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

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

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

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

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

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

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

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

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

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

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

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

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

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

measuring the forage production of shrubs.

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

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

Meadow Unit

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

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

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

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

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

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

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

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

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

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

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

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

Cover Type - Area Level

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

Area

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

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

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

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

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

Cover Type - Overall

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

Overall

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

Total Pounds

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

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

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

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

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

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

Other Research

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

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

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

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

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

Forage Utilization

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

Weight of Forage Used by Ground Squirrels

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

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

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

1/ Forage production on plots grazed by ground squirrels

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

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

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

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

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

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

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

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

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

[3] n = number of plot pairs.

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

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

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

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

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

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

1/ Forage production on plots grazed by ground squirrels

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

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

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

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

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

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

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

3/ n = number of plot pairs.

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

Weight of Forage Used by All Herbivores

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

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

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

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

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

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

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

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

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

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

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

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

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

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

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

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

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

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

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

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

[1] Unprotected plots open to grazing.

[2] Plots protected against herbivore grazing.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Effects on Species Coverage

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Response of Grazing Animals to Cages

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

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

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

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

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

2/ Represents use by ground squirrels.

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

4/ Represents use by ground squirrels and big game.

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

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

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

2/ Represents use by ground squirrels.

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

4/ Represents use by ground squirrels and big game.

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

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

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

2/ Represents use by ground squirrels.

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

4/ Represents use by ground squirrels and big game.

