	1851 / 23	2425 / 8	100 / 13
NCIII	400	13 / 22	69 / 17	39 / 48	57 / 100
NCIV	400	0 / 7	0 / 4	0 / 4	0 / 57
NCV	200	48 / 319	24 / 117	18 / 179	38 / 56
NCVI	600	340 / 183	340 / 62	204 / 83	60 / 45
NCVII	1000	75 / 113	42 / 30	24 / 33	32 / 29
NCVIII	1200	148 / 157	192 / 21	128 / 23	67 / 15
NCIX	800	0 / 731	0 / 240	0 / 391	0 / 53
NCX	1200	976 / 57	1495 / 16	1049 / 12	70 / 20
Total		3782 / 1775	4602 / 554	4292 / 793	
Percent of maximum biomass		82 / 100	100 / 31	93 / 45	

^aU = Umbelliferae bear foods (Hela and Osch).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

Table 12. Biomass values from the South Dupuyer Creek (SD) pasture, 1985, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured				Percent of maximum at end of grazing period
		Day 0	Day 20	Day 41	Day 63	
		U ^a / NU ^b	U / NU	U / NU	U / NU	U / NU
SDI	1000	10510 / 11	10510 / 11	574 / 128	129 / 35	1 / 28
SDII	1200	40603 / 87	40603 / 87	695 / 95	260 / 76	1 / 80
SDIII	1400	43761 / 314	63380 / 1225	135 / 408	170 / 160	tr ^c / 13
SDIV	1600	74 / 659	160 / 1713	14 / 832	1 / 524	1 / 31
SDV	1800	8480 / 777	9860 / 1375	243 / 372	310 / 396	3 / 29
SDVI	2000	2418 / 445	975 / 1652	87 / 756	86 / 510	4 / 31
SDVII	200	8372 / 302	0 / 46	168 / 61	265 / 56	3 / 19
SDVIII	1800	75760 / 563	73750 / 676	766 / 107	4 / 85	0 / 13
SDIX	1800	8646 / 329	10001 / 751	647 / 231	201 / 168	2 / 22
SDX	1000	492 / 130	492 / 130	39 / 157	20 / 90	4 / 57
Total		199116 / 3616	209731 / 7665	3368 / 3147	1445 / 2101	
Percent of maximum biomass		95 / 47	100 / 100	2 / 41	1 / 27	

^aU = Umbelliferae bear foods (Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

^ctr = trace, a value less than 0.05%.

Table 13. Biomass values from the South Dupuyer Creek (SD) pasture, 1986, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured			Percent of maximum at end of grazing period U / NU
		Day 0	Day 20	Day 42	
		U ^a / NU ^b	U / NU	U / NU	
SDI	1000	25690 / 274	27140 / 295	210 / 37	1 / 12
SDII	1200	47630 / 593	25705 / 591	1620 / 95	3 / 16
SDIII	1400	49905 / 1542	18308 / 1572	335 / 129	1 / 8
SDIV	1600	115 / 4731	28 / 3359	35 / 961	30 / 20
SDV	1800	12409 / 3742	1561 / 2169	205 / 781	2 / 21
SDVI	2000	1447 / 2008	333 / 2356	69 / 800	5 / 34
SDVII	200	9736 / 438	79 / 51	25 / 26	tr ^c / 6
SDVIII	1800	70420 / 1106	7692 / 533	488 / 90	1 / 8
SDIX	1800	10515 / 1545	10185 / 1650	749 / 458	7 / 28
SDX	1000	580 / 324	95 / 249	22 / 93	4 / 29
Total		228447 / 16301	91126 / 12825	3758 / 3469	
Percent of maximum biomass		100 / 100	40 / 79	2 / 21	

^aU = Umbelliferae bear foods (Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo.)

^ctr = trace, a value less than 0.05%.

Table 14. Biomass values from the Tom Salansky (TS) pasture, 1986, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured					Percent of maximum at end of grazing period
		Day 0	Day 23	Day 35	Day 57	Day 76	
		U ^a / NU ^b	U / NU	U / NU	U / NU	U / NU	U / NU
TSI	1600	4624 / 573	9645 / 1716	9490 / 2311	1106 / 1341	356 / 960	4 / 42
TSII	1800	12397 / 443	36246 / 2315	23884 / 2243	1530 / 1060	624 / 367	2 / 16
TSIII	1400	16177 / 627	4485 / 882	3616 / 735	568 / 226	214 / 188	1 / 21
Total		33198 / 1643	50376 / 4913	36990 / 5288	3204 / 2627	1194 / 1516	
Percent of maximum biomass		66 / 31	100 / 93	73 / 100	6 / 50	2 / 29	

^aU = Umbelliferae bear foods (Anar, Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

Table 15. Biomass values from the Hightower (HT) pasture, 1986, for Umbelliferae (U) and Nonumbelliferae (NU) bear foods.