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

Plant Phenology

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

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

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

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

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

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

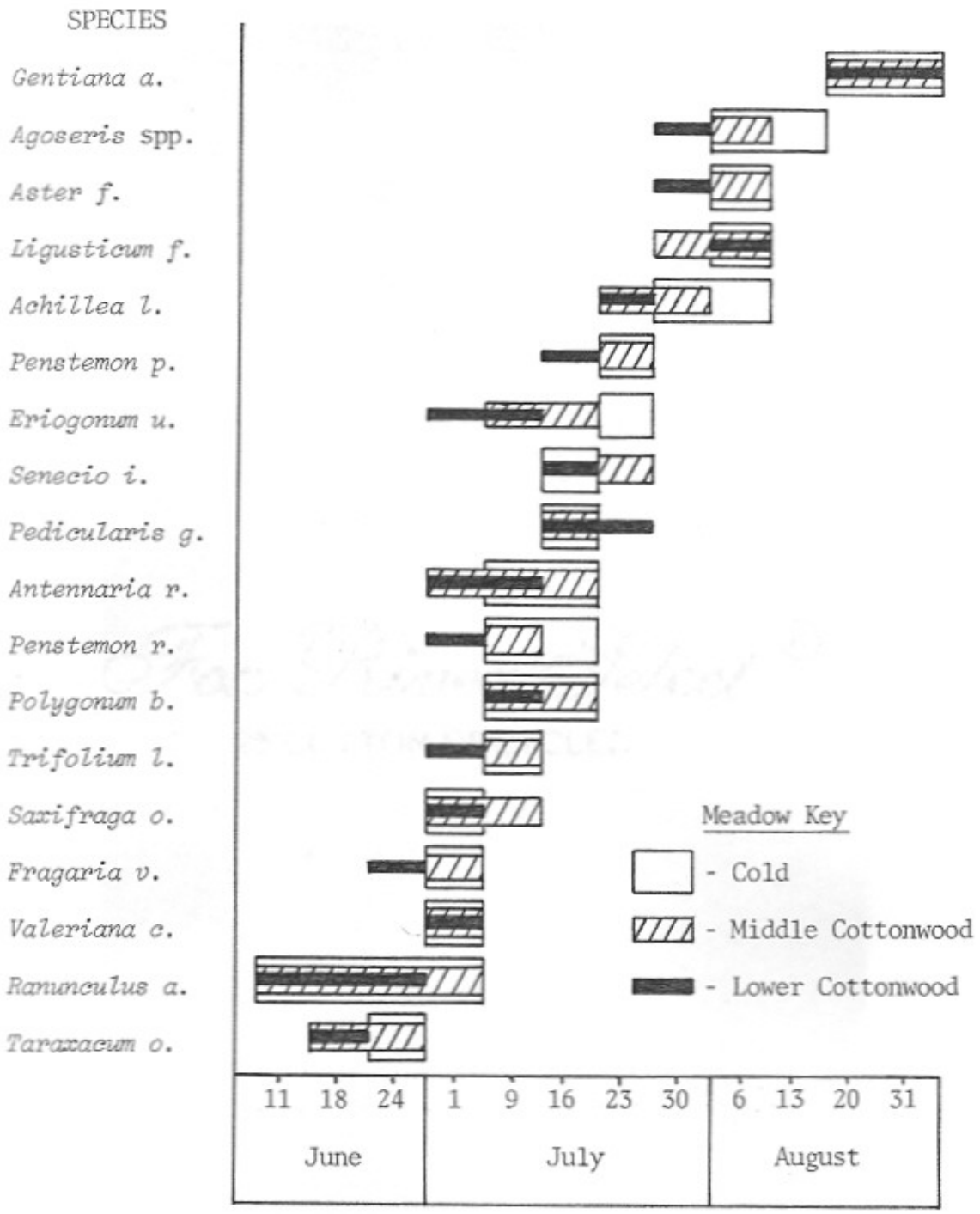

Figure 9. Full bloom periods of eighteen species of forbs on three mountain meadows.

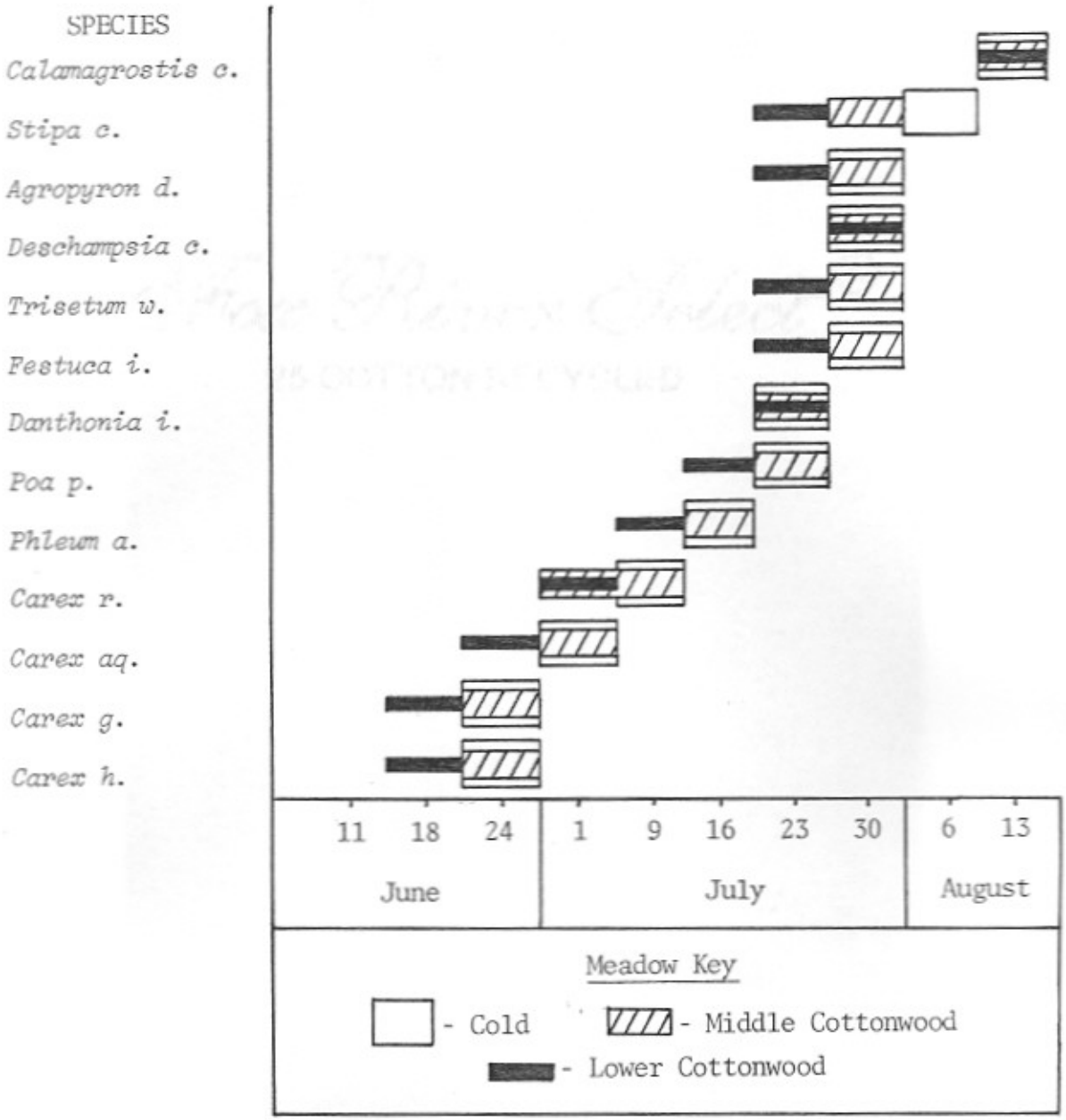

Figure 10. Full bloom periods of major grass and sedge species on three mountain meadows.

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

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

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

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

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

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

Forage Preferences of Elk

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

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

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

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

Table 58. Continued.

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

Table 58. Continued.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Timing of Forage Species Use by Elk

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

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

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

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

2/ All percentages over 30 percent are italicized.

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

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

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

2/ All percentages over 30 percent are italicized.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

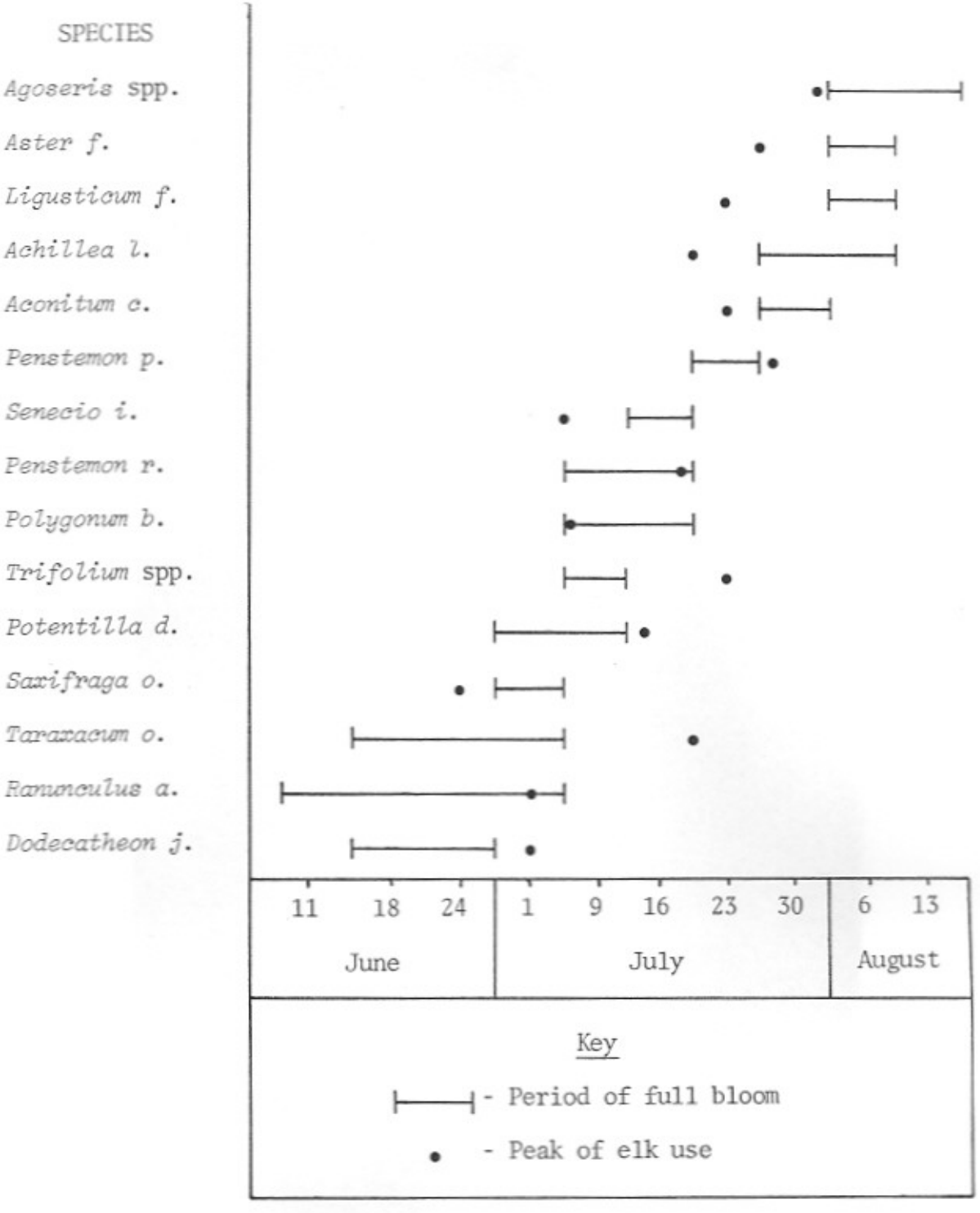

Figure 11. The relationship between dates of blooming and peaks of elk utilization for common meadow forbs.