Plot number	Distance from gate (m)	Days of grazing when measured					Percent of maximum at end of grazing period U / NU
		Day 0	Day 18	Day 49	Day 69	Day 89	
		U ^a / NU ^b	U / NU	U / NU	U / NU	U / NU	
HTI	400	612 / 26	1519 / 56	674 / 24	590 / 7	446 / 5	29 / 9
HTII	400	59 / 256	95 / 463	73 / 222	96 / 121	141 / 112	100 / 24
HTIII	800	15 / 225	52 / 191	45 / 175	8 / 122	9 / 97	17 / 43
HTIV	1600	88 / 152	229 / 186	160 / 179	60 / 111	64 / 92	28 / 49
HTV	1400	32 / 327	165 / 224	88 / 170	135 / 81	126 / 104	76 / 32
Total		805 / 986	2060 / 1119	1039 / 771	889 / 443	786 / 410	
Percent of maximum biomass		39 / 88	100 / 100	50 / 69	43 / 40	38 / 37	

^aU = Umbelliferae bear foods (Hela and Osch).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

Table 16. Mean percent of maximum biomass for all pastures through the grazing period.

Pasture	Year	Percent of maximum measured through the grazing period				
		1st.	2nd.	3rd.	4th.	5th.
		U ^a / NU ^b	U / NU	U / NU	U / NU	U / NU
KH	1985	100 / 100	65 / 32	69 / 34	- ^c	-
NC	1985	82 / 100	100 / 31	93 / 45	-	-
SD	1985	95 / 47	100 / 100	2 / 41	1 / 27	-
SD	1986	100 / 100	40 / 79	2 / 21	-	-
TS	1986	66 / 31	100 / 93	73 / 100	6 / 50	2 / 9
HT	1986	39 / 88	100 / 100	50 / 69	43 / 40	38 / 37
Total		482 / 466	505 / 435	289 / 310	50 / 117	40 / 66
Mean percent of maximum biomass		80 / 78	84 / 73	48 / 52	17 / 39	20 / 33

^aU = Umbelliferae bear foods (Anar, Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

^cPasture not measured.

Table 17. Mean percent of maximum biomass at end of grazing period for all pastures/plots by distance categories from the gate cattle entered the pasture.

	Percent of maximum biomass at end of grazing period for all plots by distance categories			
	0 - 0.5 km	0.5 - 1.0 km	1.0 - 1.5 km	1.5 - 2.0 km
	U ^a / NU ^b	U / NU	U / NU	U / NU
	38 / 56	100 / 13	44 / 10	40 / 30
	3 / 19	60 / 45	80 / 25	57 / 100
	tr ^c / 6	100 / 52	67 / 15	1 / 31
	57 / 100	68 / 9	70 / 20	30 / 20
	0 / 57	0 / 53	1 / 80	28 / 49
	29 / 9	17 / 43	3 / 16	4 / 42
	100 / 24	42 / 20	40 / 41	3 / 29
		99 / 37	100 / 82	0 / 13
		100 / 50	tr / 13	2 / 22
		32 / 29	1 / 8	2 / 21
		1 / 28	76 / 32	1 / 8
		4 / 57	1 / 21	7 / 28
		1 / 12		2 / 16
		4 / 29		4 / 31
				5 / 34
Mean percent of maximum biomass	38 / 39	48 / 34	40 / 30	12 / 32

^aU = Umbelliferae bear foods (Anar, Hela, Osch, and Osoc).

^bNU = Nonumbelliferae bear foods (grasses, sedges, Taof, and Trlo).

C_{tr} = trace, a value less than 0.05%.

APPENDIX C

WEATHER INFORMATION

Table 18. Average temperature ($^{\circ}\text{C}$), total precipitation (cm), total snowfall (cm), and deviation from the long term average for Choteau, Montana airport from April 1985 through September 1986.

Month	Temperature ($^{\circ}\text{C}$)		Precipitation (cm)		
	Mean	Deviation ($^{\circ}\text{C}$) from long-term average	Amount	Deviation (cm) from long-term average	Snowfall (cm)
April 1985	9.22	+3.72	1.85	-0.51	16.51
May 1985	13.94	+2.72	4.01	-1.47	0.00
June 1985	15.83	+0.28	1.52	-5.16	0.00
July 1985	22.00	-2.67	0.08	-3.45	0.00
Aug. 1985	16.28	-2.11	10.24	+7.06	0.00
Sept. 1985	9.11	-4.22	10.57	+8.43	m
Oct. 1985	7.50	-1.11	1.70	+0.58	27.90
Nov. 1985	-9.90	-10.89	1.24	+0.25	44.45
Dec. 1985	-1.80	1.33	0.43	-0.41	10.20
Jan. 1986	3.67	10.39	0.28	-0.58	7.62
Feb. 1986	-6.11	-3.56	1.14	+0.38	43.18
March 1986	7.22	7.44	0.41	-0.51	m
April 1986	6.33	0.83	1.63	-0.74	12.70
May 1986	12.72	1.50	2.06	-3.43	0.00
June 1986	19.06	3.50	5.36	-1.32	0.00
July 1986	18.22	-1.11	1.63	-1.91	0.00
Aug. 1986	20.28	1.89	3.86	+0.69	0.00
Sept. 1986	10.33	-3.00	7.75	+5.61	0.00

^mmissing data.

APPENDIX D

MAPS

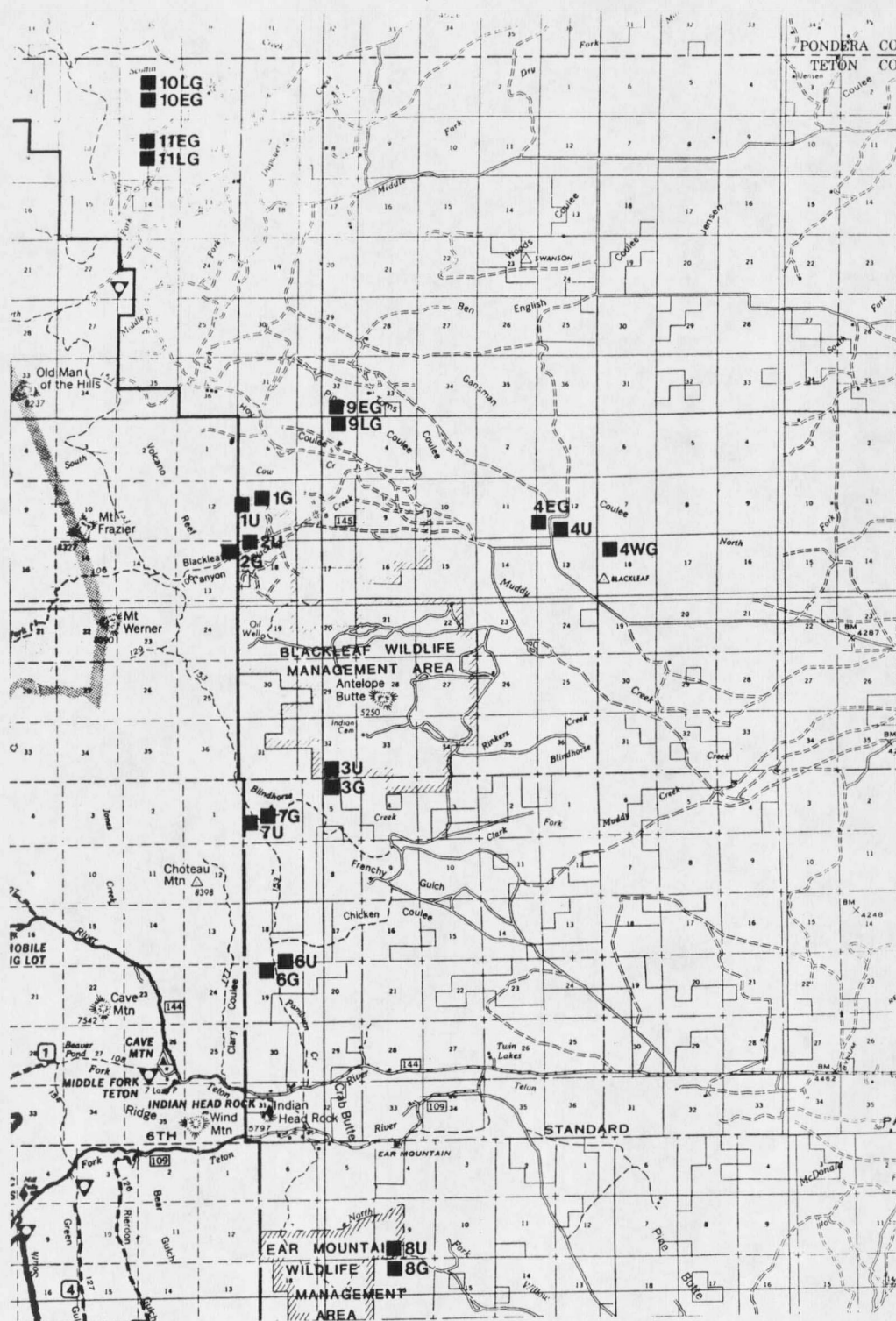


Figure 7. Map showing locations of paired contrast sites.