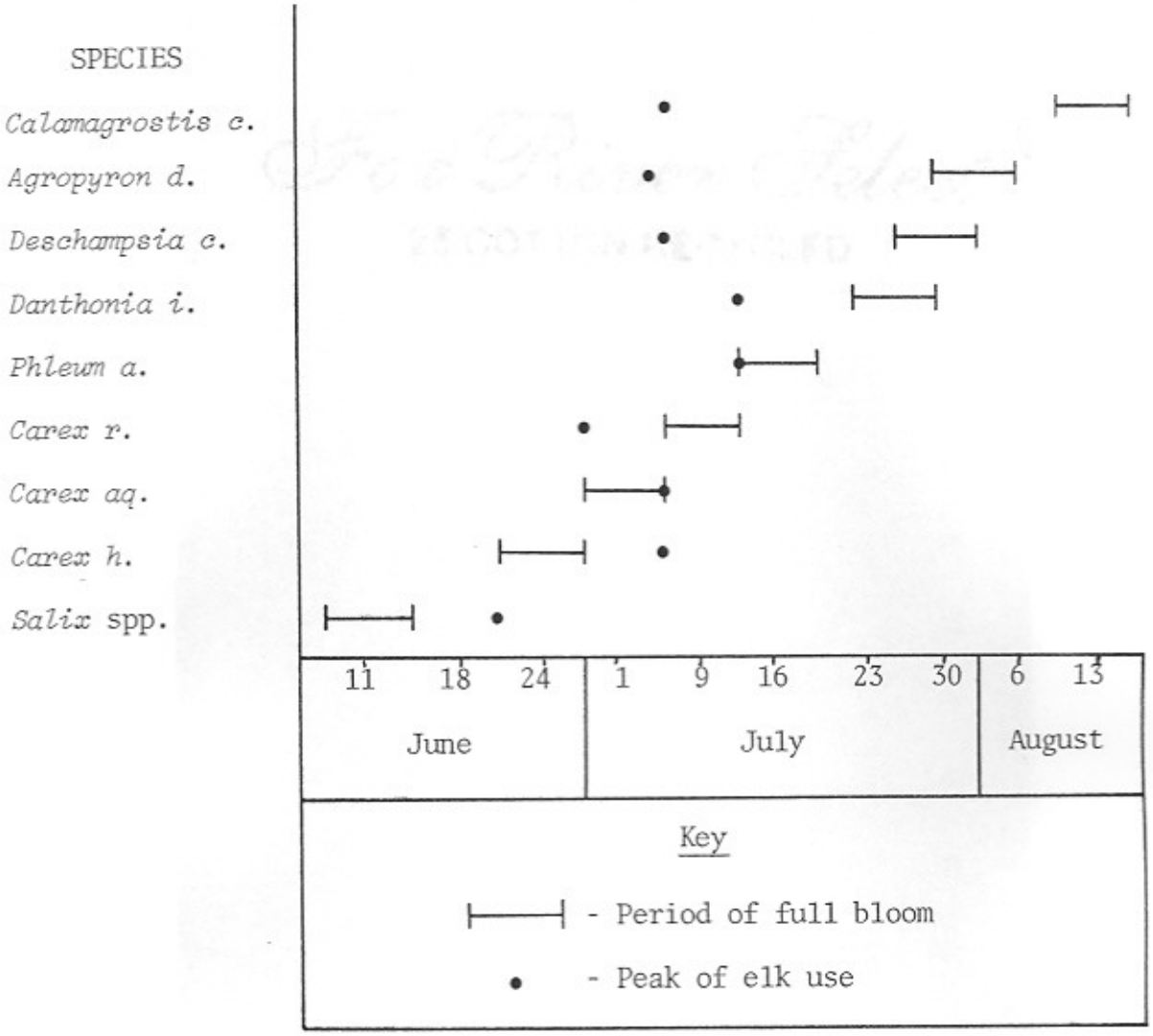

Figure 12. The relationship between dates of blooming and peaks of elk utilization for common meadow grasses, sedges, and shrubs.

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

Ground Squirrel Activities

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

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

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

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

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

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

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

DISCUSSION AND CONCLUSIONS

Applicability of Results

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

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

Status of Meadow Forage Resource

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

Meadow Values

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

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

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

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

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

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

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

Effects of Past Use

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

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

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

Trend

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

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

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

Recommendation

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

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

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

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

SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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APPENDIX I

List of plant species encountered on five mountain meadows

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

Forbs

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

Table 71. Continued.

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

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

APPENDIX II

Lists of standard errors for forage production and utilization means

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

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

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

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

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

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

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

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