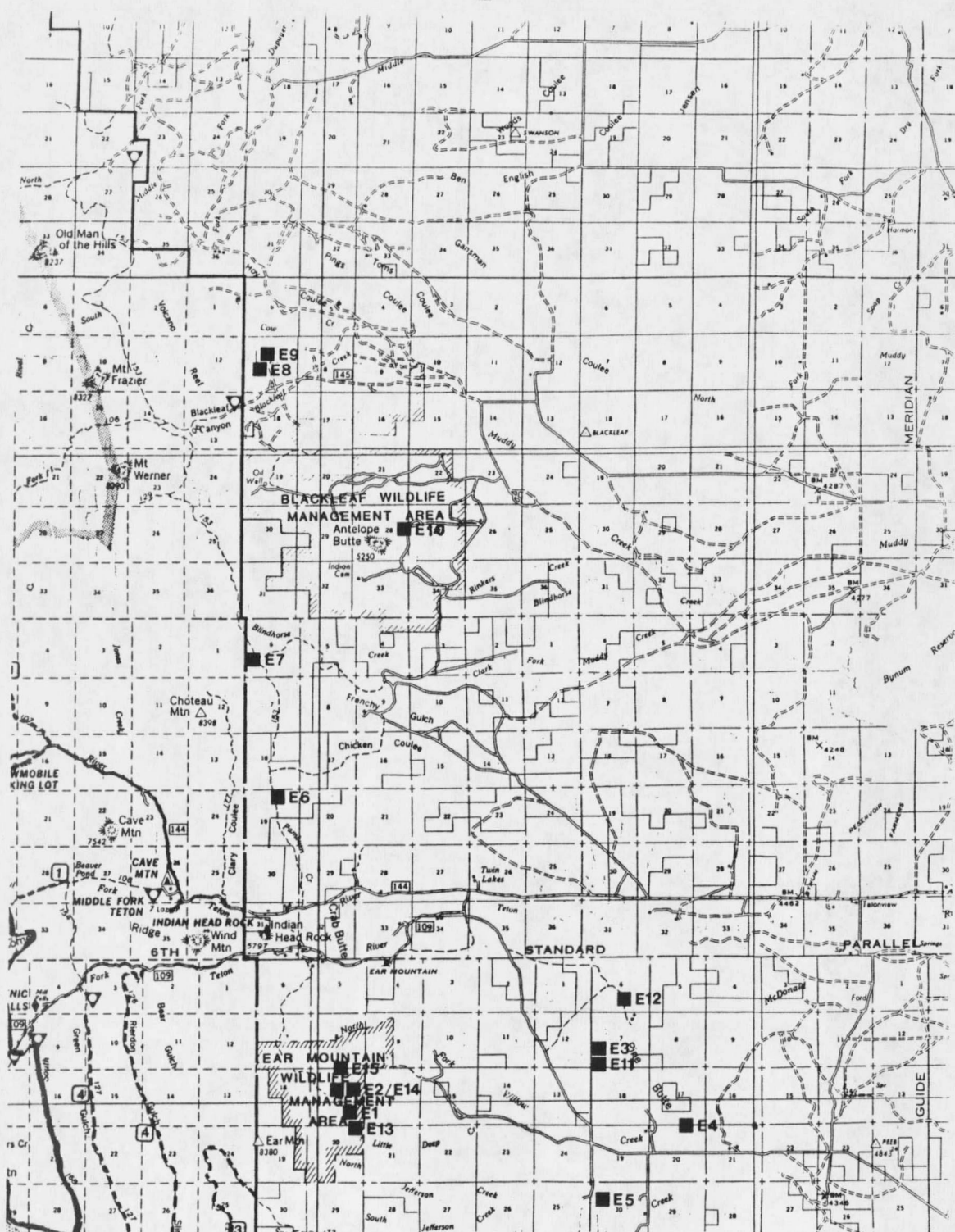


Figure 9. Map showing locations of experimental planting sites.

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